PLEXON
Neurotechnology Research Systems

User Guide

Radiant Version 2.3, August 2019

PlexBright® 4 Channel Optogenetic Controller with Radiant™ Software

Part of the PlexBright Optogenetic Stimulation System

Plexon Inc
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CAUTION

THIS OPTOGENETIC CONTROLLER IS NOT FOR USE IN HUMANS.

CAUTION

READ THE ENTIRE MANUAL BEFORE ATTEMPTING TO OPERATE THIS EQUIPMENT.

CAUTION

In LED mode the output of the PlexBright 4 Channel Optogenetic Controller can range up to 12V. This high compliance voltage makes it possible to drive several LEDs in series from one controller output channel. Some external devices may be damaged by the voltages the controller can generate. Exercise caution when connecting the PlexBright 4 Channel Optogenetic Controller output to other devices to avoid inadvertently applying voltages up to 12V to those devices.

PlexBright® 4 Channel Optogenetic Controller with Radiant™ Software

Part of the PlexBright Optogenetic Stimulation System

User Guide

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Plexon Inc

Publication History

August 2019

This release updates information to reflect Radiant™ software Version 2.3.
The software runs on both Windows® 7 and 10 operating systems.
In addition, some trademark information and links have been updated.

November 2016

This release of the user guide is based on Radiant software Version 2.2.
The following changes have been made in the software:

- Rising-ramp and falling-ramp primitives have been added. Both primitives allow the user to specify an initial amplitude value, final amplitude value and duration.
  (The legacy ramp primitive from previous software releases can be loaded and its parameters can be modified, but no new legacy ramp primitives can be added.)
- Additional dialog boxes and progress bars have been added for improved usability.
- The LED list has been updated to include the new Plexon LEDs.
- If the user changes the Total Duration for a primitive so that it is equivalent to more than 999 repetition, and then switches back to Repetitions, the displayed value in the Repetitions field will be 999 (maximum allowed), and Total Duration will be updated to be equivalent to 999 repetitions. The system displays an appropriate informational message.
- If an .opt pattern file contains information about channel settings different than currently selected in the channel, the system displays an appropriate warning message before the channel parameters are updated to match information from .opt file.
- Patterns loaded to a channel from an .opt or .txt file exceeding 20 MB are shown schematically as green trapezoids indicating start and end of the pattern. This feature prevents unnecessary redrawing of multiple points of the pattern as it loads.

June 2016

This release of the user guide is based on Radiant™ software Version 2.1. It reflects a significant redesign of the user interface.

April 2014

In Section 1, added hardware part number 08-06-A-04-C.

In Section 11, changed voltage output accuracy from ±10mV, ±1% to ±18mV, ±2%.

In section 11 in the second row (Weight), changed “stimulator” to “controller” and changed 1.2 lbs to 1.1 lbs.

Updated the cross-references to the cautions on the inside front cover of the document.

December 2013

Added pattern generation and licensing, and updated hardware. Updated images, screenshots and illustrations accordingly.

December 2012

This is the first release of the manual.

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PlexBright® 4 Channel Optogenetic Controller with Radiant™ Software

1 Before You Begin

Before using your Plexon® PlexBright® 4 Channel Optogenetic Controller system, please check www.plexon.com for any software updates.

PlexBright 4 Channel Optogenetic Controllers manufactured prior to November 21, 2013 are eligible for a no charge upgrade to revision A. You can determine the revision of the controller by looking at the label on the bottom of the controller or by looking in the Radiant™ software under the info section for each controller (Radiant software Version 2.0 and later).

Please see the caution on the inside front cover. Contact Plexon Support at +1 214-369-4957 or support@plexon.com if you would like additional information.

The information in this version of the user guide refers to:

- Hardware Versions 08-06-A-04-A, 08-06-A-04-B, 08-06-A-04-C and later
- Firmware Version 08-06-A-32-B
- Radiant software Version 2.3

After the software is running on your computer, you will be able to view the hardware and firmware versions and the serial number of your controller(s) in the **Info** display of the user interface. As a convenience, there are labels placed on the underside of each controller with its hardware version and serial number. The software version is shown in the user interface in the **Help > About Radiant** menu.

2 Introduction

The PlexBright 4 Channel Optogenetic Controller (referred to in this document as “the controller”) is a 4 channel current output (LED mode) or voltage output (Laser mode) optical stimulation device. It has four individually programmable channels that can be configured from a host computer using the Radiant graphical user interface software. In LED mode the controller can output up to 1100mA from each channel and the compliance voltage can range up to 12V to drive multiple LEDs in series. In Laser mode the controller can output voltages from 0 – 5V for modulating the output of a Laser or other device. User defined output limits may be defined with 8-bit precision and output waveforms may be defined with 8-bit resolution within those output limits.

Playback of stimulation pulses and arbitrary waveform patterns can be initiated independently on each channel. Each channel has:

- Four stimulation playback controls—start, pause, unpause and stop—that can be controlled from the user interface on the host PC or triggered in response to external digital inputs.
- Four dedicated digital outputs to signal to other devices the precise time when stimulation events are occurring.

The graphical user interface incorporates a Pattern Generator tool that allows you to quickly define complex output patterns for the controller to play back. Arbitrary stimulation patterns can also be loaded from user defined text files or the outputs can be controlled directly by the user in manual mode.

Thank you for purchasing this Plexon product. We hope you are pleased with every aspect of it. Do not hesitate to contact Plexon Support at +1 214-369-4957 or support@plexon.com if you have any questions.

3 System Requirements

A 64-bit personal computer running Windows® 7 or Windows 10 with a free USB 2.0 port and 8 GB of memory is required to operate the system.

4 System Components

When you receive your PlexBright 4 Channel Optogenetic Controller, confirm that you have the following pieces:

1	USB memory with software and drivers (in box)	Plexon	
2	AC power cord (7.5 ft) This item is applicable to systems shipped within North America. For other destinations, see below. *****	Volex	17250 10 B1
3	Power Supply	Plexon	08-06-A-37
4	USB Cable (2m)	Monoprice	5438
5	Optogenetic Controller	Plexon	One of the following controller versions: 08-06-A-04-A 08-06-A-04-B 08-06-A-04-C or later
6	License Key (in software box)	Plexon	
7	Color-coded Insulated BNC Cables (4)	Plexon	06-03-A-04-CCLL

* The stimulator power supply has an International Electrotechnical Commission (IEC) 60320 C14 inlet for AC power (shown below). The AC power cord supplied with the stimulator has an IEC 60320 C13 connector on one end and a plug on the other end that is compatible with the AC wall outlets in the region to which the system was shipped.

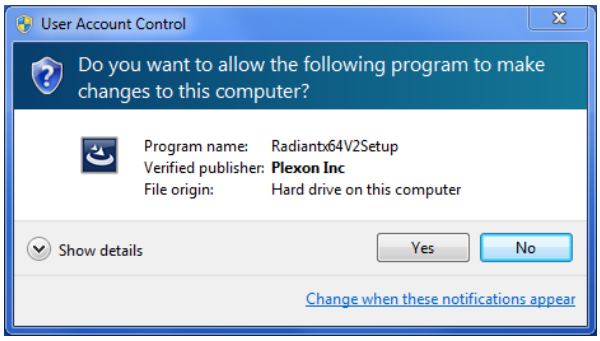
The hardware and cables are shown in the following photograph.

5 Installation

Read the entire installation section before proceeding with the installation. Follow the installation steps in the order that they are presented. Install the software first, followed by the hardware. Do not connect the controller to an implant until you have read the entire manual.

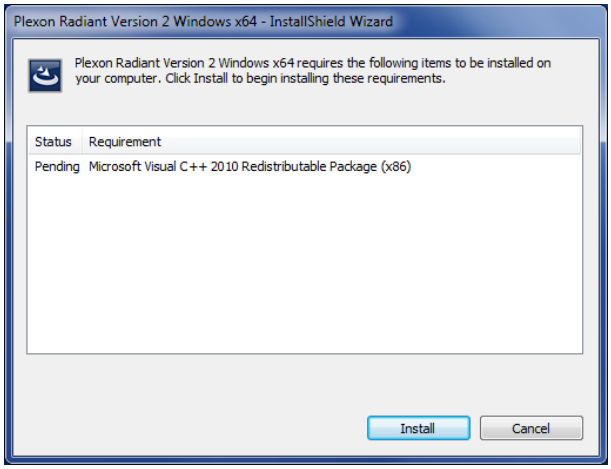
5.1 Software Installation

1. Browse to the \PLEXON_SW\RadiantV2\x64 folder on the USB flash drive.
2. Right-click the file Radiantx64V2Setup.exe and select **Run as Administrator** to begin the installation process. On some computers, you will get a **User Account Control** dialog.

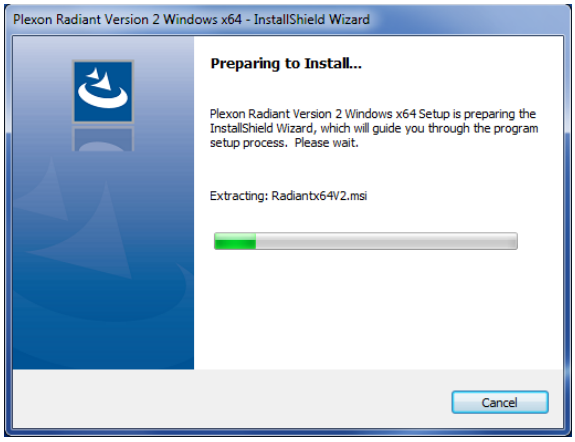


3. Click Yes to continue.
4. If the installation process requires installation of the Microsoft Visual C++ Redistributable Package, you will see the following dialog box.

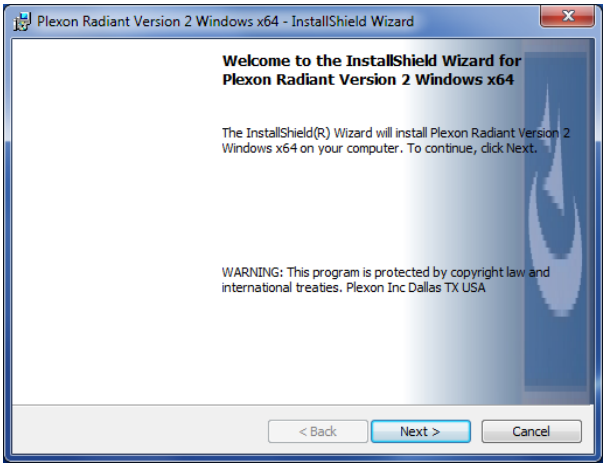
   If you see this dialog, click Install.

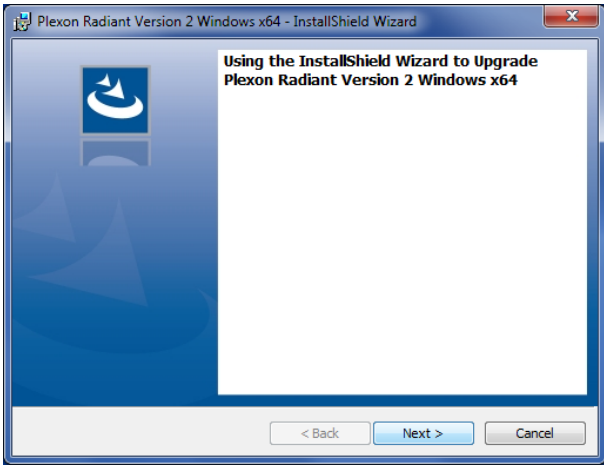


The InstallShield Wizard screen appears and the system begins extracting the file.

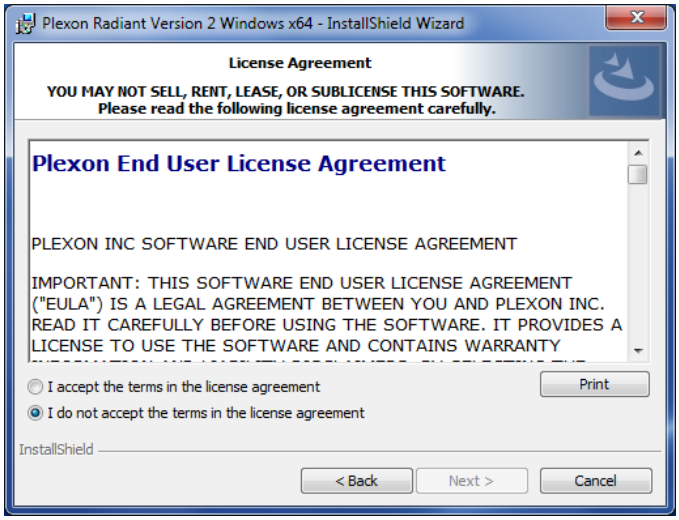


The welcome screen appears. If the software is already installed, the welcome screen gives you the option to repair (re-install) or remove the software as shown on the right, below. If the software is not already installed, the welcome screen shown on the left appears.



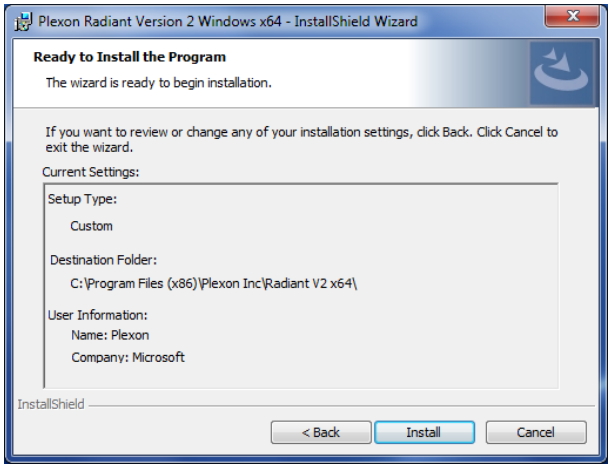


5 Click Next to continue.
The Plexon End User License Agreement dialog is displayed.

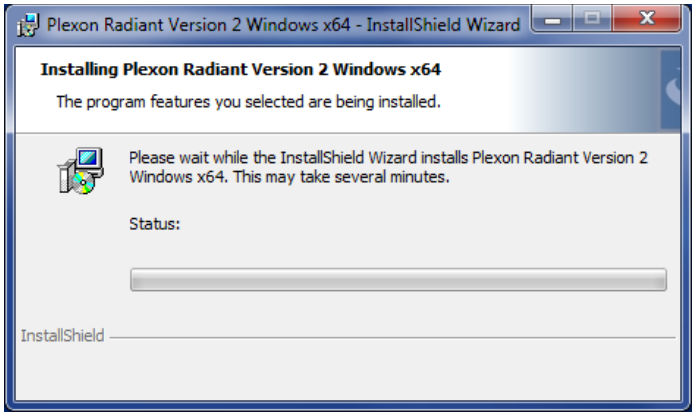


6 Read and accept the Plexon End User License Agreement. Then click Next to Continue.

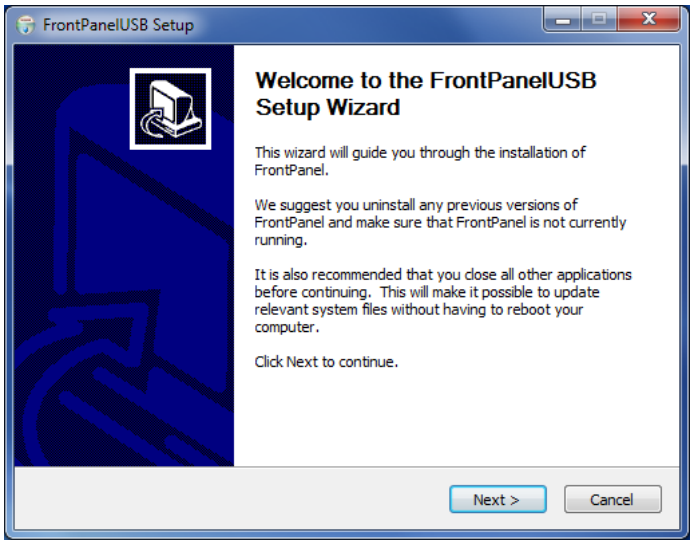
7 You will be asked to confirm where the files will be stored. Click Install to Continue.



A dialog, “Installing Plexon Radiant Version 2 Windows x64” dialog will pop up.

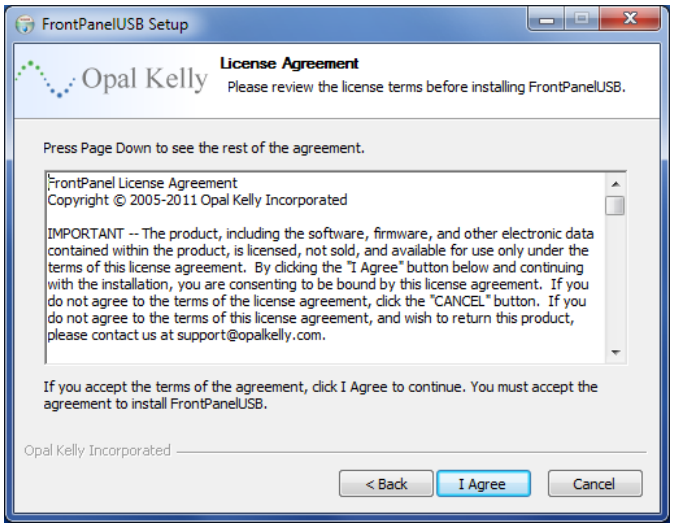


A second dialog will also appear:

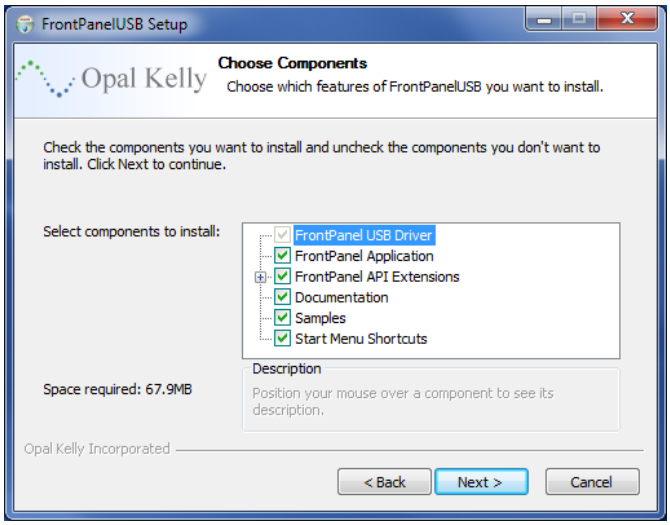


8 Click Next.

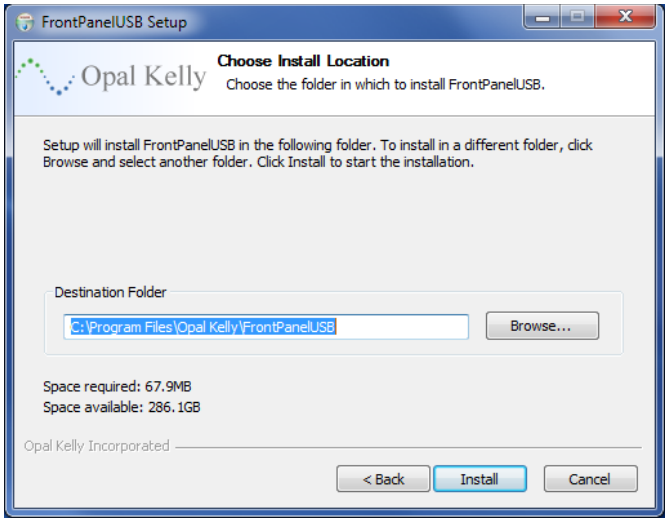
9 Accept the Opal Kelly License Agreement.



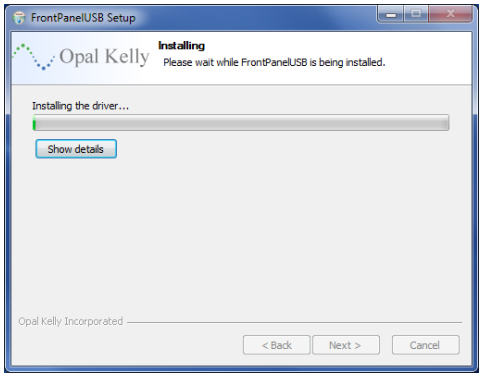
10 If the following dialog appears, click Next to accept the Opal Kelly components.

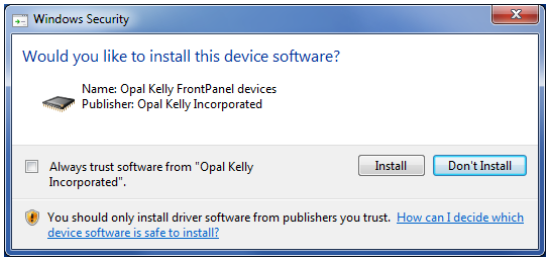


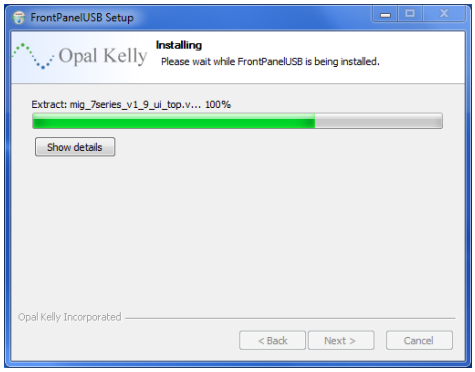
11 Click Install.

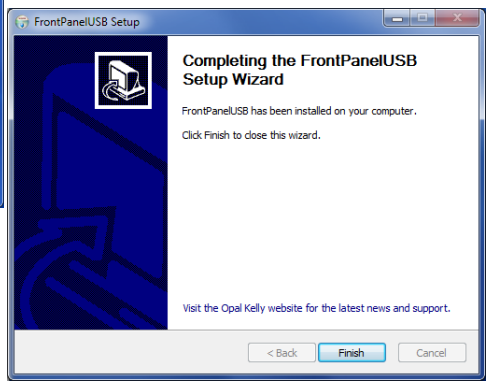


12 Several dialog boxes will appear in sequence. Click Install and Finish to continue the installation process.

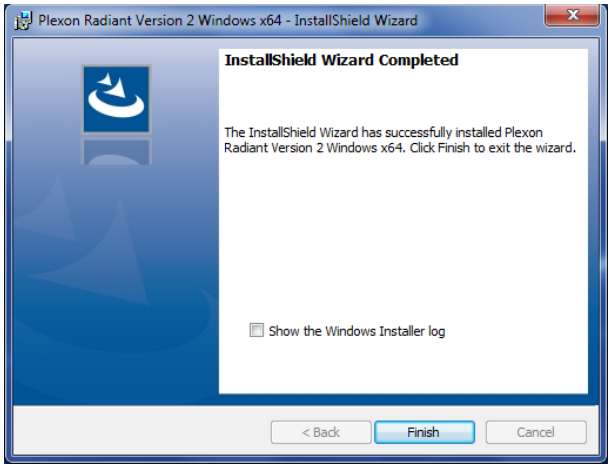




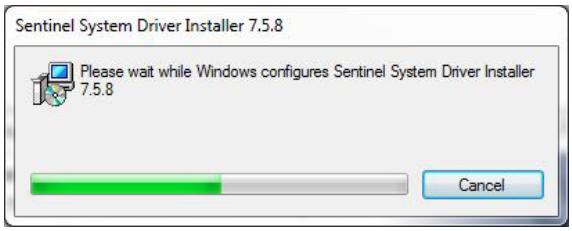




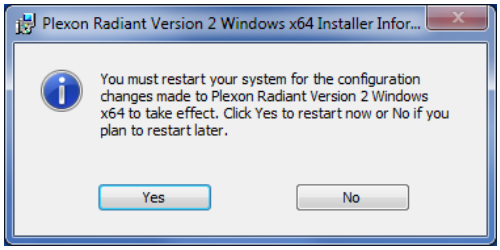
13 Click Finish in the Plexon Radiant installation window when it appears.



14 Sentinel System Drivers will install for the license key. (The system checks whether these drivers are already present on your machine, and does not display this dialog if the drivers are present.) If this dialog appears, allow it to complete.



15 Restart the computer to complete the installation.



5.2 Hardware Installation

Read the entire Hardware Installation section before proceeding with any of the steps.

1 Connect the AC power cord between the AC outlet and the power supply.

2 Connect the DC power cord between the power supply and the controller.

3 Connect the USB cable between the controller and the computer.

4 When you are ready to deliver stimulation through the LEDs or lasers, you can connect the BNC cables as described in Section 19.4, "Current or Voltage Output Connectors" on page 115, but it is not necessary to connect these cables at this time.

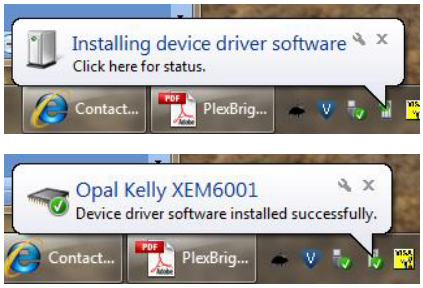
5 Repeat this procedure as needed for additional controllers. The system can operate up to four controllers from one computer.

5.3 Turning on the Power for the First Time

1 Flip the power switch to the on position. The LED next to the switch on the end of the controller should illuminate.

2 The first time you turn the stimulator on a “Found New Hardware” balloon will appear in the lower right hand corner of the computer screen. The Windows balloon changes from “Installing device driver software” to “Opal Kelly XEM6001”. Choose Install the software automatically. After it is finished, the balloon will change to “Your new hardware is installed and ready to use.”

The following diagram shows the dialog boxes for this process.



The first time that you plug in the USB license key you will see an installation message as well.

6 Getting Started with Radiant Software

This section explains how to launch the Radiant software, upgrade firmware and view system information.

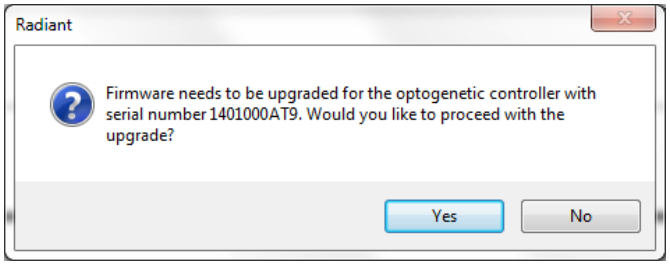
6.1 Launching the Radiant Software

1. Make sure all of the PlexBright 4 Channel Optogenetic Controllers are connected to the computer and turned on. (Up to four controllers can be used with a single computer.)

2. Launch the Radiant software by double clicking on the **RadiantV2** desktop icon  .

3. If the Radiant software user interface opens, go to Step 10.

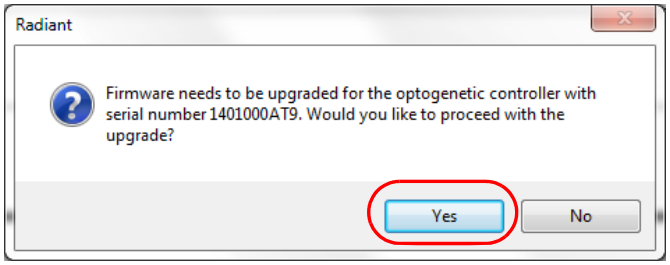
4. If you are installing (or upgrading to) a new version of software, the firmware also needs to be upgraded to the latest version. The system will detect this automatically for you, and you will see a dialog similar to this on your screen:



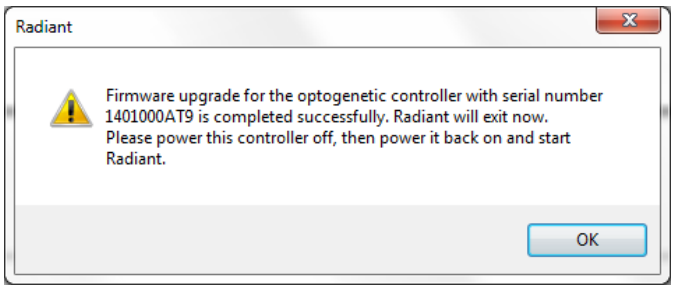
If you see the above dialog, perform the firmware upgrade beginning with Step 5.

Upgrading the Firmware (if necessary)

5. Click **Yes** and allow the firmware upgrade to finish (typically in less than a minute).



6. The following dialog will appear. Click OK. (The Radiant application will exit automatically.)



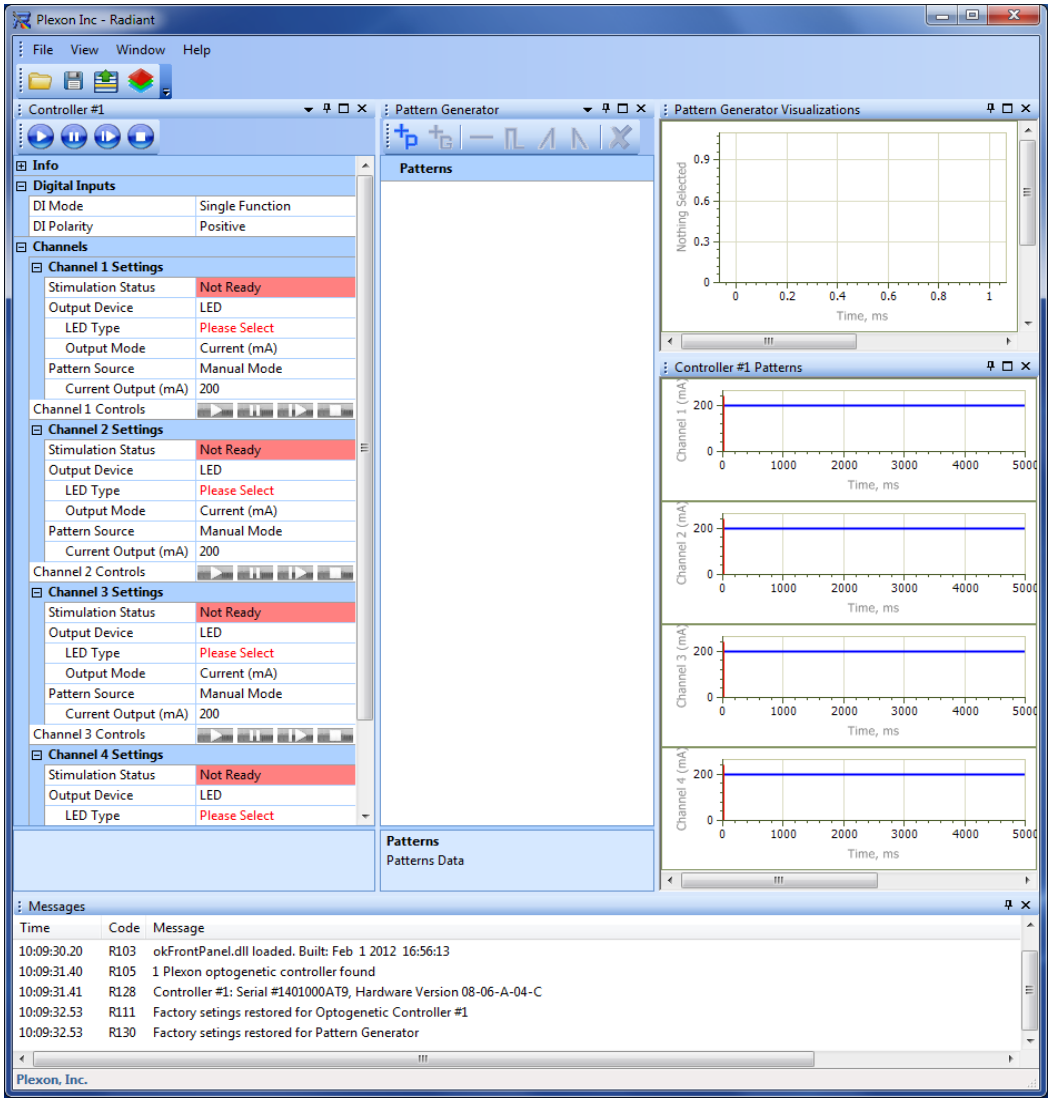
7 Turn off the power on the controller, then turn it on again.

8 Restart the Radiant software.

9 If you have multiple controllers, the system will upgrade one controller each time you launch the Radiant software. After the Radiant software is restarted after each upgrade, the next controller will be upgraded. This continues until all attached controllers have the latest firmware.

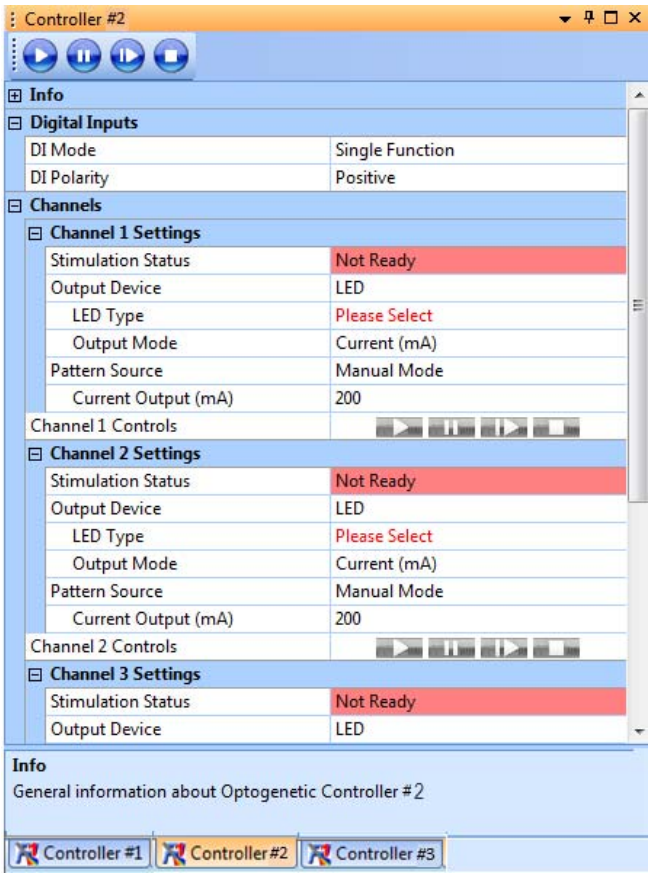
Viewing the Radiant user interface

10 You should see the factory default graphical user interface as shown in the figure below.



11 Ensure that the system has recognized all of the controllers (up to four controllers) that are connected to the computer. Note that the number of controllers that are connected will determine the number of tabs in the bottom left of the screen. If multiple controllers are connected but their tabs do not show up, they can be added by from the **View** drop down in the menu bar. Also, the LEDs on the end panel of the

controller will indicate the device number 1 – 4. In the example below, there are three controllers turned on and connected to the computer, and Controller #2 has been selected for viewing.

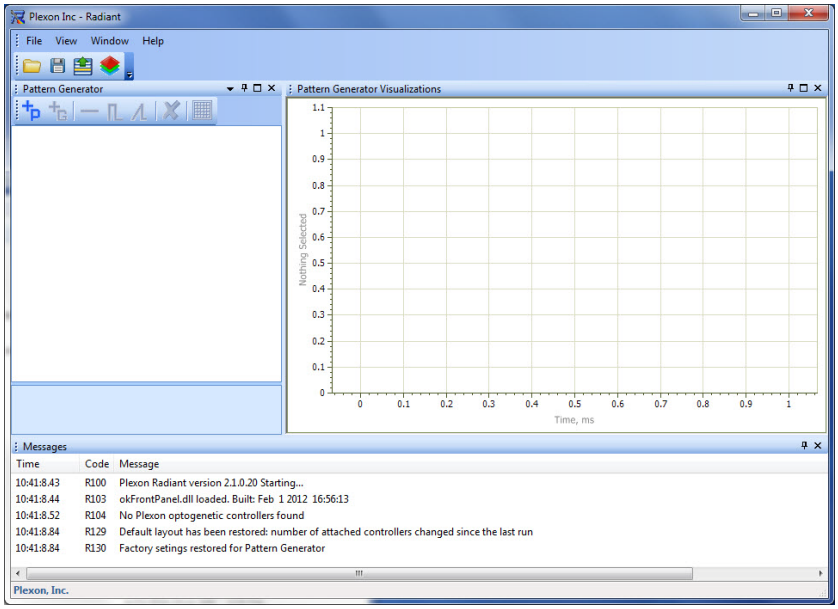


TIP

Restoring factory settings

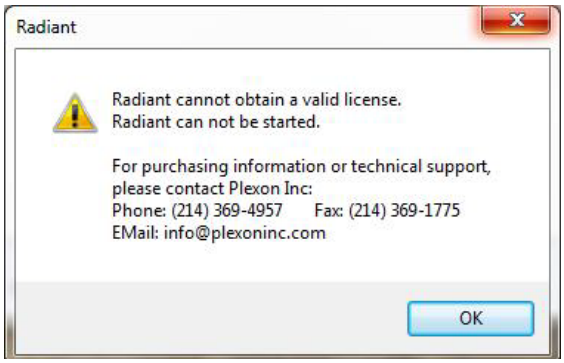
You may load the factory default configuration at any time by clicking **File – Restore Factory Settings**.

Note that if the USB cable is not connected to the controller or if the controller power is turned off when the software is started, the software will open the pattern generator only, as seen in the image below. There will be no window for configuring stimulation channels.



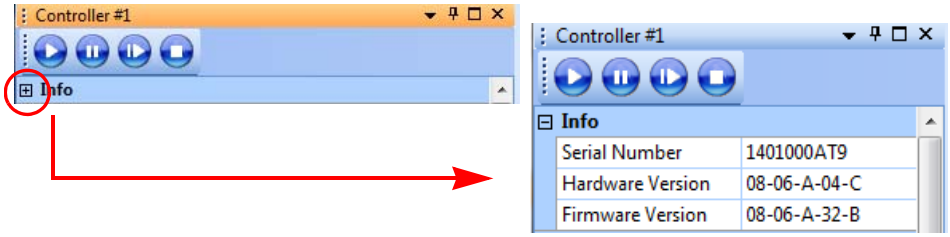
If you see the window like the one shown below, and your stimulator is connected, it is possible that your layout has changed. Go to **Window – Layout – Reset to Default Layout**.

Radiant software requires a USB license key to be operated. If the key is not plugged into the computer, you will see the following warning.

