LED Light Source

User Manual

Version 2.1.1

Contents

1

Safety Information

1.1 Important Safety Information

Light-emitting diodes (LEDs) used with sufficiently high power levels can be dangerous for the eyes. NEVER LOOK directly into the beam exiting from the FC connector of an LED module or from any optical fiber connected to the FC connector.

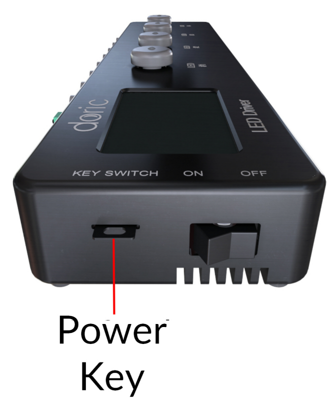
Doric LED Drivers are provided with a safety **interlock connector** on its rear panel (Fig. 1.1a). When the interlock circuit connector is shorted with the interlock plug, the driver is enabled. The shorting electric wire in the interlock plug can be removed and replaced by the safety interlock circuit of the laboratory. This safety feature is highly recommended with UV and infrared (IR) LEDs.

The **Power Key Switch** is located on the left side of the driver (Fig. 1.1b) to control the use of the device. All light sources connected to the driver can be enabled only when the power key is properly inserted.

REMINDER

To be enabled, LED Drivers must have its **interlock circuit connector shorted** with the interlock plug and the **power key properly inserted.**

(a) *Interlock connector plug connected*



(b) *Properly inserted key switch*

Figure 1.1: *Safety procedure*

1.2 Activation Safety Features

The built-in safety features (including the **Micro-controller**, **Key Switch**, **Interlock Plug** and **Current Driver**) are connected in series in the driver circuits, as shown in the block diagram (Fig. 1.2). This means that if any single safety feature are not properly in place, the light source cannot be activated.

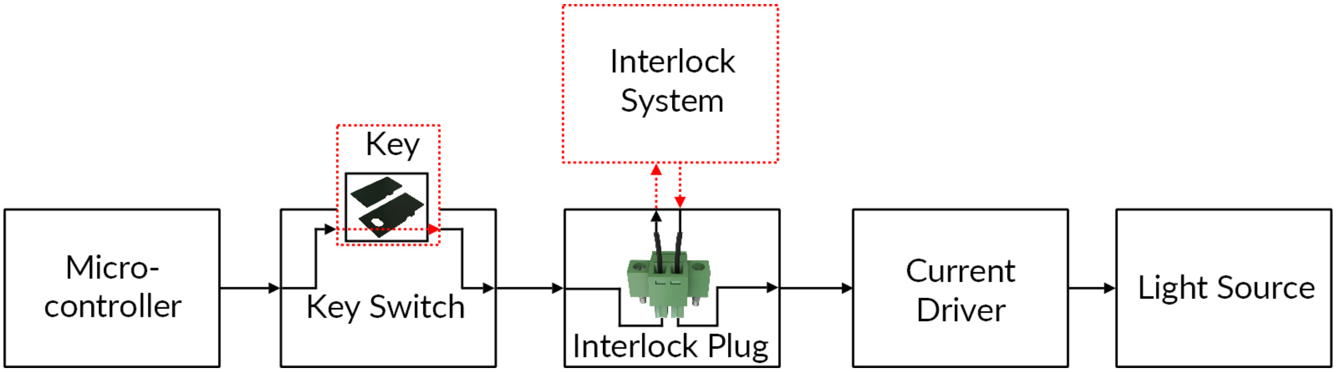


Figure 1.2: *Safety feature block diagram*

- The **Micro-controller** is used to control the light source driver.
- The **Key Switch** (Safety feature 1) (Fig. 1.1a), located on the left side of the driver, is required to activate any light source. If removed, no data can be sent from the micro-controller to the **Current Driver**.
- The **Interlock plug** (Safety feature 2) (Fig. 1.1b) is used to integrate the driver into an **Interlock Circuit**.
  - The **Interlock Plug** comes with a small wire short-circuiting it. This wire must be removed before integrating it into an **Interlock Circuit**.
  - Connect the **Interlock circuit** in series with the **Interlock Plug** so the circuit may function properly.
- The **Current Driver** sends current to any connected light source. If the **Key** is absent or the **Interlock Plug** has an open circuit, it cannot receive signals from the micro-controller, preventing it from sending out current.

2

Device Overview

2.1 Connectorized LEDs (CLED)

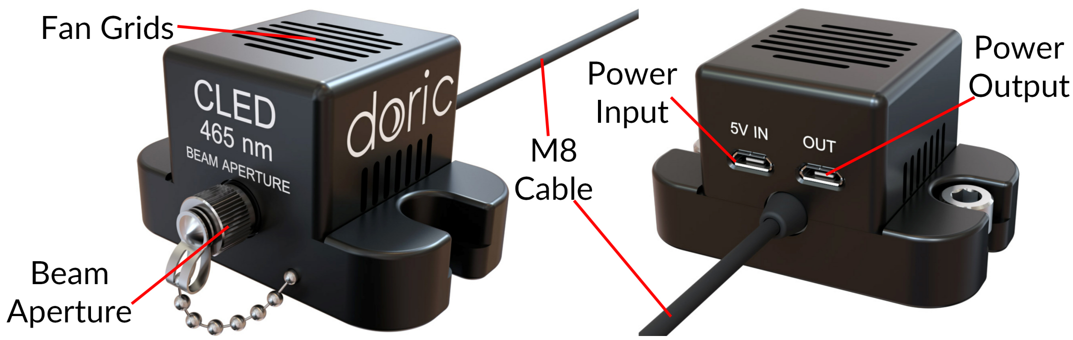


Figure 2.1: *Connectorized LED*

The Doric *Connectorized LED* is a compact module that couples a high brightness LED into an optical fiber via an FC receptacle. It is available in wavelengths from 365 nm to 940 nm, as well as white (5500 K temperature). The module connects to the Doric *LED Driver* over the pigtailed M8 electrical cable. Each module contains a fan, which is powered using a micro USB 5 V power supply. This fan cools the LED and allows stable output performance and long device lifespan. The following elements are found on the outside of the light source.

- The output beam exits from the **Beam aperture**. The aperture is composed of a fiber coupling assembly that injects the emitted light into an optical fiber. The standard model uses an FC fiber connector. A safety FC metal cap is attached to the optical head to block the output light beam when no patch-cord is in place.
- The **Fan grids** are found on the top and sides of the light source.
- The **M8 electrical cable** links the light source to the driver. An EPROM within the light source allows the driver to identify it when the cable is connected.
- The **Power input** is a 5 V micro-usb port used to power the fan.
- The **Power output** is a 5 V micro-usb port. A micro-usb/micro-usb cable is used links the port to the **Power input** of a different LED.

For a better cooling of the CLED, we recommend using the **LED Breadboard** which is a small breadboard used to hold two *Connectorized LEDs*; this also allows the light sources to be easily moved when necessary. It is ordered separately from the light source.

Figure 2.2: *LED Breadboard with LEDs Installed*

2.2 Connectorized LEDs - High Power (CLED_HP)

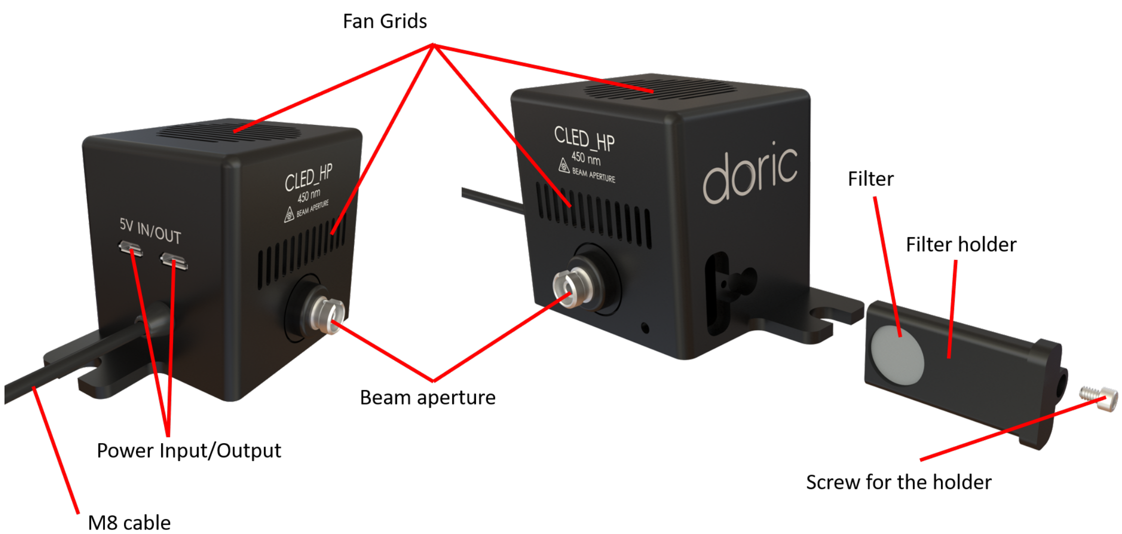


Figure 2.3: *Connectorized High Power LED*

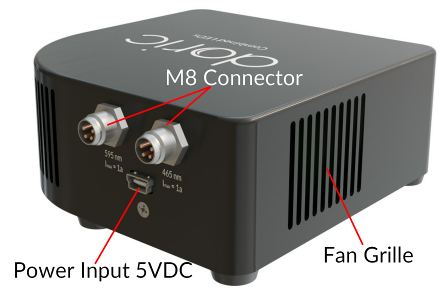
The Doric *Connectorized LED - High Power* is a compact module that handles larger powers than the classic CLED. High Power CLEDs are available in four wavelengths: 450 nm, 475 nm and 560 nm. As with the classic CLEDs, High Power LEDs are connected to the Doric's *LED Driver* using a pigtailed M8 electrical cable. Each module also contains a fan, which is powered using a micro USB 5 V power supply. This fan cools the LED and allows stable output performance and a long device lifespan. The following elements are found on the outside of the light source:

- The output beam exits the **Beam aperture**. The aperture is composed of a fiber coupling assembly that injects the emitted light into an optical fiber. The standard model uses an FC fiber connector. A safety FC metal cap is attached to the optical head to block the output light beam when no patch-cord is in place.
- The **Fan grids** are found on the top and sides of the light source. The grids must not be obstructed to ensure proper cooling of the CLED.
- The **M8 electrical cable** links the light source to the driver. An EEPROM within the light source allows the driver to identify it when the cable is connected.
- The **Power In/Out** are 5 V micro-usb ports used to bring power to the fan in the CLED_HP and can be used to link the port to the **Power In/Out** of a different CLED (with a maximum of 10).
- The **Filter** and its holder are used to restrict the bandwidth or attenuate the power of the light source in some experiments (especially when used in fiber photometry).

2.3 Combined LEDs (LEDC)

The Doric Lenses *Combined LEDs* allows the combination of multiple LED light sources of different wavelengths into a single fiber connector output. Each module is provided with a stand for vertical orientation. A *LED Driver* is required to use the *Combined LEDs*. The *Combined LEDs* contains the following elements:

(a) *2-LED Model, Front*



(b) *2-LED Model, Back*

(c) *3 and 4-LED Model*

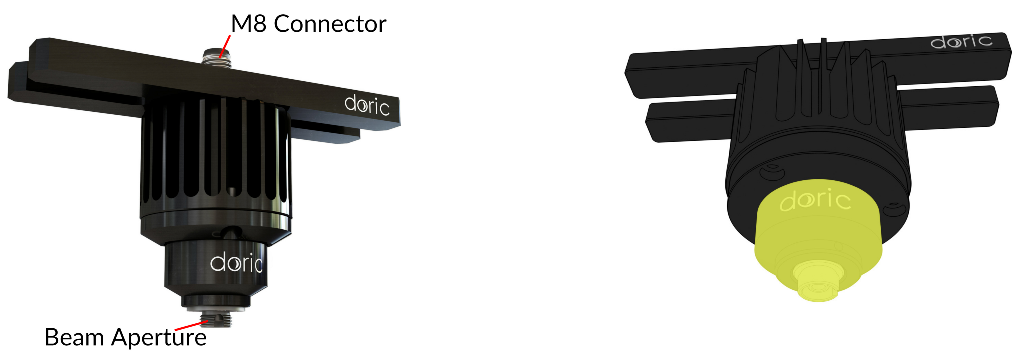
Figure 2.4: *Combined LEDs Modules*

- The **Beam Aperture** (Fig. 2.4a) outputs the combined light beams. It is integrated into an FC optical receptacle. It is important to leave the cap screwed onto the receptacle when not in use.
- The **M8 connectors** (Fig. 2.4b) are used to provide power to the LEDs. There is a single port per LED. The pinout can be found in Fig. 5.1.
- The **Power Input 5VDC** (Fig. 2.4b) is used to power the light source fans using a 5V power supply provided with the light source.
- The **Fan Grilles** (Fig. 2.4a, 2.4b) are used by fans inside the module to evacuate excess heat. The grilles must be kept clear of interference to avoid LED overheating.

2.4 LED + Fiber-optic Rotary Joint (LEDFRJ)

The Doric *LED + Fiber-optic Rotary Joint* are rotary joints integrated with one or several LEDs. This allows higher throughput in comparison with conventional **Fiber-optic Rotary Joints** combined with a *Connectorized LED light source*.

2.4.1 Connectorized LED with Fiber-optic Rotary Joint



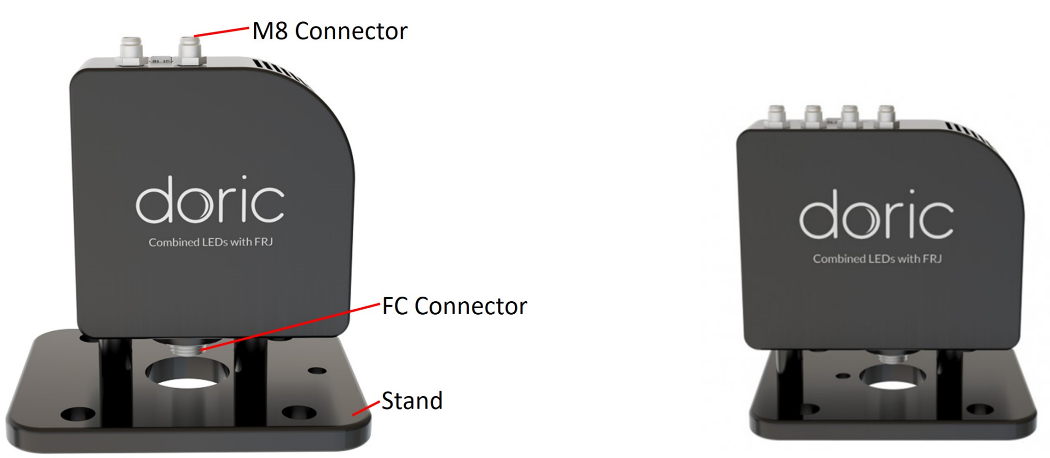
(a) *Standard mount* (b) *Rotor (Yellow) and Stator (Black)*

Figure 2.5: *Connectorized LED with Fiber-optic Rotary Joint*

The *Connectorized LED with Fiber-optic Rotary Joint* is a rotary joint with a single integrated LED. The light source is integrated into the **Stator (Black)**, with the light leaving through the **Rotor (Yellow)** (Fig. 2.5b). It has the following elements:

- The **M8 connector port** is used to provide power to the LED. The pinout can be found in Figure 5.1.
- The **Beam aperture** outputs light. The standard model uses an FC-type connector.

2.4.2 Combined LEDs with fiber-optic rotary joint



(a) *2-LED model* (b) *3 or 4-LED model*

Figure 2.6: *Combined LEDs with fiber-optic rotary joint*

The *Combined LEDs with fiber-optic rotary joint* are composed of a standard *Combined LED* body where the **FC connector** has been replaced with a **Fiber-optic rotary joint**. The light sources are integrated into a **Stator**, with the light leaving through a **Rotor**. They contain the following elements:

- The **M8 connector ports** are used to provide power to the LEDs. There is a single port per LED. The pinout can be found in Figure 5.1.
- The **Beam aperture** outputs light. The standard model uses an FC-type connector.
- The **Fan grids** are found on the sides. They must be kept clear at all times to prevent overheating.
- The **Power Input 5VDC** is used to power the light source fans using the provided mini-USB cable.
- The **Stand** is used to hold the LED vertically for easy use of the rotary joint.