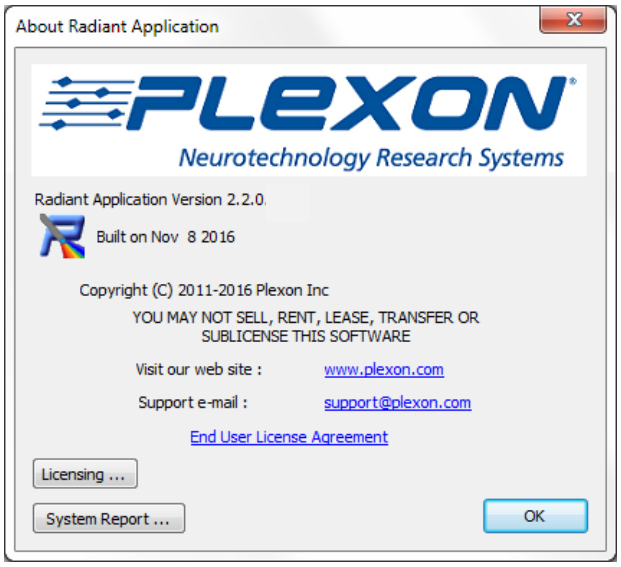


6.2 Viewing the System Information

1. Make sure all of the PlexBright 4 Channel Optogenetic Controllers are connected to the computer and turned on.
2. Click on the **+** sign next to **Info** in the user interface to display the serial number and hardware version for your controller, which should match the information on the labels on the bottom of your controller box. The display will also indicate the firmware version that has been loaded.



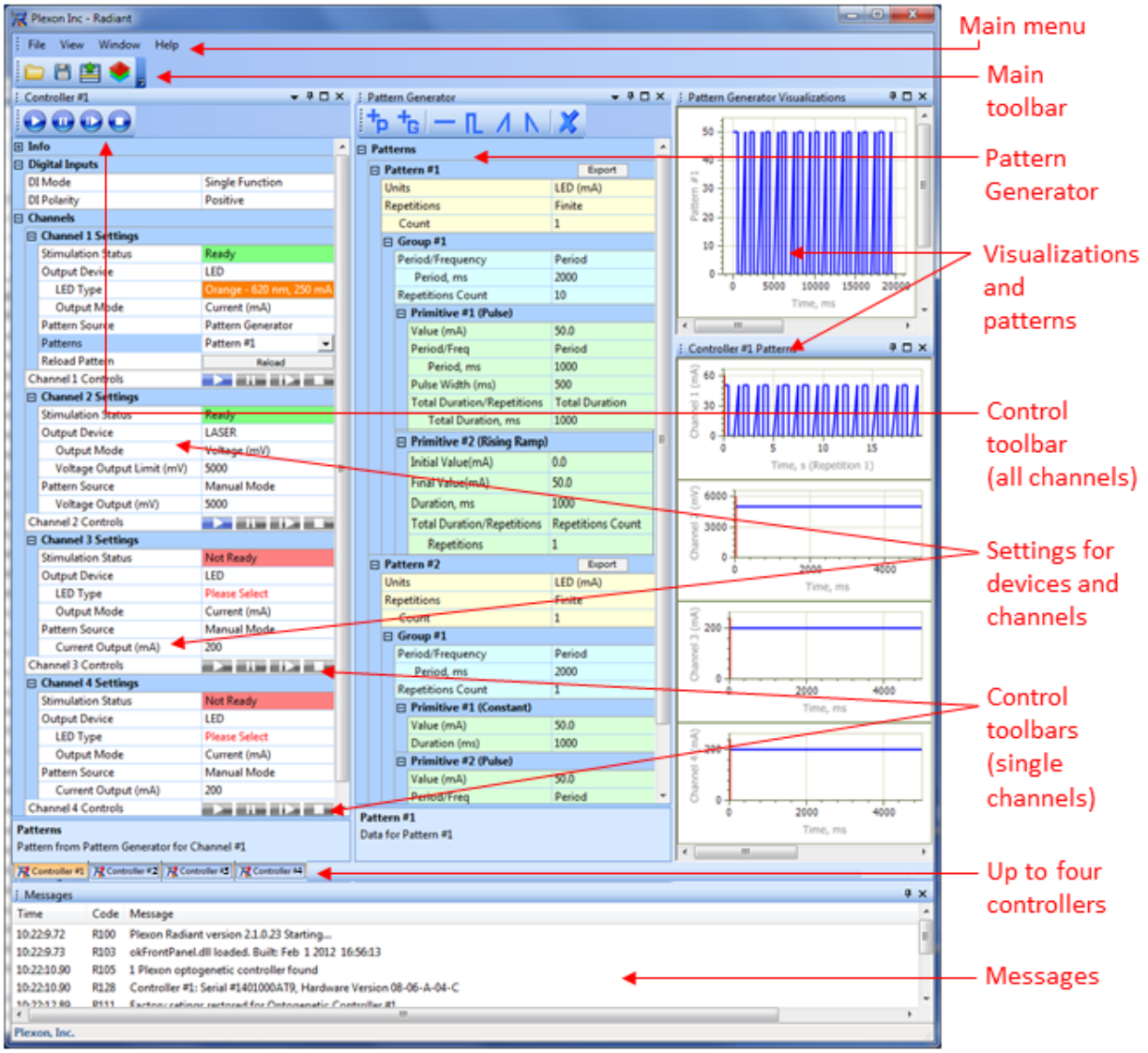
3. Click the **–** sign next to **Info** to minimize these lines.
4. To view the software version that is loaded on your PC, click **Help > About Radiant** from the main menu. The following dialog box will appear, and you will see the software version displayed there. Your version might be more recent than the version displayed in the example below.



5. To view the current license, click on the **Licensing...** button.
6. If you have any questions about the hardware, firmware, software or licensing versions, check for the latest software download at http://www.plexon.com. Feel free to contact Plexon Support at +1 214-369-4957 or support@plexon.com if you would like additional information or assistance.

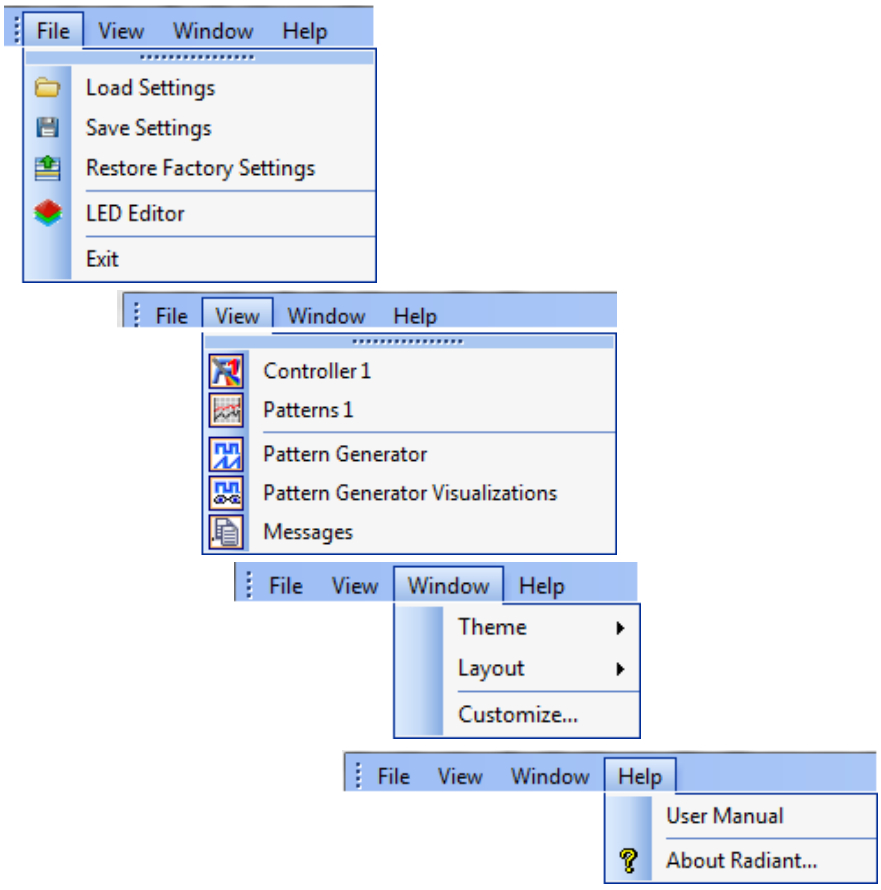
7 Understanding the User Interface

The image below highlights the sections, menus and toolbars in the user interface. The main menu and main toolbar features are described later in this section. (Additional features and functions in the user interface are explained in more detail in other sections of this user guide.)

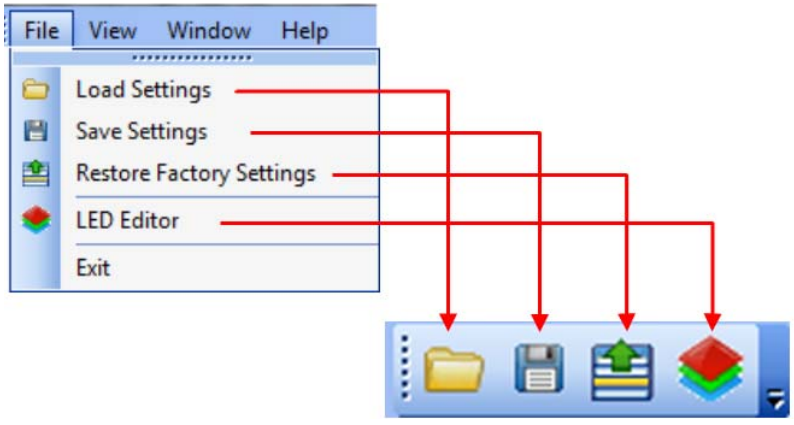


The image (above) shows the Control toolbar (all channels); you can use these controls to start, pause, unpause and stop all channels in the controller. There is also a control toolbar for each individual channel. The specific actions of these toolbars is explained in Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

The main menu options are shown in the following images. For a description of each of these options, see Section 18, "GUI Function Reference" on page 108.



The main toolbar icons are related to the options in the **File** menu as shown in the image below. It is recommended that you become familiar with the **Save Settings** option—It allows you to save all your stimulation channel settings and stimulation patterns to a user-named file (with .ops extension) for future use. The **Load Settings** option allows you to load any of your previously saved .ops files. See Section 18.8, "File Save Settings / File Load Settings / Restore Factory Settings" on page 111.



8 Overview of Procedures

This section summarizes the procedures to follow to create stimulation patterns and deliver stimulation through LEDs or lasers.

Configuring the output devices

Section 9, "Configuring the Output Devices—LEDs and Lasers" on page 24—Configure the stimulation output device for each channel.

Creating stimulation patterns and controlling stimulation from the user interface

Every optogenetic stimulation protocol begins with the definition of the stimulation pattern. The graphical user interface (GUI) provides options for [1] manually setting the output value, [2] creating a stimulation with the Pattern Generator or [3] loading a stimulation pattern from a user-created text file. Once defined, the stimulation pattern is downloaded into the controller memory for playback.

The following sections explain how you can create stimulation patterns and assign them to channels.

- Section 10, "Setting Stimulation Parameters in Manual Mode" on page 35
- Section 11, "Creating Stimulation Patterns with the Pattern Generator" on page 38
- Section 12, "Creating Stimulation Sequence Files (.txt and .opt)" on page 65
- Section 13, "Assigning Stimulation Sequence Files to Channels" on page 69

Understanding the stimulation control options

There are two ways to initiate a stimulation pattern:

- With the host PC through software (the user interface)
- With a hardware digital input

A pattern started from software can be stopped with a digital input and vice versa.

Controlling stimulation from the user interface

Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80—See how the stimulation start, stop, pause and unpause controls work.

Controlling stimulation from digital inputs

See Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

Verifying and scaling output values

Section 16, "Verifying Output Signals and Scaling the Output Values” on page 100—Use this procedure in conjunction with the main procedures listed above.

Adding or deleting LEDs from the LED Type list

Section 17, "Managing the LED List with LED Editor” on page 104.

Reference materials

Section 18, "GUI Function Reference” on page 108

Section 19, "Input and Output Connectors” on page 114

Section 20, "Sample Arbitrary Waveform Pattern Files” on page 119

Section 21, "Timing Considerations” on page 120

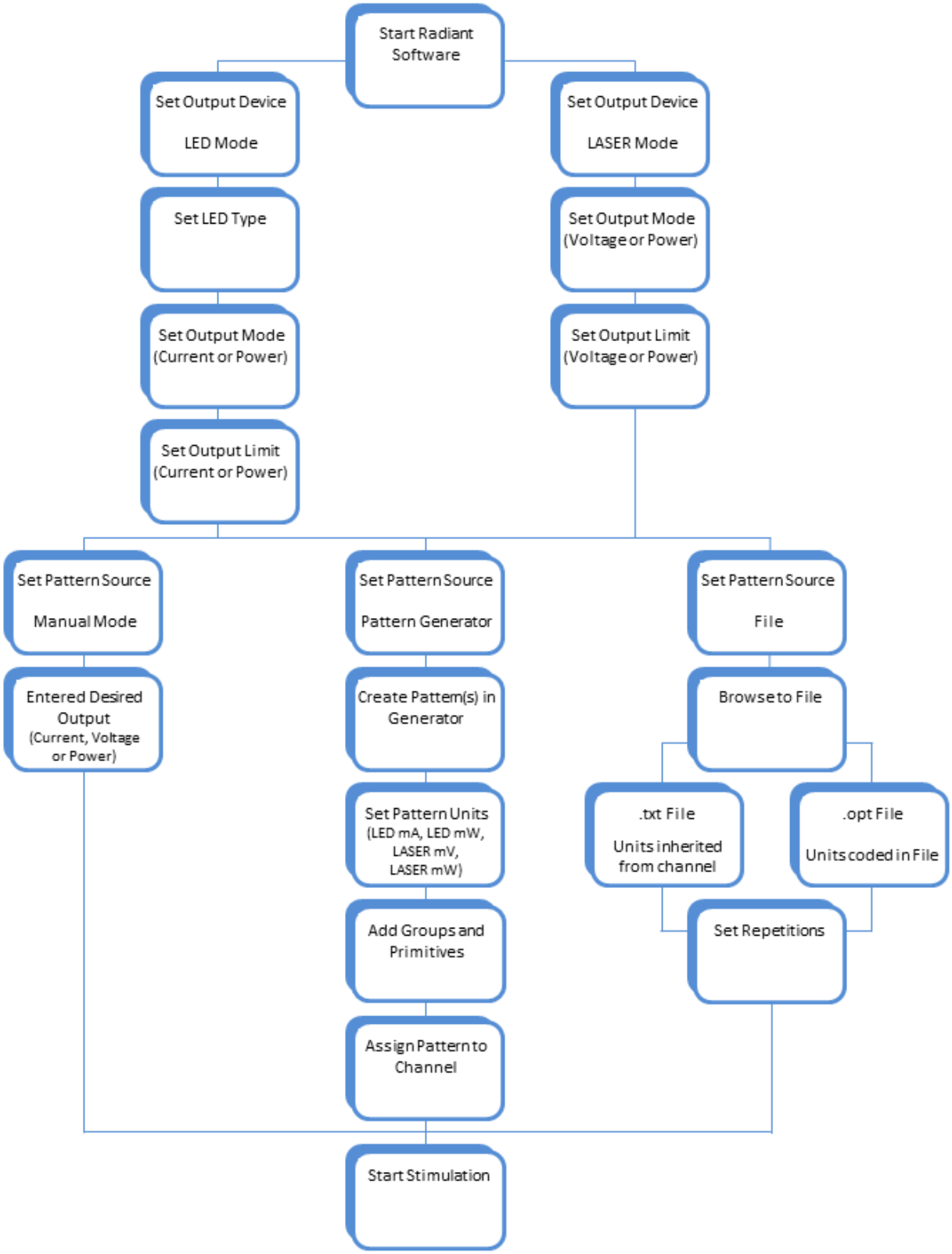
Section 22, "Specifications” on page 124

TIP

Direct verification of output amplitudes and patterns

It is highly recommended that you practice the applicable procedures in these sections before attempting to do any type of live stimulation.

This flowchart summarizes the process of configuring stimulation parameters.



9 Configuring the Output Devices—LEDs and Lasers

The procedures in this section configure the stimulation output device for each channel as either an LED or a laser:

- Section 9.1, "LEDs" on page 24
- Section 9.2, "Lasers" on page 30

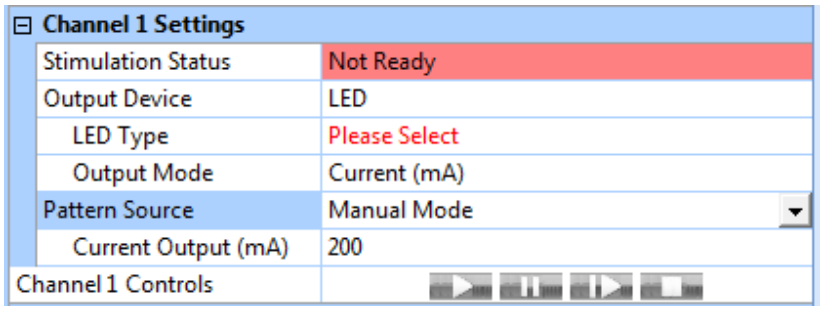
Note: The **Pattern Source** is assumed to be **Manual Mode** in this section; the software starts in this mode by default the first time the software is run. Other sections in this document explain how to operate with different pattern sources (**File** or **Pattern Generator**) and how to use digital inputs to the hardware.

9.1 LEDs

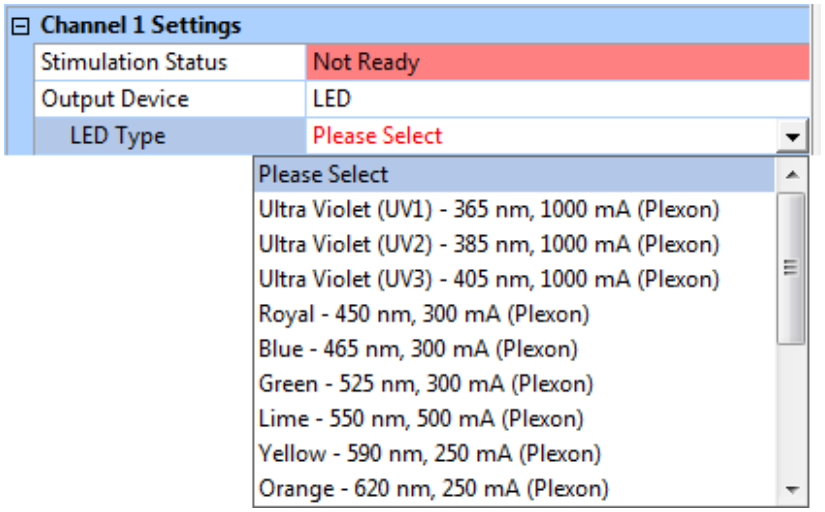
1. Make sure all of the PlexBright 4 Channel Optogenetic Controllers are connected to the computer and turned on.
2. Set the **Output Device** to **LED**. This is the default value, so your system may already display it as **LED**.

Notice that the system displays the default values as shown in the following image:

- LED Type = Please Select
- Output Mode = Current (mA)
- Pattern Source = Manual Mode
- Current Output (mA) = 200



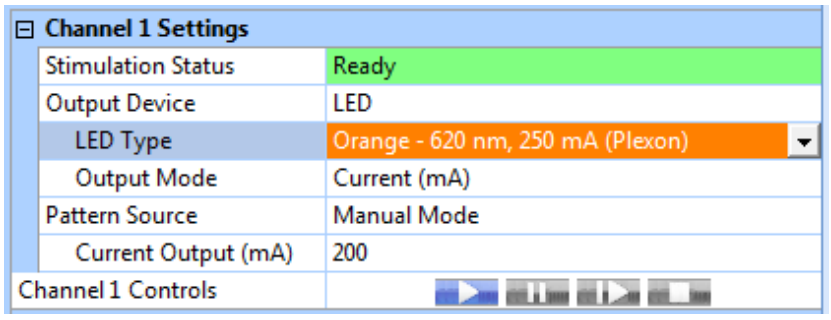
3 Select the appropriate LED from the **LED Type** dropdown list.



Note: This dropdown list contains all of the standard LED types available for purchase from Plexon. Notice the scroll bar on the right side of the list.

Later versions of Radiant software might contain additional LED types as they become available. If you are using an LED type that is not included in this dropdown list, you can add that LED to the list by following the procedure in Section 17, "Managing the LED List with LED Editor" on page 104.

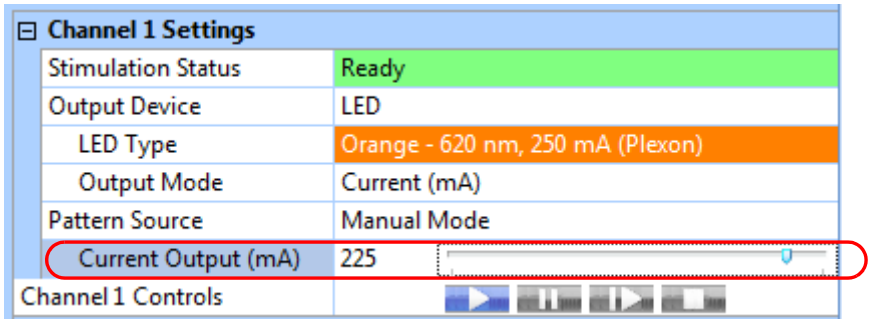
4 After you click on one of the LED types in the list, it is displayed in the **LED Type** line, and the **Stimulation Status** changes to green (**Ready**).



5 If you are satisfied with the **Output Mode** as **Current (mA)**, continue with Step 6.

However, if you want to change the **Output Mode** to **Power (mW)**, go to Step 7.

6 Click in the row labeled **Current Output (mA)**. The system will then display a slider in this row. This slider is your manual adjustment. Move the slider (by clicking and dragging it) to the desired value, 225mA in the following example.



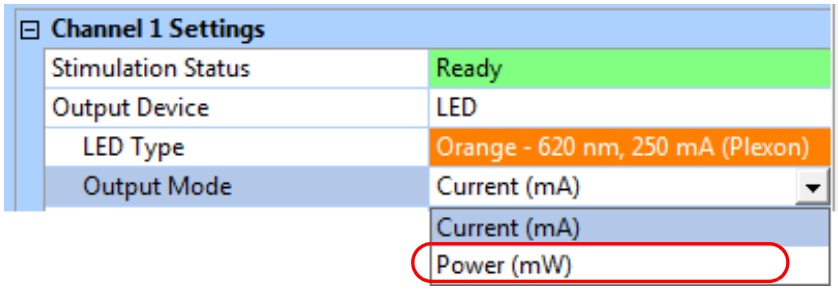
TIP

Fine tuning the slider value

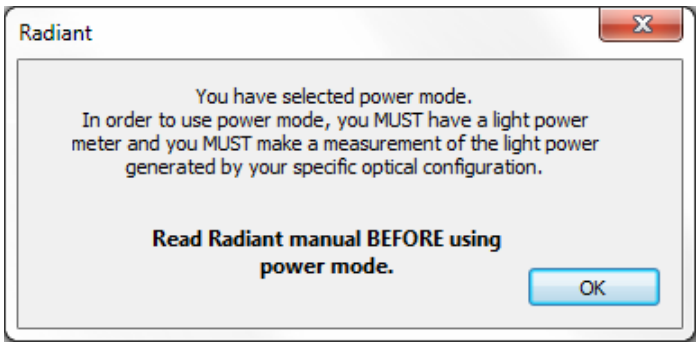
Fine incremental changes can be made to the slider value using the up and down arrow keys or the scroll wheel on your mouse.

Perform **Step 7** through **Step 11** only if you want to use Output Mode = Power (mW)

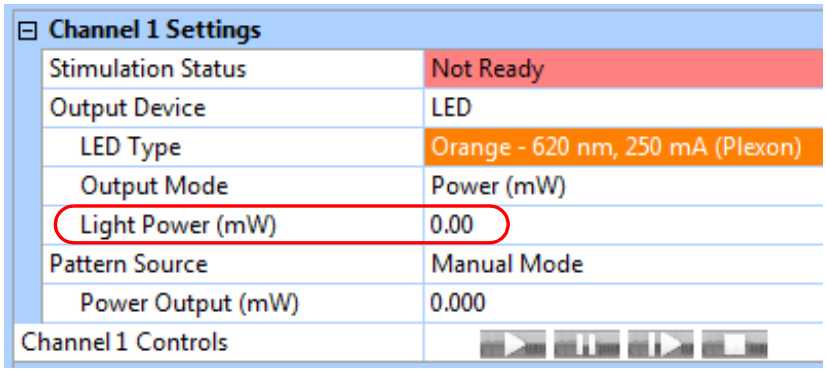
7 Select **Power (mW)** from the **Output Mode** dropdown list. In this mode, the system will deliver a user-specified amount of light power at the end of the LED.



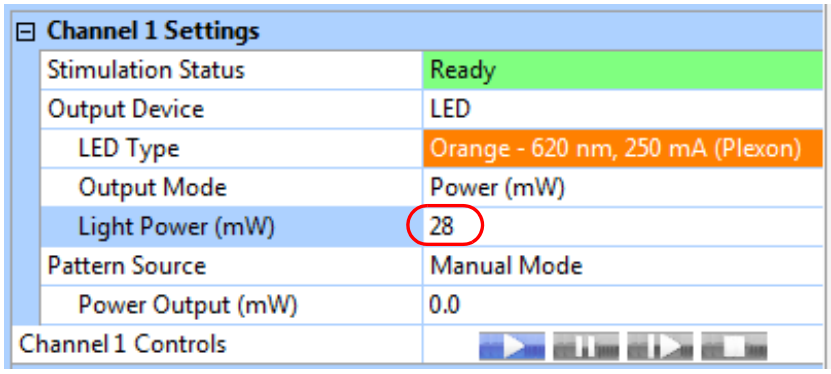
8 When you select **Power (mW)**, the system displays a dialog.



9 Click **OK** to accept the change. The system displays a value for **Light Power (mW)**.



10 Use a light meter to make a measurement of the actual light power generated by your specific optical configuration when the LED is set to its maximum current (which is the current listed in the **LED Type** row). In this step, “specific optical configuration” means that you must make the light power measurement at the far end of the entire assembled optical system (the delivery end)—The PlexBright 4 Channel Optogenetic Controller – BNC cable – LED module – Optical patch cable – Optical fiber implant. This light measurement is further described in Section 16.2, "Using Different Scaling Options” on page 101. Enter the measured power as the value for **Light Power (mW)**, 28mW in this example. (Numbers from 0-100 with up to five significant figures can be entered.)

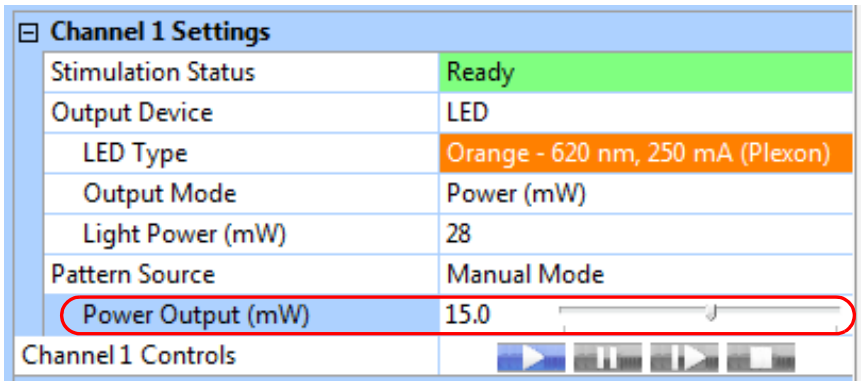


11 To set the actual power output for the LED, click on the **Power Output (mW)** row. The system will then display a slider in this row. This slider is your manual adjustment. Move the slider (by clicking and dragging it) to the desired value, 15.0mW in the following example.

TIP

Fine tuning the slider value

Fine incremental changes can be made to the slider value using the up and down arrow keys or the scroll wheel on your mouse.



Configure additional channels

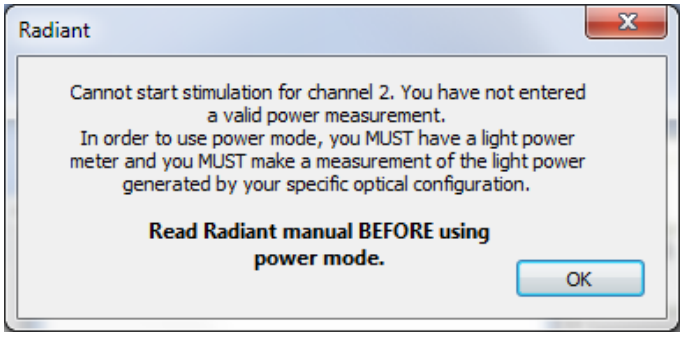
12 Repeat the steps in this procedure as needed to configure additional channels for LED stimulation.

Configure additional controllers

13 Repeat the steps in this procedure as needed to configure additional controllers for LED stimulation. To switch between controllers, click on the tabs at the bottom of the controller display. The image below is an example in which there are three controllers connected and turned on, and Controller #2 has been selected for viewing. (The system can run up to four controllers on one PC.)

All-channels control toolbar operation with channels in power mode

The measurement of light power is required when **Output Mode** is set to **Power (mW)**. If a channel is in power mode with the **Light Power (mW)** value set to 0, the channel **Stimulation Status** is **Not Ready**. If you click the **Start stimulation for all channels** icon, the system displays a dialog box reminding you to measure the actual light power for the channel and enter a valid (non-zero) value in the **Light Power (mW)** row.



Where to go next

If you want to add custom LEDs to your **LED Type** dropdown list, go to Section 17, "Managing the LED List with LED Editor" on page 104.

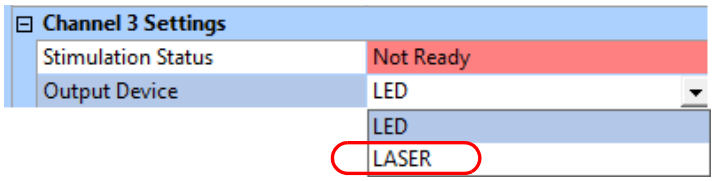
Currently, your **Pattern Source** is set to **Manual Mode**. If you want to use **Pattern Generator** or **File** as your **Pattern Source** instead, go to Section 11, "Creating Stimulation Patterns with the Pattern Generator" on page 38 or Section 12, "Creating Stimulation Sequence Files (.txt and .opt)" on page 65.

If you are using **Manual Mode** as your **Pattern Source**, your system is already configured for manual operation. If you need to see how the controls in the user interface work, go to Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80. Otherwise, go to Section 10, "Setting Stimulation Parameters in Manual Mode" on page 35.

If you want to configure other channels to use lasers for stimulation, go to Section 9.2, "Lasers" on page 30.

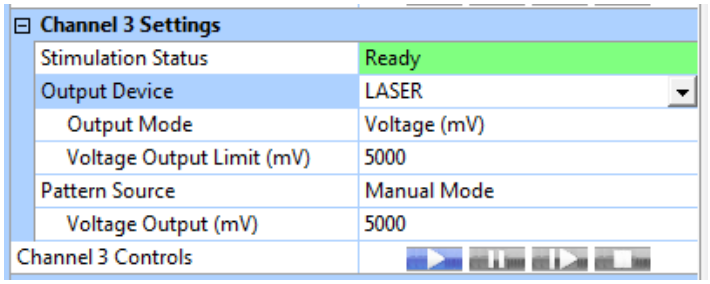
9.2 Lasers

1. Make sure all of the PlexBright 4 Channel Optogenetic Controllers are connected to the computer and turned on.
2. Set the **Output Device** to **LASER**.



The **Stimulation Status** turns green (**Ready**). Notice that the system displays the default values as shown in the following image:

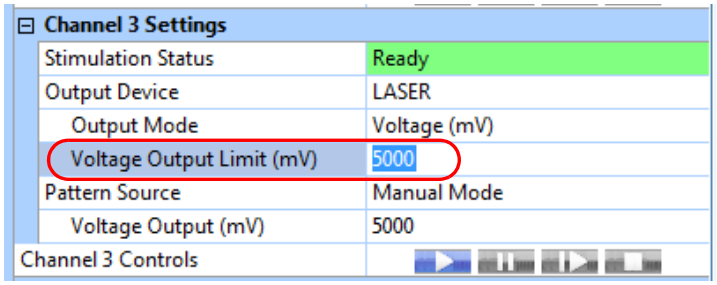
- Output Mode = Voltage (mV)
- Voltage Output Limit (mV) = 5000
- Pattern Source = Manual Mode
- Voltage Output (mV) = 5000



3. If you are satisfied with the **Output Mode** as **Voltage (mV)**, continue with Step 4.

   However, if you want to change the **Output Mode** to **Power (mW)**, go to Step 6.

4. Set the **Voltage Output Limit (mV)** to the maximum output voltage the laser can accept, or to a lower voltage that corresponds to the maximum light power you want to use for your experiment. (**5000mV** is the default value and it is also the maximum allowed value.) To change the value, double click to select it, then type in the new value. (The **Voltage Output (mV)** value will change automatically to match the **Voltage Output Limit (mV)** setting.)

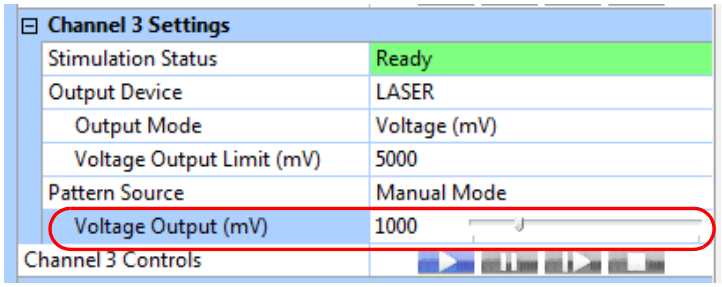


5 Click in the row labeled **Voltage Output (mV)**. The system will then display a slider in this row. This slider is your manual adjustment. Move the slider (by clicking and dragging it) to the desired value, 1000mV in the following example.

TIP

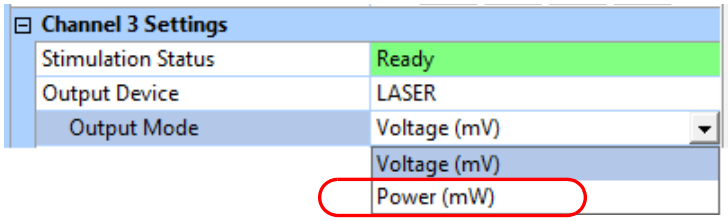
Fine tuning the slider value

Fine incremental changes can be made to the slider value using the up and down arrow keys or the scroll wheel on your mouse.

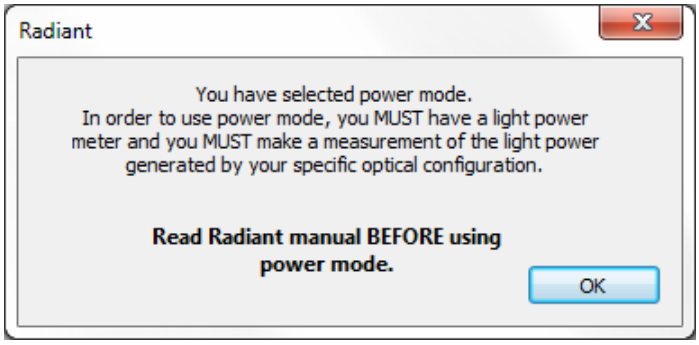


Perform **Step 6** through **Step 11** only if you want to use Output Mode = Power (mW)

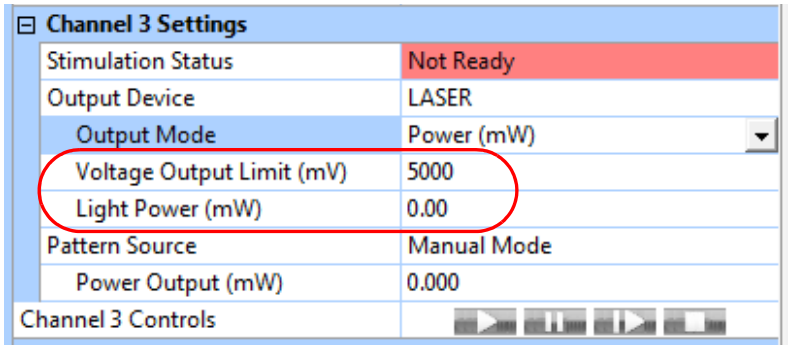
6 Select **Power (mW)** from the Output Mode dropdown list. In this mode, the system will deliver a user-specified amount of light power from the laser.



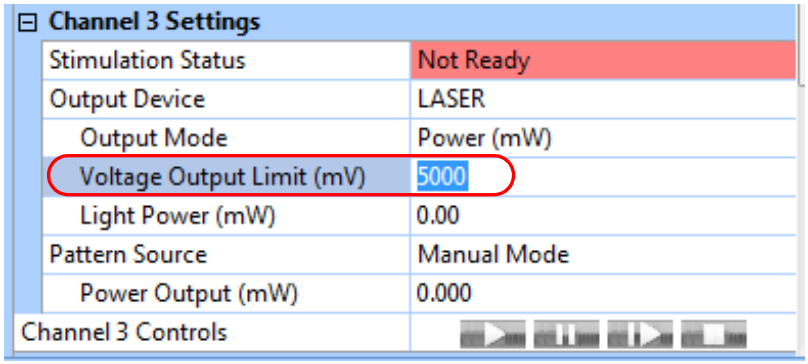
7 When you select **Power (mW)**, the system displays a dialog.



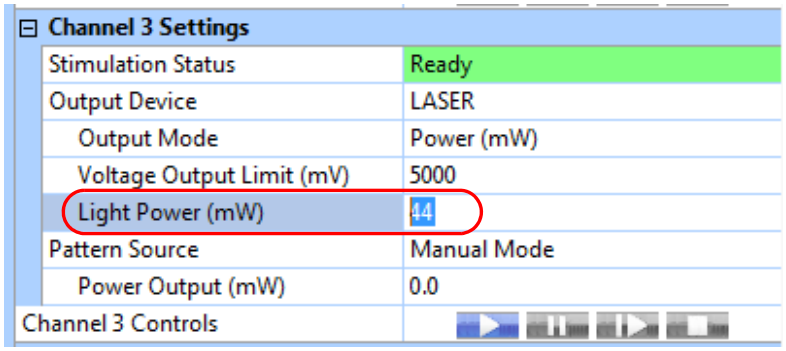
8 Click OK to accept the change. The system displays a value for **Voltage Output Limit (mV)** (default value = 5000) and **Light Power (mW)**.