2.5 LED Drivers

The *LED driver* is used to provide power and control of various LED modules. The *Connectorized LED* and *Connectorized LED with Fiber-optic Rotary Joint* can be used with the *1, 2 or 4-channel LED driver*. The *Combined LEDs* and *Combined LEDs with fiber-optic rotary joints* can be used with any driver having at least as many channels as the number of combined LEDs.

For safety precautions, the LED driver must be powered only by the power supply provided with the product.

Figure 2.7: *LED Drivers; 1-, 2- and 4-channel*

Each *LED Driver* channel can be controlled manually or via the *Doric Neuroscience Studio* software. During stand-alone operation, it is possible to change the operating mode (CW, external TTL, or external analog mode) and the current sent to each LED. These changes can be done directly on the device with the **Control Knobs** and the **LCD Display**.

The driver is designed and is tested to be used only with Doric light sources. For safety precautions, do not connect other devices in the M8 connectors.

Connecting the *LED Driver* to a computer provides the user with more options. Doric Neuroscience Studio software allows the access to more operating modes like Continuous Wave, External TTL, External Analog, Square Sequence(s), and Complex Sequence(s) modes. The *Doric Neuroscience Studio* enables the creation of different sequences of light source activation. It also provides the possibility to let these sequences be triggered or paused by an external signal. If more power is needed, it is possible to overdrive the *LED Driver* with the software for some LED with overdrive capability.

- The **LCD display** (Fig. 2.8) allows easy operation and monitoring. For each channel, the LCD displays the type of light source (LED), the operating mode, the center wavelength in nm and the current setting.

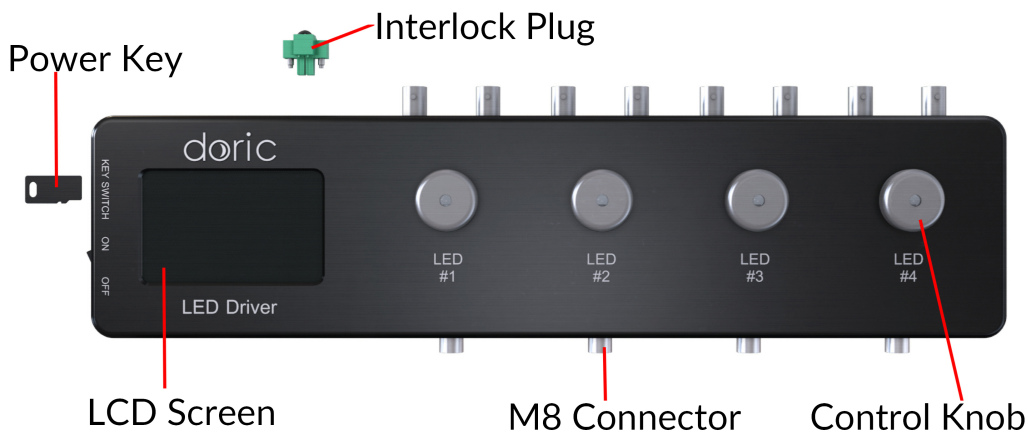


Figure 2.8: *Top view of a 4-channel LED Driver*

- The **Power key** must be properly inserted into the key switch to enable operation of the light source(s) connected to the driver. Note that, despite its similar shape, the power key is not a standard micro SD card such as those used in some digital cameras. Do not attach the Key to a key fob or similar holder; this may prevent proper insertion of the **Power key**.
- The **M8 connector** is used to link the driver and the LED.
- The **Interlock Connector Plug** (Fig. 2.9) allows the user to connect the driver to an interlock system. It is recommended to connect the interlock plug to a laboratory interlock system. This is critical when using LEDs in the UV or Infrared spectrum, as they are invisible to the naked eye.

Figure 2.9: *Rear view of a 4-channel LED Driver*

- The **Input BNC** allows the control of the LED driving current of the corresponding source with an analog or TTL signal.
- The **Output BNC** are used to monitor the driving current of the corresponding light source.
- The **12 VDC power input** connects the driver to its 12 VDC power supply.
- The **USB-B Connector** allows the driver to be connected to a computer using a USB-A/USB-B cable.
- The **On/Off switch** (Fig. 2.11) turns on/off the driver.
- The **USB-A port** (Fig. 2.10) is used, for some devices, to power the external light source module cooling fan. There is no data transfer possible with this port.

Figure 2.10: *Front view of a 4-channel LED Driver*

Figure 2.11: *Side view of a 4-channel LED Driver*

2.6 LED Fiber Light Source (LEDFLS)

The Doric *LED Fiber Light Source* integrates the *LED Driver* and the light source(s) into one convenient device that reduces the number of optical connections and the system's overall footprint. The Doric *LED Fiber Light Source* comes in different packages from 1 to 4 channels, which can be used stand-alone or with a computer via USB connection. The module has one or more beam apertures, each emitting a different wavelength (Fig. 2.12).

For safety precautions, the LED Fiber Light Source must be powered only by the power supply provided with the product.

Each module contains the following elements:

- The **Beam aperture** (Fig. 2.13) is where the light exits the light source. The aperture is composed of a fiber coupling assembly that injects the emitted light into an optical fiber. The standard model uses an FC fiber connector. A safety FC metal cap is attached to the **Beam aperture** head to block the output light beam in absence of optical fiber.

Figure 2.12: *LED Fiber Light Sources: 1-, 2- and 4-channels.*

Figure 2.13: *LED Fiber Light Source front*

- The **LCD display** allows easy operation and monitoring. The LCD display shows the mode for each channel as well as the constant or maximal current in mA.
- The **Control knob** is used to change the maximum current to the LED, as well as change the operation mode of the system.
- The **Safety key** must be in place to enable module operation. Despite its similar shape, the safety key is not a standard micro SD card such as those used in some digital cameras. Do not attach the Key to a key fob or similar holder; this may prevent proper insertion of the Key Switch.
- The **On/Off** switch turns on and off the light source.

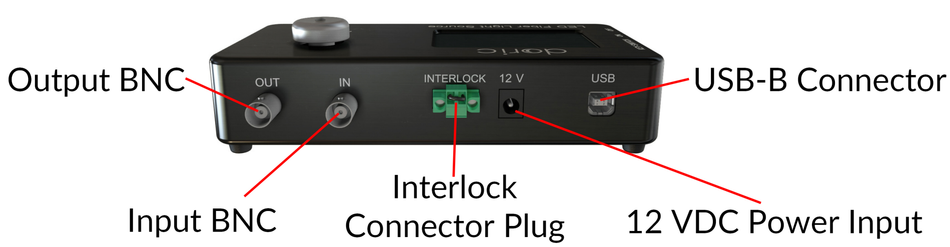


Figure 2.14: *LED Fiber Light Source rear elements*

- The **Interlock connector plug** (Fig. 2.14) allows the user to connect the driver to an interlock system. It is recommended to connect the interlock plug to a laboratory interlock system. This is critical when using LEDs in the UV or Infrared spectrum, as they are invisible to the naked eye.
- The **Input BNC** allows external TTL or analog signals to control each individual light source.
- The **Output BNC** are used to monitor the current on each LED.
- The **12 VDC power input** connects the module to its 12 VDC power supply.
- The **USB-B connector** allows the module to be connected to a computer using a USB-A/USB-B cable.

3

Operation Guide

To reduce the risk of eye injury, it is sound practice to NOT CONNECT/DISCONNECT OPTICAL FIBERS when the light source is turned on

Notes:

- On all relevant devices, it is critical not to block or insert objects into the ventilation grids as this could block airflow and reduce cooling efficiency.
- When not in use, place caps on the connectors for protection and cleanness.

3.1 Connectorized LEDs Setup

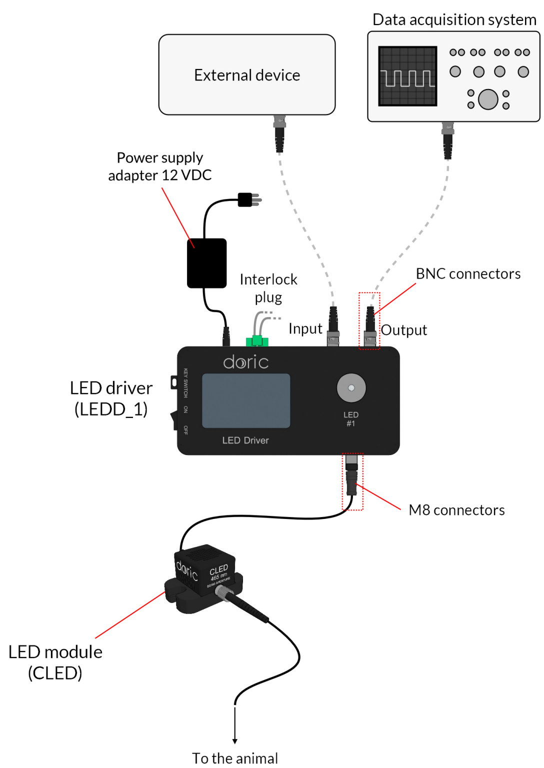


Figure 3.1: *Connections of a Connectorized LED to a 1-channel LED Driver in stand-alone mode*

1. Connect the **LED Driver** to the **12 VDC power supply**.
2. Ensure the **power key** and the **interlock** (green) connectors are properly set in place.
3. Connect the **Connectorized LED (CLED)** to the driver. Align the M8 connector pins in the female receptacle on the Doric LED driver, slide in and screw the nut in place.
4. Connect the **CLED Fan Micro-USB 5V Input** to the LED Driver 5V 1A Front USB Port with the provided USB cable. A Micro-USB to Micro-USB cable can be used to power the fan of multiple LEDs by connecting the Micro-USB output of a LED with the Micro-USB input of another LED.
5. For optimal performances, place the module in a well ventilated area. Overheating will affect LED power and reduce its lifetime.

3.2 Combined LEDs Setup

1. Connect the *LED Driver* to the 12 V power supply.
2. Connect the *Combined LEDs* 5V DC Mini USB port to the *LED Driver* 5V front USB port using the mini-USB cable.
3. Ensure the **power key** and the **interlock** (green) connectors are properly set in place.
4. Connect each channel of the *LED driver* to the corresponding input connectors of the *Combined LEDs* using M8 cables.
5. Switch ON the *LED driver*.

3.3 LED + Fiber-optic Rotary Joint Setup

1. Installation depends on the specific source chosen. If using:
   - *Single-LED* model, the rotary joint must first be installed in its holder (*Holder_FRJ_large*, *GH_FRJ*). It can then be mounted into the setup using 1/4 or M6 nuts and screws.
   - *Combined LED* model, the holder is already integrated. It can then be mounted into the setup using 1/4 or M6 nuts and screws.
2. Connect the Doric ***LED Driver*** to the 12 V power supply.
3. Connect the ***LEDFRJ*** **5V DC Mini USB** port to the **LED Driver** 5V front USB port (for the 2, 3, and 4 channels model) using the mini-USB cable.
4. Connect each channel of the *LED driver* to the corresponding input connectors of the ***LEDFRJ*** using **M8 cables**.
5. Ensure the **power key** and the **interlock connector** (green) are properly set in place.
6. Switch ON the **LED driver**.

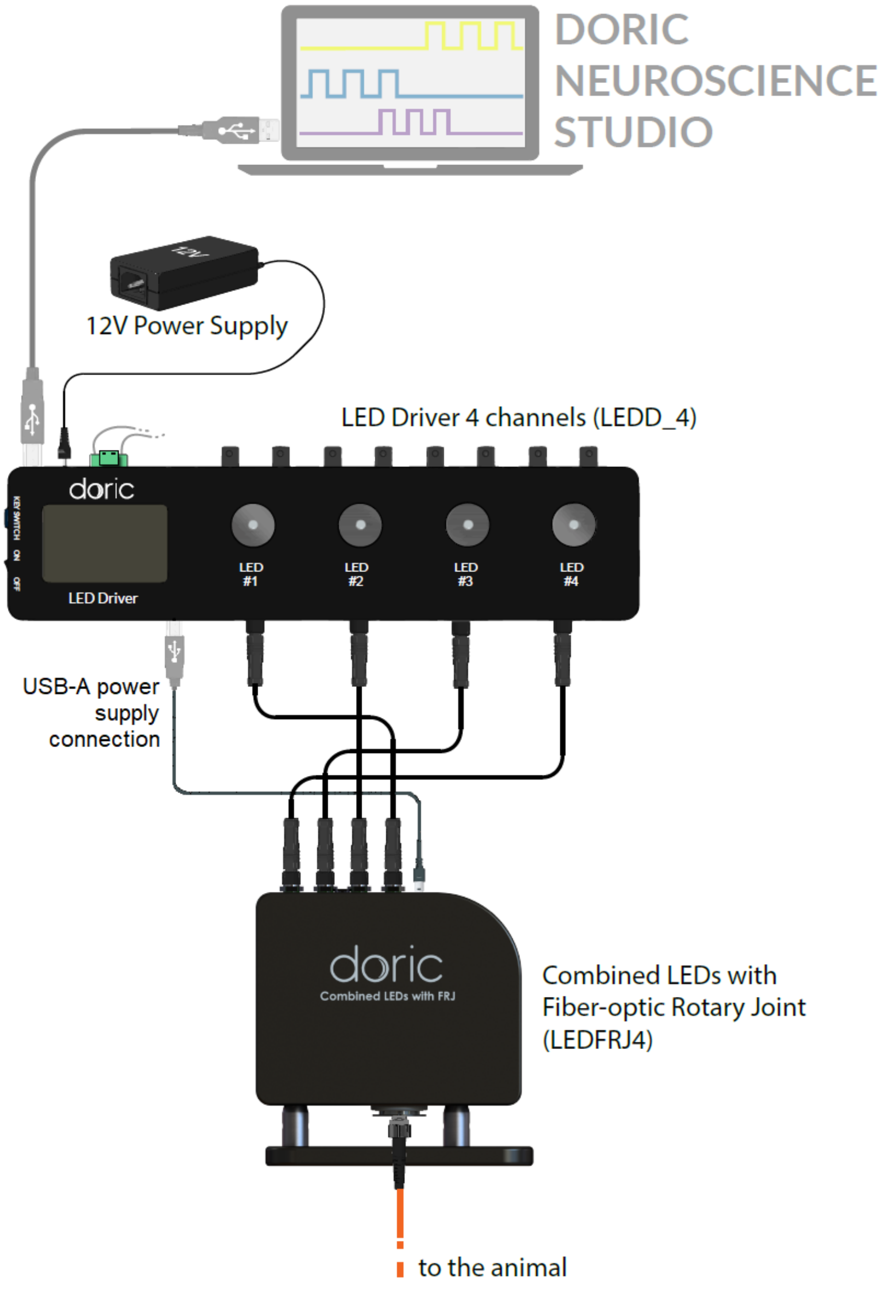


Figure 3.2: *LEDFRJ connection schema*

3.4 LED Fiber Light Sources Setup

1. Connect the **LED Fiber Light Source** to the **12 VDC Power Supply**.
2. For optimal performances, place the module in a well ventilated area, especially if used in continuous mode for long period of time. Overheating will affect LED power and reduce its lifetime.
3. The *LED Fiber Light Source* is operated with the driver's stand-alone capabilities (Section 3.6) or using the *Doric Neuroscience Studio* software (Section 4).

3.5 FC Connector Installation

1. Clean the optical fiber connector before insertion. Use isopropanol and a lint-free wipe.
2. With an FC connector, the connector key must be oriented to enter within the receptacle slot to ensure proper connection (Fig. 3.3).

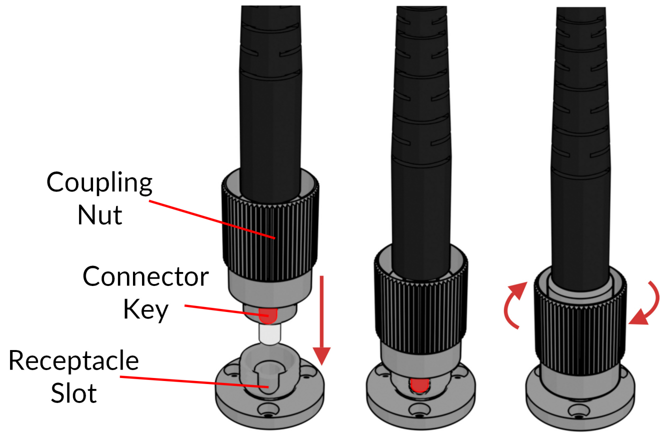


Figure 3.3: *FC connector, Fiber Installation*

WARNING!