9 Set the **Voltage Output Limit (mV)** to the maximum output voltage the laser can accept, or to a lower voltage that corresponds to the maximum light power you want to use for your experiment. (**5000mV** is the default value and it is also the maximum allowed value.) To change the value, double click to select it, then type in the new value.



10 Use a light meter to make a measurement of the actual light power generated by your specific optical configuration when the laser is set to its maximum value (the **Voltage Output Limit (mV)**). In this step, “specific optical configuration” means that you must make the light power measurement at the far end of the entire assembled optical system (the delivery end)—The PlexBright 4 Channel Optogenetic Controller – BNC cable – laser module – Optical patch cable – Optical fiber implant. This light measurement is further described in Section 16.2, "Using Different Scaling Options" on page 101. Enter the measured power as the value for **Light Power (mW)**, 44mW in this example. (Numbers from 0-100 with up to five significant figures can be entered.)

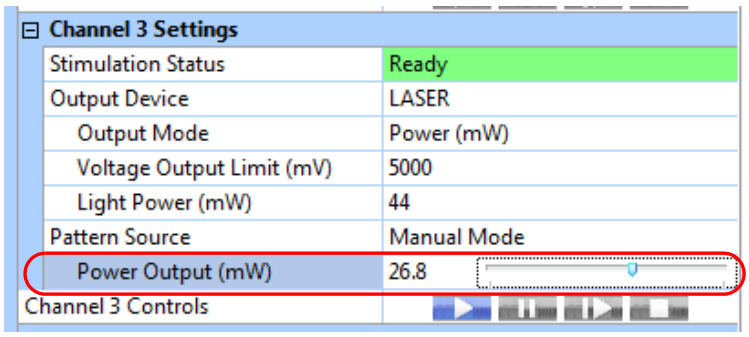


11 Click in the row labeled **Power Output (mW)**. The system will then display a slider in this row. This slider is your manual adjustment. Move the slider (by clicking and dragging it) to the desired value, 26.8mW in the following example.

TIP

Fine tuning the slider value

Fine incremental changes can be made to the slider value using the up and down arrow keys or the scroll wheel on your mouse.



Configure additional channels

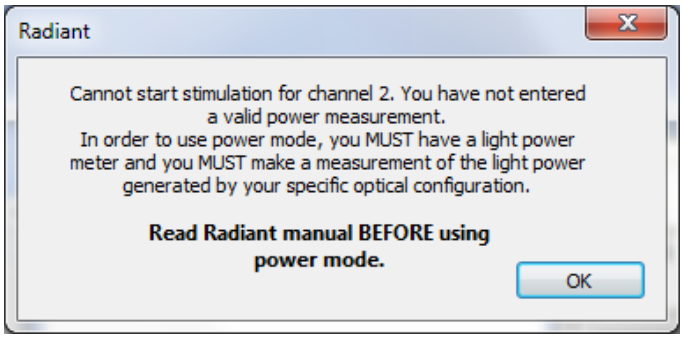
12 Repeat the steps in this procedure as needed to configure additional channels for Laser stimulation.

Configure additional controllers

13 Repeat the steps in this procedure as needed to configure additional controllers for laser stimulation. To switch between controllers, click on the tabs at the bottom of the controller display. The image below is an example in which there are three controllers connected and turned on, and Controller #2 has been selected for viewing. (The system can run up to four controllers on one PC.)

All-channels control toolbar operation with channels in power mode

The measurement of light power is required when **Output Mode** is set to **Power (mW)**. If a channel is in power mode with the **Light Power (mW)** value set to 0, the channel **Stimulation Status** is **Not Ready**. If you click the **Start stimulation for all channels** icon, the system displays a dialog box reminding you to measure the actual light power for the channel and enter a valid (non-zero) value in the **Light Power (mW)** row.



Where to go next

Currently, your **Pattern Source** is set to **Manual Mode**. If you want to use **Pattern Generator** or **File** as your **Pattern Source** instead, go to Section 11, "Creating Stimulation Patterns with the Pattern Generator" on page 38 or Section 12, "Creating Stimulation Sequence Files (.txt and .opt)" on page 65.

If you are using **Manual Mode** as your **Pattern Source**, your system is already configured for manual operation. If you need to see how the controls in the user interface work, go to Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80. Otherwise, go to Section 10, "Setting Stimulation Parameters in Manual Mode" on page 35.

If you want to configure other channels to use LEDs for stimulation, go to Section 9.1, "LEDs" on page 24.

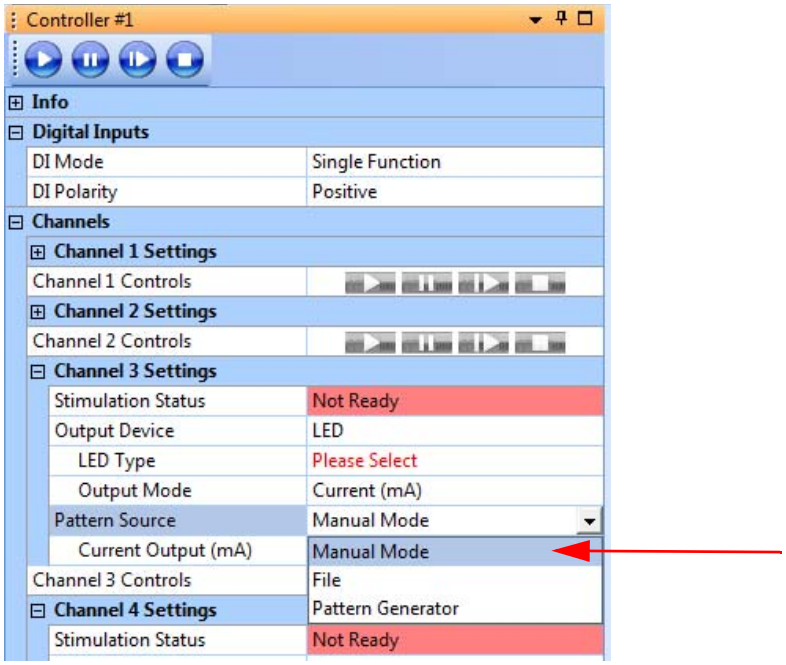
10 Setting Stimulation Parameters in Manual Mode

This section explains how to set stimulation parameters for LED or laser stimulation in **Manual Mode**. The software starts in this mode by default the first time the software is run.

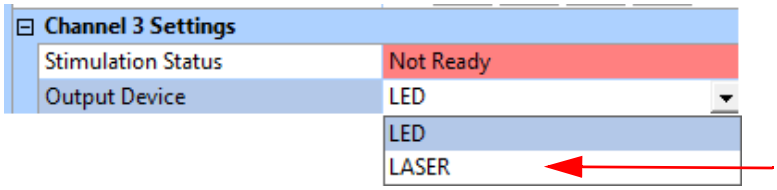
Note: Some of the images in this section display the Stimulation Status and control toolbar for the stimulation channels. For information on using these controls to start, stop, pause and unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

10.1 Setting the Manual Mode Parameters

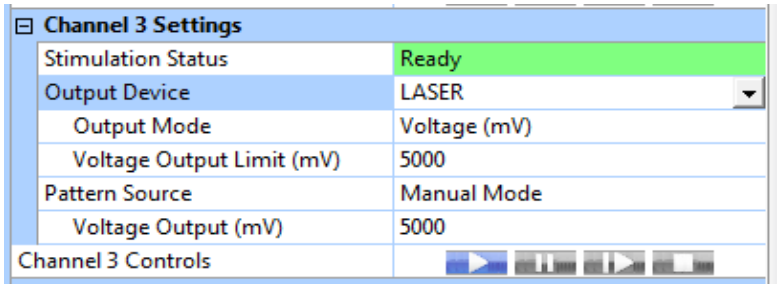
1. Make sure all of the PlexBright 4 Channel Optogenetic Controllers are connected to the computer and turned on.
2. If the channel is not already in **Manual Mode**, select it by clicking the drop down list next to **Pattern Source**. (In the examples below, Channel 3 will be configured for laser stimulation with **Output Mode** set to **Voltage (mV)**.)



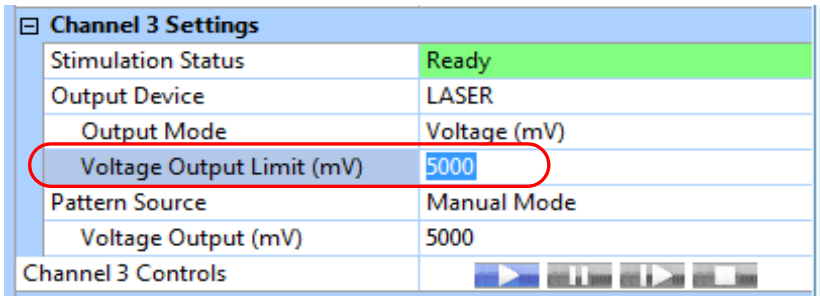
3. Set the **Output Device** to **LED** or **LASER**. (In this example, it will be set to **LASER**.)



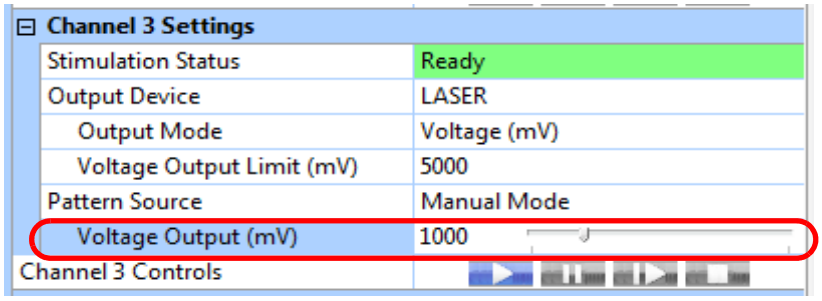
The **Stimulation Status** changes to **Ready** (green):



4 Set the **Voltage Output Limit (mV)** to the maximum output voltage the laser can accept, or to a lower voltage that corresponds to the maximum light power you want to use for your experiment. (**5000mV** is the default value and it is also the maximum allowed value.) To change the value, double click to select it, then type in the new value. (The **Voltage Output (mV)** value will change automatically to match the **Voltage Output Limit (mV)** setting.)



5 Click in the row labeled **Voltage Output (mV)**. The system will then display a slider in this row. Move the slider to the desired value, 1000mV in the following example. Move the slider by clicking and dragging it. This slider is your manual adjustment.

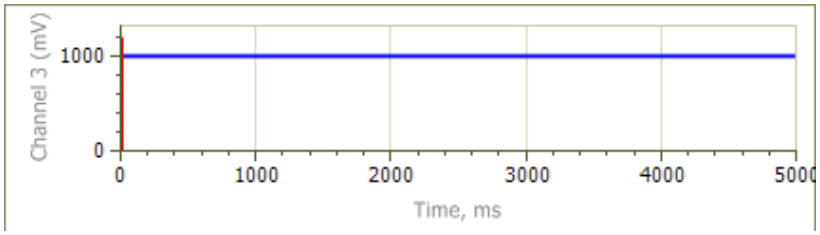


TIP

Fine tuning the slider value

Fine incremental changes can be made to the slider value using the up and down arrow keys or the scroll wheel on your mouse.

6 View the **Controller Pattern** to verify it displays the correct value, 1000mV in this case.



TIP

You can adjust voltage output while a channel is running

Once the channel is running, you can adjust the slider in the **Voltage Output (mV)** row to change the voltage output. The output will remain at the set voltage until you change it again.

10.2 Where to Go Next

Starting and stopping stimulation from the User Interface

For information on using the control icons to start/stop/pause/unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

Starting and stopping stimulation with Digital Inputs

For this information, see Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

Overview of procedures

For a summary of all procedures, see Section 8, "Overview of Procedures" on page 21.

11 Creating Stimulation Patterns with the Pattern Generator

This section explains how to create stimulation patterns with the Pattern Generator.

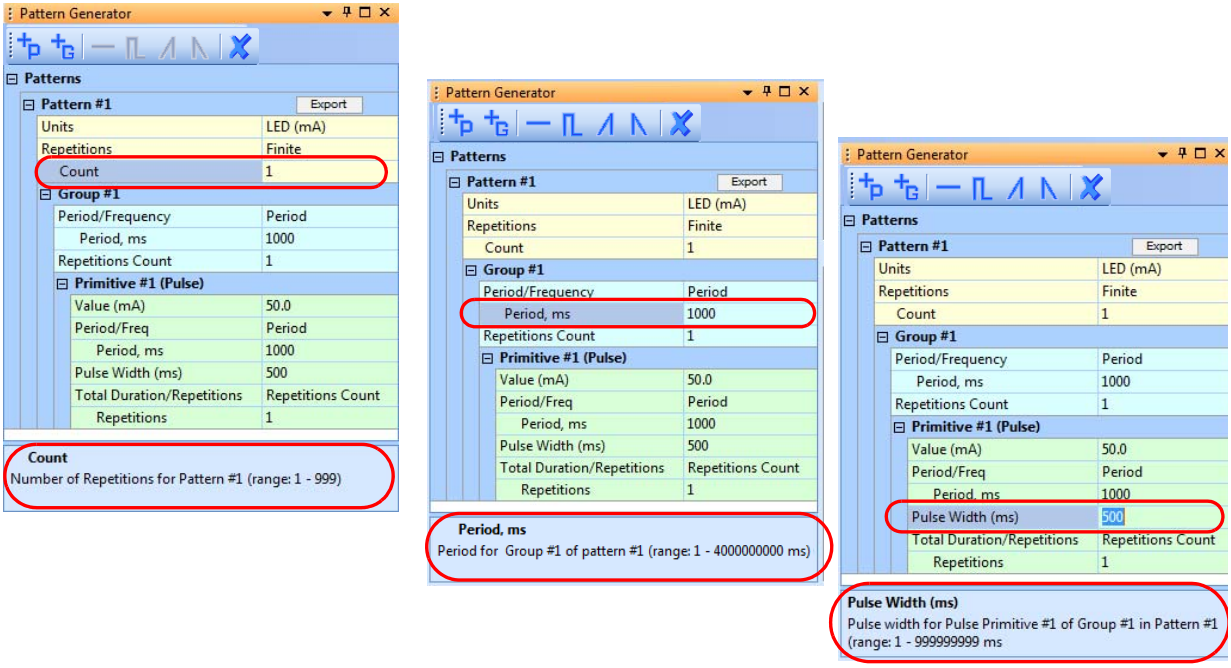
11.1 Defining a Pattern with the Pattern Generator

The most common patterns used in optogenetic experiments can easily be defined with the Pattern Generator. This is a built-in tool that is used to create hierarchical patterns consisting of constant values, square pulses, and ramp pulses. These can be individually repeated or included in a group that is repeated.

Understanding Patterns, Groups and Primitives

A Pattern must have at least one Group, and each Group must have at least one Primitive. The following procedure [1] creates a Pattern, then a Group and then a Primitive, and [2] configures parameters for the Primitive, then the Group and then the Pattern. At any time, you can add more Groups and Primitives into an existing Pattern.

The user interface displays the allowed range for each of these parameters as you click on them. (The upper limits on these ranges have been set very high, so it is anticipated that any realistic stimulation pattern can be achieved.) Here are some examples of the user interface displays.

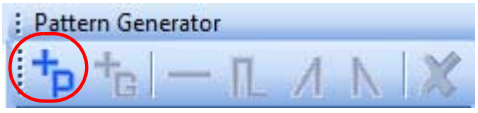


Limits for Repetitions and Durations in Patterns, Groups and Primitives

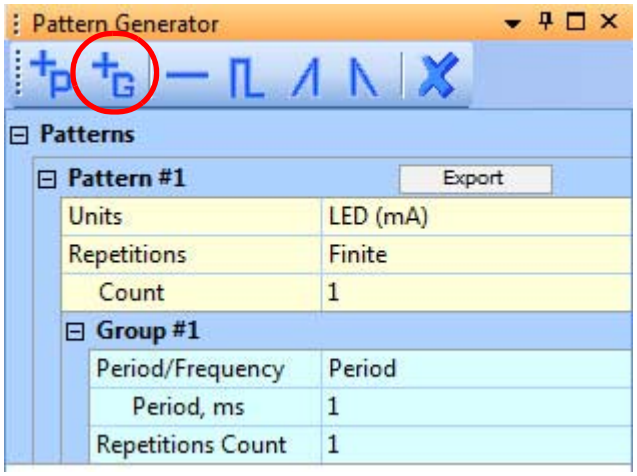
The ranges (upper and lower limits) for parameters in the Pattern Generator are listed later in this section.

Create a Pattern, Group and Primitive

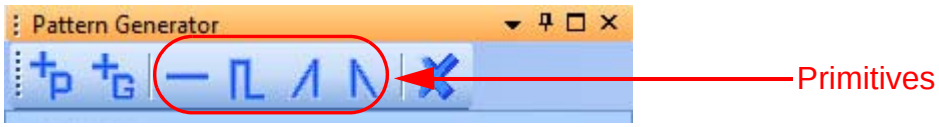
1 To create a pattern, click the **+P** icon.



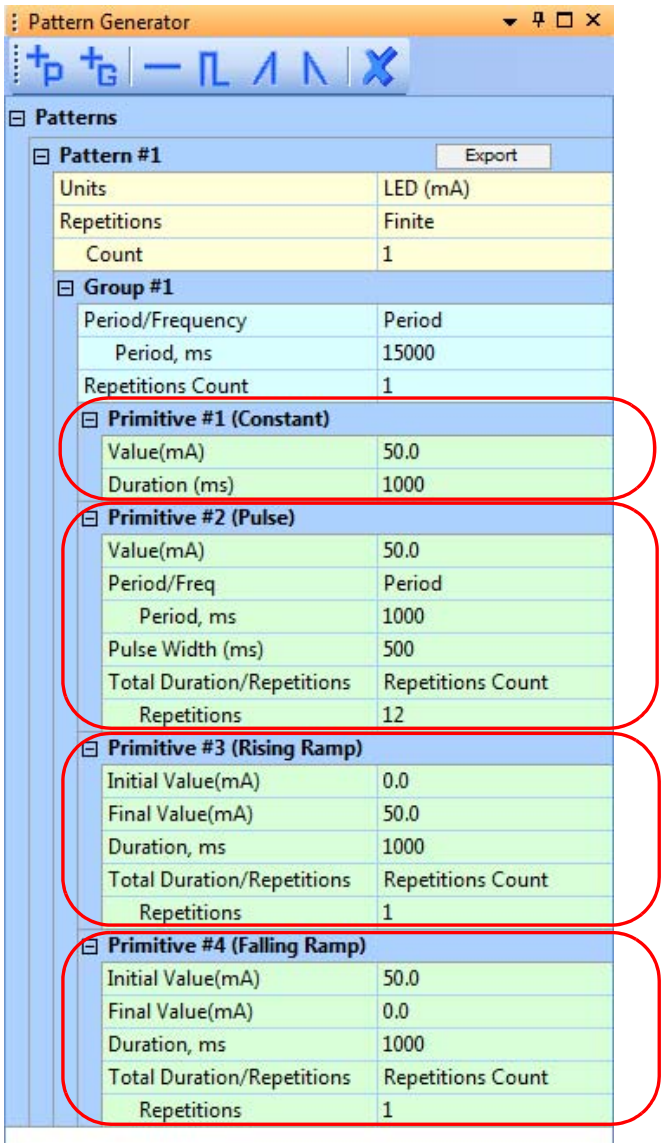
2 To add a group to the pattern, click the **+G** icon. A pattern must have a minimum of one group.



3 To add a primitive to the group, click one of the icons to the right of the **+G** icon. (A group must have at least one primitive. A primitive can be a constant value, a square pulse, or a rising or falling ramp.)

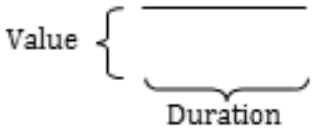


The image below shows an example in which four primitives (one of each type) have been added to a group. You can add multiple primitives of any type to create the stimulation sequence you want for your experiment.



Configure the parameters for each primitive

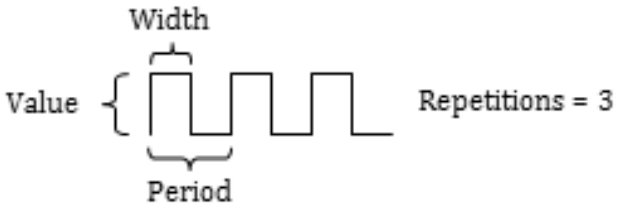
4 For a Constant primitive, to set the **Value** and **Duration**, double click on the numbers and enter the desired value. The **Value** can be set to 0 to create a pause, or to a non-zero value to hold an output. Its units correspond to the units set for the pattern.



5 For a **Pulse** primitive, set the values as explained in this step:

- The **Value** is the amplitude. Its units correspond to the units set for the pattern. Double click on the number and enter the desired value.
- The **Period (ms)** is the total time of the pulse pattern (on + off) for this primitive. The **Frequency (Hz)** is the number of pulse patterns (on + off) per second for this primitive. Click in the field in the **Period/Freq** row and select **Period** or **Frequency** from the dropdown list. Then double click on the number in the next row and enter the desired value.
- The **Pulse Width (ms)** is the amount of time that the pulse holds the non-zero value.
- Click in the field in the **Total Duration/Repetitions** row and select **Total Duration** or **Repetitions Count** from the dropdown list. Then double click on the number in the next row and enter the desired value.

  The **Repetitions Count** sets how many times the pulse pattern of this primitive is repeated. The **Total Duration** sets a total amount of time that the pulse pattern (on + off) for this primitive will run, regardless of how many repetitions occur. Note that if you enter a value for **Total Duration** that does not correspond to a whole number of repetitions (and would therefore result in a partial pulse stimulation being delivered), the system will display an informational dialog box and will automatically round up the **Total Duration** value to a whole number of repetitions.



6 For **Rising Ramp** or **Falling Ramp** primitives, set the values as explained in this step. You can enter as many **Rising Ramp** and **Falling Ramp** primitives as needed.

- The **Initial Value** is the initial amplitude of the ramp. Its units correspond to the units set for the pattern. Double click on the number and enter the desired value.
- The **Final Value** is the ending amplitude of the ramp. Its units correspond to the units set for the pattern. Double click on the number and enter the desired value.

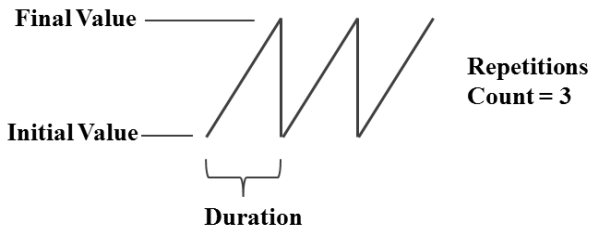
Note: For a **Rising Ramp**, the **Final Value** must be greater than the **Initial Value**. For a **Falling Ramp**, the **Final Value** must be less than the **Initial Value**. The system provides a prompt if you attempt to enter an invalid value.

- The **Duration, ms** is the total ramp time for this primitive. The system applies an amplitude that varies linearly from the **Initial Value** to the **Final Value** over the specified **Duration**.

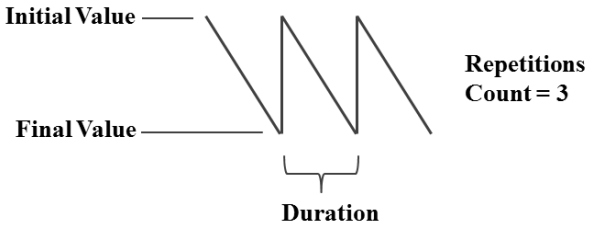
- Click in the field in the **Total Duration/Repetitions** row and select **Total Duration** or **Repetitions Count** from the dropdown list. Then double click on the number in the next row and enter the desired value.

  The **Repetitions Count** sets how many times the ramp pattern of this primitive is repeated. The **Total Duration** sets a total amount of time that the ramp pattern for this primitive will run, regardless of how many repetitions occur. Note that if you enter a value for **Total Duration** that does not correspond to a whole number of repetitions (and would therefore result in a partial ramp stimulation being delivered), the system will display an informational dialog box and will automatically round up the **Total Duration** value to a whole number of repetitions.

Rising Ramp primitive

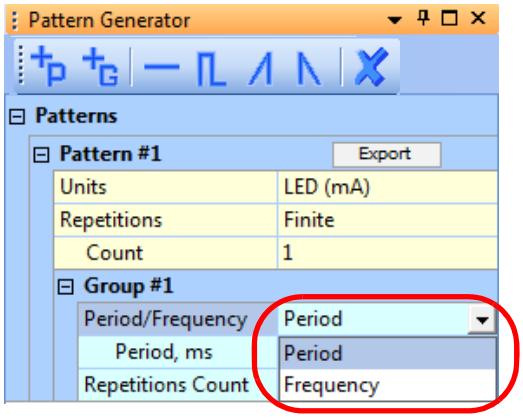


Falling Ramp primitive

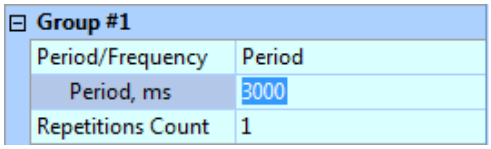


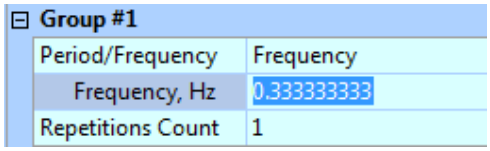
Configure parameters for the group

7 To specify a period or frequency for the group, (**Period/Frequency**), click in the field to the right of **Period/Frequency** and select a value from the dropdown list.

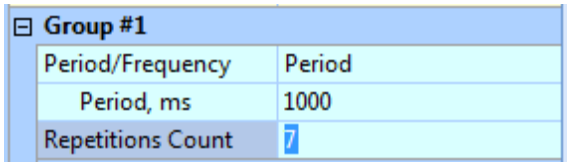


8 Double click in the field to the right of **Period, ms** (or **Frequency, Hz**) and enter the value you want for this group.





9 If you want to edit the **Repetitions Count** for the group, double click in the field to the right and enter the value you want for the number of repetitions of this group.

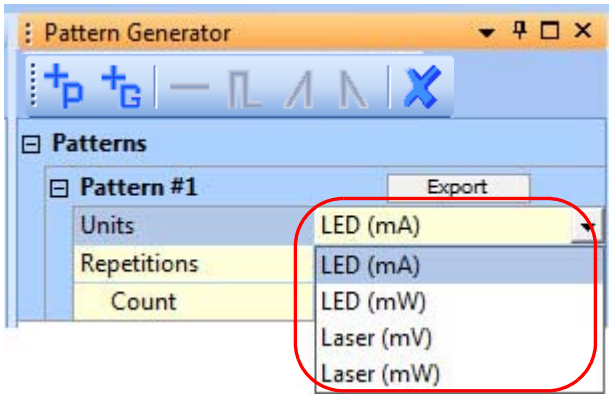


Configure parameters for the pattern

Note: Multiple patterns can be defined in the Pattern Generator, but only one pattern can be assigned to a stimulation channel at a time.

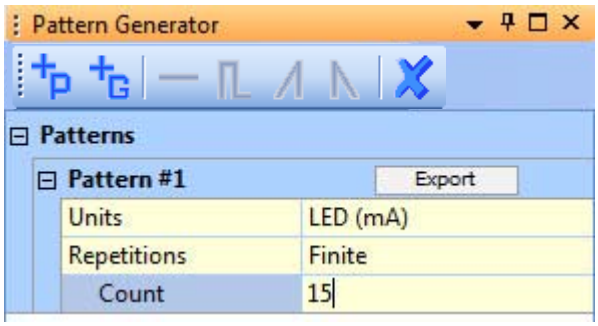
10 If you want to change the output type or units for the pattern, click in the field to the right of **Units**, and select the units from the dropdown list. The default value is

LED (mA).The units of the pattern must match the units of the stimulation channel that you want to assign it to.



11 The **Repetitions** value can be set to **Finite** (the default value) or **Continuous**.

12 If the **Repetitions** value is set to **Finite**, the **Count** parameter is displayed and can be adjusted. Double click on the number (the default value is 1) and enter the number of repetitions you want (1–999). In the example below, the value has been changed to 15.



TIP

You can save your patterns for future use

You can save one or more patterns for use in ongoing or future experiments. The procedure is presented later in this section.

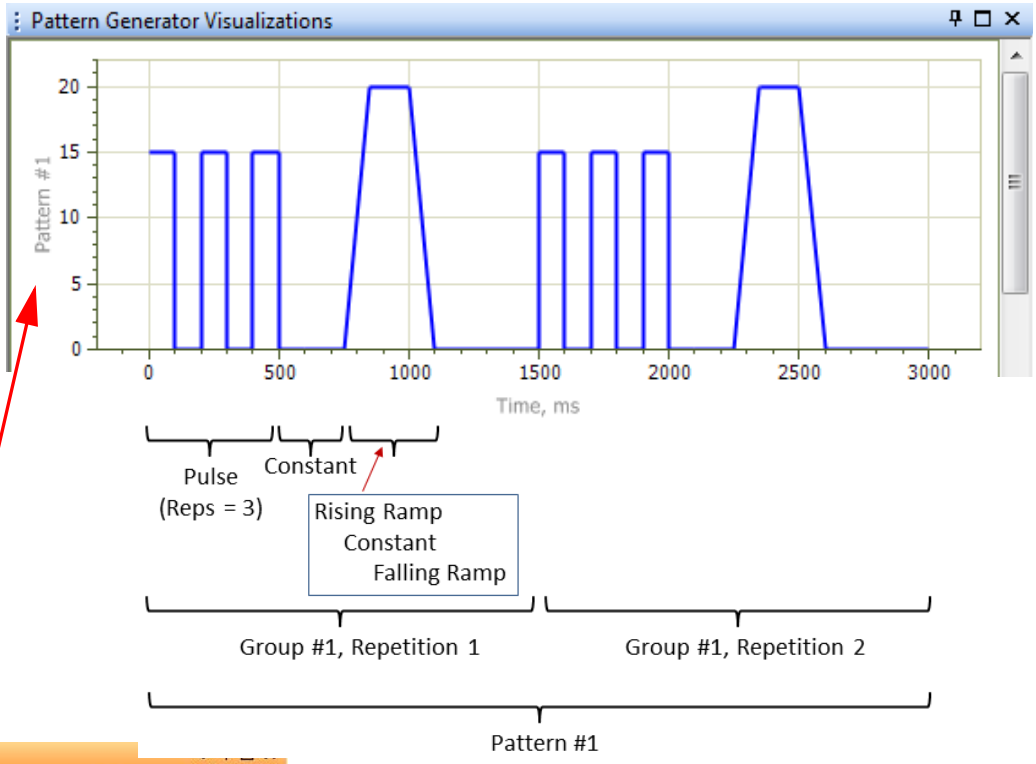
11.2 Viewing the Pattern Generator Visualizations Graph

Interpreting the graph

The **Pattern Generator Visualizations** display is an important tool for checking the accuracy of your stimulation sequence. At any time, you can click on a specific Primitive, Group or Pattern and see what you have defined by looking at the **Pattern Generator Visualizations** window. The display automatically changes to show the Primitive, Group or Pattern you have clicked.

In the image below, the user has clicked on the banner for Pattern #1, so the **Pattern Generator Visualizations** graph displays the complete pattern. Within the pattern, you can see the configured Primitives, Group and Pattern.

Note: The Pattern Generator Visualization will only show one repetition of the pattern, even if more repetitions are specified.

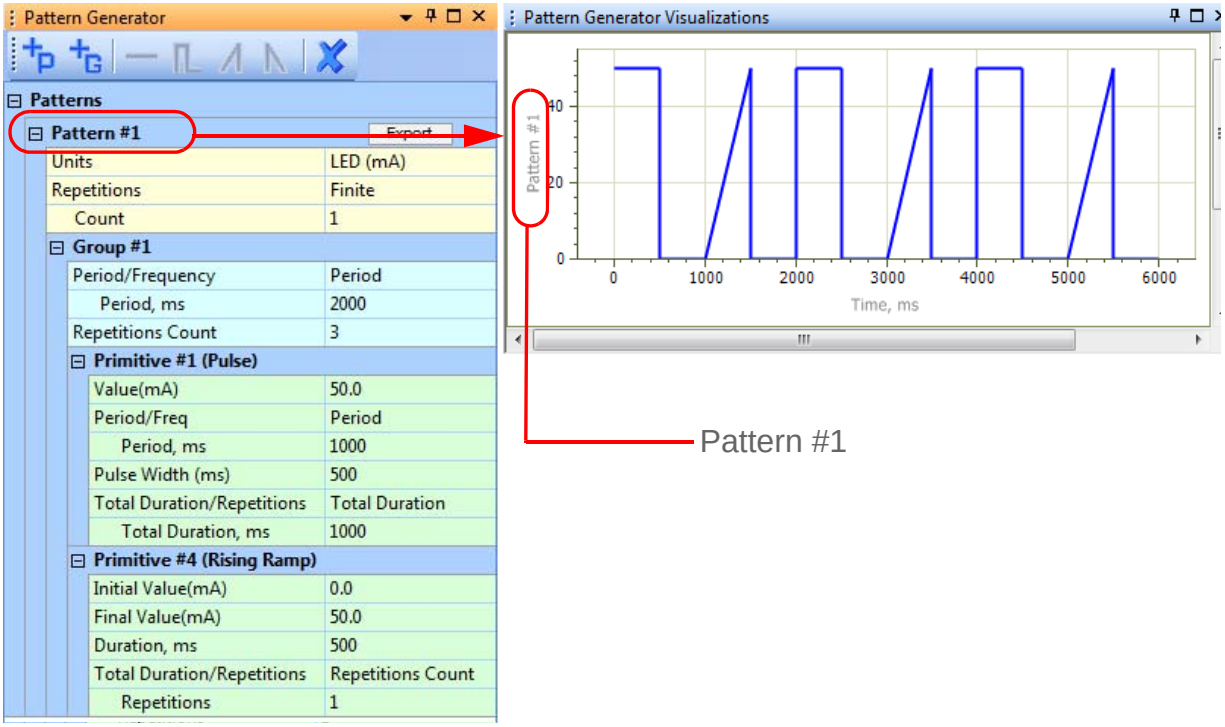


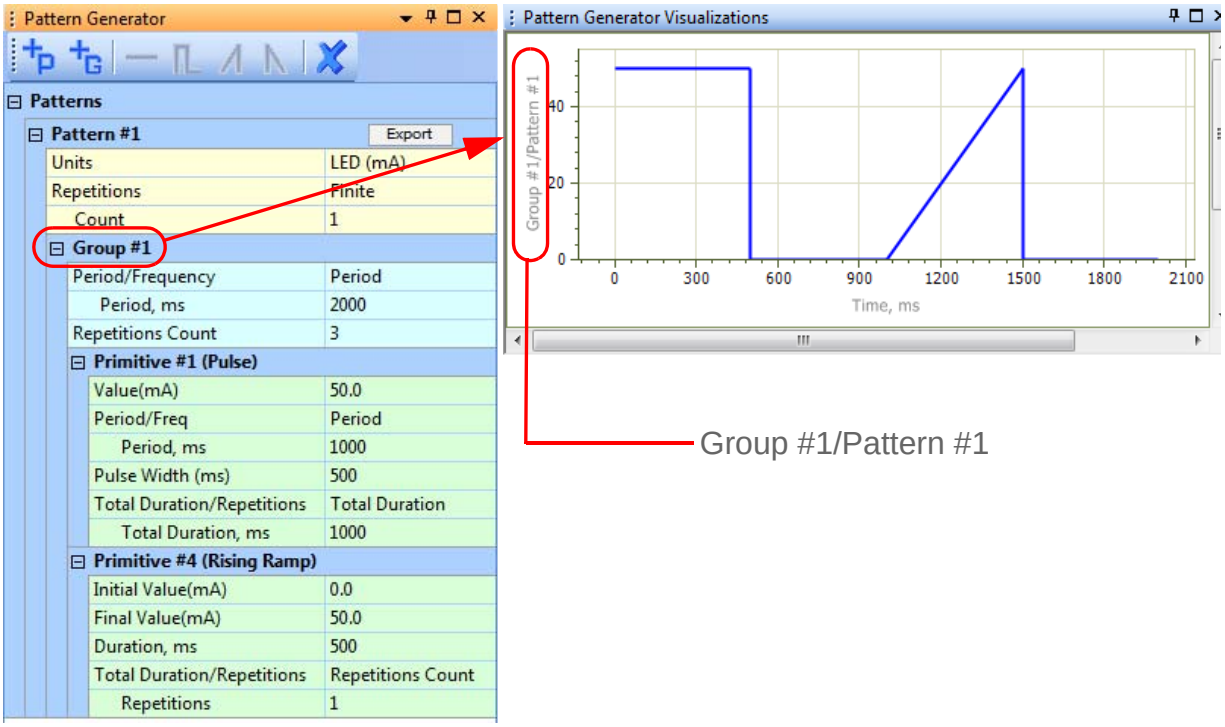
Pattern Generator

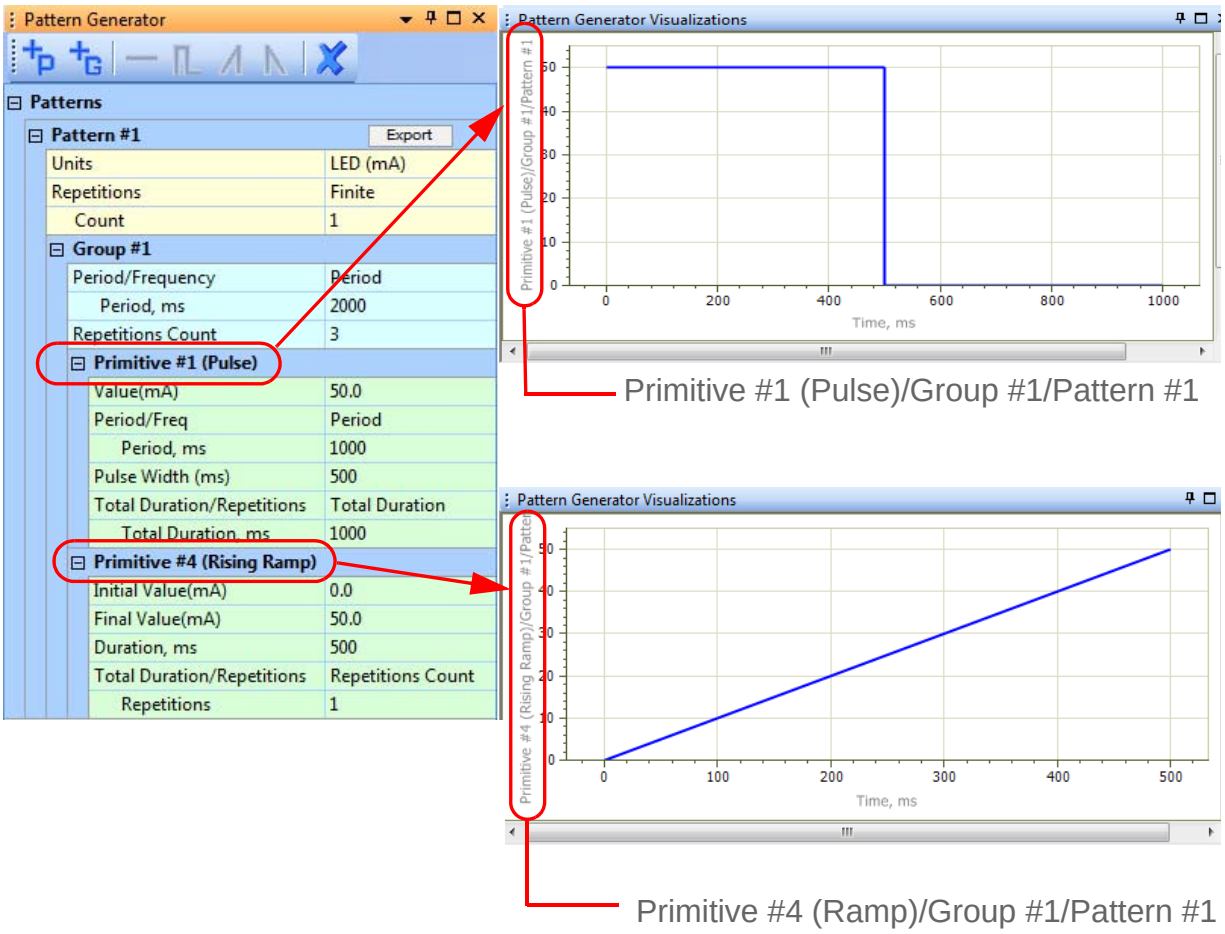
Patterns	
Pattern #1	Export
Units	LED (mA)
Repetitions	Finite
Count	1
Group #1	
Period/Frequency	Period
Period, ms	1500
Repetitions Count	2
Primitive #1 (Pulse)	
Value(mA)	15
Period/Freq	Period
Period, ms	200
Pulse Width (ms)	100
Total Duration/Repetitions	Repetitions Count
Repetitions	3
Primitive #2 (Constant)	
Value(mA)	0
Duration (ms)	150
Primitive #3 (Rising Ramp)	
Initial Value(mA)	0.0
Final Value(mA)	20
Duration, ms	100
Total Duration/Repetitions	Repetitions Count
Repetitions	1
Primitive #4 (Constant)	
Value(mA)	20
Duration (ms)	150
Primitive #5 (Falling Ramp)	
Initial Value(mA)	20
Final Value(mA)	0.0
Duration, ms	100
Total Duration/Repetitions	Repetitions Count
Repetitions	1

Y-axis label

If you click on the **Pattern** banner, the label on the Y axis of the Visualizations window is “Pattern” and the graphical data is applicable to the entire pattern. If you click on a **Group** banner or **Primitive** banner, the Y axis and graphical data change accordingly, as shown in the images below.



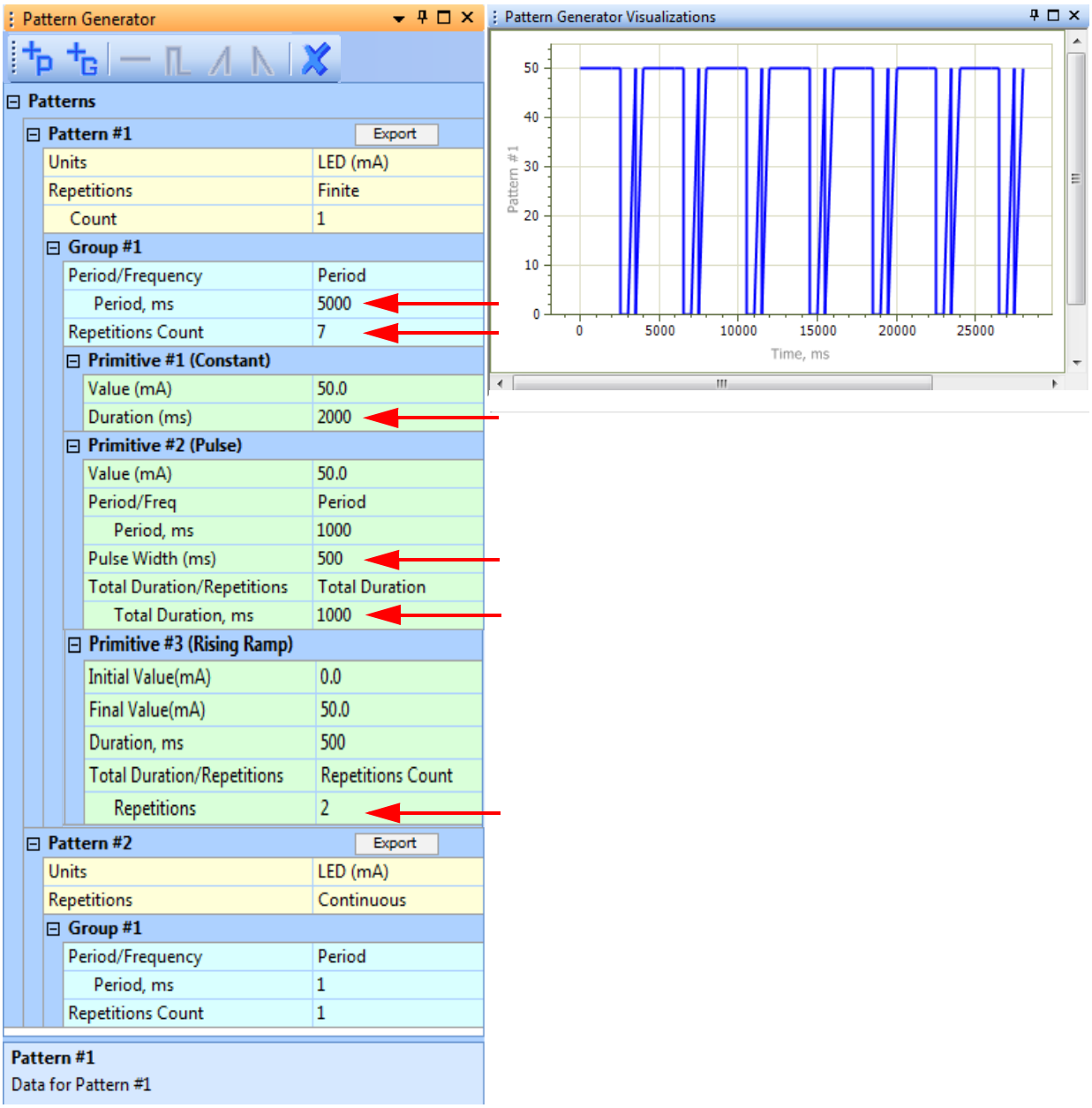




Note: In the image above, notice that Group #1 contains Primitive #1 (Pulse) and *Primitive #4* (Rising Ramp)—Primitive #2 and Primitive #3 are not present. This situation (nonsequential primitive numbers) occurs when primitives are created and then deleted from a group. In the above example, Primitive #2 and Primitive #3 were created and then deleted; Primitive #4 remains.

11.3 Using the Period/Frequency and Total Duration/Repetitions Parameters

As shown in the image below, there are many ways to combine repetitions and/or durations for Primitives, Groups and Patterns to create the stimulation sequence that you want.



11.4 Automatic Updating of the Pattern Generator Parameters

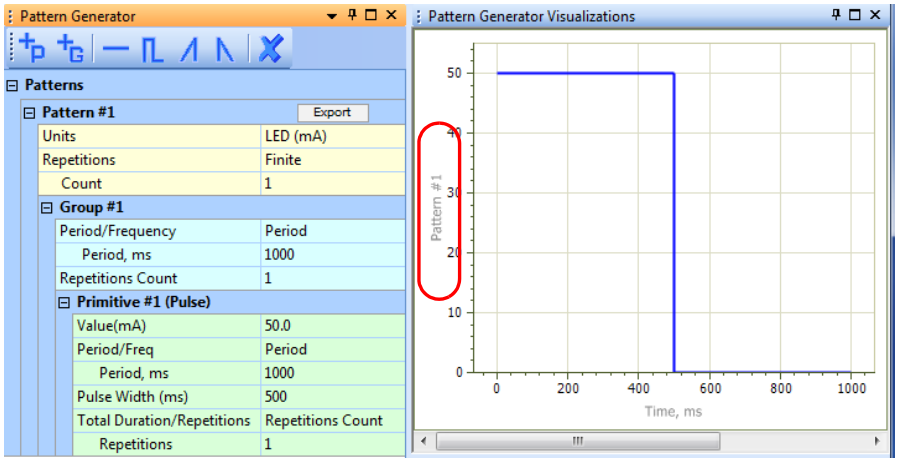
It is important to understand how the Pattern Generator automatically updates Group parameters whenever you modify Primitive parameters:

- If you *increase* the **Total Duration** or **Repetitions Count** of a Primitive, the period of the Group automatically increases, if necessary, to be able to play the full duration of the Primitive. (If the period of the Group is already large enough to accommodate the increase in the Primitive duration or repetitions, the period of the Group does not change.)
- If you *decrease* the **Total Duration** or **Repetitions Count** of a Primitive, the period of the Group *does not* automatically decrease. Instead, the period of the Group is unchanged. When all the Primitives in the Group have completed playing, the stimulation level goes to zero for the remainder of the Group period. This effect can be useful—The zero stimulation time acts as a delay before the Primitive pattern is repeated.
- If you change the Total Duration for a primitive so that it is equivalent to more than 999 repetitions, and then switch back to Repetitions Count, the displayed value in the Repetitions field will be 999 (maximum allowed), and Total Duration will be updated to be equivalent to 999 repetitions. The system displays an appropriate informational message.
- If you remove all Primitives from an existing Group, the Group period reverts to its original default value of 1ms.

Example

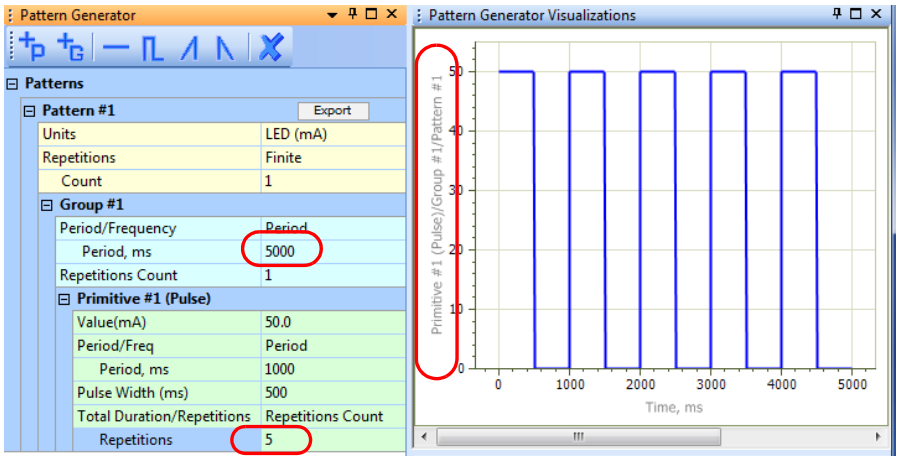
Note: Review Section 11.2, "Viewing the Pattern Generator Visualizations Graph" on page 45 to see how to display Patterns, Groups and Primitives visualizations, especially the Y-axis labels.

1 Click on then then to display a default Pattern, Group and Primitive (Pulse).



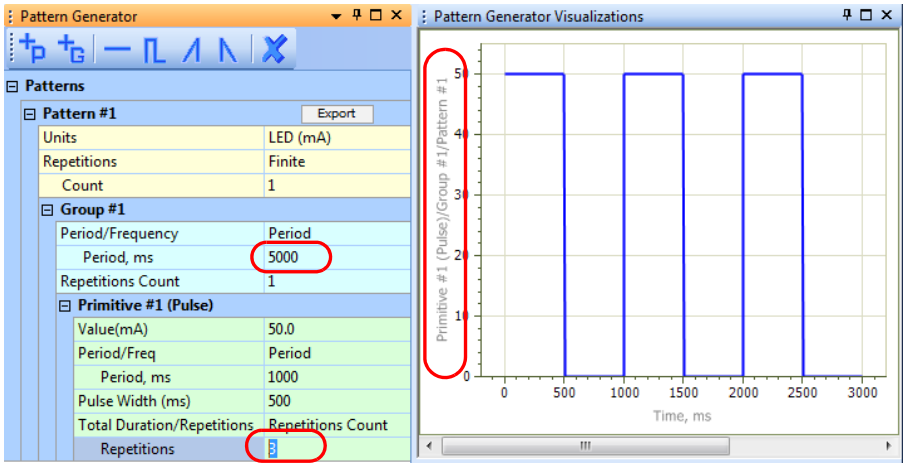
2 Change the **Repetitions Count** of the Primitive (Pulse) to 5 and press the **Enter** key on your keyboard.

In the image below, notice that the graph for this Primitive shows the five repetitions of the Primitive. Also notice that the Period of the Group has increased to 5000ms to allow all five repetitions to be played (5 x 1000ms = 5000ms).

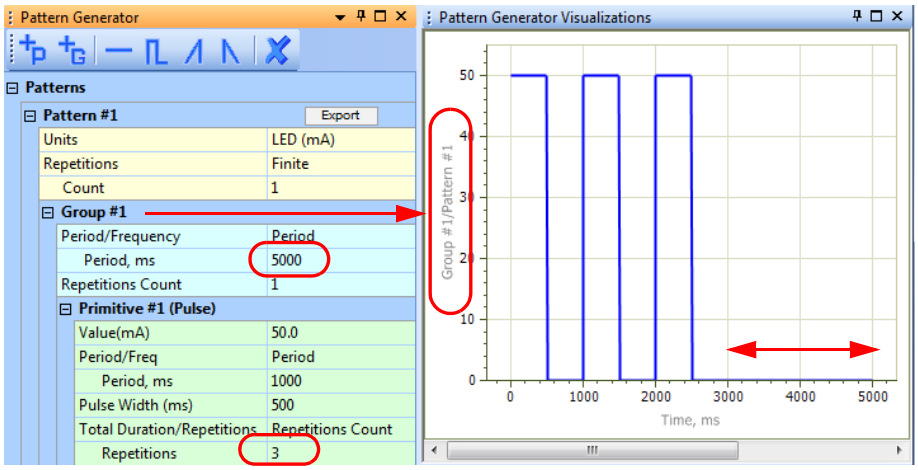


3 Change the **Repetitions Count** of the Primitive to 3 and press the **Enter** key.

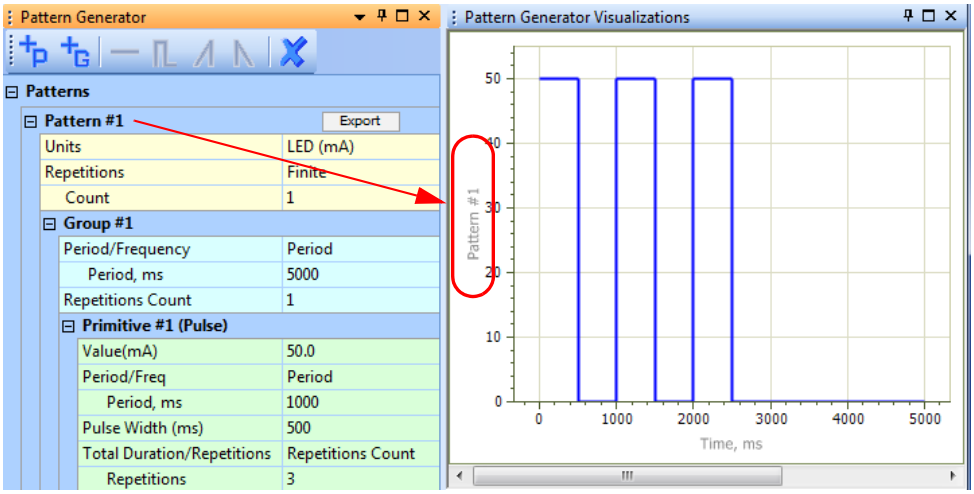
In the image below, notice that the graph for this Primitive shows the three repetitions of the Primitive, but the Period of the Group has remained at 5000ms.



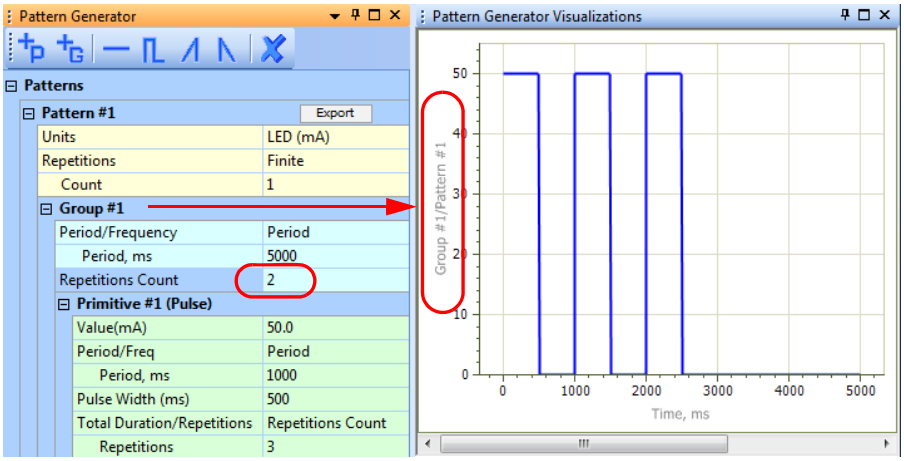
4 Click on the banner for Group #1. This causes the graph for Group #1 to be displayed. Notice that the graph shows that the Primitive plays three times (from 0–3000ms) and then the stimulation goes to zero for the remainder of the Period of the Group (from 3000ms–5000ms).



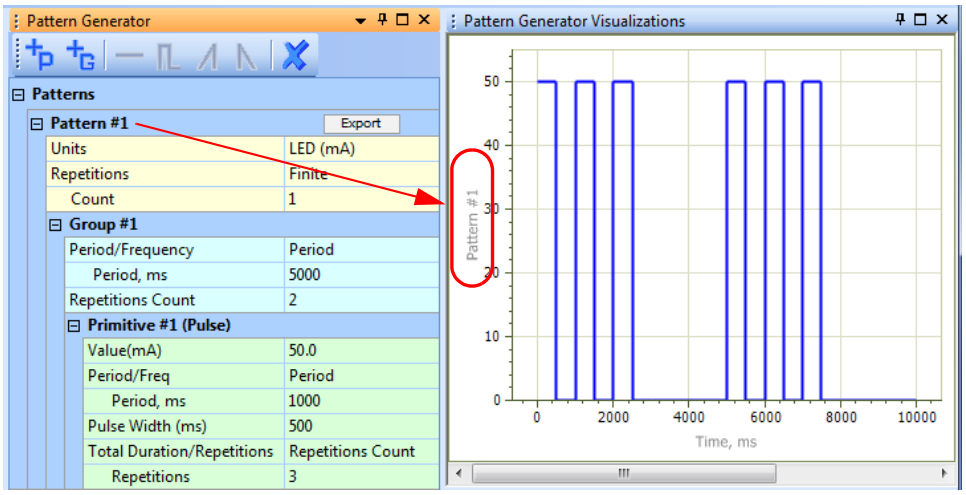
5 Click on the banner for Pattern #1. Notice that the graph is the same (except for the Y-axis label). This is because the Group #1 stimulation Repetition Count is 1.



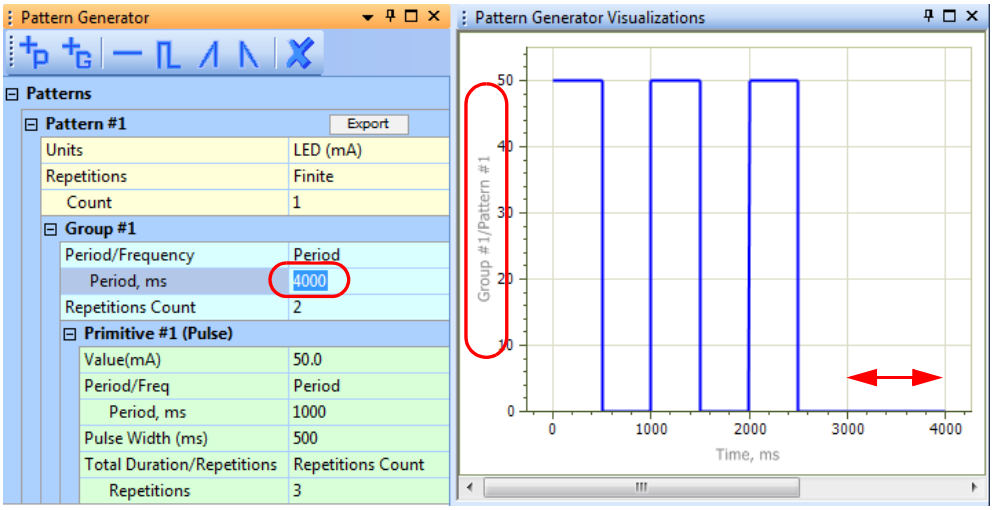
6 Change the Group #1 **Repetitions Count** to 2 and press the **Enter** key. The graph for Group #1 is unchanged. The Period for this group has not changed but you have now specified that it will be repeated two times.



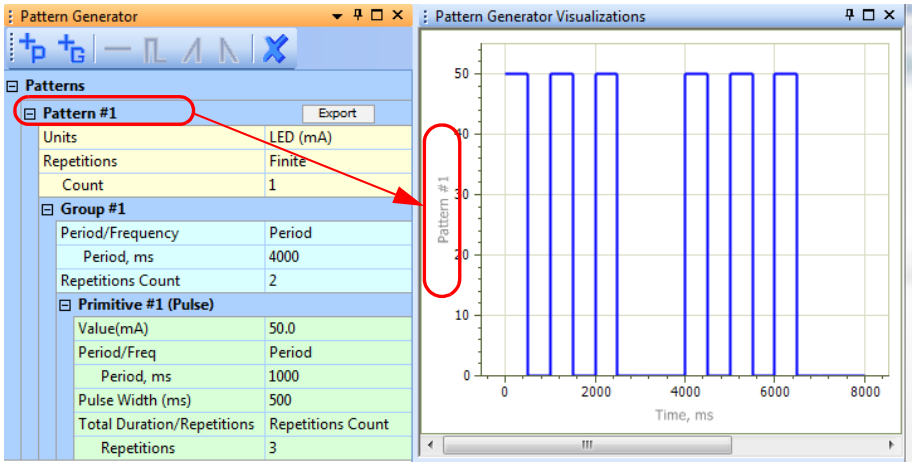
7 Click on the banner for Pattern #1. This causes the graph for Pattern #1 to be displayed. Notice that the graph shows that the Primitive plays three times for Group #1, and that Group #1 is repeated two times in Pattern #1.



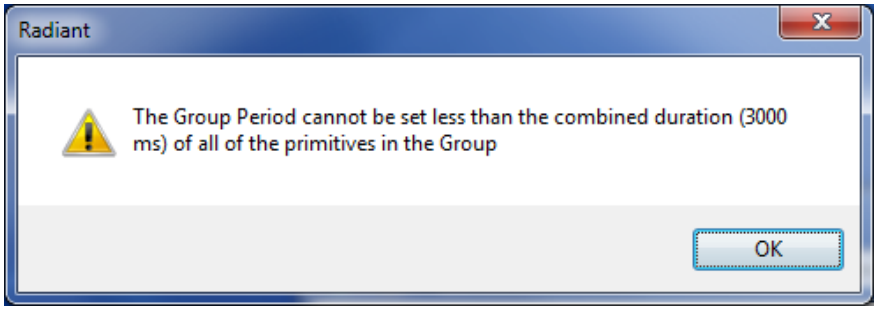
8 Change the **Period** of Group #1 to 4000ms (double click on the number and enter 4000). This causes the graph for Group #1 to show the updated stimulation sequence. The graph shows that the Primitive plays three times (from 0–3000ms) and then the stimulation goes to zero for the remainder of the Period of the Group (from 3000ms–4000ms).



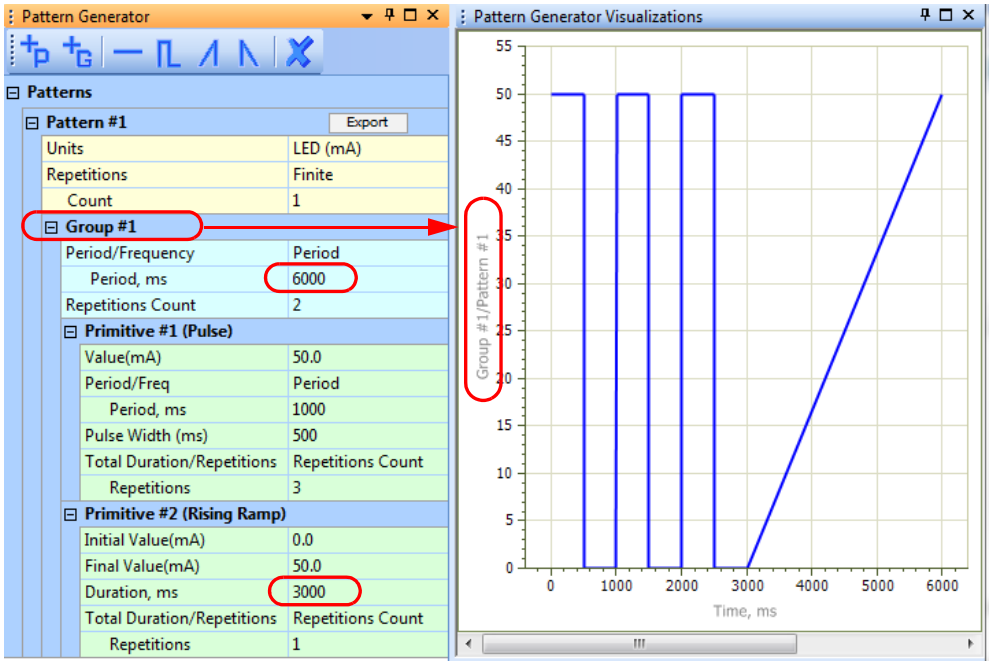
9 Click on the banner for Pattern #1. This causes the graph for Pattern #1 to be displayed. Notice that the graph shows Group #1 playing two times, which takes a total of 8000ms. In this example, the 1000ms duration at the end of each Group repetition (from 3000–4000ms and from 7000ms–8000ms) acts as a delay during which no stimulation is occurring.)



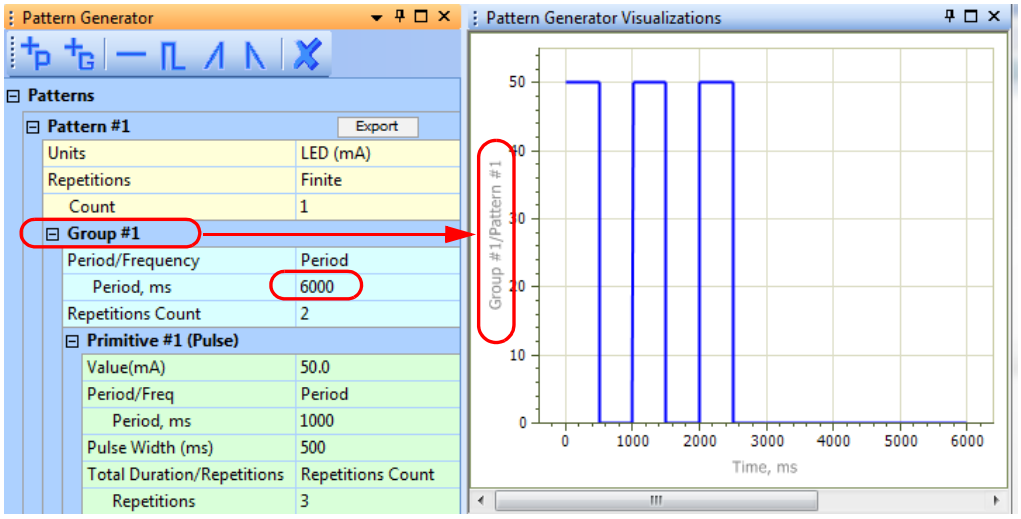
10 Double click on the **Period** of the Group, enter the value 2500 and press the **Enter** key. The system does not execute the command, but displays a dialog box, similar to the one below, explaining the error; the stimulation pattern is unchanged.



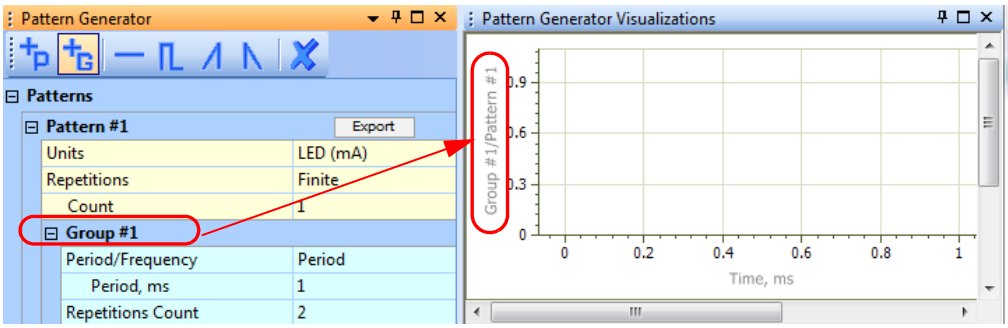
11 Add another Primitive, a Rising Ramp with a duration of 3000ms in this example. Notice that the Group Period increases accordingly to 6000ms.



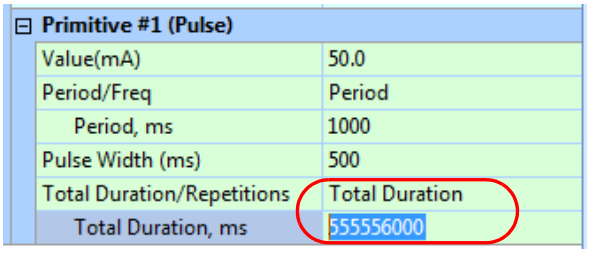
12 Now delete the Rising Ramp primitive that you just added in Step 11. Notice that the Group Period *does not* decrease; it is still 6000ms.

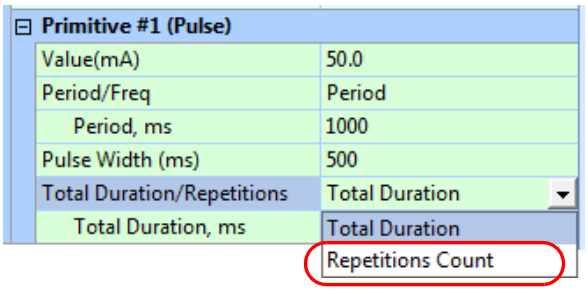


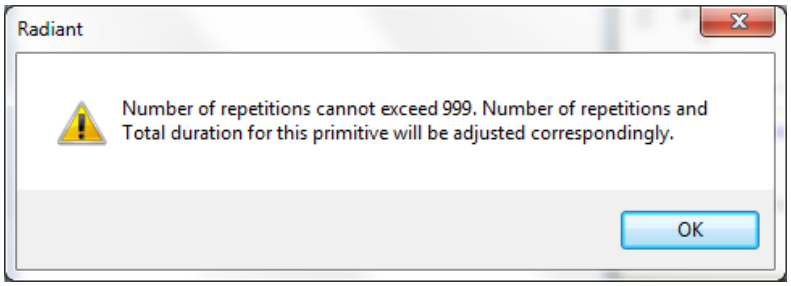
13 If you delete all the Primitives from the Group, the period of the Group returns to the default value (1ms), the same as when it was first created (before any Primitives were added).



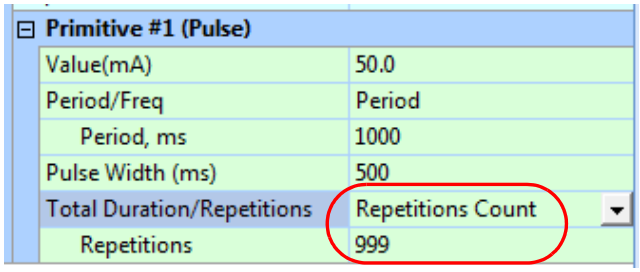
14 If you change the Total Duration for a primitive so that it is equivalent to more than 999 repetitions, and then switch back to Repetitions Count, the displayed value in the Repetitions field will be 999 (maximum allowed), and Total Duration will be updated to be equivalent to 999 repetitions. In the following example, the Total Duration has been changed to 555556000ms. Then the parameter is changed back to Repetitions Count. The system informs the user that the number of repetitions cannot exceed 999.

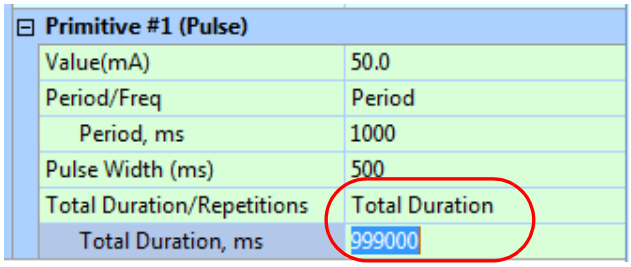






In the image below, the system has reset the number of repetitions to 999 and adjusted the Total Duration to match the 999 repetitions.





It is recommended that you practice modifying the parameters in the Pattern Generator and viewing the resulting graphs for Primitives, Groups and Patterns. You can experiment with multiple Groups and Primitives, and you can edit various numbers. You can also change the options for Period/Frequency and Total Duration/Repetitions. The system behavior will be consistent with the example presented above.

11.5 Pattern Generator Parameter Ranges

Numerical ranges for the parameters in the Pattern Generator fields are displayed at the bottom of the Pattern Generator window. For reference, these values are listed below.

Note: If you enter a value that is out of range for the parameter (and then press the **Enter** key on your keyboard), the system does not accept the new value. Instead, it displays the current value again.

Note: Some of these parameters are interrelated, and the system checks whether the new value you enter is consistent with the other existing parameter values. If the value is disallowed, the system displays an appropriate message (dialog box).

Pattern Generator Level	Parameter	Range
Pattern	Count (when Repetitions = Finite)	1 to 999
Group	Period, ms	1 to 4000000000 (1 to 4e09) Note: Must be an integer
	Frequency, Hz	0.00000025 to 1000 (2.5e-7 to 1000)
	Repetitions Count	1 to 999
Primitive (Constant)	Value (mA or mV or mW) [a]	0 to 1100mA (LEDs) 0 to 5000mV (Lasers) 0 to 1000mW (LEDs and Lasers)
	Duration (ms)	1 to 4000000000 (1 to 4e09) Note: Must be an integer
Primitive (Pulse)	Value (mA or mV or mW) [a]	0 to 1100mA (LEDs) 0 to 5000mV (Lasers) 0 to 1000mW (LEDs and Lasers)
	Period, ms	1 to 999999999 (1 to 9.99999999e08) Note: Must be an integer
	Frequency, Hz	0.000001 to 1000 (1e-06 to 1000)
	Pulse Width (ms)	1 to 999999999 (1 to 9.99999999e08) Note: Must be an integer
	Repetitions	1 to 999
	Total Duration, ms	1 to 4000000000 (1 to 4e09) Note: Must be an integer

Pattern Generator Level	Parameter	Range
Primitive (Rising Ramp or Falling Ramp)	Initial Value (mA or mV or mW) [a]	0 to 1100mA (LEDs) 0 to 5000mV (Lasers) 0 to 1000mW (LEDs and Lasers)
	Final Value [b] (mA or mV or mW) [a]	0 to 1100mA (LEDs) 0 to 5000mV (Lasers) 0 to 1000mW (LEDs and Lasers)
	Duration, ms	1 to 4000000000 (1 to 4e09) Note: Must be an integer
	Repetitions	1 to 999
	Total Duration, ms	1 to 4000000000 (1 to 4e09) Note: Must be an integer

a. The maximum values (mA, mV, mW) are set on a per channel basis based on the LED or laser that is connected to that channel. If you try to load a pattern with a larger value than the maximum specified for that channel, the system displays a dialog and truncates the value (shown graphically with a dashed red line). This feature is covered in Section 11.6, "Assigning a Pattern to a Channel" on page 61.

b. For a Rising Ramp, Final Value must be greater than Initial Value. For a Falling Ramp, Final Value must be less than Initial Value. If you enter an invalid value, the system displays a dialog box and does not change the existing value.