To reduce the risk of eye injury, **it is sound practice to**
NOT CONNECT/DISCONNECT OPTICAL FIBERS
when the light source is turned on

3.6 Stand-alone mode (without Doric Neuroscience Studio Software)

The following sections details stand-alone operation of the *LED driver* and the *LED Fiber Light Source*. For installation of the light sources in stand-alone mode, see section 3.1 for *Connectorized LED*, 3.2 for *Combined LEDs*, 3.3 for *LEDs with fiber-optic rotary joint*.

If either the *LED driver* and the *LED Fiber Light Source* are used as a stand-alone devices, 3 modes are available: Constant current (CW), External TTL (Ext. TTL), and External Analog (Ext. Ana). The operating mode is changed by pressing the **Control knob** (See Fig. 2.8 and Fig. 2.13). The maximal driving current is set by turning **Control knob**. Use a fast/slow rotation for coarse/fine adjustment. The operating mode and the maximum driving current setting are independently adjusted for each channel.

Constant current (CW)

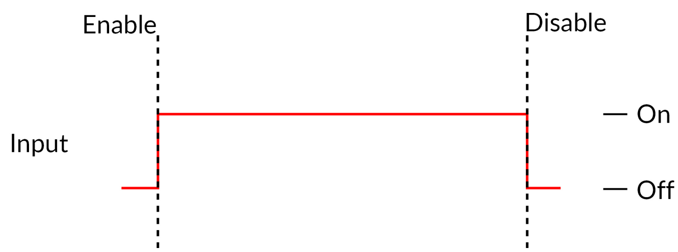


Figure 3.4: *Constant Current Mode Driver Signal*

When using the CW mode, the user simply sets the driving current applied to the light source. The light source is activated and an output beam will be visible as long as the driving current is above the minimum driving current (Fig. 3.4).

External TTL (TTL)

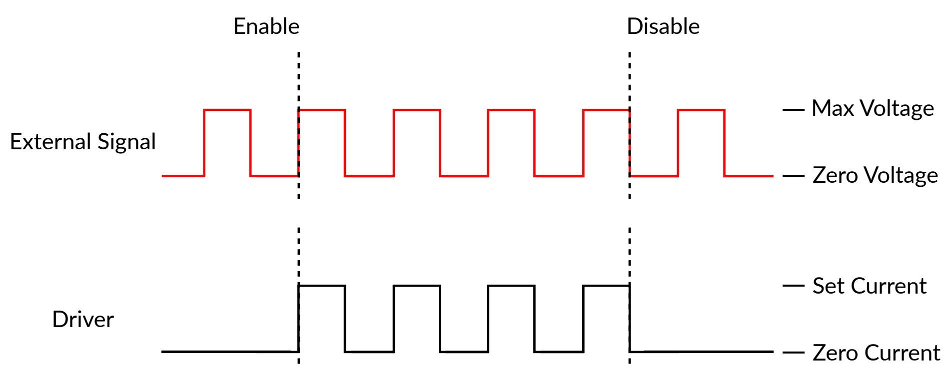


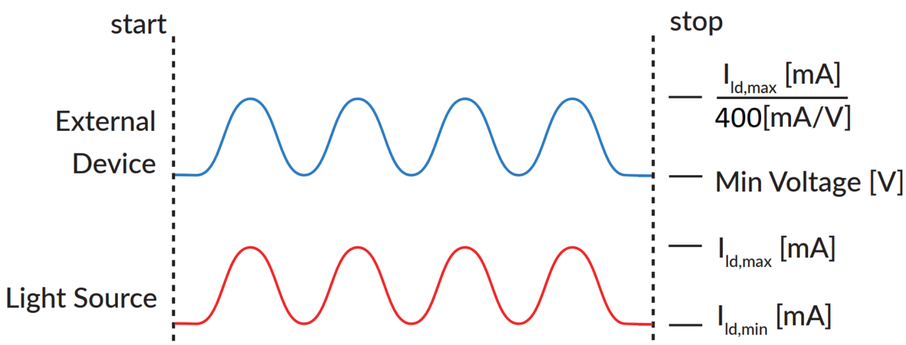
Figure 3.5: *Driver Signal Response to External Source in External TTL Mode*

In the External TTL mode, the driver is activated by an input TTL signal coming from an external device. This activation will follow the TTL pulse waveform. The driving current is set with the control knob, and is constant during each TTL activation pulse.

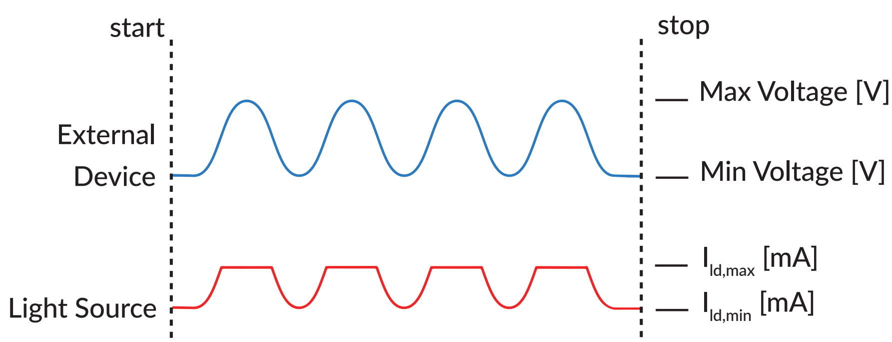
External Analog (Ext. Ana.)

The External Analog mode is similar to the External TTL, except that the driving current is proportional to the voltage applied to the BNC input connector (Fig. 3.6a). On the input BNC, a maximum voltage signal corresponds to a maximum of 2000 mA current. Most LED light sources have a maximum current below this value which could result in a clipping to the current output (see Fig. 3.6b).

To avoid this clip on the output waveform the maximum voltage setting must be equal to the maximal current divided by 400 mA/V (the value of the relationship between current and input voltage) (Fig. 3.6a). For square modulations, it is preferable to use External TTL mode instead of External Analog mode.



(a) *Adjusted tension to maximum current*



(b) *Clipping of light source current output*

Figure 3.6: *External Analog output is proportional to the External Device voltage*

Low power mode

To enable **Low power mode**, press the control knob for two seconds and a minus sign will appear indicating the switch to the current divide mode. This option reduces the current, therefore the optical power. It is useful to get stable signals in experiments requiring lower power (e.g. fiber photometry experiments). In this mode, the maximal current is 200 mA (corresponding to a 5 V input) and the minimum is 2.5 mA. This allows a more stable LED power output at lower electrical currents.

3.7 Connect to Doric Neuroscience Studio Software

1. Connect the *LED Driver* or the *LED Fiber Light Source* to the power outlet with the included 12 V power adapter and switch ON the device. **Always power the *LED Driver* or the *LED Fiber Light Source* before connecting the USB cable to the computer for a proper installation.**

2. Install the Doric Neuroscience Studio Software on the computer. Double-click on the DoricNeuroscienceStudioSetup_vX.X.X.X.exe file located on Doric USB memory stick supplied with the *LED driver* or download it from Doric Lenses website. Follow the on-screen instructions for software setup.

3. Connect the **USB-A/USB-B cable** to the *LED Driver* or the *LED Fiber Light Source* and the computer.

4. If using the *LED drivers*, connect each **M8 connector** of the light source of choice to the *LED driver* using an M8 electric cable.

5. With the system connected, the software can be used to control the device in **External TTL, Square Sequence(s), External Analog and Complex Sequence(s)** modes. See chapter 4 for more details on using the software.

4

Doric Neuroscience Studio

Doric Light Sources can be controlled by the Doric Neuroscience Studio software. These include *LED Modules*, *Laser Diode Modules*, and ⋆*LISER*^{TM} *Light Source*[1]. The interface is separated into two main sections, **Control & Settings** and the **Acquisition View**. Each light source driver has several **Channels**, each one controlling a light source of its given type.