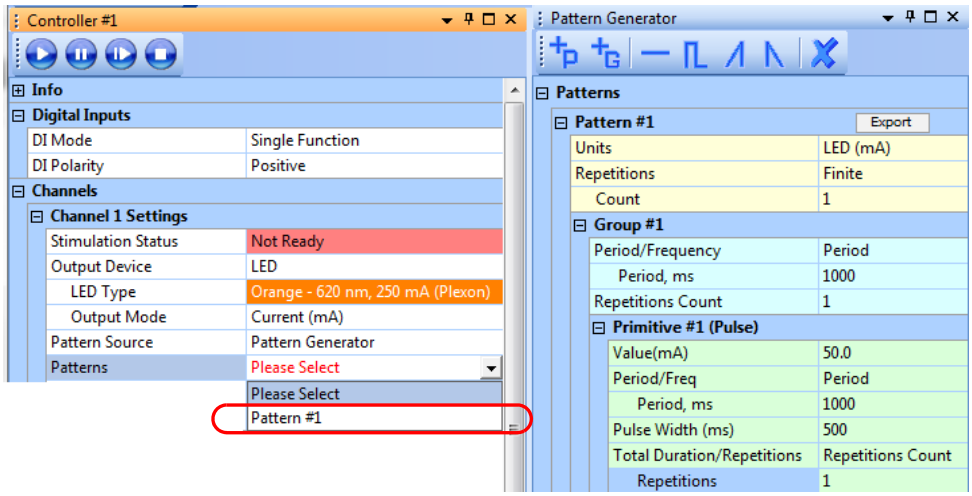
Upper limit on very long stimulation patterns

The maximum total duration of continuous stimulation (total pattern duration) supported by the system is 119 hours.

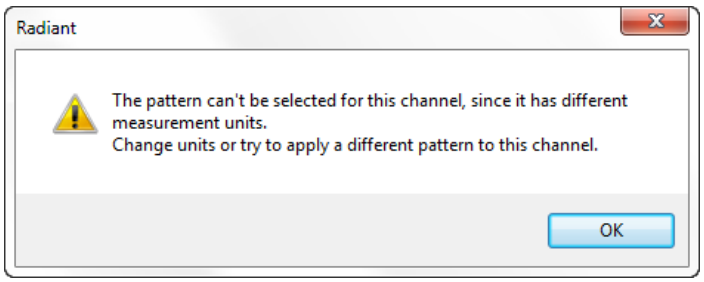
11.6 Assigning a Pattern to a Channel

Note: Some of the images in this section display the Stimulation Status and control toolbar for the stimulation channels. For information on using these controls to start, stop, pause and unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

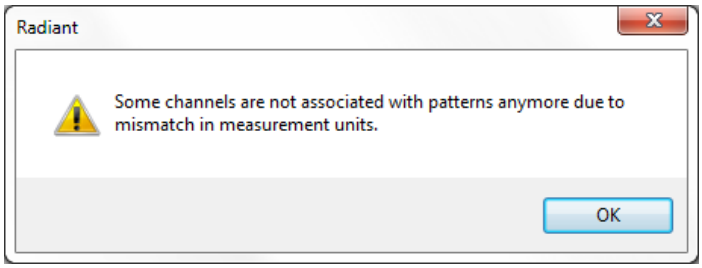
1 After a pattern has been defined it needs to be associated with a channel. The units of the pattern must match the units of the channel. Select **Pattern Generator** from the **Pattern Source** dropdown list. Then select the pattern that you want to load.



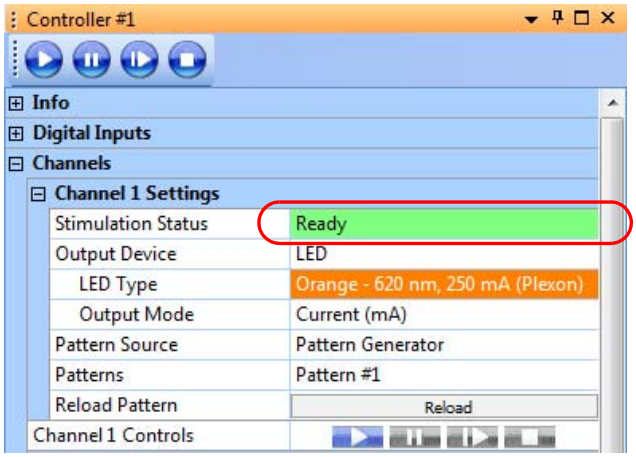
2 If the units of the pattern do not match the units of the channel—for example, if the units for the pattern are Laser (mV) and the channel output mode is Current (mA)—the following error message will pop up. In that case, click **OK** and modify either the channel or the pattern so the units match.



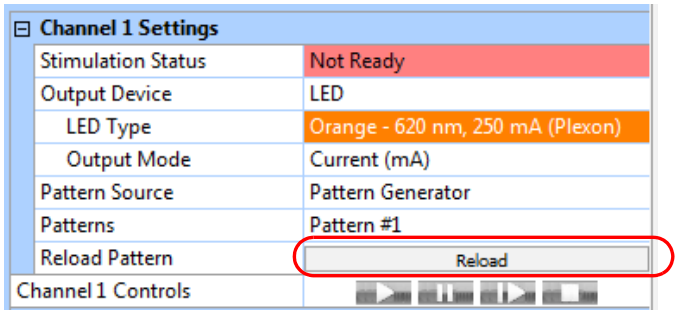
In addition, if you assign a pattern to a channel, and then change the units in the pattern—for example, if the channel output mode is Current (mA), and you change the units of the pattern from LED (mA) to LED (mW)—the system will remove the pattern from the channel and the following error message will pop up. In that case, click **OK** and modify either the channel or the pattern so the units match.



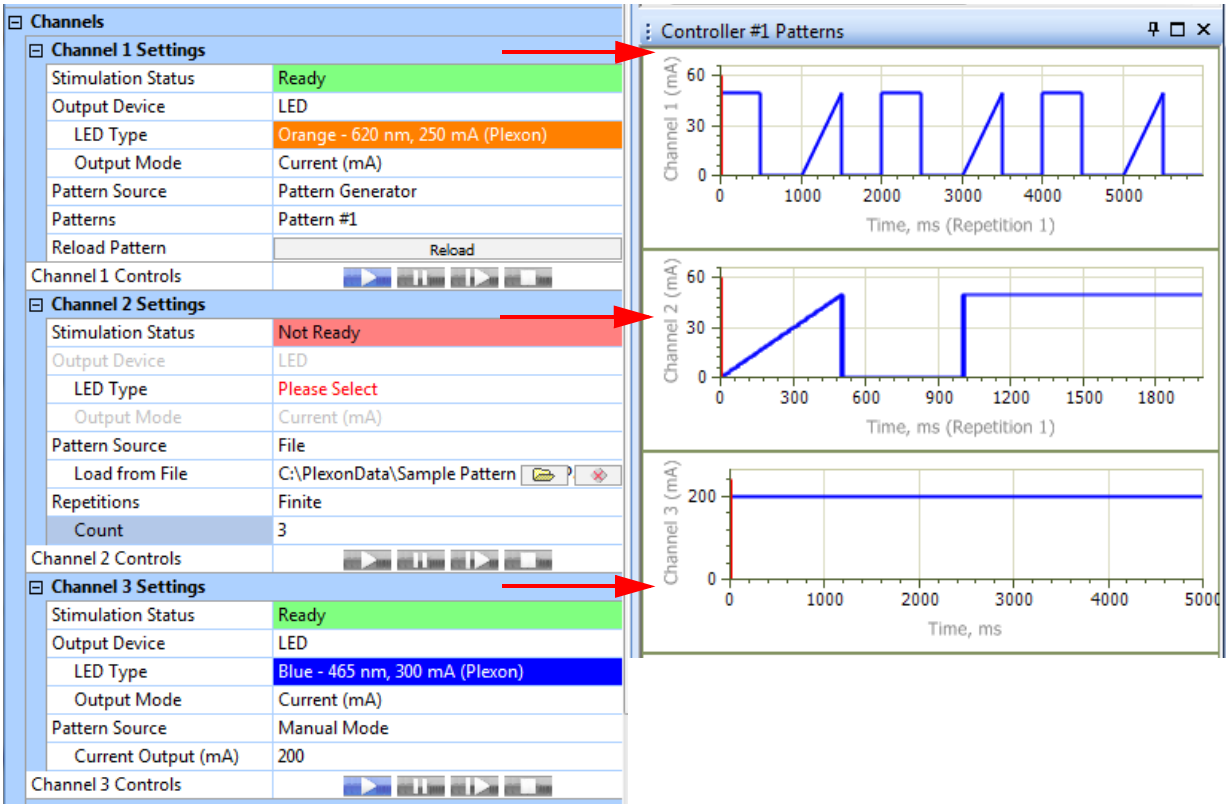
After a pattern has been associated with a channel, the channel is ready to start stimulation.



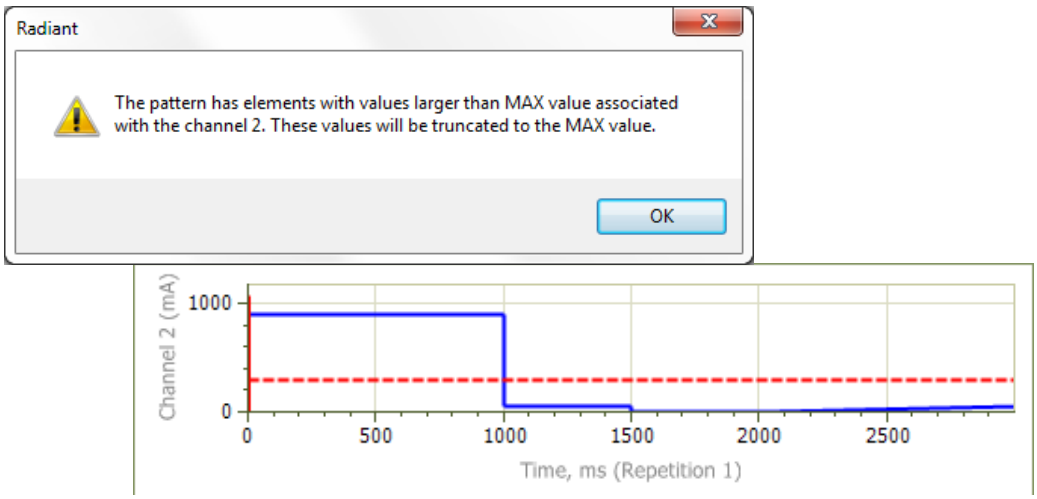
3 If you change a parameter in the Pattern Generator, the channel **Stimulation Status** will change to **Not Ready**. The system is waiting for you to click the **Reload** button. To assign the updated pattern to this channel click the **Reload** button and the status will change to **Ready**.



4 View the **Controller Patterns** graphs to see the stimulation pattern that is currently assigned to each channel.



5 If you assign a pattern to a channel, and the amplitude of the pattern (in mA, mV or mW) exceeds the capability of the hardware assigned to the channel, the system displays a dialog, and automatically truncates the amplitude to its maximum allowed value. The maximum allowed value is displayed with a red dotted line.



11.7 Where to Go Next

You can save your stimulation patterns to a file, then load the saved patterns to specific channels at a later time. See Section 12, "Creating Stimulation Sequence Files (.txt and .opt)" on page 65 and Section 13, "Assigning Stimulation Sequence Files to Channels" on page 69.

Starting and stopping stimulation from the User Interface

For information on using the control icons to start/stop/pause/unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

Starting and stopping stimulation with Digital Inputs

For this information, see Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

12 Creating Stimulation Sequence Files (.txt and .opt)

This section explains how to create stimulation sequence files. You can create and save several of these files if you wish, and then assign them to specific stimulation channel(s) in the controller(s).

There are two types of stimulation sequence files the system can use in **File** mode—.opt and .txt. An .opt file is created with the **Pattern Generator** and has a header that defines stimulation parameters such as units, while a .txt file is created with a text editor and is just a series of amplitudes.

Note: This section also explains how you can save all stimulation patterns by means of a Settings (.ops) file. Keep in mind that this type of file saves many other settings in addition to all the stimulation patterns.

12.1 Saving a Pattern as an .opt File

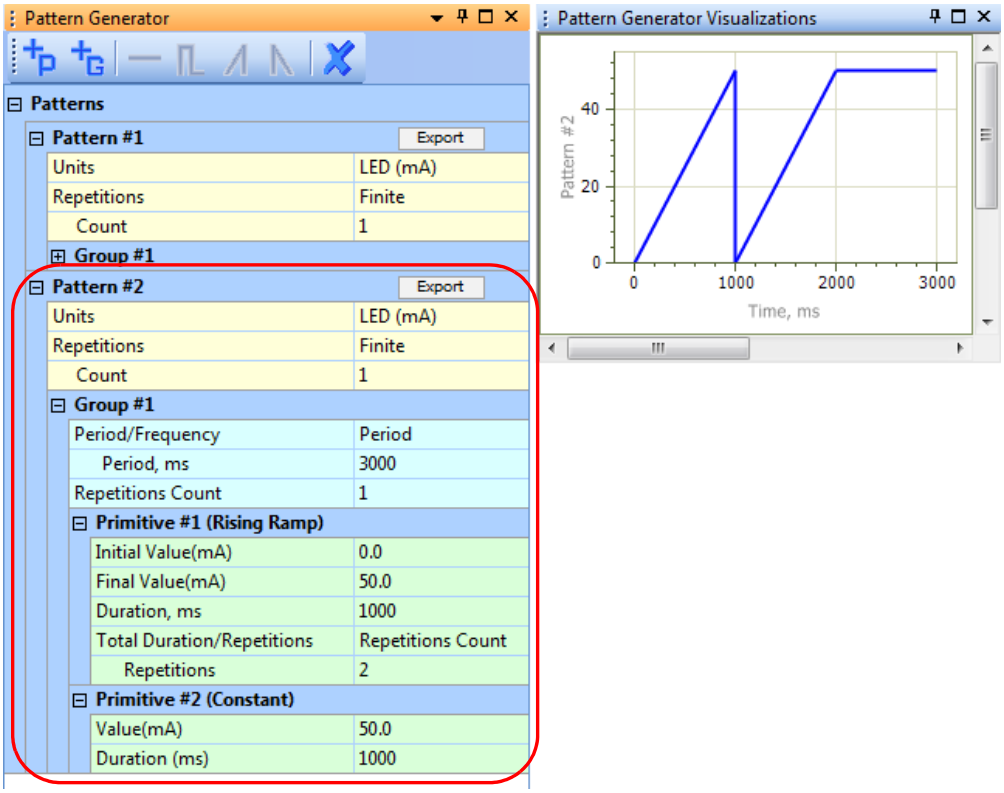
You can define a stimulation pattern (sequence) in the **Pattern Generator**, then click the **Export** button to save the pattern as an .opt file. Later, you can load the .opt file with that pattern on any channel.

When to save an .opt file

In many cases, .opt file sizes can be quite large, especially when your patterns have many repetitions. Therefore, it is recommended that you save *settings* instead of an .opt file whenever possible (see Section 12.3, "Saving All Patterns and Other Settings to a Settings (.ops) File" on page 68). You should save an .opt file only if you want to access stimulation amplitudes on a point-by-point basis for use or editing in another software package such as a text editor.

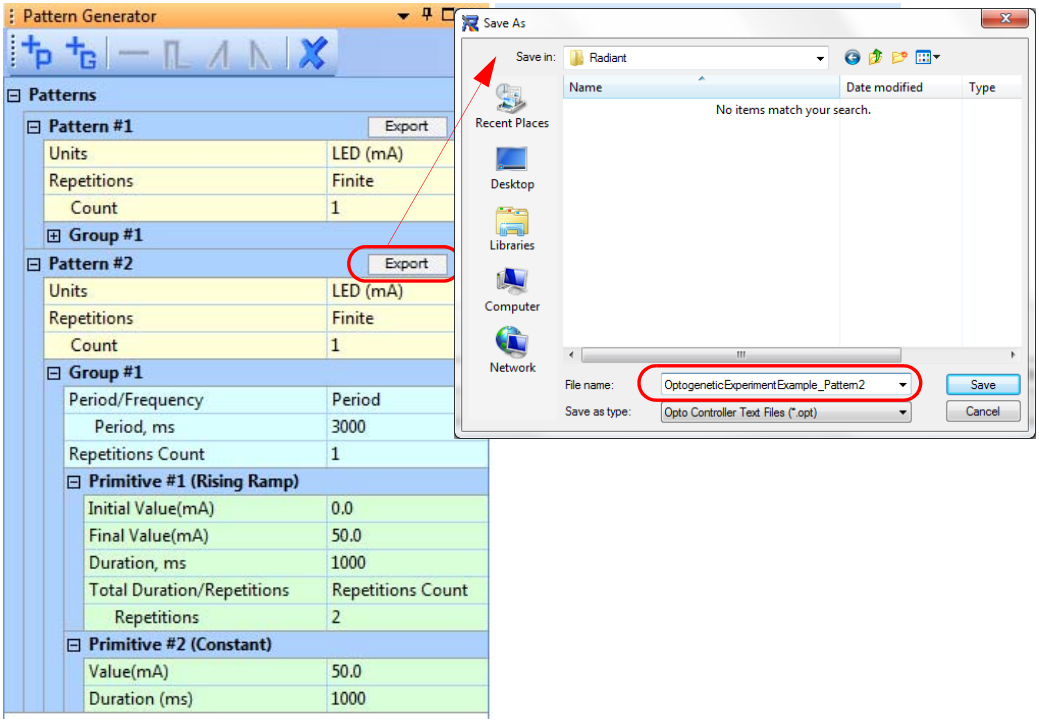
Procedure

1 Create the desired pattern in the **Pattern Generator** as described in Section 11, "Creating Stimulation Patterns with the Pattern Generator" on page 38. In the example below, Pattern #2 is ready to be exported.



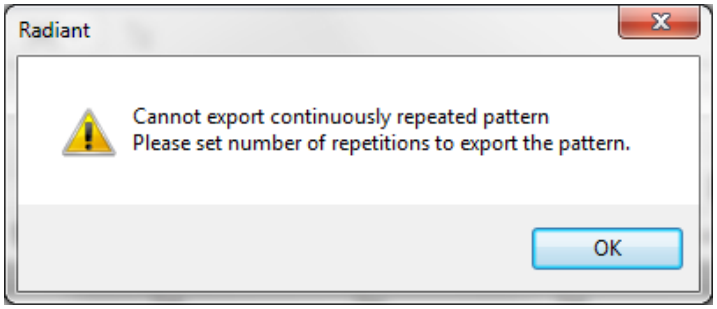
2 Click the **Export** button for the pattern; the system displays a dialog box.

Enter a name for the file and click **Save**.



3 If the **Repetitions** parameter is set to **Continuous**, the system prompts you to change the value to **Finite** for the purpose of saving the .opt file. If you see this dialog box, click **OK** to close the box, then change the Pattern Generator **Repetitions** parameter to **Finite**, set **Count** to 1, and repeat Step 2.

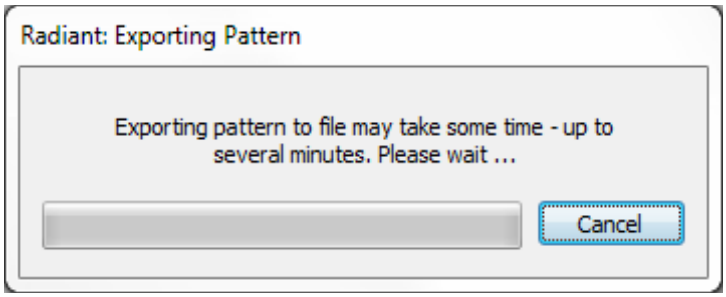
Note: You can set **Count** to any value, but it is recommended that you set it to 1 because this will give the greatest flexibility when you reopen the file.



Note: Later, when you load that file to a particular channel, you can set the **Repetitions** parameter of the channel to **Continuous**, as explained in Section 13.1, "Loading a Pattern from an .opt File" on page 69.

4 If the **Repetitions** parameter is set to **Finite** but the pattern has an extremely long duration, the system displays an informational dialog box (shown below). The system saves the file in the normal manner and the dialog box closes automatically after the file is saved.

If you manually cancel the operation by clicking the **Cancel** button, the dialog box closes and the system does not create the file.



Note: The system disables digital input (DI) functions while an Export ("Save As") dialog box is open and while an export operation is occurring. DI functions are described in Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

12.2 Defining and Saving a Pattern with a .txt File

Stimulation patterns can be defined in simple text files using any text editor software (Microsoft® Word, Notepad, etc.). More advanced users can programmatically create files using software such as MATLAB® or LabVIEW™.

The text file is simply a list of amplitudes. When it is played back, each amplitude is updated every 100µs. To maintain a value longer than 100µs, the value is repeated. Several sample files are included in the installation package.

The amplitude units can be mA or mW for LEDs, and mV, or mW for lasers. The units are not specified in the text file; you need to specify the units when setting up the channel in the user interface *before* loading the .txt file.

12.3 Saving All Patterns and Other Settings to a Settings (.ops) File

Typically, in an experiment session you will have patterns defined in the Pattern Generator and patterns, files or manual settings assigned to various channels. You can save all of these patterns and settings in a single .ops file by clicking the **Save settings to file** icon or by selecting **Save settings** from the **File** menu. See Section 18.8, "File Save Settings / File Load Settings / Restore Factory Settings" on page 111.

Later, you can load the .ops file to restore those same patterns and settings. Keep in mind that loading an .ops file will affect values for much more than just a single stimulation pattern—It will affect all **Channel** parameter settings *and* all **Pattern Generator** settings.

13 Assigning Stimulation Sequence Files to Channels

Note: See Section 12, "Creating Stimulation Sequence Files (.txt and .opt)" on page 65 for information on creating .opt, .txt and .ops files.

This section explains how to assign a stimulation sequence file to an individual channel in the controller. After the file is assigned to the channel, the channel will be able to output the specified stimulation pattern.

.opt and .txt files

There are two types of stimulation sequence files the system can use—.opt and .txt. An .opt file is created with the **Pattern Generator** and has a header that defines stimulation parameters such as units, while a .txt file is created with a text editor and is just a series of amplitudes. See Section 13.1, "Loading a Pattern from an .opt File" on page 69 and Section 13.2, "Loading a Pattern from a .txt File" on page 75.

.ops files

You can load all previously saved stimulation patterns and channel settings by means of an.ops file. See Section 13.3, "Loading Stimulation Patterns and Other Settings from an .ops File" on page 78. It is important to understand that the .ops file contains all Radiant parameter settings, not just the stimulation patterns.

Note: Some of the images in this section display the Stimulation Status and control toolbar for the stimulation channels. For information on using these controls to start, stop, pause and unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

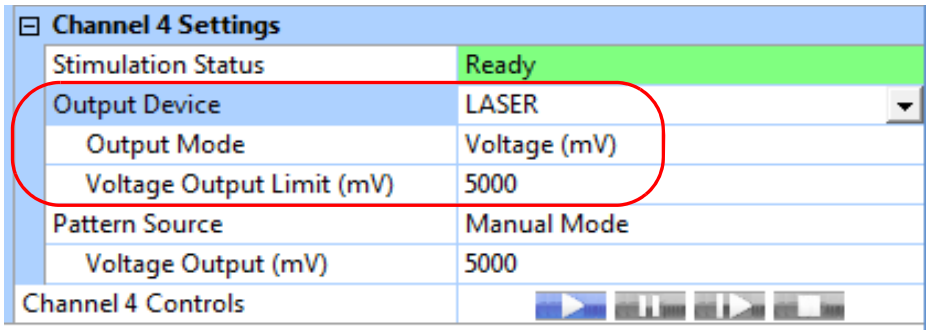
13.1 Loading a Pattern from an .opt File

You can load a pattern from a file that you created previously in the **Pattern Generator** (Section 11.1, "Defining a Pattern with the Pattern Generator" on page 38 and Section 12.1, "Saving a Pattern as an .opt File" on page 65).

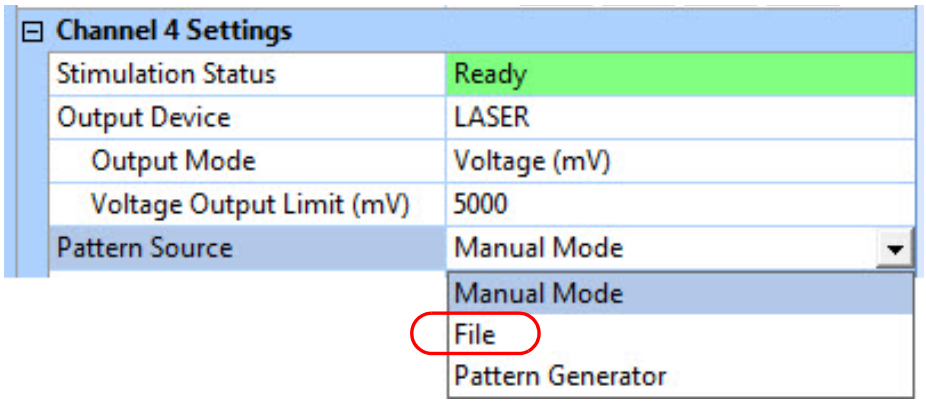
Note: In the following example, the **Output Device** is **LASER**. The procedure for LEDs is similar.

Note: If you need to see how the start/stop/pause/unpause controls in the user interface work, go to Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

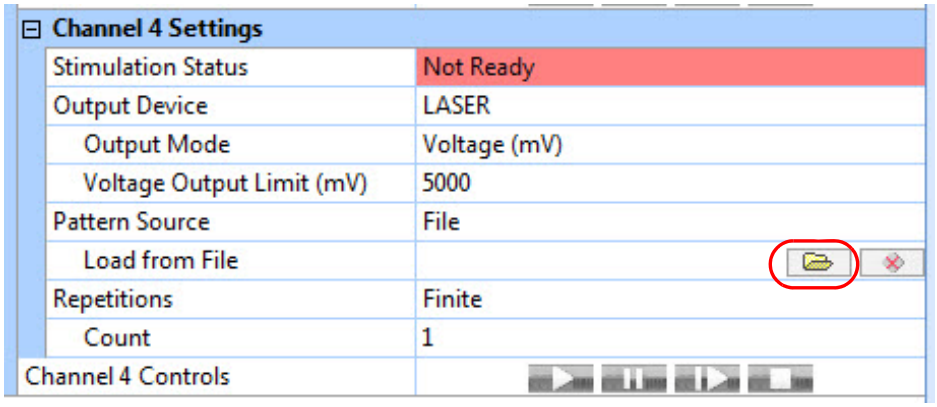
1 For this example, we are setting parameters for Channel 4, and we set the **Output Device** as **LASER**, **Output Mode** as **Voltage (mV)**, and **Voltage Output Limit (mV)** to 5000.



2 Select **File** from the **Pattern Source** drop down menu.

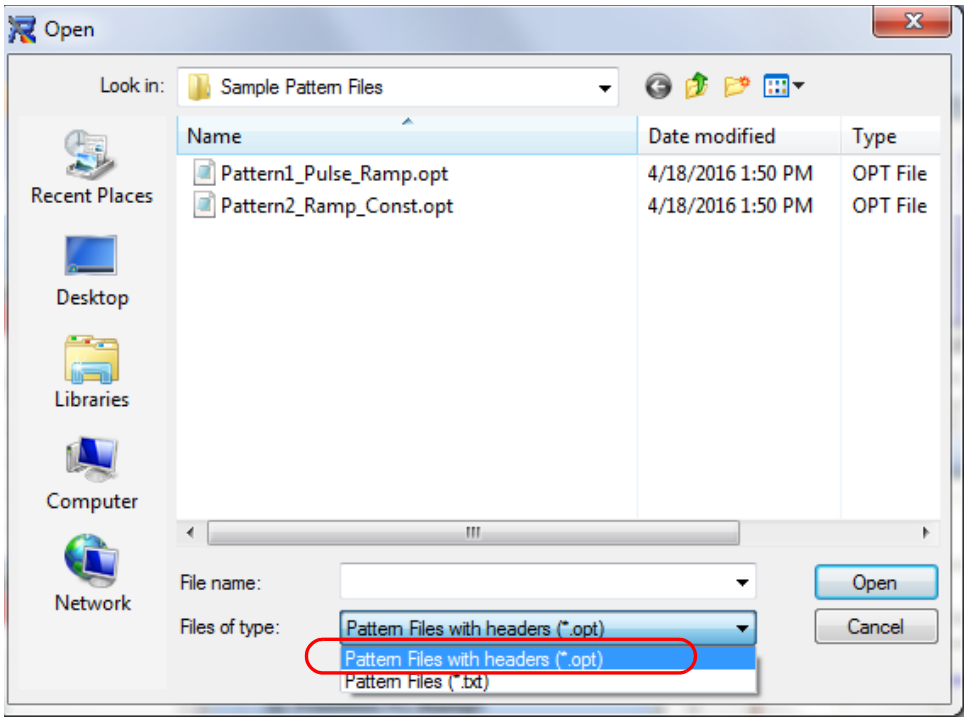


3 Click on the folder icon in the field next to **Load from File**. Notice that the **Stimulation Status** changes to Not Ready, because now it is waiting for you to select a specific file. (Also notice that three new rows are displayed—**Load from File**, **Repetitions** and **Count**. These will be discussed later in this section.)



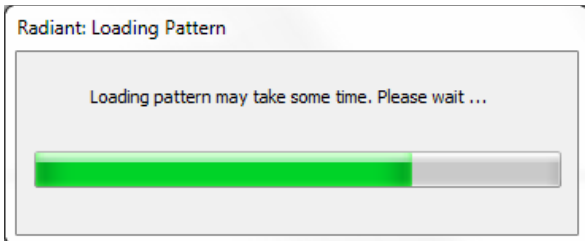
A dialog box will pop up, allowing you to choose a file.There are two types of stimulation sequence files (.opt and .txt). An .opt file is created with the **Pattern Generator** and has a header that defines stimulation parameters such as **Output Device** and **Output Mode** (units), while a .txt file is created with a text editor and is just a series of amplitudes.

4 For this example, select a file from a list of sample .opt files that were created with the **Pattern Generator** previously and saved at C:\Plexon Data\Sample Pattern Files. When you load an .opt file, the channel settings change to match the settings in the header of the .opt file, specifically, the **Output Device** and **Output Mode** (units).

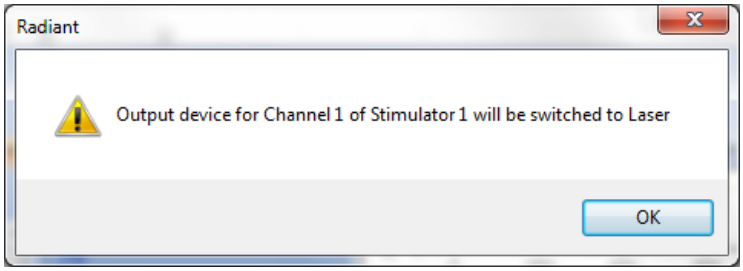


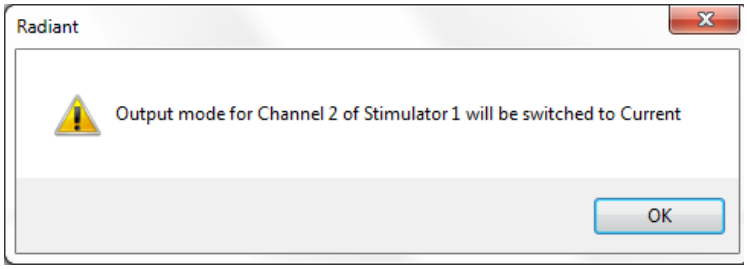
5 Consider whether any of the following conditions apply, and take any actions appropriate for your experiment:

- Complex .opt files might take several seconds to load. You might see a progress bar when a large file is being loaded to the channels.



- If the .opt file has a different configuration (**Output Device** and/or **Output Mode**) than is currently set for the channel, the system displays a dialog to notify you (examples below). Furthermore, the .opt file settings will *override* the present settings on the channel. Verify that the settings on the channel are the ones you want to use for your experiment.

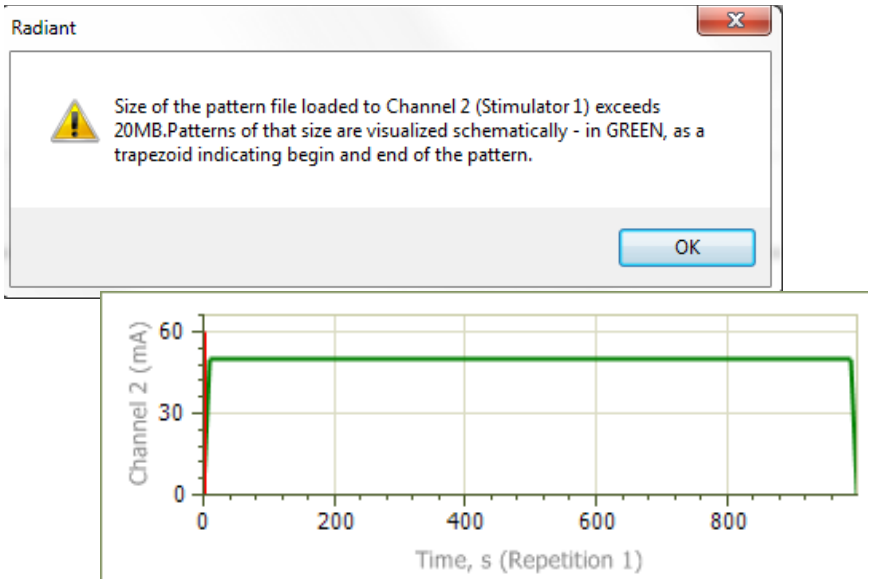




CAUTION

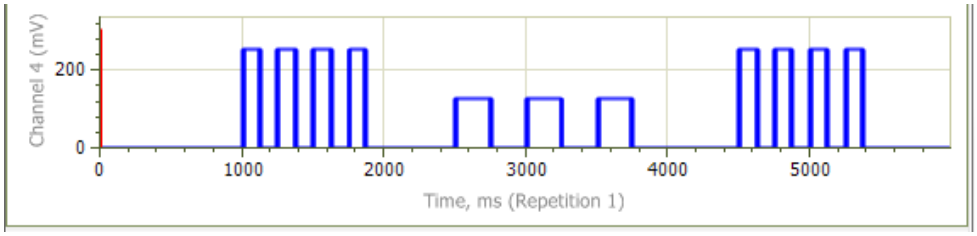
If you see the above caution message, check carefully that the channel stimulation parameters are set correctly for your experiment.

- If a pattern file larger than 20MB is being loaded to a channel, the system displays a dialog box and displays the pattern as shown in the example below.

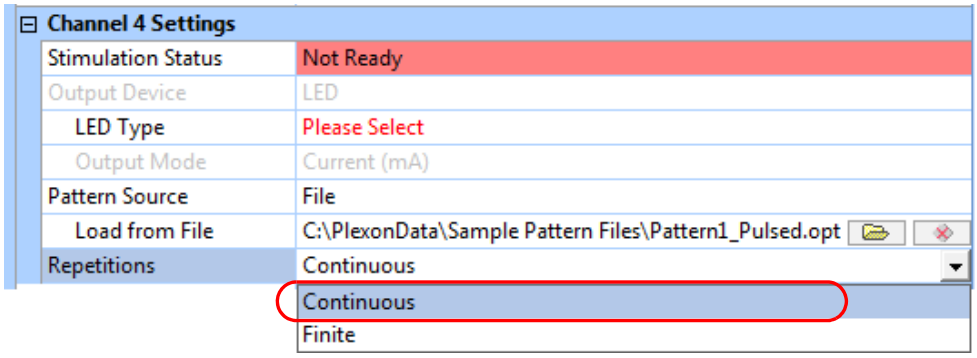


- Sample data files provided by Plexon are marked as Read Only. They should be copied and renamed before removing the Read Only flag to avoid accidentally overwriting them.
  Pattern files that you create are editable (unless you change them to Read Only in your Windows dialog box). To change them, right click the file name and select Properties from the drop down.

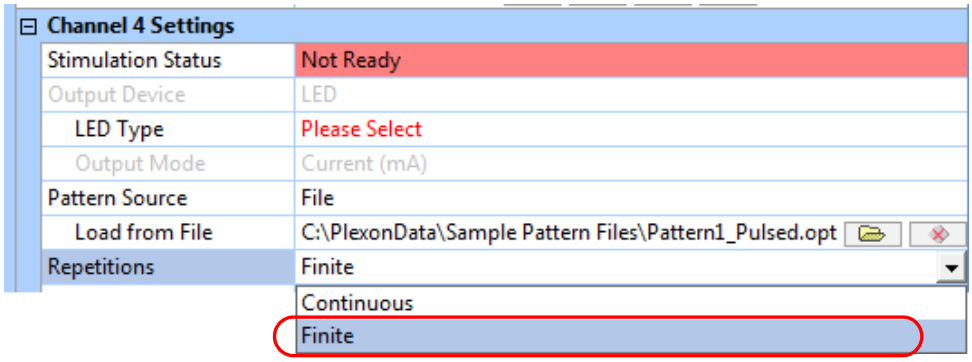
After you select the file, the channel is ready and the **Start** icon becomes active. A preview will appear in the **Controller Patterns** window. (Note that the channel number is shown on the Y-axis, Channel 4 in this example.)



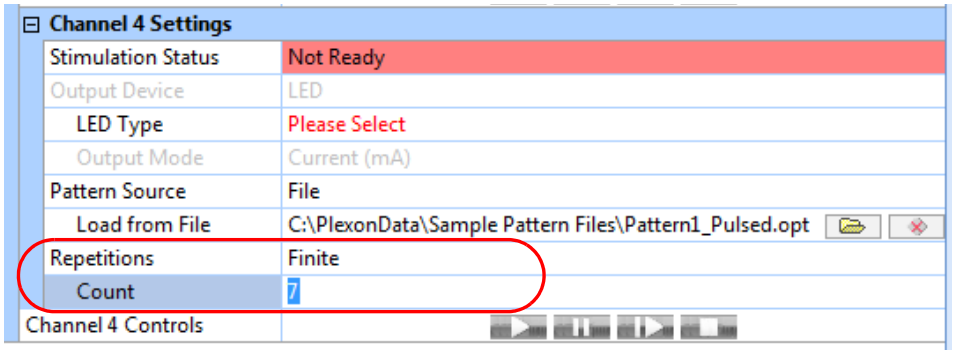
6 The pattern stored in the file can be repeated a finite number of times or repeated continuously. This is set in the fields below **Load from File.** Note that if the pattern is repeated, the first value in the file will immediately follow the last value with no gap. If your pattern defines a series of pulses, you may want to add some zeros at the end the pattern to maintain a constant pulse “rate” during repeated playback. For this example, select **Continuous** from the **Repetitions** dropdown list.



7 For this example, select **Finite** from the **Repetitions** dropdown list.



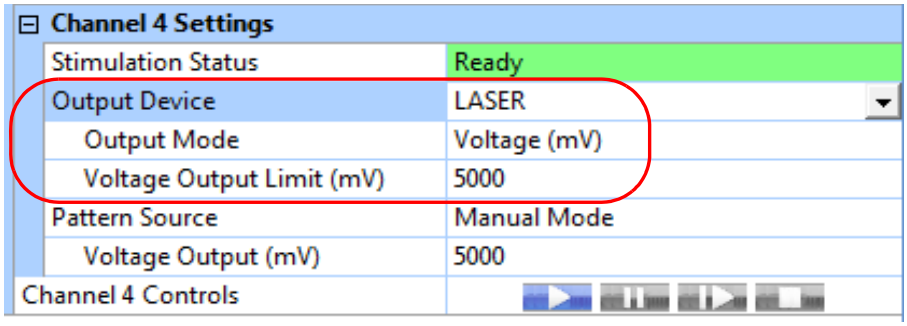
8 After you select Finite, a new row (**Count**) appears. In this example, set the **Count** parameter (the number of repetitions of the stimulation pattern in the file) to 7. The allowed range for this parameter is 1–32767.



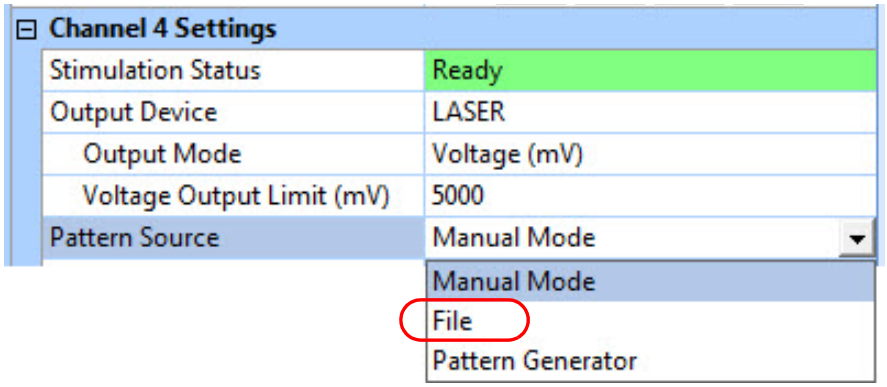
13.2 Loading a Pattern from a .txt File

Note: In the example below, the **Output Device** is **LASER**. The procedure for LEDs is similar.

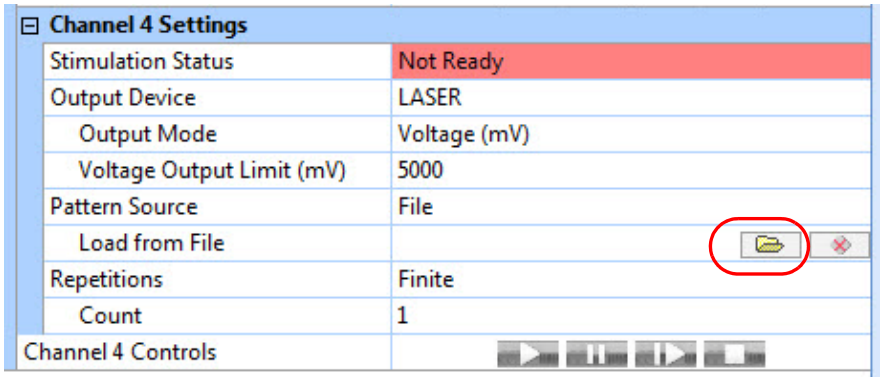
1 For this example, we are setting parameters for Channel 4, and we set the **Output Device** as **LASER**, **Output Mode** as **Voltage (mV)**, and **Voltage Output Limit (mV)** to 5000.



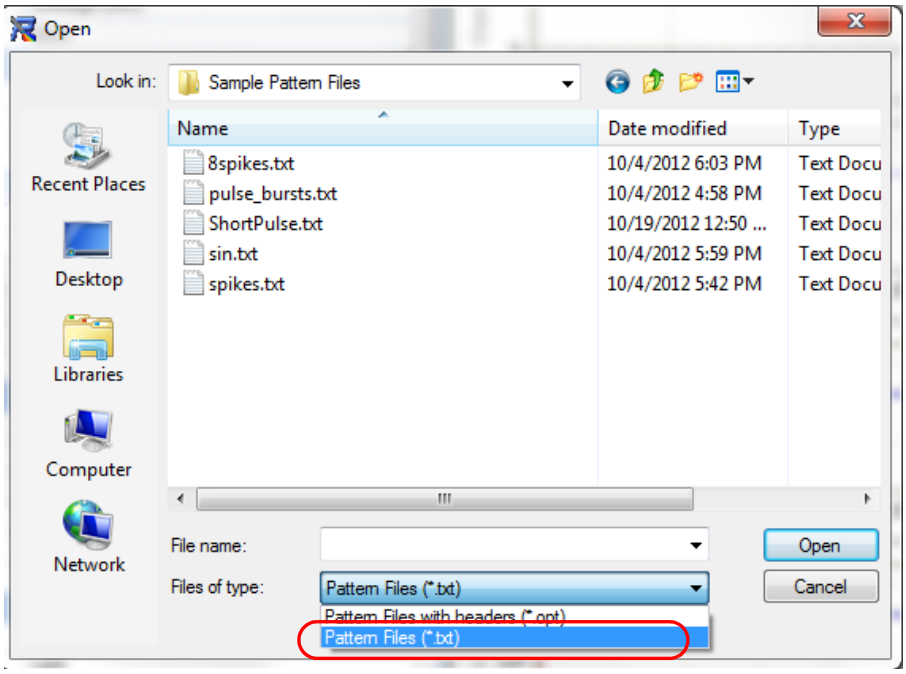
2 Select **File** from the **Pattern Source** drop down menu.



3 Click on the folder icon in the field next to **Load from File**. Notice that the **Stimulation Status** changes to Not Ready, because now it is waiting for you to select a specific file. (Also notice that three new rows are displayed—**Load from File**, **Repetitions** and **Count**. These will be discussed later in this section.)



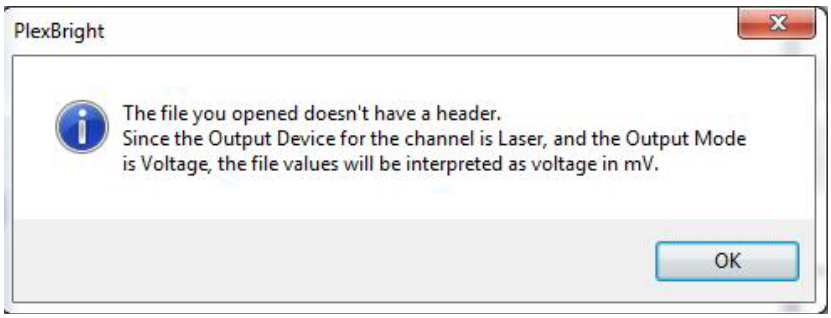
A dialog box will pop up, allowing you to choose a file.There are two types of stimulation sequence files (.opt and .txt). An .opt file is created with the **Pattern Generator** and has a header that defines stimulation parameters such as **Output Device** and **Output Mode** (units), while a .txt file is created with a text editor and is just a series of amplitudes.



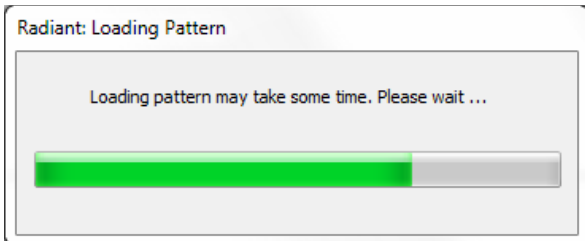
4 For this example, select the file pulse_bursts.txt that is located at D:\Plexon Data\Sample Pattern Files.

Note: The sample files provided by Plexon are marked as Read Only. They should be copied and renamed before removing the Read Only flag to avoid accidentally overwriting them.
Pattern files that you create are editable (unless you change them to Read Only in your Windows dialog box). To change them, right click the file name and select Properties from the drop down.

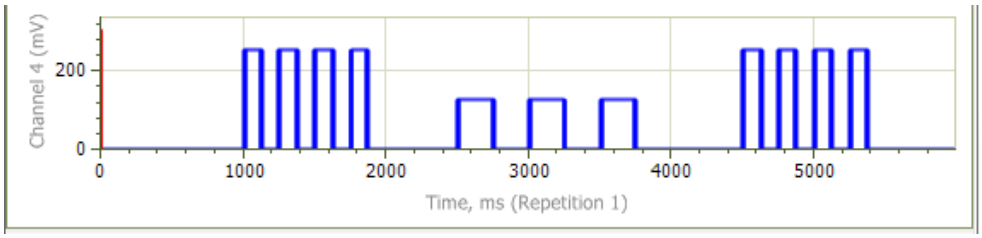
5 A dialog box will pop up explaining the units being applied to the file. Click OK.



Note: Complex .txt files might take several seconds to load. You might see a progress bar when a large file is being loaded to the channels.



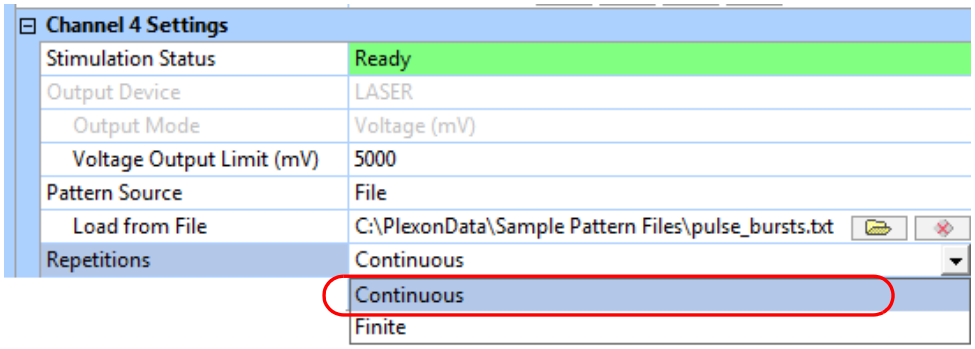
6 After you select the file, the channel is ready and the Start icon becomes active. A preview will appear in the **Controller Patterns** window. (In the image below, the pattern appears in the “Channel 4 (mV)” window, because we are using Channel 4 in this example.) View the pattern and verify it is the one you want for your experiment.



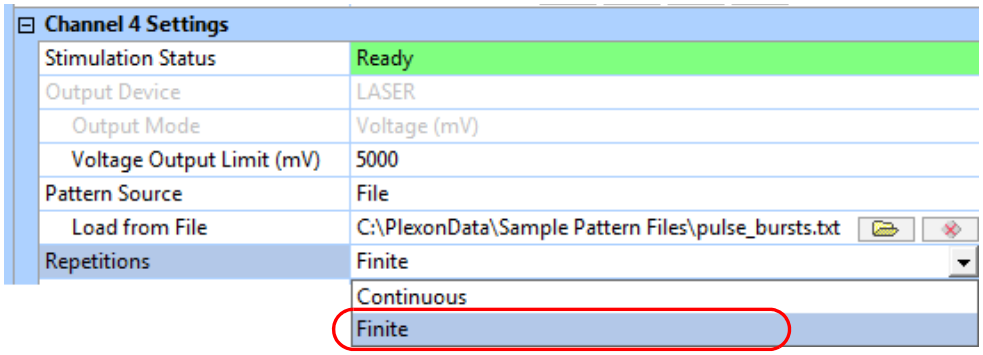
7 Select the appropriate Repetitions options as described below.

The pattern stored in the file can be repeated a finite number of times or repeated continuously. This is set in the fields below **Load from File.** Note that if the pattern is repeated, the first value in the file will immediately follow the last value with no gap. If your pattern defines a series of pulses, you may want to add some zeros at the end the pattern to maintain a constant pulse “rate” during repeated playback.

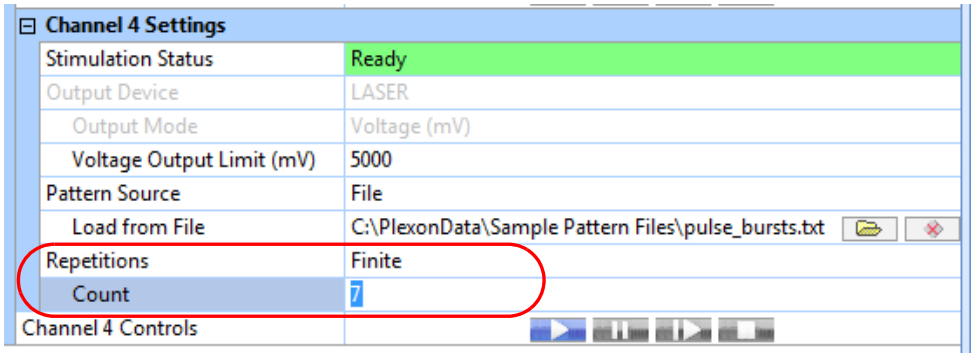
In the example below, **Continuous** has been selected from the **Repetitions** dropdown list.



In the example below, **Finite** has been selected from the **Repetitions** dropdown list.



After you select Finite, a new row (**Count**) appears. In the example below, the **Count** parameter (the number of repetitions of the stimulation pattern in the file) has been set to 7. The allowed range for this parameter is 1–32767.



13.3 Loading Stimulation Patterns and Other Settings from an .ops File

If you have defined one or more stimulation patterns in the Pattern Generator, then saved settings, the settings (.ops) file saved all of the patterns you have defined. See Section 18.8, "File Save Settings / File Load Settings / Restore Factory Settings" on page 111. Keep in mind that loading the .ops file will affect values for much more than just a single stimulation pattern—It will affect all channel parameter values and all Pattern Generator settings.

If the .ops file contains patterns, .opt or .txt files assigned to several channels, those patterns and files will be loaded to the appropriate channels. You will see progress bars and dialog boxes similar to those described in Section 13.1, "Loading a Pattern from an .opt File" on page 69 and Section 13.2, "Loading a Pattern from a .txt File" on page 75.

13.4 Where to Go Next

Starting and stopping stimulation from the User Interface

For information on using the control icons to start/stop/pause/unpause stimulation, see Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

Starting and stopping stimulation with Digital Inputs

For this information, see Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

14 Controlling Stimulation Manually from the Control Toolbars

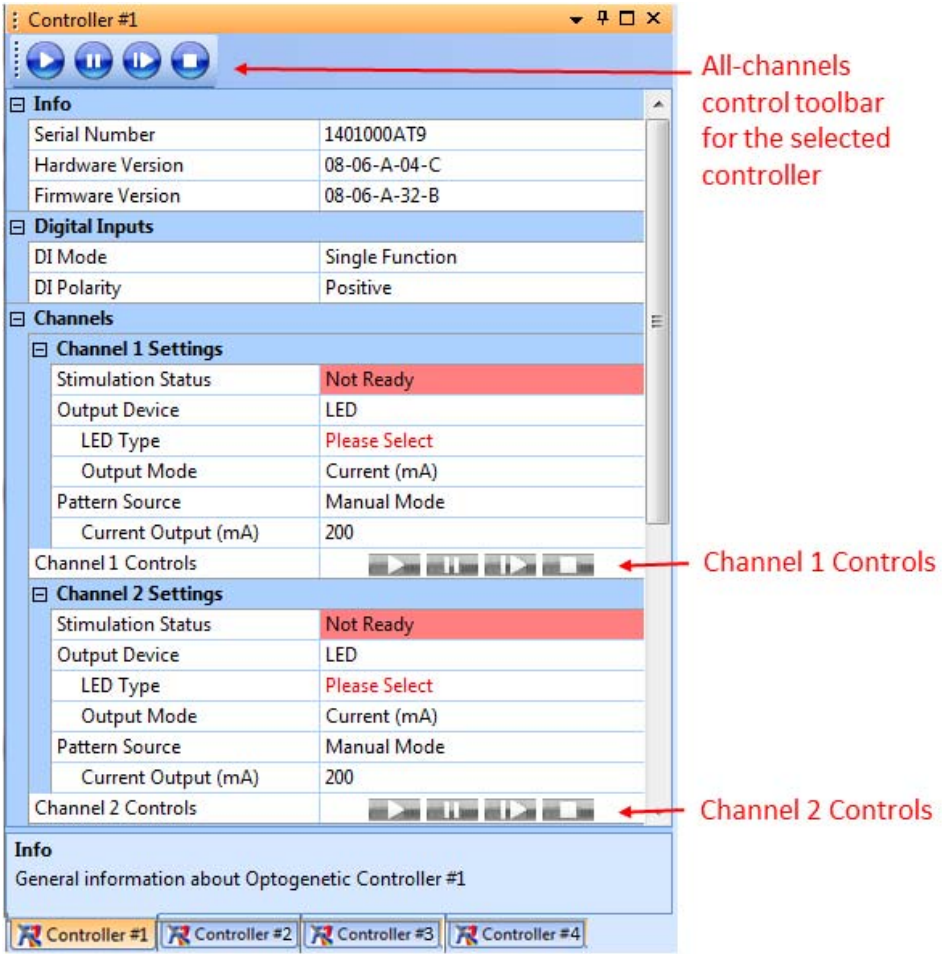
This section explains how to operate the stimulation controls in the user interface and how to interpret the channel status indicators.

It is strongly recommended that you measure the light intensity at the end of your implant before performing live experiments. For practical information on using the output measurements, see Section 16, "Verifying Output Signals and Scaling the Output Values" on page 100. See the Plexon website for a description of the PlexBright Light Measurement Kit, sold separately.

14.1 Control Toolbars

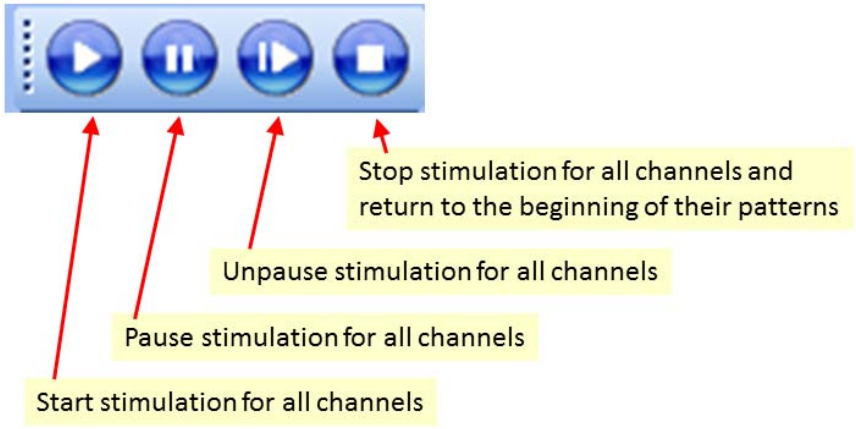
The image below shows a system with four controllers connected to the PC and turned on (powered). The tab for Controller #1 is selected, so the parameters for Controller #1 are displayed and editable.

The system provides one "All-channels control toolbar" located just under the banner for the controller. This toolbar allows you to control all the channels of a single controller simultaneously. In addition, each individual channel within a controller has a separate dedicated control toolbar. (Each controller has four channels available; the image below shows the first two channels of Controller #1.)



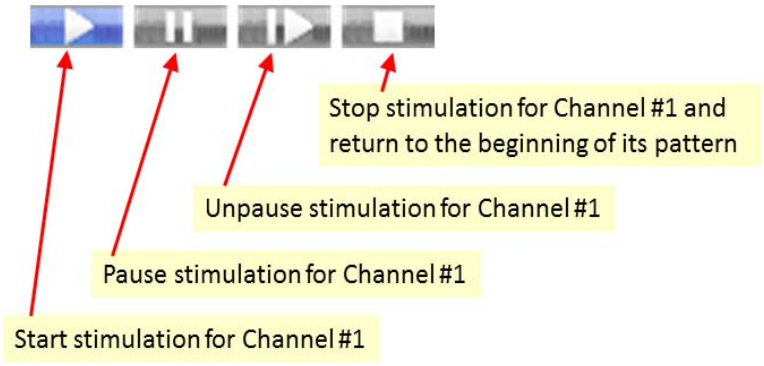
Note: If you have multiple controllers connected to the computer, there is an all-channels control toolbar for controlling all channels within that controller simultaneously, and a separate control toolbar for each individual channel.

The all-channels control toolbar in the controller contains the icons shown in the image below.



Note: These all-channel control toolbar icons are always displayed as blue (active). If you roll your mouse over one of these icons, the background color behind that icon changes to orange.

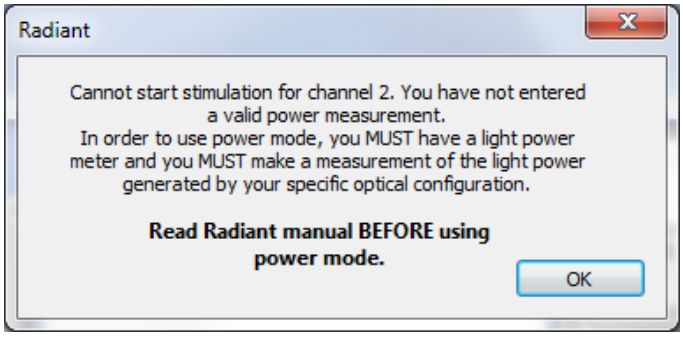
The control toolbar for each individual channel contains the icons shown in the image below. This example shows descriptions for Channel #1; the descriptions for Channels #2, 3 and 4 are similar.



All-channels control toolbar operation with channels in power mode

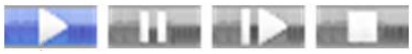
If you click the **Start stimulation for all channels** icon  , only the channels that are in **Ready** or **Paused** mode will actually start.

If a channel is in power mode with the **Light Power (mW)** value set to 0, the channel **Stimulation Status** is **Not Ready**. When you click the **Start stimulation for all channels** icon, the system displays a dialog box reminding you to measure the light power and enter the valid (non-zero) value in the **Light Power (mW)** row.



Summary of icon functions

This table explains how the individual channel controls work.



Start/Stop/Pause/Unpause Icons for Individual Channels

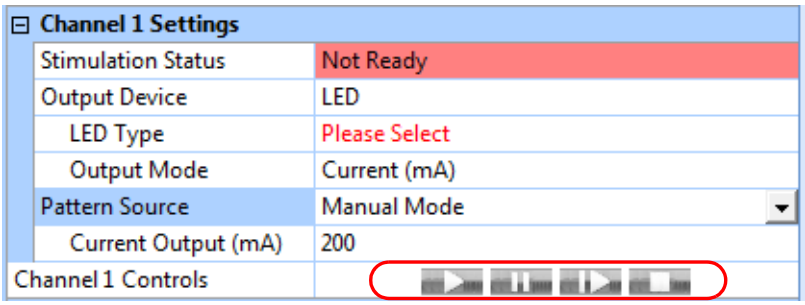
Current State of Channel	If You Click this Icon	The Result Is	New State of the Channel	These Icons Have No Effect (Disabled)
Ready	Start	The stimulation pattern starts playing	Playing	Pause Unpause Stop
Playing	Pause	Stimulation output goes to zero. The system pauses at the current point in the pattern.	Paused	Start Unpause
	Stop	Stimulation output goes to zero. The system returns to the start of the pattern and remains there.	Ready	
Paused	Unpause	Stimulation resumes from its current point in the pattern.	Playing	Start [a] Pause
	Stop	The system returns to the start of the pattern and remains there.	Ready	

a. Note that the all-channel Start icon is not disabled. Clicking the all-channel Start icon will cause the channel to unpause.

How the system displays the control toolbar functions

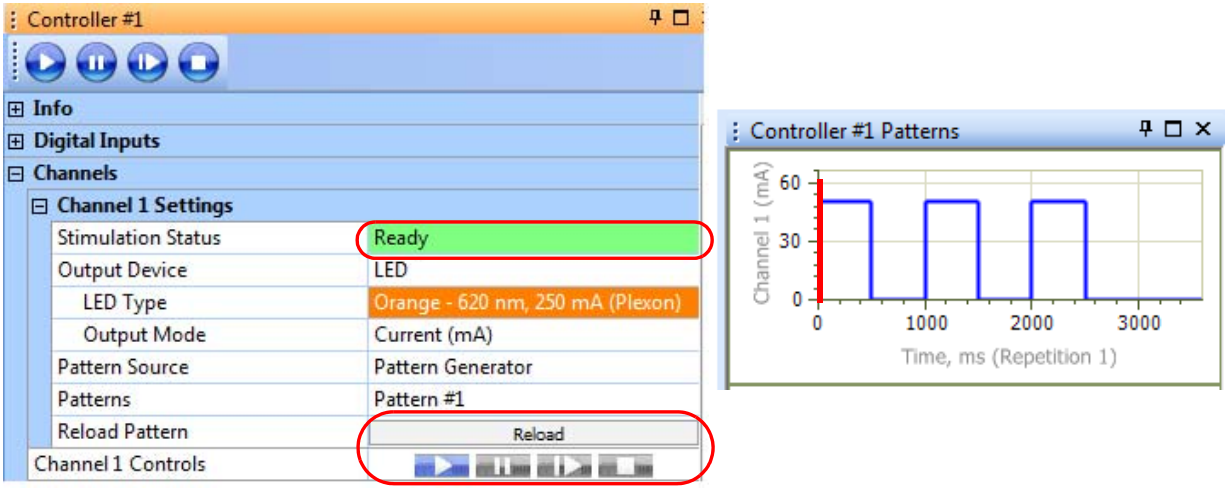
This section shows how the user interface display changes as you click on the start/stop/pause/unpause icons.

In the image below, Channel 1 is not ready to run. The control icons are all disabled (grayed out).

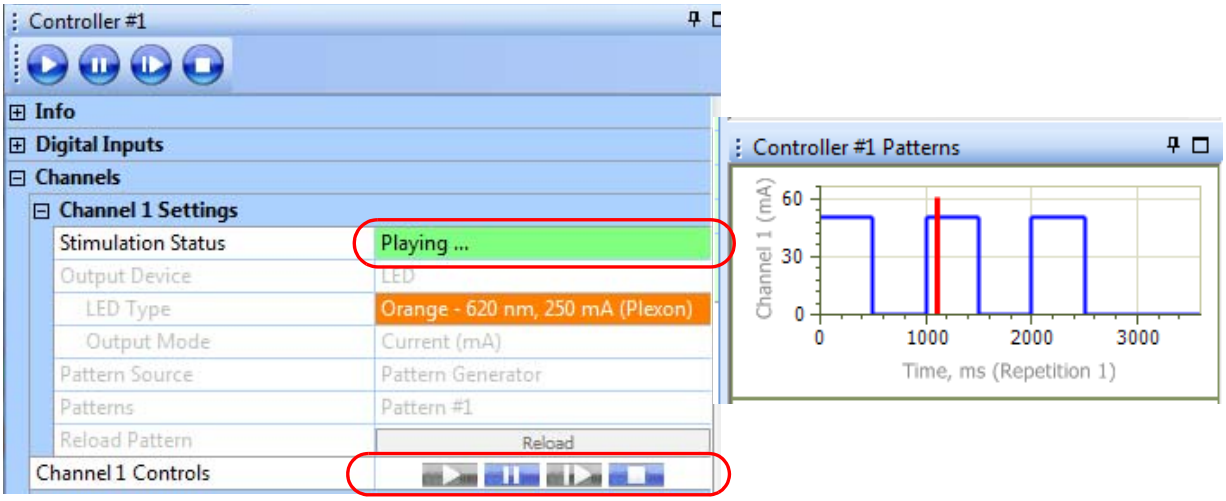


In the image below, the parameters for Channel 1 have been set. The Orange LED is selected, the **Pattern Source** is set to **Pattern Generator**, and Pattern #1 has been selected. Channel 1 is in **Ready** status. The **Start** icon is enabled (blue background) and the other three icons are disabled (grayed out). On the right side of the image (Controller #1 Patterns), the red progress bar is at Time=0. (Note that the all-channels control toolbar icons are always displayed as active.)

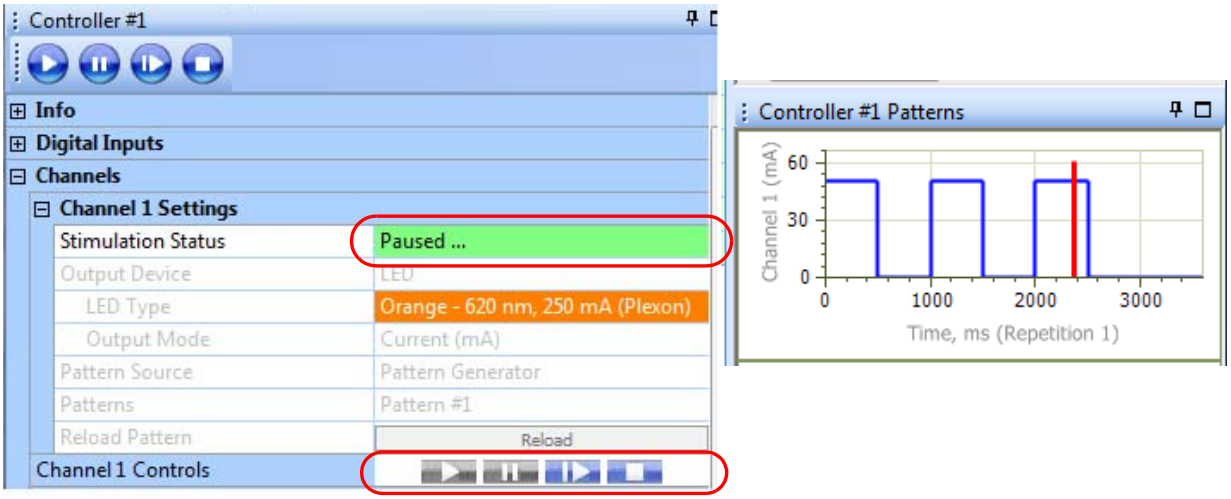
Note: If you change any parameter values in the Pattern Generator, the **Stimulation Status** of the channel will change back to **Not Ready** until you click the **Reload** button for that channel.



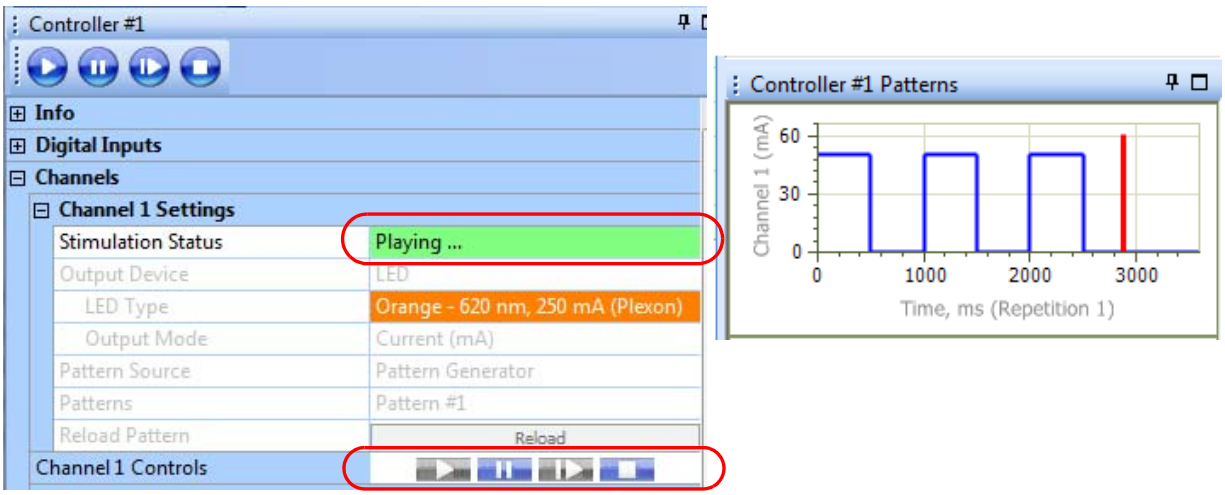
If you click the Start icon for Channel 1 (or the **Start** icon in the all-channels control toolbar), Channel 1 stimulation begins, and the red progress bar moves. The Channel 1 toolbar changes: The **Pause** and **Stop** icons become enabled, and the **Start** and **Unpause** icons are disabled. The channel is in **Playing** status, as shown in the image below.



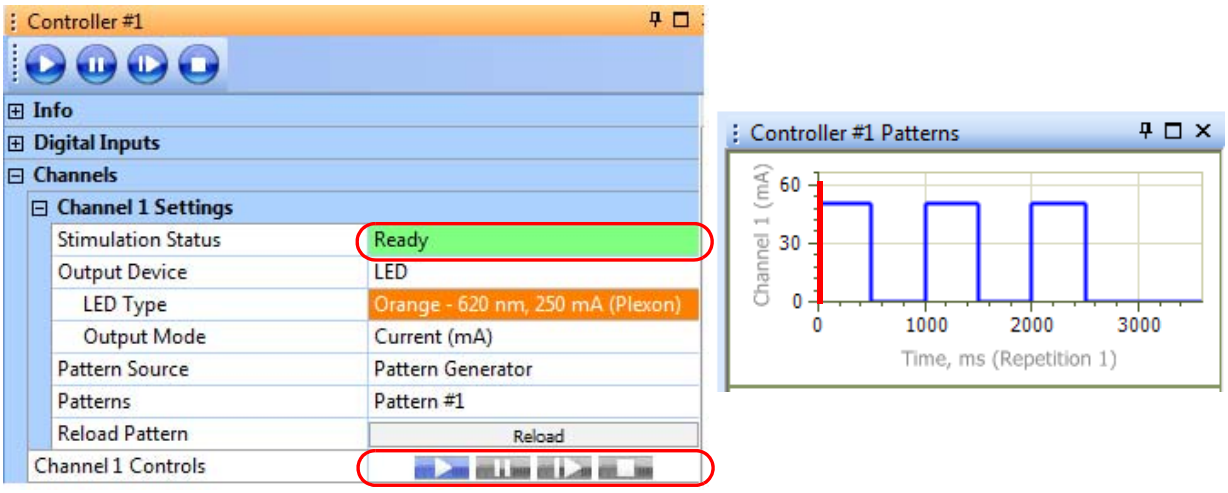
If you click the **Pause** icon for Channel 1 (or the **Pause** icon in the all-channels control toolbar), Channel 1 stimulation stops and the red progress bar remains at its present position. The Channel 1 toolbar changes: The **Unpause** and **Stop** icons are enabled, and the **Start** and **Pause** icons are disabled. The channel is in **Paused** status.



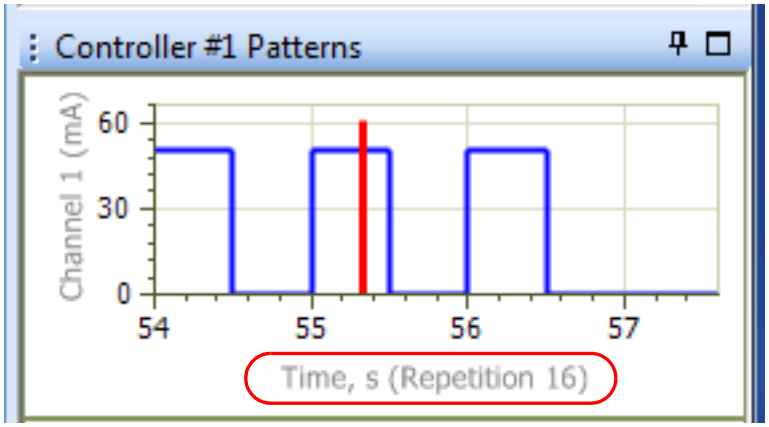
If you click the **Unpause** icon for Channel 1 (or the **Unpause** icon in the all-channels control toolbar), Channel 1 stimulation resumes from its current (paused) position, and the red progress bar moves again. The Channel 1 toolbar changes: The **Pause** and **Stop** icons are enabled, and the **Start** and **Unpause** icons are disabled. The channel is in **Playing** status.



When Channel 1 is in **Playing** or **Paused** status and you click the **Stop** icon for Channel 1 (or the **Stop** icon in the all-channels control toolbar), Channel 1 stimulation stops and the red progress bar moves to the start of the pattern. The channel returns to **Ready** status.



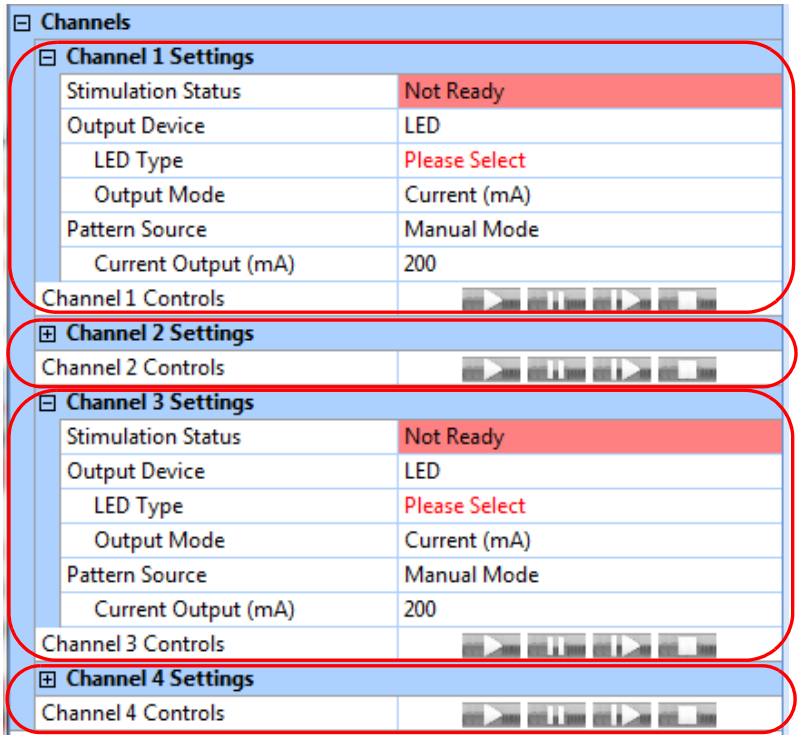
As a stimulation pattern repeats, the Controller Patterns graph displays the number of repetitions and the total elapsed time since the **Start** icon was pressed. In the example below, the stimulation pattern is in its 16th repetition and the total elapsed time since the **Start** icon was pressed is just over 55 seconds.