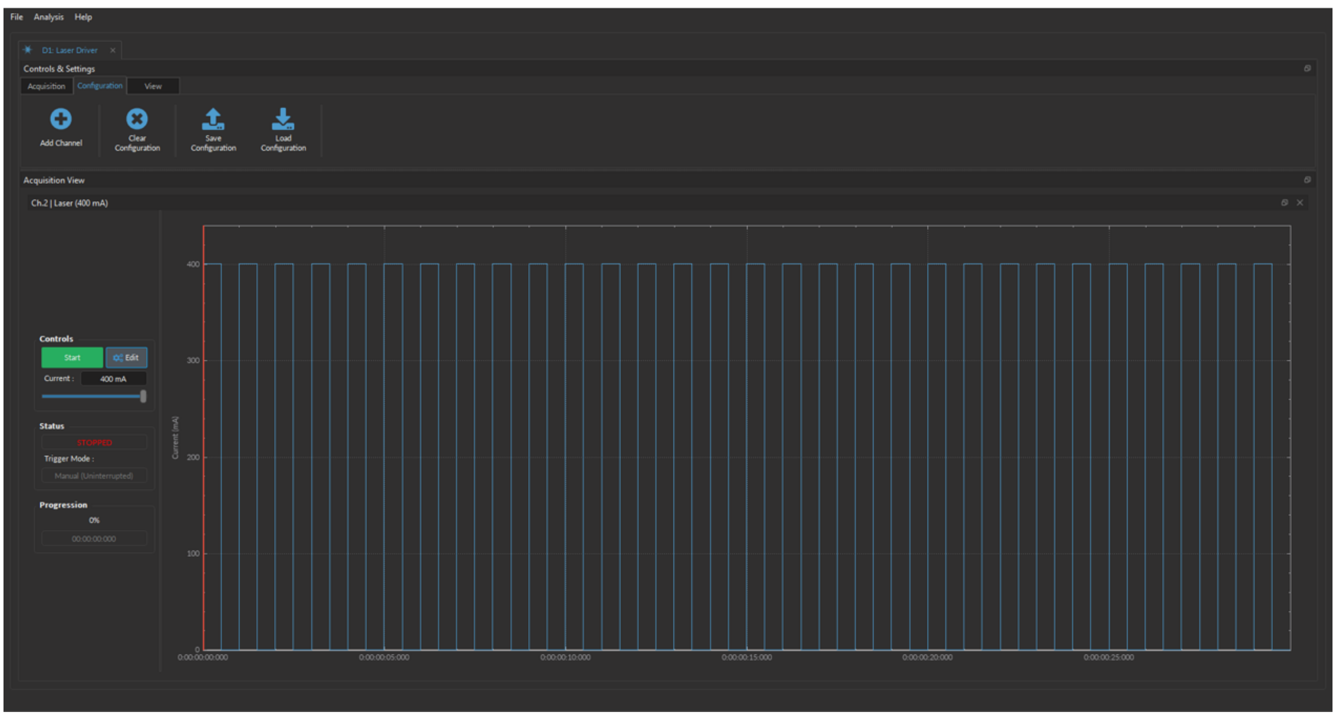


Figure 4.1: *Light Source Driver Tab*

[1]The ⋆LISER^{TM} Light Source are also known in older models as Ce: YAG Fiber Light Source.

4.1 Controls and setings

The **Control and Settings** box is used to manage the different parts of the software. It contains three tabs, the **Acquisition**, **Configuration**, and **View** Tabs.

4.1.1 Acquisition Tab

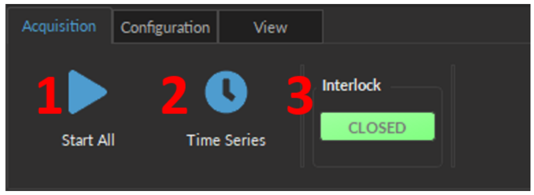


Figure 4.2: *Acquisition Tab*

The different buttons of the **Acquisition Tab** are shown in Figure 4.2 and their functions are explained below.

1. The **Start All** button starts all currently configured channels.
2. The **Time Series** button opens the Time Series window (Fig. 4.3). This tool allows all channels to share the same timing. The window is composed of:

Figure 4.3: *Time Series Window*

   a) The **Number of series** sets the number of times that the sequence will be repeated, with a minimum of 1.
   b) The **Time Active** sets the duration of each series in hh:mm:ss:zzz format. The **Time series** can be used in combination with a sequence such as the Square Sequence(s) or the Complex Sequence(s) Mode. If the **Time Active** duration is shorter than the sequence time length, the sequence will stop at the end of the **Time Active** time length.
   c) The **Interval between series** sets the duration between each series in hh:mm:ss:zzz format.
   d) The **Total Duration** displays the total duration of the sequence in d:hh:mm:ss:zzz format.
   e) The **Progression** bar displays the progression of the sequence in %, while the **Time Elapsed** counter displays the progression in hh:mm:ss:zzz format.
   f) The **Launch** button starts the sequence.

3. The **Interlock** indicator displays 

when the interlock is correctly connected, and 

when disconnected (more details in the section 1.2).

4.1.2 Configuration Tab

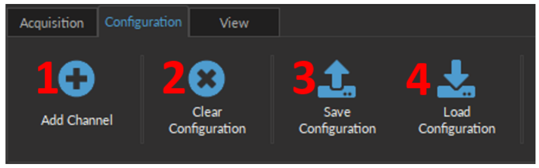


Figure 4.4: *Configuration Tab*

The different buttons of the **Configuration Tab** are shown in Figure 4.4 and their functions are explained below.

1. The **Add Channel** button opens the **Channels Configuration** window to set up the channels. This window is detailed in the section 4.2.
2. The **Clear Configuration** button resets the acquisition view and all other parameters set. Any configurations already set will be lost.
3. The **Save Configuration** button is used to save the Light Source configuration in a **.doric** format.
4. The **Load Configuration** button allows a Light Source configuration in **.doric** format to be loaded. Recorded data files also contain the configuration used during the experiment and this configuration can be loaded using this button.

4.1.3 View Tab

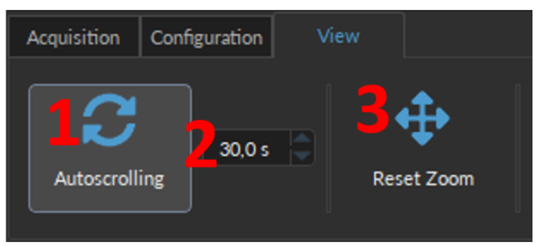


Figure 4.5: *View Tab*

The different buttons and fields of the **View Tab** are shown in Figure 4.5.

1. The **Autoscrolling** button, when clicked, makes the graphs scroll as new data appears.
2. The duration (in seconds) kept on display by the Autoscrolling function.
3. The **Reset Zoom** button resets the horizontal axis of all graphs displayed in the **Acquisition View** to the duration chosen in the **Autoscrolling** field.

4.2 Channel Configuration

4.2.1 Channel Configuration Window Overview

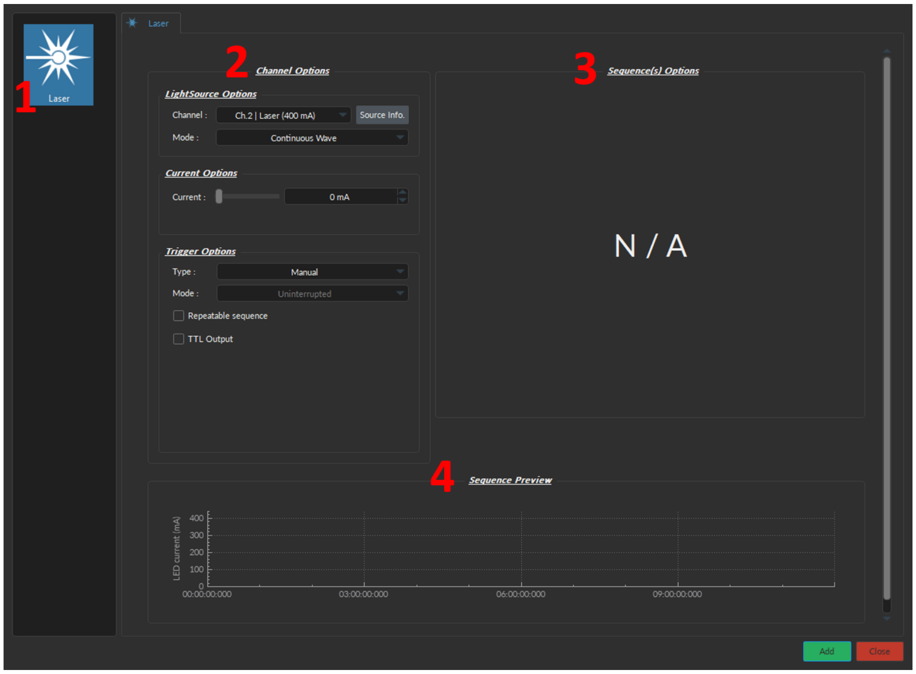


Figure 4.6: *Channels Configuration Main Interface*

The **Channels Configuration** window is used to configure each channel. The window can be accessed by using either the **Add Channel** or **Edit** buttons. This window is separated into multiple sections shown in Figure 4.6 that are defined below.