TIP

You can hide the Channel parameters if desired

If you would like to hide the parameters for a channel, click on the – sign to the left of the Channel name. The use of the + and – signs is illustrated in the image below; the displays for Channels 2 and 4 are hidden (minimized).



14.2 Verifying and Scaling the Output

For information on verifying the output signal on an oscilloscope and scaling your output to the desired value, see Section 16, "Verifying Output Signals and Scaling the Output Values" on page 100.

15 Controlling Stimulation with Digital Inputs

Note: This section covers the digital input (DI) functions on the controller. For information on digital output (DO) functions, see Section 19.6, "Digital Out" on page 117.

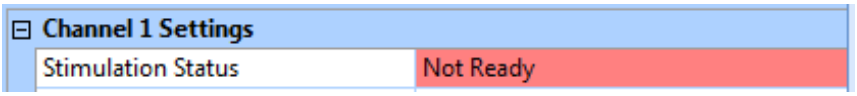
In hardware there are TTL-compatible digital inputs for controlling each channel (start, stop, pause and unpause). Inputs should range from 0 – 5 V. Inputs <0.8V are logic "0" and >2.0V are logic "1".

The Digital In connector is shown below.

The pinout assignments for the Digital In connector depend on the type of DI signaling mode that you configure in the user interface. These modes and pin assignments are explained below.

15.1 DI Functions Not Available Under Certain Conditions

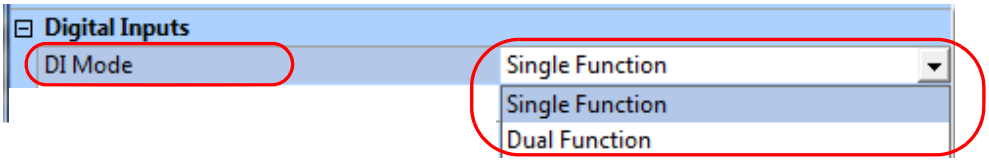
If a channel **Stimulation Status** is **Not Ready** (as shown in the user interface image below), the system ignores any digital inputs to that channel.



The system disables DI functions while a Pattern Generator **Export** ("Save As") dialog box is open and while an export operation is occurring. The export operation is described in Section 12.1, "Saving a Pattern as an .opt File" on page 65.

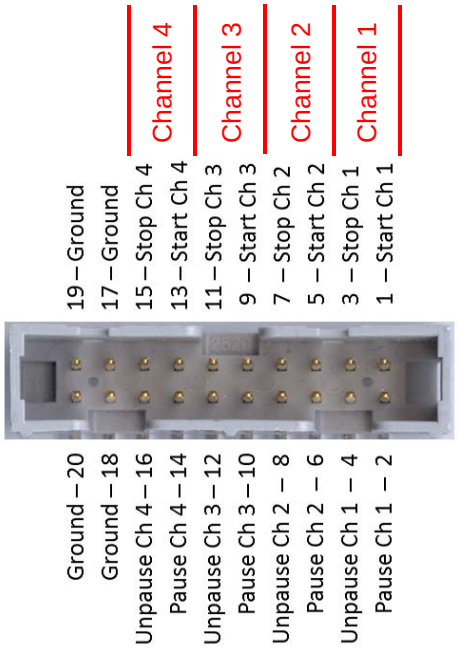
15.2 Digital Input Mode Settings

The digital inputs can be operated in either **Single Function** mode or **Dual Function** mode, as explained in the sections that follow. To select the digital input (DI) mode, click the drop down menu next to **DI Mode** at the top of the screen.

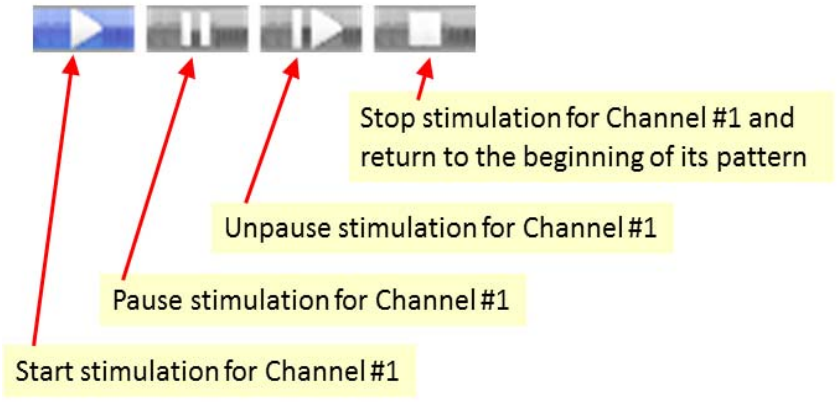


15.3 DI Single Function Mode

In DI **Single Function** mode, each channel is associated with four pins on the DI connector, and each of the four pins has a single function.



The function of each pin on the DI connector corresponds to one of the channel control icons in the user interface. The control icons are shown in the image below (for Channel #1), and their functions are described in more detail in Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.



Stimulation start, stop, pause and unpause

Assuming the DI Polarity (as described later in this section) is set to its default value (Positive), the DI signals have the following effect:

- If a channel is in Ready state, a rising edge on the start pin starts stimulation.
- If a channel is in Playing state, a rising edge on the pause pin pauses stimulation at the present point in the pattern.
- If a channel is in Paused state, a rising edge on the unpause pin causes stimulation to resume from the present point.

Note: A rising edge on the start pin has the same effect as a rising edge on the unpause pin (it causes stimulation to resume from the present point). This effect is different than the effect of the Start icon in the user interface. In the user interface, the Start icon is disabled when the channel is in Paused state, and you must use the Unpause icon to resume playing.

- If a channel is in Paused or Playing state, a rising edge on the stop pin stops stimulation and returns to the beginning of the pattern.

System reactions to DI signals

If a system is in the middle of a stimulation pattern and a digital input signals the stimulation to stop or pause, the system takes immediate action and the pattern will be cut short. In the case of a stop signal, the system returns to the start of the pattern and the Radiant software automatically reloads the pattern in preparation for another start signal. In the case of a pause signal, the system waits at the point in the pattern where stimulation was paused.

Stimulation stops if the pattern plays to completion, and the Radiant software automatically reloads the pattern in preparation for another start signal.

Note: The process of detecting the end of a pattern and/or reloading the pattern takes some time, and it may be on the order of 100ms before the pattern is ready to be triggered again.

Summary of DI Single Function operations

This table summarizes the operation of the Single Function digital inputs.

Digital Inputs (Single Function Mode) on the DI Start/Stop/Pause/Unpause Pins with DI Polarity Set to Positive

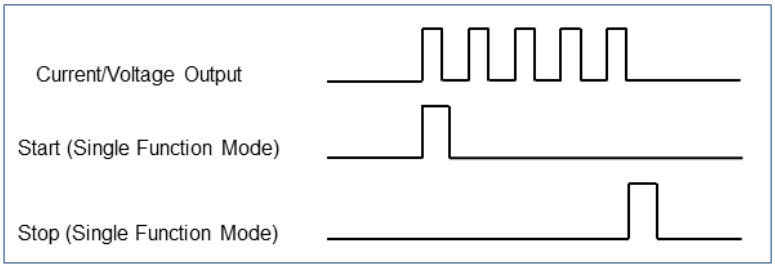
Current State of Channel [a]	DI Pin Receiving the Input	The Result Is	New State of the Channel	Inputs on These DI Pins Have No Effect
Ready	Start	The stimulation pattern starts playing	Playing	Pause Unpause Stop
Playing	Pause	Stimulation output goes to zero. The system pauses at the current point in the pattern.	Paused	Start Unpause
	Stop	Stimulation output goes to zero. The system returns to the start of the pattern and remains there.	Ready	
Paused	Start [b]	Stimulation resumes from its current point in the pattern.	Playing	Pause
	Unpause	Stimulation resumes from its current point in the pattern.	Playing	
	Stop	The system returns to the start of the pattern and remains there.	Ready	

a. If the current state of the channel is **Not Ready**, all digital inputs (and all control icons) for that channel are disabled)

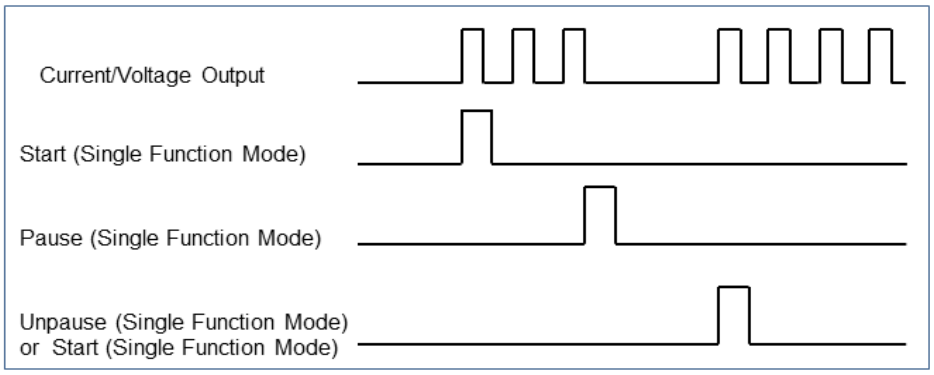
b. When the channel is in Paused state, a digital input on the Start pin has the same effect as a digital input on the Unpause pin. This behavior of the Start pin is different than the behavior of the channel Start icon in the user interface. In the user interface, the channel Start icon is disabled when the channel is in Paused state (and the Unpause icon is active).

Illustration of DI Single Function operations (with DI Polarity Positive)

The start and stop DI Single Function behaviors are illustrated below.



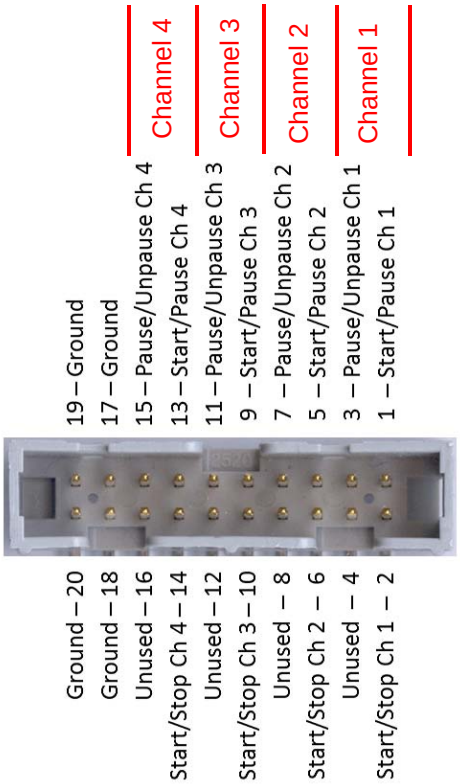
The pause and unpause DI Single Function behaviors are illustrated below.



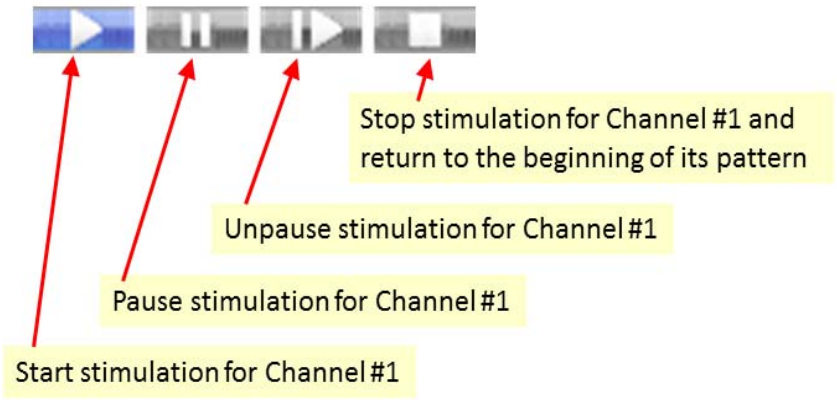
Note: In the above diagram, note that an input on the Start pin has the same result as an input on the Unpause pin. This effect of a DI on the Start pin is not the same as the effect of the Start icon in the user interface, as discussed earlier in this section.

15.4 DI Dual Function Mode

In **Dual Function** mode, each channel is associated with three pins on the DI connector, and each of the three pins has two functions.



The functions of each pin on the DI connector correspond to two of the channel control icons in the user interface. The control icons are shown in the image below (for Channel #1), and their functions are described in more detail in Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.



Stimulation start, stop, pause and unpause

Assuming the DI Polarity (as described later in this section) is set to its default value (Positive), the DI signals have the following effects in **Dual Function** mode.

The stimulation pattern starts when the Start/Stop or Start/Pause input transitions from 0 to 1, and continues until the pattern is complete or the Start/Stop or Start/Pause input transitions from 1 to 0. Once the stimulation pattern is playing, you can also use the Pause/Unpause input to toggle the pattern between the Paused and Playing states. Details of these transitions are provided in the remainder of this section.

System reactions to DI signals during stimulation

If a system is in the middle of a stimulation pattern and a digital input signals the stimulation to stop or pause, the system takes immediate action and the pattern will be cut short. In the case of a stop signal, the system returns to the start of the pattern and the Radiant software automatically reloads the pattern in preparation for another start signal. In the case of a pause signal, the system waits at the point in the pattern where stimulation was paused.

Stimulation stops if the pattern plays to completion, and the Radiant software automatically reloads the pattern in preparation for another start signal.

Note: The process of detecting the end of a pattern and/or reloading the pattern takes some time, and it may be on the order of 100ms before the pattern is ready to be triggered again.

Summary of DI Dual Function operations

The following table summarizes the operation of the Dual Function digital inputs.

Digital Inputs (Dual Function Mode) on the DI Pins with DI Polarity Set to Positive

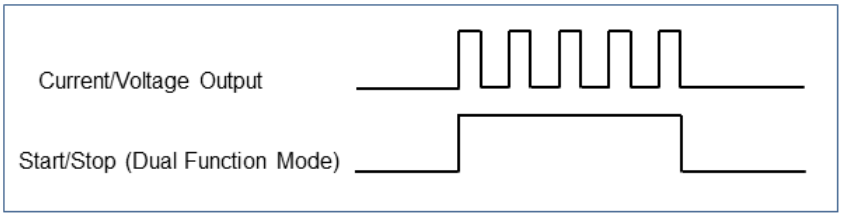
Current State of Channel [a]	DI Pin Receiving the Input	Transition of the Input	The Result Is	New State of the Channel	Inputs on These DI Pins Have No Effect
Ready	Start/Pause	0 – 1	The stimulation pattern starts playing	Playing	Pause/Unpause
	Start/Stop	0 – 1	The stimulation pattern starts playing	Playing	
Playing	Start/Pause	1 – 0	Stimulation output goes to zero. The system pauses at the current point in the pattern.	Paused	(none)
	Start/Stop	1 – 0	Stimulation output goes to zero. The system returns to the start of the pattern and remains there.	Ready	
	Pause/ Unpause	0 – 1	Stimulation output goes to zero. The system pauses at the current point in the pattern.	Paused	
Paused	Start/Pause	0 – 1	Stimulation resumes from its current point in the pattern.	Playing	(none)
	Start/Stop	1 – 0	Stimulation output goes to zero. The system returns to the start of the pattern and remains there.	Ready	
		0 – 1 [b]	Stimulation resumes from its current point in the pattern.	Playing	
	Pause/ Unpause	1 – 0	Stimulation resumes from its current point in the pattern.	Playing	

a. If the current state of the channel is **Not Ready**, all digital inputs (and all control icons) for that channel are disabled)

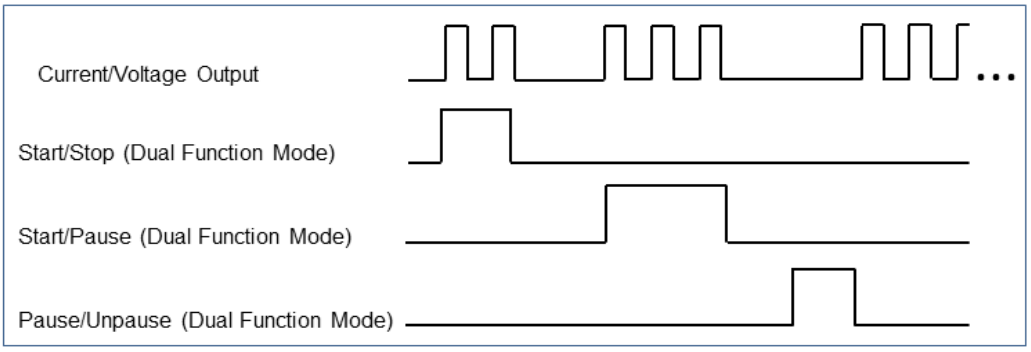
b. When the channel is in Paused state, a transition from 0 – 1 on the Start/Stop or Start/Pause pin has the same effect as a transition from 1 – 0 on the Pause/Unpause pin. This behavior of the digital inputs is different than the behavior of the channel Start icon in the user interface. In the user interface, the channel Start icon is disabled when the channel is in Paused state (and the Unpause icon is active).

Illustration of DI Dual Function operations (with DI Polarity Positive)

The Start/Stop function is illustrated below.



The pause and unpause functions are illustrated below.



15.5 System Response to Multiple Signals Separated by Microseconds

Commands sent at a rate greater than 10kHz (with less than 100µs between commands) can result in complex behavior as described below. To sidestep this complexity, ensure that there is more than 100µs between commands.

When a channel is playing the output current or voltage, the output value is updated at a 10kHz rate, and each output value is maintained for a minimum of 100µs. Thus, when a command (Start, Stop, Pause, etc…) is received, the output of the channel often cannot change immediately. Rather, the remaining portion of the 100µs sample period that is in progress must expire before the channel output can change. If a second command also arrives during this time period, it can override the previous command before that command has a visible effect. For example, if a channel is playing and a Pause and Unpause command both arrive before the 100µs sample period has expired, the channel will continue playing. The Unpause command effectively rescinds the previous Pause command before it can take effect.

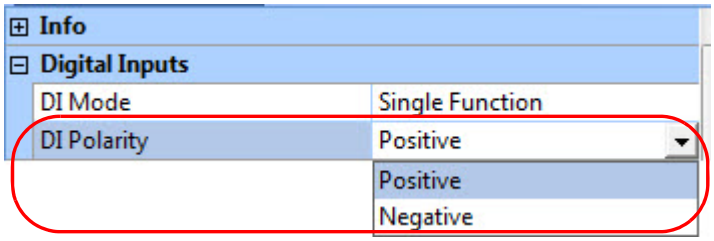
The digital outputs of the channel always reflect the actual state of the channel. They reflect the commands that have been acted upon, they do not merely acknowledge that a command has been received. Thus, in the example above, if the Unpause command rescinds a prior Pause command, the digital outputs will not change because the channel continues playing and never actually pauses.

This type of behavior can occur anytime there is less than 100µs between commands. Such rapid commands typically will not occur from GUI inputs alone, but could occur from digital inputs or from a combination of digital inputs and GUI inputs. More generally, if there is less than 100µs between commands, then the same command sequence can result in different behaviors depending on when the commands arrive in relation to the sample period. Consider the Pause Unpause example again assuming that the Pause and Unpause commands are separated by 50µs. In one scenario, the Pause and Unpause command will both arrive during the same sample period and the Unpause command will rescind the Pause command as described above. There will be no change in the channel output or the digital outputs. However, in the other scenario, the Pause command will arrive, the sample period will end, and then the Unpause command will arrive. In this case, the Unpause command will go into effect at the end of its sample period, 100µs after the Pause command took place. The channel output and digital outputs will correctly reflect the fact that channel did pause, albeit briefly.

Note also that all of the channels are synchronized; their outputs change at the same time. When a second channel starts, it must synchronize to the already playing channel. The sample period for all channels is set by the first channel that starts playing. This synchronization can result in slightly different behavior when only one channel is operating versus when multiple channels are operating. Consider a Start command that is followed by a Stop command 50µs later. If no channels are playing, then the “first” channel can start right away. It does not need to wait and synchronize with another channel. This quick Start Stop command sequence will always result in the “first” channel starting. Now consider the case when another channel is already playing. There are two possible outcomes. When the Start command arrives, the “second” channel must wait for sampling period (set by the first channel) to end before it can act on the Start command. If the Stop command also arrives before the end of the sample period then it will rescind the Start command and the channel will not start. However, if the sample period ends before the Stop command arrives then the channel will start and will run briefly until the Stop command is processed. Similar situations can occur when other command pairs such as Start & Pause, Pause & Unpause, Unpause & Stop, Pause & Stop, Unpause & Pause, or Unpause & Stop occur in rapid succession.

15.6 Understanding the Digital Input Polarity Settings

There are two ways to set the polarity of the digital inputs: **Positive** and **Negative**. This option can be accessed from the dropdown list **DI Polarity** at the top of the screen.



The following table summarizes the operation of the **DI Polarity** settings.

Digital Input Polarity Settings [a]

DI Polarity Setting	DI Rising or Falling Edge	DI Mode Setting	The Result Is
Positive (default value)	Rising Edge	Single Function	The controller executes the function on the pin.
		Dual Function	The controller executes the first of the two functions on the pin.
	Falling Edge	Single Function	The controller does not take any action.
		Dual Function	The controller executes the second of the two functions on the pin.
Negative	Rising Edge	Single Function	The controller does not take any action.
		Dual Function	The controller executes the second of the two functions on the pin.
	Falling Edge	Single Function	The controller executes the function on the pin.
		Dual Function	The controller executes the first of the two functions on the pin.

a. For the functions assigned to each pin, see the pinout diagrams in Section 15.3, "DI Single Function Mode" on page 90 and Section 15.4, "DI Dual Function Mode" on page 94.

15.7 Verifying and Scaling the Output

For information on verifying the output signal on an oscilloscope and scaling your output to the desired value, see Section 16, "Verifying Output Signals and Scaling the Output Values" on page 100.

16 Verifying Output Signals and Scaling the Output Values

16.1 Verifying the Laser Voltage Output on an Oscilloscope

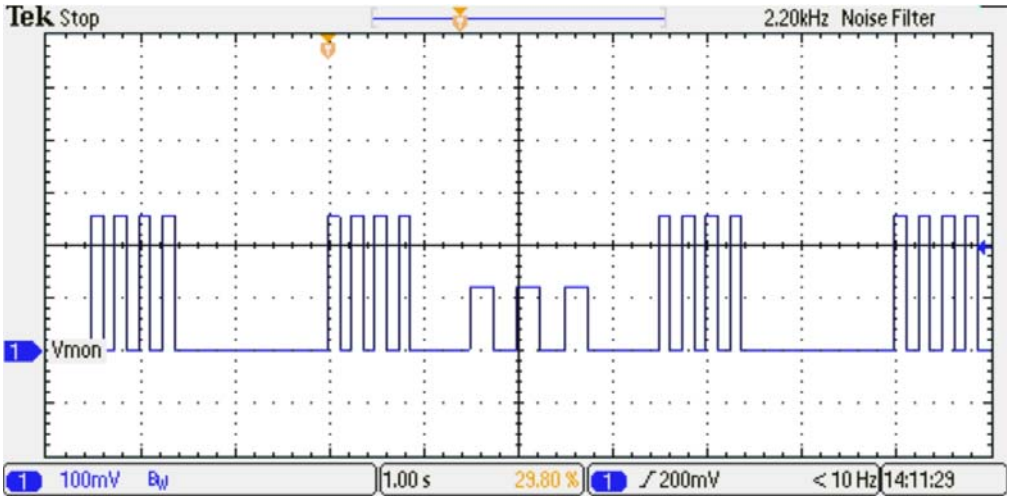
Before connecting the output to an oscilloscope, confirm that the channel is in voltage output mode. There are two ways to do this. The GUI should say Output Device = Laser, Output Mode = Voltage (mV) and the I(on) V(off) LED on the controller end panel should be off indicating voltage output.

TIP

The channel might be in current mode

If the channel is not playing but the voltage is still ~1.25V, the channel is in current mode. In current mode, the LED is held at a voltage just below the turn-on threshold so that it can be turned on more quickly when stimulation starts. Do not connect the output to an oscilloscope if the channel is configured for an LED. The oscilloscope trace will not provide any useful information for LEDs.

The output for the Pattern1_pulse_bursts.txt file that was loaded in LASER mV mode should look like the image below. Note that the scaling is 100mV per division and 1 second per division.



16.2 Using Different Scaling Options

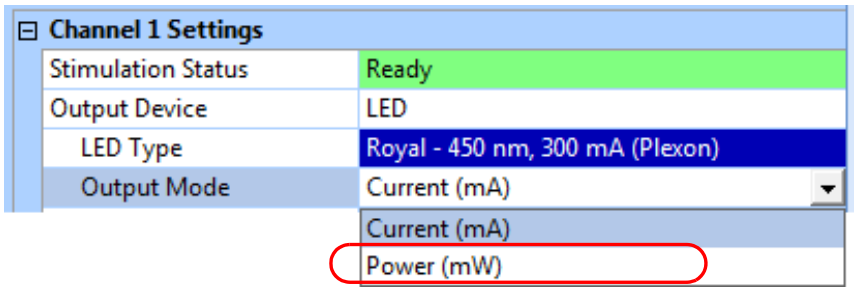
The controller typically outputs either a 0–5V signal to control a laser or a 0–1100mA signal to directly power an LED. The Radiant software allows patterns to be specified in voltage (for lasers) or current (for LEDs), but some users may prefer to specify their stimulation pattern in terms of light output power.

Scaling for LEDs

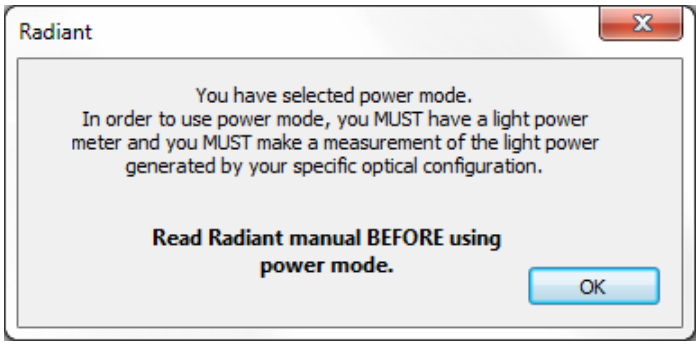
To find the light output at the maximum current, assemble the entire system (PlexBright 4 Channel Optogenetic Controller – BNC cable – LED module – Optical patch cable – Optical fiber implant). Then, with the LED at full current, measure the power of the light output at the end of the implant with a light meter. This method compensates for any losses at each optical connection as well as any variability between LED modules.

Note: The maximum current is predetermined by the **LED Type**.

First, select **Power (mW)** from the **Output Mode** dropdown list.



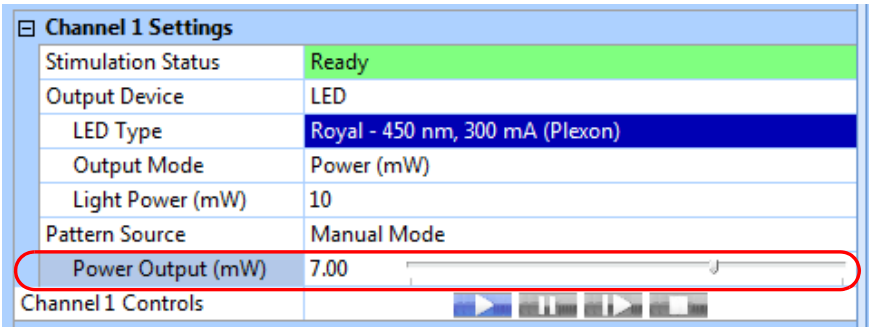
When you select **Power (mW)**, the system displays a dialog.

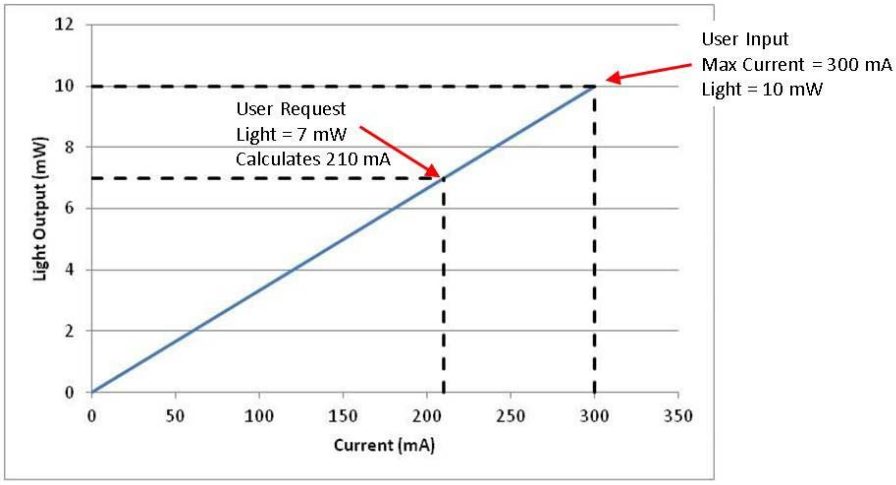


In the user interface, you need to enter the light power measured *at the end of the implant (at full current)* in the **Light Power (mW)** field. You will then use the slider adjustment in the **Power Output (mW)** field to request a specific power level to be used with the stimulation pattern.

When you input (in the **Light Power (mW)** field) the amount of light produced at the maximum current, the system sets up a linear interpolation. The software then calculates the amount of current or voltage required to generate the light output that you specified in the **Power Output (mW)** field.

As an example of the calculation performed by the system, if a given LED outputs 10mW of light at 300mA, and the user requests 7mW, the software can automatically calculate that 300 mA * (7mW/10mW) = 210 mA of current is required. This calculation is transparent to the user.

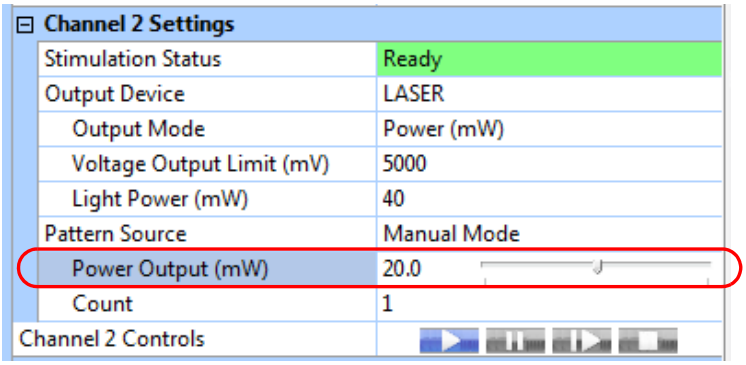




Scaling for lasers

If the **Output Device** is **LASER**, selecting **Power (mW)** as the **Output Mode** will bring up the **Voltage Output Limit (mV)** and **Light Power (mW)** fields. You need to manually enter the maximum voltage in the **Voltage Output Limit (mV)** field (usually 5000), and enter the corresponding power measured at the end of the implant (at full voltage) in the **Light Power (mW)** field. You will then use the slider adjustment in the **Power Output (mW)** field to request a specific power level to be used with the stimulation pattern.

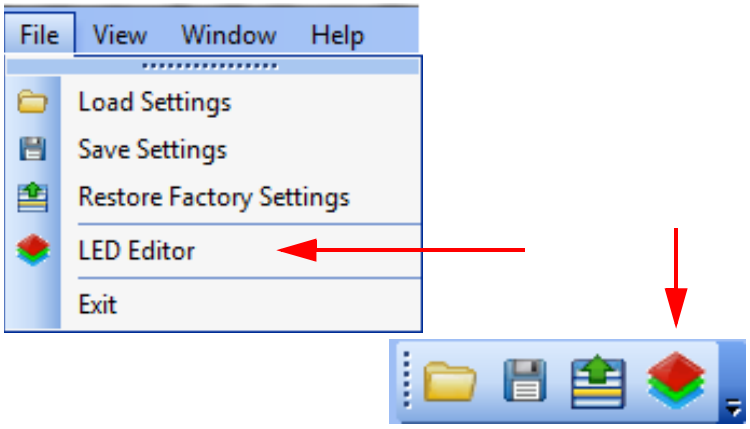
As a voltage example for lasers, put 40mW as the power at 5V. Next request 20mW of light in **Manual Mode**. If you measure the actual voltage being output on an oscilloscope, you will see that it is 2.5V (5V*20mW/40mW).



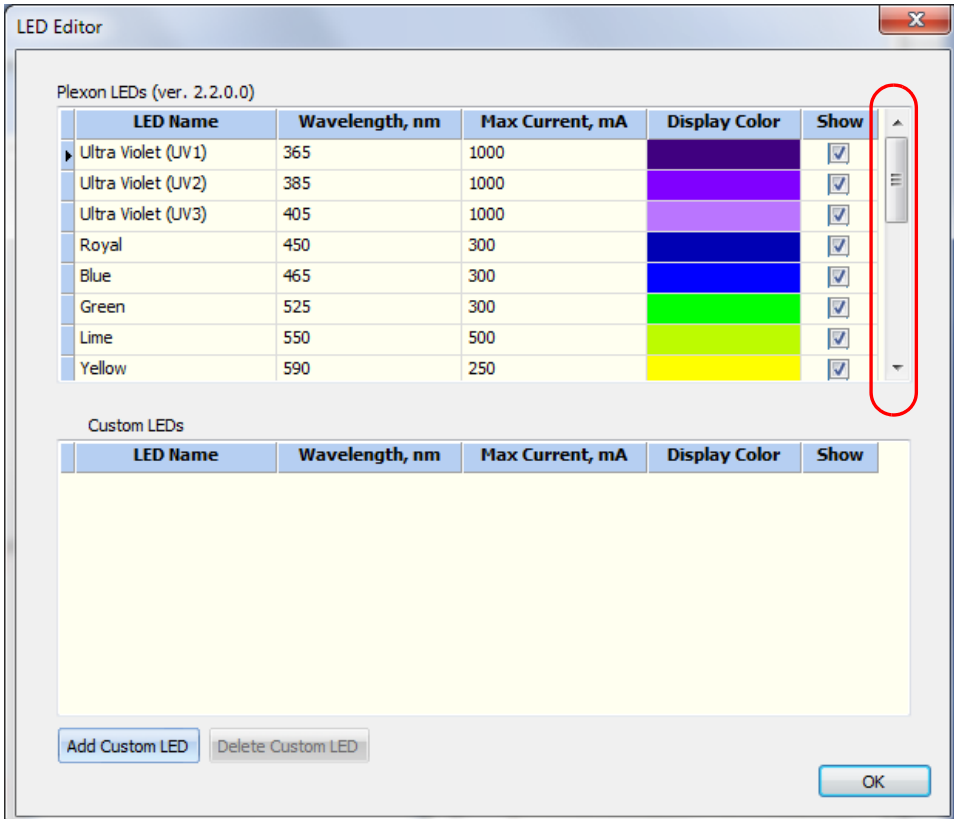
17 Managing the LED List with LED Editor

This section explains how you can use the **LED Editor** to add, edit and delete custom LEDs in the **LED List**. By default, the **LED List** includes all of the Plexon standard LEDs that were available at the time the software was released.

1 Access the LED Editor from the main menu or from the **LED Editor** icon.

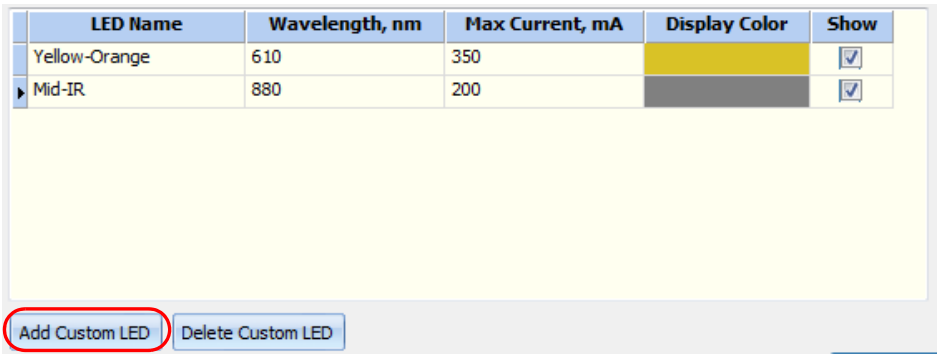


The LED Editor dialog opens. Notice the scrollbar at the right side. Use the scrollbar to view down through the list.



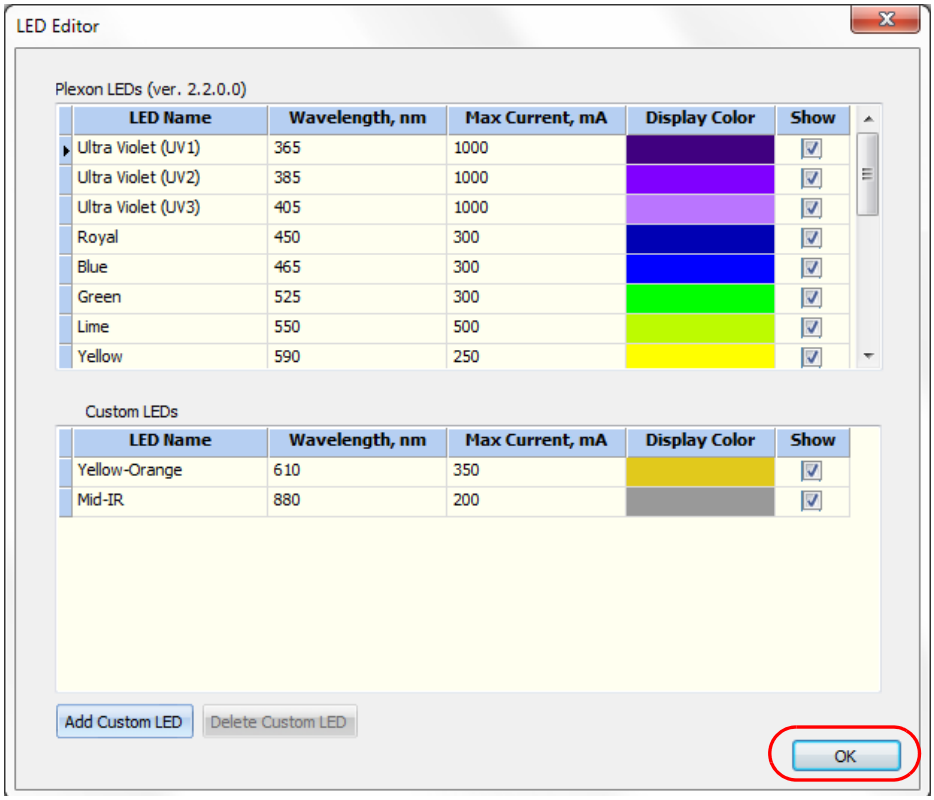
2 To add a Custom LEDs, click the **Add Custom LED** button. A new line will open in the Custom LEDs section. Fill in the information appropriate for your new LED—Name, Wavelength, Max Current and Display Color.

Here is an example with two Custom LEDs added.



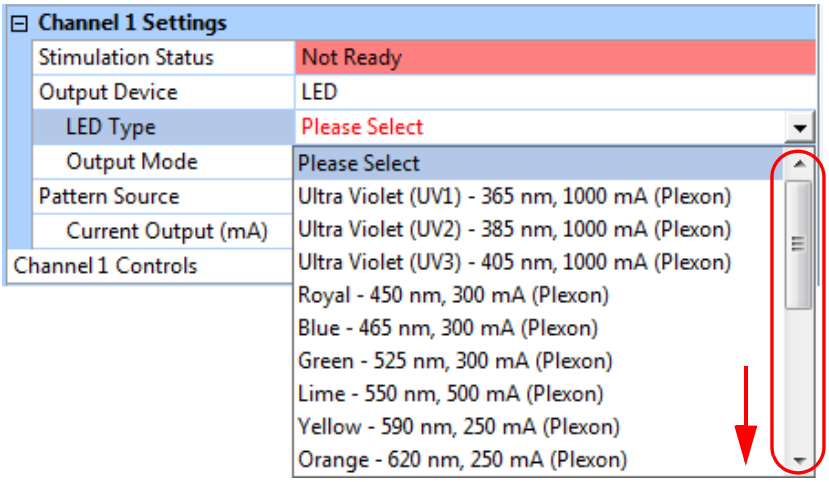
Note: Be sure to enter the appropriate current limit to avoid risk of damage to your custom LED. For added security, you may wish to use a limit that is less than the actual maximum allowed for your custom device. Reducing the current limit has the additional benefit of increasing output resolution, because the output always has 8 bit resolution between zero output and the current limit. So if your limit is 1000mA, your resolution will be approximately 3.9mA. Reducing the limit to 300mA makes your resolution 1.2mA.

Click OK to accept the additions or changes in the LED Editor.



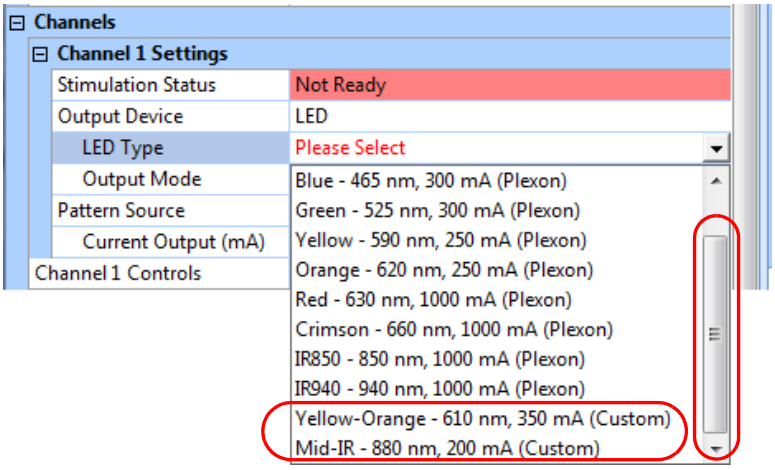
3 To assign an LED to a channel, use the **LED Type** dropdown list and select the desired LED for stimulation on this channel.

Notice the scrollbar at the right side.

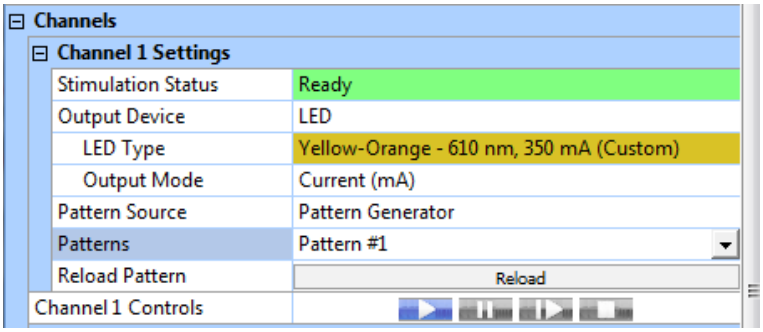


4 If necessary, use the scrollbar to view down through the list.

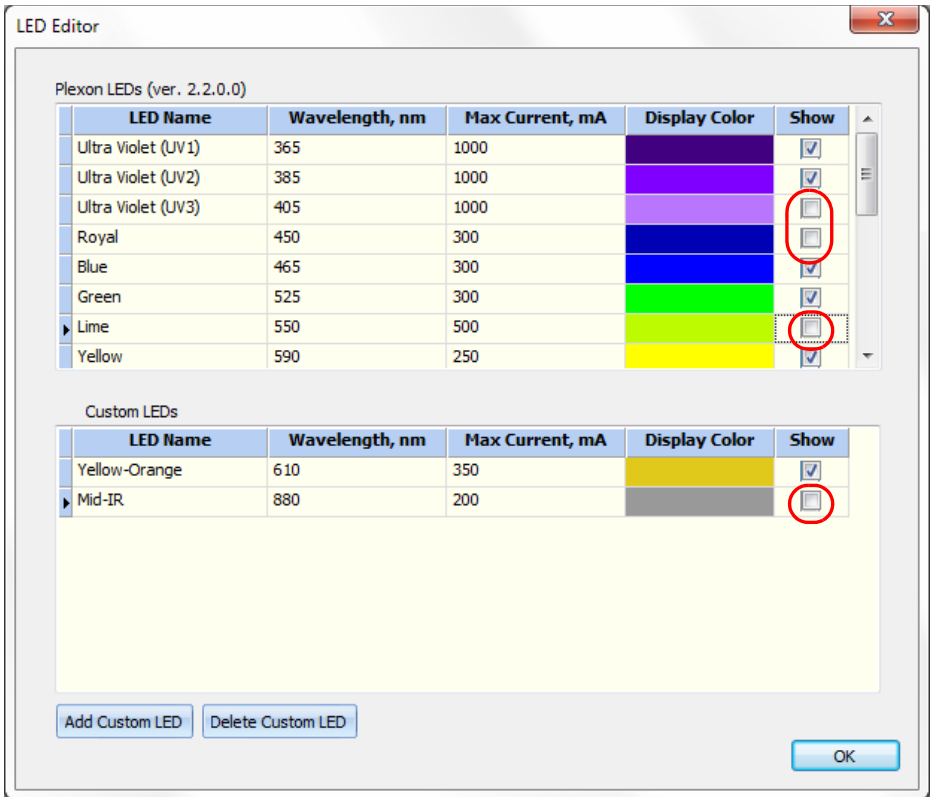
In the image below, notice that the two Custom LEDs (Yellow-Orange and Mid-IR), which were added in a previous step, appear at the bottom of the list. Also notice that the standard Plexon LEDs are labeled “Plexon” and the new LEDs that you added are labeled “Custom.”



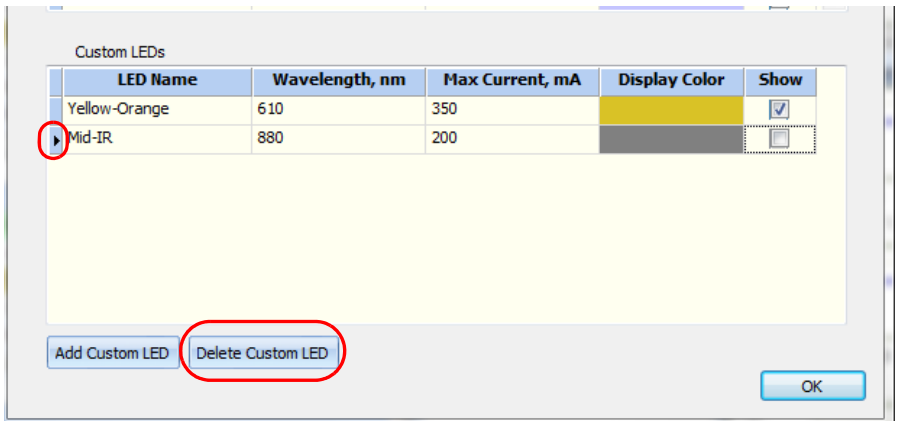
In the example below, the LED Type selected is Yellow-Orange (Custom).



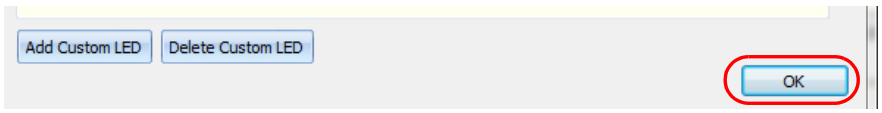
5 You can specify which LEDs are displayed in the **LED Type** field by selecting or deselecting the **Show** checkbox in the **LED Editor**. In the example below, the **Show** field for the Green, Yellow, Crimson and Mid-IR LEDs have been deselected, so they will no longer appear in the **LED Type** dropdown list for any channel. (The **Show** fields can be selected again later to include them in the **LED Type** dropdown list.)



6 If you want to delete any of the Custom LEDs from the list, click in the applicable row to select the item to be deleted, then click the Delete Custom LED button. In this example, the Mid-IR LED will be deleted.



7 Click OK to accept the additions or changes in the LED Editor.



18 GUI Function Reference

18.1 Status

The Stimulation Status of a given channel can be Not Ready, Ready, Playing or Paused. Until a pattern for a channel has been defined, the Stimulation Status bar will say Not Ready and the **Start** icon for that channel will be grayed out. Digital inputs to that channel will have no effect until the status changes to Ready.

The start/stop/pause/unpause controls in the user interface are explained in Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

18.2 Output Device

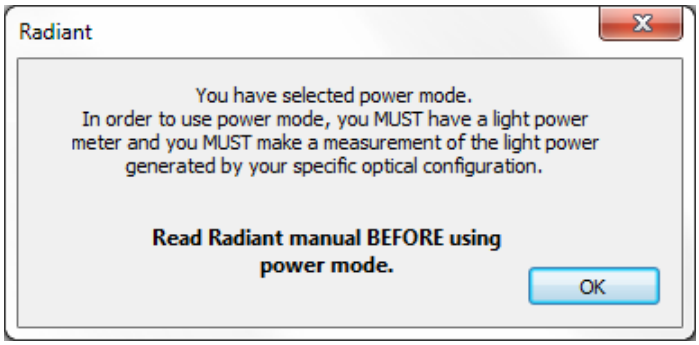
There are two choices in the drop down menu for Output Device:

- LED
- LASER

Whenever LED is selected, the controller will output a current. Selecting LASER will output a voltage. This voltage is intended to be used to control a laser with an analog control signal.

18.3 Output Mode

When the output device is set to LED, the output mode is set to **Current (mA)** by default. If you want to set the output mode to **Power (mW)**, the system displays this dialog:



The light measurement must be performed as described in Section 9.1, "LEDs" on page 24. Note that when using one of the pre-configured Plexon LED modules, the current limit is set automatically and is shown next to the wavelength in the LED Type window.

When the output device is set to LASER, the output mode is set to **Voltage (mV)** by default. If you want to set the output mode to **Power (mW)**, the system displays the dialog as shown above. The light measurement must be performed as described in Section 9.2, "Lasers" on page 30.

18.4 Current or Voltage Limit

For LEDs—In current mode, the system limits the current to the range specified for the selected LED. In the LED Editor, the current limits for the standard Plexon LEDs are fixed (not editable), but you must manually enter the current limit for any custom LED that you add. For instructions on viewing the LED list and entering custom LEDs, see Section 17, "Managing the LED List with LED Editor" on page 104.

For lasers—In voltage mode, the output can range from 0-5V. If you do not need the full 5V range, you can increase the output resolution by setting a voltage limit that is below 5V.

18.5 Pattern Source

There are three options within the Pattern drop down: Manual Mode, File, and Pattern Generator.

Manual Mode

In manual mode, a value is entered for the amplitude of a constant output. The units are mV, mA, or mW. If power (mW) is used to specify the output, a current-to-power or voltage-to-power scaling must be performed as outlined in Section 16, "Verifying Output Signals and Scaling the Output Values" on page 100.

File

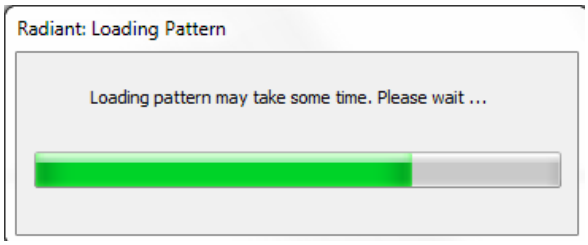
In file mode, the output amplitude of the channel is controlled by amplitude values read from a .txt or .opt file. The .txt file is just a list of numbers (see below). When the .txt file is opened, the output device and output mode of the channel determine how the file is interpreted. The .opt file contains header information that specifies the output device and output mode.

Creating a stimulation pattern file

The controller operates at 10kHz, meaning the stimulation output is updated every 100µs. A user-defined pattern file is simply an ASCII text file that contains a list of stimulation output values that are desired every 100µs. Each value is followed by a "line feed" and a "carriage return." This means that if you want to maintain the same value for a longer period of time, you must repeat the value (desired time/100µs) times. For example, stimulating 100mA for 1ms would require 10 consecutive lines of "100."

Loading complex files

Complex .opt or .txt files might take several seconds to load. You might see a progress bar when a large file is being loaded to the channels.



Pattern Generator

The Pattern Generator is a tool for creating patterns consisting of square pulses, ramp pulses, and constant outputs that can be grouped and repeated. The hierarchy used in the Pattern Generator is Pattern – Group – Primitive.

Pattern

A pattern consists of one or more groups and can be repeated. It has units associated with it that must match the units of any channel that it is loaded to.

Group

A group consists of one or more primitives and can be repeated. It has a period at which it is repeated. As more primitives are added the period automatically lengthens to accommodate the added primitives. If primitives are deleted, the period will not automatically shorten. For additional details about this process, see the example in Section 11.3, "Using the Period/Frequency and Total Duration/Repetitions Parameters" on page 49.

Primitive

There are several types of primitives: constant value, pulse, rising ramp and falling ramp.

- A constant value holds an output for a set amount of time.
- A pulse holds a value for its width and then returns to zero output for the remainder of its period.
- A rising ramp increases from an initial value to its final value over the specified duration of the ramp.
- A falling ramp decreases from an initial value to its final value over the specified duration of the ramp.

18.6 Repetitions and Count (File Mode)

A file-based pattern can be played continuously or a finite number of times based on the setting of the Repetitions parameter. When Finite is selected for Repetitions, the number of repetitions may be set using the Count parameter. Note that these controls are not visible when Manual Mode or Pattern Generator is selected as the pattern source.

18.7 Trigger Options

You can trigger (initiate) stimulation by means of control icons in the user interface or with digital inputs (DIs) to the hardware. In all cases, the stimulation pattern for the channel must be defined before it can be triggered and the channel must be enabled (**Stimulation Status** cannot be **Not Ready**).

For digital inputs, the specific action taken by the controller depends on the **DI Polarity** setting as well as the digital input signal.

Triggering from the User Interface

Stimulation can be initiated by clicking on the individual channel **Start** icon or the **Start** icon in the all-channels control toolbar in the GUI. Detailed information on the control icons is provided in Section 14, "Controlling Stimulation Manually from the Control Toolbars" on page 80.

Triggering from a Digital Input

Stimulation can be initiated on an individual channel by means of digital inputs to pins associated with the channel. Detailed information on the pins and digital inputs is provided in Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

DI Polarity

The **DI Polarity** setting affects the response of a controller channel when a DI signal is received on a pin associated with the channel. (The default polarity value is **Positive**.) See Section 15.6, "Understanding the Digital Input Polarity Settings" on page 99.

18.8 File Save Settings / File Load Settings / Restore Factory Settings

Save Settings

The settings for all stimulation channels can be saved to a user named file for future use by clicking the **Save settings to file** icon or by selecting **Save settings** from the **File** menu. These configuration files have an extension of

".ops". The .ops file saves the configuration of each channel and all of the patterns defined in the pattern generator.

TIP

Settings (.ops) file contains all stimulation patterns

If you have defined one or more stimulation patterns in the Pattern Generator, then save your settings, the settings (.ops) file also saves all of the patterns you have defined.

Note: The .ops file *does not* save the window layout (see Section 18.10, "Window" on page 112).

Load Settings

You can load an existing settings (.ops) file by clicking the **Load settings from file** icon or by selecting **Load settings** from the **File** menu.

Restore Factory Settings

The default values of the parameters can be restored by selecting File – Restore Factory Settings. You can also go to Window – Layout – Reset to Default Layout to set the windows of the GUI back to their default state.

18.9 View

When one controller is connected to the computer, there will be five choices under the View menu bar: Controller 1, Patterns 1, Pattern Generator, Pattern Generator Visualizations, and Messages. Each additional controller that is connected to the computer will have an additional window for Controller and Patterns. The number corresponds to the LED number that is illuminated under "Device" on the end panel of the controller.

Selecting a window under the View menu will cause it be highlighted in the GUI (the title bar turns orange) if it is present in the current layout. If the selected window is not present in the current layout, selecting it will cause it to be displayed.

18.10 Window

Radiant software allows the user to make considerable customizations to the appearance of the graphical user interface. Each window can be resized, docked, undocked, or hidden completely. Once you have configured the GUI the way you want it, you can save the layout by selecting Window, Layout, Save As Layout 1, Save As Layout 2, or Save Layout to file. Saved layouts can be reloaded by selecting Apply Layout 1, Apply Layout 2, or Load Layout From File. You can also return to the default layout at any time by selecting Reset to Default Layout.

The Window > Theme menu option provides two functions: Text Below Toolbar Icons and Hide Window Title Bars. Clicking on either of these options toggles the display (shows/hides text below the toolbar icons or shows/hides window title bars).

18.11 Help

The Help menu gives access to the User Manual as well as the software version number (About Radiant...). The About Radiant... dialog box also displays buttons for Licensing and a System Report.

19 Input and Output Connectors

19.1 Power In

This information is provided for reference only. Use the recommended power supply and attached cable provided by Plexon to power the controller. The power input connector is a locking 2.5 mm inner / 5.5 mm outer barrel connector. The stimulator operates from a grounded 12V power supply.

Pin	Function
Center	12V
Outside	GND

19.2 Digital In

The Digital In connector on the controller is shown below.

For information on digital inputs, see Section 15, "Controlling Stimulation with Digital Inputs" on page 89.

19.3 USB 2.0

The stimulator has a Type B USB 2.0 receptacle for communications with the host computer. The device is not powered from the USB bus. It derives power from the power input connector.

19.4 Current or Voltage Output Connectors

The stimulation outputs are delivered through the BNC connectors, one for each of the four channels. Connect one of the Plexon supplied BNC cables from the BNC connector on the controller to a BNC connector on the LED, laser or commutator for that channel. (If you want to measure the voltage output delivered to a laser, you can connect the BNC cable to an oscilloscope.)

The output can be configured in the user interface for current mode or voltage mode.

The "**I(on) V(off)**" LEDs are on when the output is in current mode, and they are off when the output is in voltage mode.

Voltage mode

In voltage mode, the inner contact is the output voltage and the outer contact is connected to ground.

Current mode

In current mode, the current going to the LED leaves the controller from the inner contact and returns to the controller on the outer contact. Care must be taken when connecting the outputs in current mode. Below are a list of Do's and Don'ts to consider when making these connections.

In Current Mode—Do:

- Make sure that the outside of the BNC connector is not touching anything. The cables that came with your PlexBright 4 Channel Optogenetic Controller are insulated for this reason.
- If you want to drive multiple LEDs with one channel, make sure they are connected in series, NOT in parallel. This can be done with a Plexon Series-Y BNC Cable.
- Set the appropriate current limit for your LED. This is done by selecting your Plexon LED type in the GUI or by making a custom LED type and setting the max current in the GUI.

In Current Mode—Don't:

- Connect the signal to an oscilloscope. You will not damage the controller or the oscilloscope (assuming your oscilloscope can handle a 12V input), but you will not see any useful signal.
- Connect to any instrument that cannot handle a 12V input. If you plan to use a voltage to control another instrument, switch the controller to voltage mode before making the connection to reduce the risk of damaging other equipment.
- Use a standard BNC "T" connector to try and split the signal between two LEDs.
- Use a standard BNC "T" connector to try to split the signal between an LED and an oscilloscope. This could permanently damage your LED and will not show anything useful on your oscilloscope.
- Try to connect two channels to one LED.

19.5 Status LEDs

There are 16 status LEDs above the output BNC connectors.

Device

The **Device** LEDs indicate which controller number each box is when multiple controllers are connected to a single computer. This is necessary to know which unit is being configured when multiple tabs appear in the GUI. The LED above "1" will illuminate for controller number 1, the LED above "2" will illuminate for controller number 2, etc.

I (on) V (off)

Each channel has a dedicated LED to indicate if it is configured for current output or voltage output. If the channel is configured for current output, the LED will be illuminated. If it is configured for voltage output it will be off.

Running

Each channel has a dedicated LED to indicate if a pattern is running. It will stay illuminated for the duration of the pattern, even if the pattern specifies a zero level output. It mirrors the output on the running digital output pin.

Non-Zero

The **Non-Zero** LEDs mirror the function of the non-zero digital output. Note that for rapidly pulsing patterns, it may not be possible to visually distinguish when the output is non-zero and when it is zero by looking at the **Non-Zero** LED. If this is the case, and you want to view the output, connect the non-zero digital output to an oscilloscope or other electronic recording device.

19.6 Digital Out

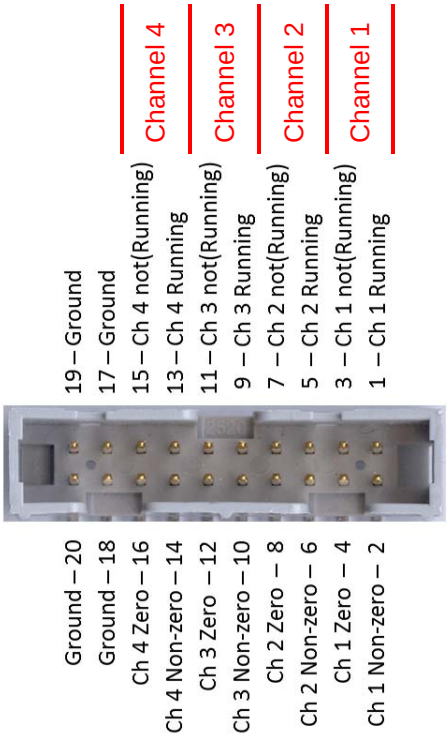
Each channel has four dedicated digital outputs that indicate when it is running, non-zero, zero, and when it is not running.

The Digital Out (DO) connector on the controller is shown below.

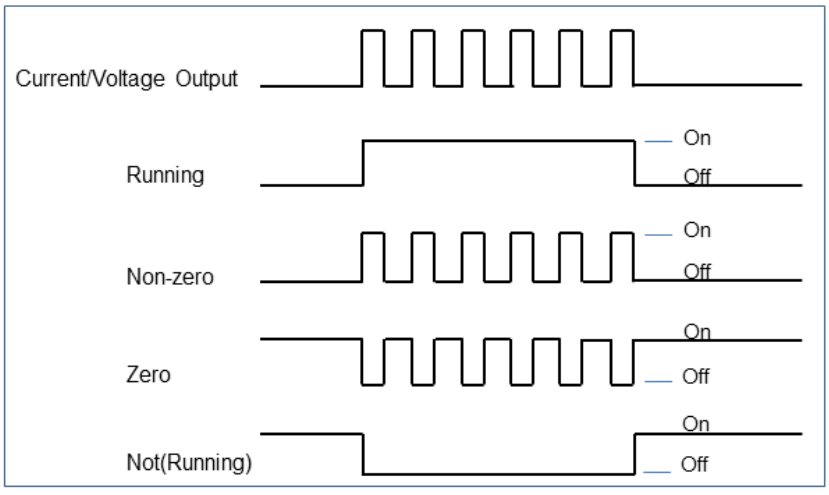
Plexon® OmniPlex® systems (both analog and digital) have digital input (DI) cards that allow the user to register the precise timing of stimulation. The DI cards can only be set to recognize rising or falling edges, however. This means that to fully know the timing of a pattern, multiple digital outputs of the PlexBright 4 Channel Optogenetic Controller need to be monitored. The rising

edge of the “running” signal indicates a pattern has started and the rising edge on the “not running” signal indicates the pattern has finished. The rising edge of the non-zero signal indicates that a pulse has started and the next rising edge of the zero signal indicates that the pulse has ended. Note that if there are programmed zeros at the end of the pattern, the running output will stay high until the zeros are done playing, at which point the “not running” signal will go high.

Each channel in the PlexBright 4 Channel Optogenetic Controller is associated with four pins on the DO connector, and each of the pins has a specific function.



The functions of the pins are shown in the diagram below.



19.7 Stimulation Cables

While any BNC cable can be used for stimulation, Plexon provides insulated BNC cables that prevent the outer contacts from touching. This is particularly important when using the controller in current output mode. The circuit that sets the current output relies on measuring the return current, so if the outer BNC contact were shorted to ground through accidental contact with something else (a metal table for example), the output current would go to unexpectedly high values.

CAUTION

To avoid risk of high currents, you *MUST* use the insulated BNC cables that were supplied by Plexon with your system. Using other cables could cause unexpectedly high current levels.

20 Sample Arbitrary Waveform Pattern Files

Several example arbitrary waveform files are installed with the Radiant software. These files were designed to illustrate how to use arbitrary waveform files and some of the things you can accomplish using arbitrary waveform files. By default these files are installed in the directory “C:\Plexon Data\Sample Pattern Files”. The files can be opened with any text editor (e.g. Notepad).

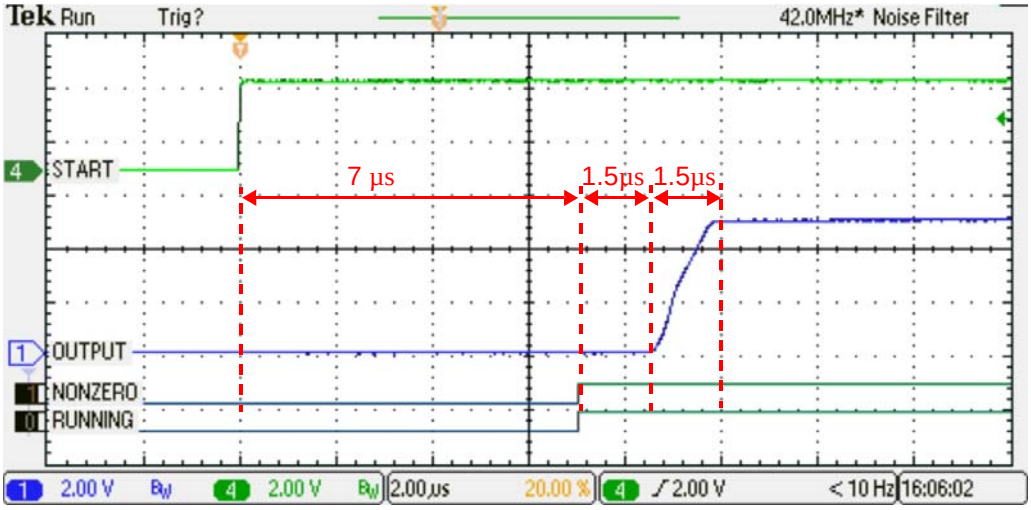
The sample files provided by Plexon are marked as Read Only. They should be copied and renamed before removing the Read Only flag to avoid accidentally overwriting them.

Note: Pattern files that you create are editable (unless you change them to Read Only in your Windows dialog box). To change them, right click the file name and select Properties from the drop down.

21 Timing Considerations

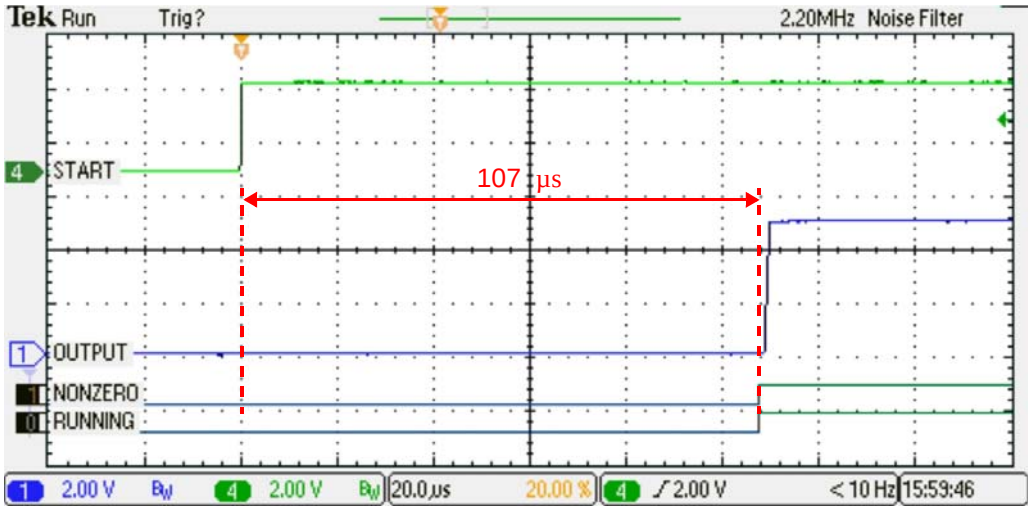
21.1 Latency from Digital Input

The most important factor determining the response latency to a digital input (or software command) is whether or not other channels are already playing at the time the digital input is received. The lowest latency response occurs when the first channel is started (or unpaused) and the other channels are not playing. This minimal latency response for LASER (voltage) mode is shown in the figure below. The digital outputs go high about 7µs after the digital input. The voltage output begins to rise 1.5µs later and reaches its maximum value 1.5µs after that. Thus the total latency from digital input to full voltage output is about 10µs. Note that the output response after the digital output goes high is analog in nature and will depend somewhat on the load attached to the Controller. In the figures that follow, the output is driving an oscilloscope with 1MΩ // 11.5pF.



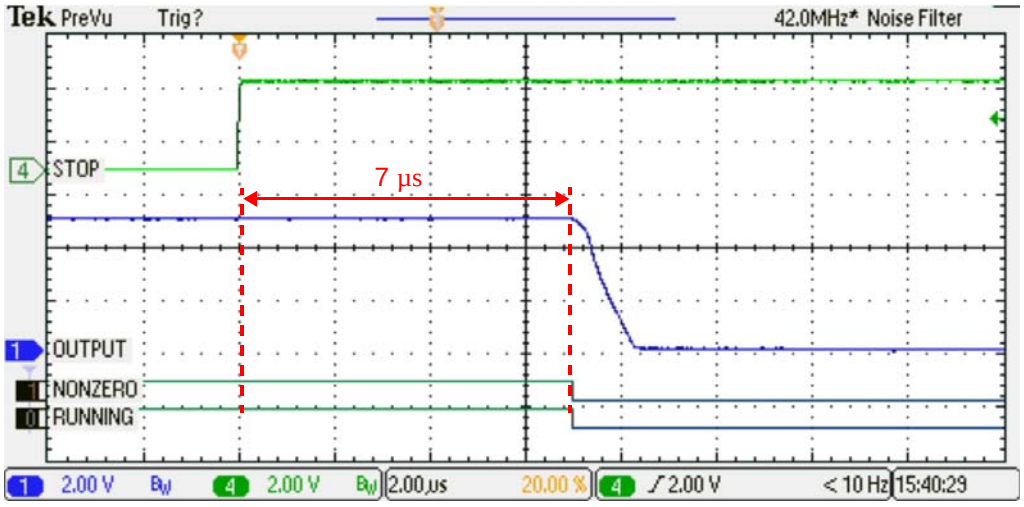
Start (or unpause) latency (1st channel always) (2nd channel, best case)

If another channel is already running, then there can be an additional latency of up to 100µs to respond to a digital input. This additional latency results from the fact that all channels operate synchronously. The second channel to start must synchronize with the channel that is already playing and because the channels playback pattern samples at 10kHz, each sample lasts for 100µs. If the digital input arrives at the very end of the sample period, then there is no additional latency. The best case latency for the second channel to start is the same as the latency for the first channel to start. However, if the digital input arrives at the very beginning of the sample period, then the channel has to wait up to 100µs to synchronize with the channel that is already playing. The worst case latency for the second channel to start is 100µs longer than for the first channel to start as shown below (note 10x change in time scale)



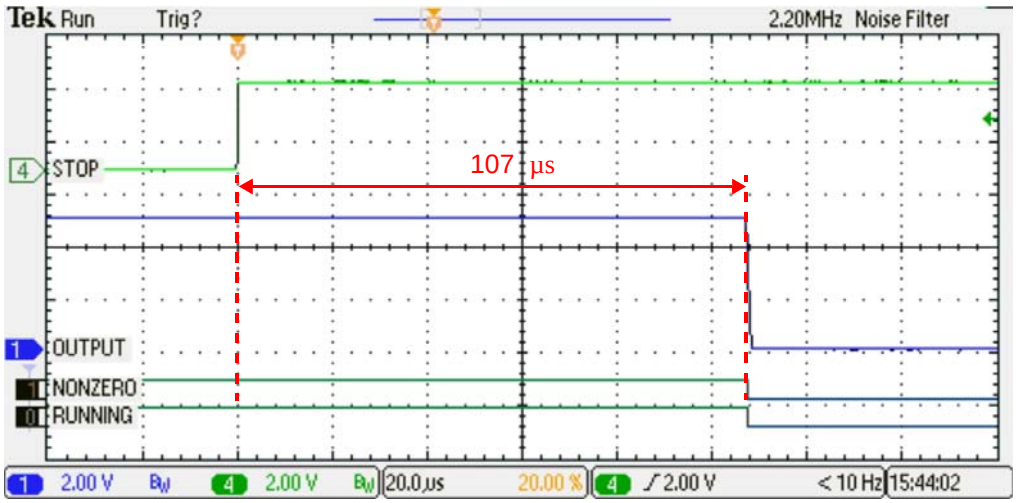
Start (or unpause) latency (2nd channel, worst case)

A similar situation occurs when a channel responds to a stop (or pause) digital input. In this case however, we know for sure that at least one channel is already running. Thus the additional 100µs latency can apply. The figure below shows the best case latency to respond to a stop (or pause) digital input of about 7µs, the same as the best case starting latency.



Stop (or pause) latency (best case)

As before, the worst case latency is 100µs longer than the best case latency as shown in the figure below (note 10x change in timescale):



Stop (or pause) latency (worst case)

In current mode, there are additional delays associated with the current generation circuit and the LED turning on. 300mA and 1000mA LEDs were tested at 100mA and their respective maximum currents. The worst case observed time between the digital input and the light reaching 90% of its maximum was 320µs. The rise time of the light output from 10% to 90% was up to 180µs, and the fall time was up to 300µs. In general, rise times were actually shorter for higher currents. Additionally, orange modules had shorter rise times than blue modules. Fall times were approximately the same across different the current values for a given module. The blue modules had longer fall times than orange ones. These delays are still small relative to the kinetics of the opsins that are available at this time.

21.2 Synchronization of Multiple Controllers

The Radiant GUI supports connecting up to four controllers to a single computer. It should be noted that each controller has its own internal clock and this will result in slight timing variations between controllers. This variation will be most noticeable during very long stimulation protocols.

The crystal that generates the clock has 50 ppm stability. In the worst case, if your pattern is an hour long, it could potentially finish 0.36 seconds earlier or later than the same pattern running on a second controller that was started at the same time (assuming one clock is 50 ppm fast and one is 50 ppm slow). This is a worst-case scenario, but there will certainly be some drift between different controllers.

If you have a long pattern that actually consists of smaller repeated pattern, the best option is to define a pattern consisting of just one basic unit and then use a digital input to trigger all of the controllers at the same time. As an example, rather than repeating a 1 second pattern 3600 times in software or a file, you could define the 1 second pattern, set the number of repetitions to 1, and trigger all of the controllers with the same 1Hz digital input. This will prevent drift between controllers.

22 Specifications

General	
Dimensions power supply controller	5.8 in x 1.3 in x 2.4 in 8.0 in x 1.9 in x 3.8 in
Weight power supply controller	1.0 lbs 1.1 lbs
Power requirements (per controller)	100 – 240VAC, 47 – 63Hz, 0.96 – 0.51A
Operating Systems	Windows 7 or Windows 10, 64-bit
Interface	USB 2.0
Maximum number of controllers per computer	4
Analog outputs	
Stimulation mode	Current, Voltage or Power
Number of analog output channels per controller	4
Maximum Current (Current Mode)	1100mA
Maximum Voltage (Voltage Mode)	5V
Resolution for setting Max Current or Voltage	4.3mA, 19.5mV
Output Resolution	(Max current or voltage)/256
Output accuracy with max set to 5V	for outputs <= 800mV: error < ±18mV for outputs > 800mV: error < ±2%
Output accuracy with max set to 1000mA	±2 SD: -3.9mA / +4.0mA
Temporal resolution	100µs
Output rise time (Voltage Mode)	<4µs 0-5V, 1MΩ, 11.5pF load
Minimum LED light pulse width	500µs (amplitude dependent)
Digital inputs/outputs	
Number of digital inputs per controller	16 (4 per channel)
Number of digital outputs per controller	16 (4 per channel)
Digital input levels	TTL, Low < 0.8V, High > 2.0V
Digital output levels	HCT, Low < 0.33V, High > 3.84V
Digital input/output latency	See Section 21
Minimum trigger pulse width	200µs
Arbitrary waveforms	
Update rate	10kHz

PlexBright® 4 Channel Optogenetic Controller with Radiant™ Software

Part of the PlexBright Optogenetic Stimulation System

User Guide

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