1. The **Channel Types** are displayed on the left side of the window. These include the ⋆**LISER**™ light sources, the **LED** light sources and the **Laser Diode** light sources.
2. The **Channel Options** section allows you to define the Light Source Options, the Current Options, and the Triggering Options. The different fields of this section are explained in more detail in section 4.2.2.
3. The **Sequence Options** defines the parameters of each pulse sequence for the channel. These parameters are different for each Channel Mode. The different fields for the different Channel Mode are explained in more detail in section 4.2.3.
4. The **Sequence Preview** section shows a visualization of the output sequence that will be generated by the current configuration.
5. The **Add** button will save the current channel configuration and enables a new channel to be configured. The **Close** button will close the window without saving the current channel configuration.

4.2.2 Channel Options Section

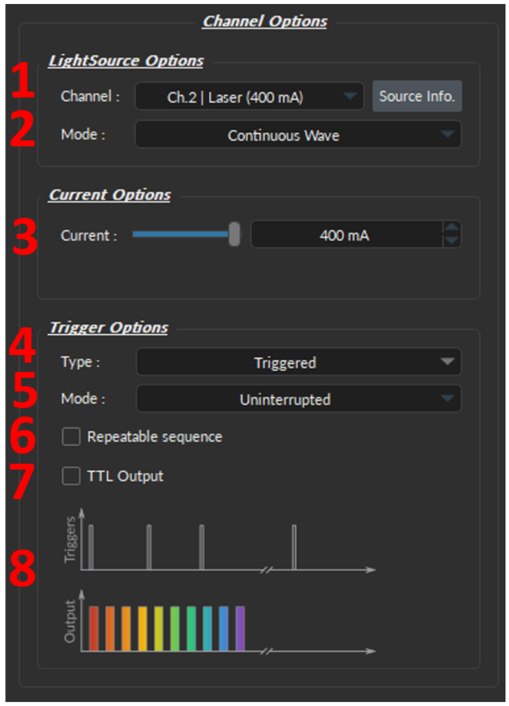


Figure 4.7: *Channel Options of the Channel Configuration Window*

The Channel Option section (Fig. 4.7) is separated into 3 sub-sections, the **Light Source Options** section that defines the channel and its mode, the **Current Options**, and the **Trigger Options** section that controls the trigger method of the selected channel.

Light Source Options

1. The **Channel** field identifies which of the available channels is currently being modified. The Light Source can be changed by selecting a new one from the drop-down list.

2. The **Mode** field identifies the mode used to generate the light. Five modes are available, **Continuous Wave** (fix current), **External TTL** (external digital command), **External Analog** (external analog command), **Square Sequence(s)** (internal digital command), **Complex Sequences(s)** (internal analog command) and **Custom File sequense(s)**. Each mode enables different options in the Sequence Option section that are explained in more detail in section 4.2.3.

Current Options

3. The **Current Options** includes the slider used to control the current sent to the light source.

Some other options can be available depending on the light source:

- The **Overdrive** checkbox appears when the light source is compatible with the overdrive option. When selected, this allows the system to exceed the normal safe current limit of the light source. **THIS SHOULD ONLY BE USED WITH PULSED SIGNALS, AS IT CAN OTHERWISE DAMAGE THE LIGHT SOURCE.**

- When using a *CLED* module, a *CLED_HP* module or a *LEDFLS* module, the **Low-Power** checkbox will appear. When selected, this allows reduced-power signaling for the same voltage. This allows low-power signals to be more stable in time. The maximal current is reduced to one-tenth of the light source's normal maximal current. If the **BNC Output** is used to monitor the LED power, its output voltage is proportional to the current passing through the light source, and not the voltage sent to it. For example, a driver with a normal maximum current of 2000 mA for a 5 V signal (400 mA/V) will have a maximum current of 200 mA for a 5 V signal (40 mA/V) in low power mode. The **BNC output** of the driver will still relate the LED current with a 400 mA/V conversion factor.

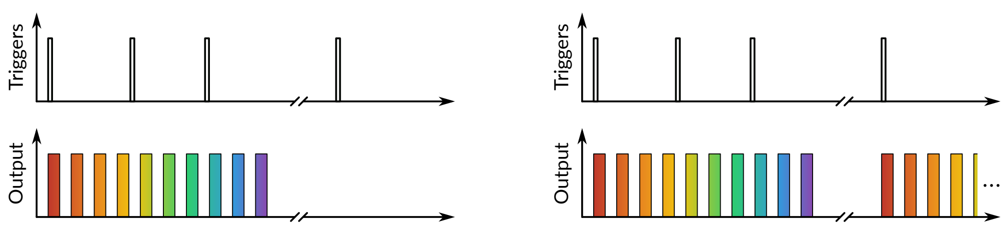
- In External Analog mode, the current is set at the maximum current and can't be changed.

Trigger Options

4. The **Type** defines the type of trigger that is used to start/stop a sequence. The **Triggered** type can start and stops a sequence at a rising edge while the **Gated** type can start the sequence at a rising edge and stops it at a falling edge. A more refined interaction of the trigger with the defined sequence can be set up using the **Mode** field. Not all Trigger Types are available for each combination of Trigger Mode and Repeatability. The different combinations are shown in Figure 4.12.

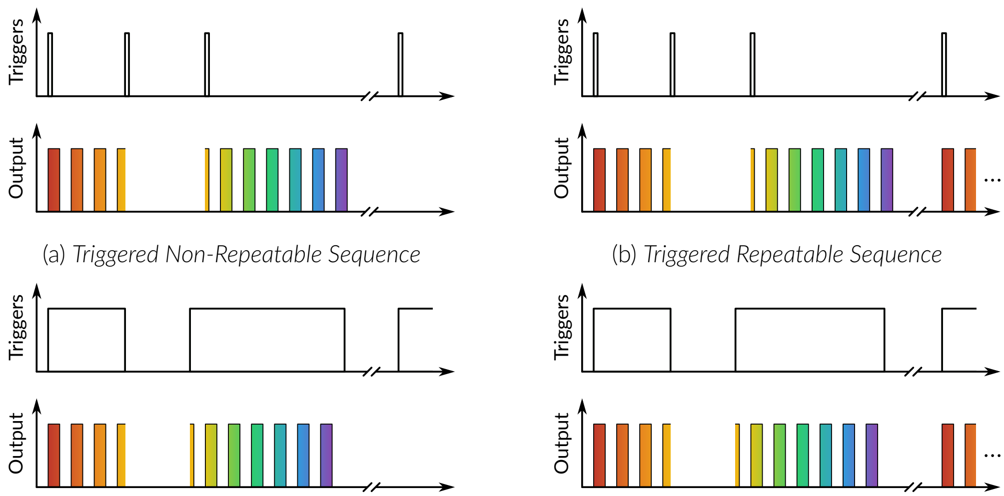
5. The **Mode** field defines how the trigger activates a sequence. Each mode is not compatible with each combination of trigger type and repeatability. Figure 4.12 shows the different available combinations for the different Trigger Modes. Four Modes are available and are the following:

   - **Uninterrupted**: This mode activates the channel sequence when an input greater than 3.3 V is detected by the BNC input. Following input pulses will be ignored while the sequence is running (Fig. 4.8). When the **Repeatable sequence** checkbox is checked, the sequence will restart with the arrival of the first input pulse after the sequence has finished (Fig. 4.8b). This mode is available for *Triggered* pulse only.
   - **Pause**: This mode activates the channel sequence when a rising edge greater than 3.3 V is detected on the BNC input (Fig. 4.9). Following input pulses (when *Triggered*, Fig. 4.9a) or falling edge (when *Gated*, Fig. 4.9c) will pause the sequence and the sequence will continue when the next rising edge is received. When the **Repeatable sequence** checkbox is checked, the sequence will restart with the arrival of the first input pulse after the sequence has finished (Figs. 4.9b and 4.9d).
   - **Continue**: This mode activates the channel sequence when a rising edge greater than 3.3 V is detected on the BNC input (Fig. 4.10). The following input pulse (when *Triggered*, Fig. 4.10a) or a falling edge (when *Gated*, Fig. 4.10c) will turn off the output, but the sequence will continue. The output will be turned back on at the reception of the following rising edge. Triggers only affect the output voltage value. When the **Repeatable sequence** checkbox is checked, the sequence will restart with the arrival of the first input pulse after the sequence has finished (Figs. 4.10b and 4.10d).
   - **Restart**: This mode activates the channel sequence when a rising edge higher than 3.3 V is detected on the BNC input. The following input pulse (when *Triggered*, Fig. 4.11a) or falling edge (when *Gated*, Fig. 4.11b) will stop the sequence and the sequence will restart from the beginning when the next rising edge is received. When the sequence is completed, it will restart with the next input pulse.



(a) *Triggered Non-Repeatable Sequence* (b) *Triggered Repeatable Sequence*

Figure 4.8: *Uninterrupted Sequence Mode*



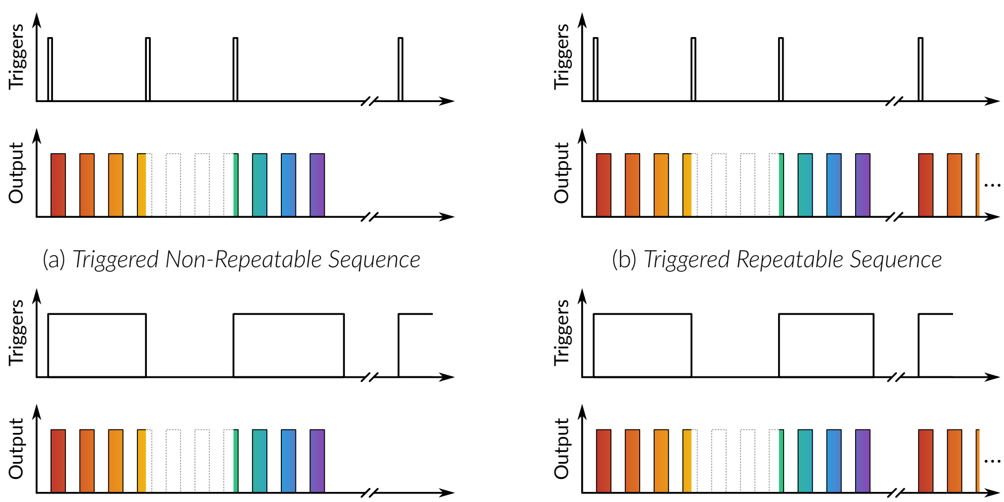
(a) *Triggered Non-Repeatable Sequence*

(b) *Triggered Repeatable Sequence*

(c) *Gated Non-Repeatable Sequence*

(d) *Gated Repeatable Sequence*

Figure 4.9: *Pause Sequence Mode*



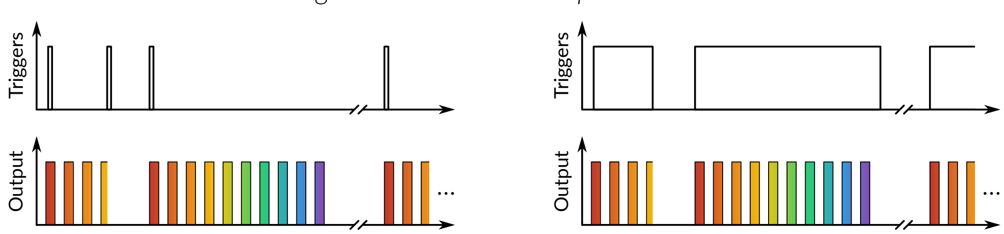
(a) *Triggered Non-Repeatable Sequence*

(b) *Triggered Repeatable Sequence*

(c) *Gated Non-Repeatable Sequence*

(d) *Gated Repeatable Sequence*

Figure 4.10: *Continue Sequence Mode*



(a) *Triggered Repeatable Sequence*

(b) *Triggered Gated Sequence*

Figure 4.11: *Restart Sequence Mode*

6. The **Repeatable sequence** checkbox, when selected, allows a sequence to be repeated. Not all modes and trigger types can be repeated. Please refer to Figure 4.12 to know the repeatable sequence combinations.
7. The **TTL Output** checkbox, when selected, allows the output BNC channel to be used as a TTL generator. The monitoring signal will provide a TTL signal instead of an analog voltage output proportional to the LED current. The output will send out a 5 V signal whenever the input current is >0 mA. This can be used even if a light source is not connected.

8. The **Sequence Visualisation** shows a graphical representation of the behavior of the selected Trigger Option Type, Mode, and Repeatability.

	Triggered		Gated	
	Non-repeatable sequence	Repeatable sequence	Non-repeatable sequence	Repeatable sequence
Uninterrupted	✓	✓		
Pause	✓	✓	✓	✓
Continue	✓	✓	✓	✓
Restart		✓		✓

Figure 4.12: *Trigger options possibilities*

4.2.3 Sequence options

The **Sequence options** box (Fig. 4.6, number 3) is where sequence options are defined depending on the mode. The **Continuous wave, External TTL** and **External Analog** modes have no additional sequence options.

Continuous Wave

The **Continuous Wave** mode (Fig. 4.13) produces a continuous signal at the chosen current. This mode can only be triggered manually. When this mode is active, the driver channel will show **CW** under **MODE**. This mode has no additional sequence options.

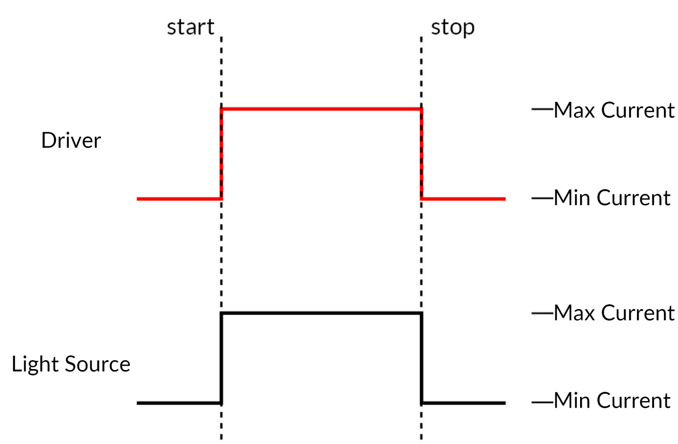


Figure 4.13: *Constant Current Mode Driver Signal*

External TTL

The **External TTL** mode (Fig. 4.14) has the light source follow a TTL signal provided by an external source connected to the **BNC Input**. When this mode is active, the driver channel will show **ExTTL** under **MODE**. This mode has no additional sequence options.

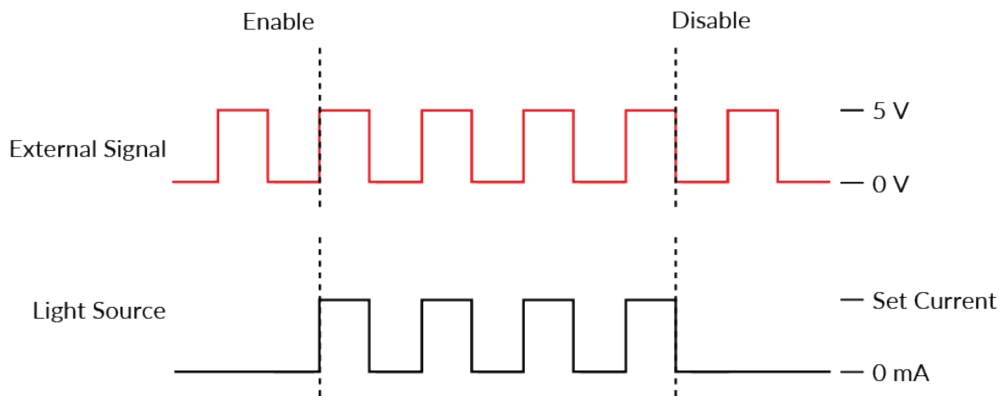
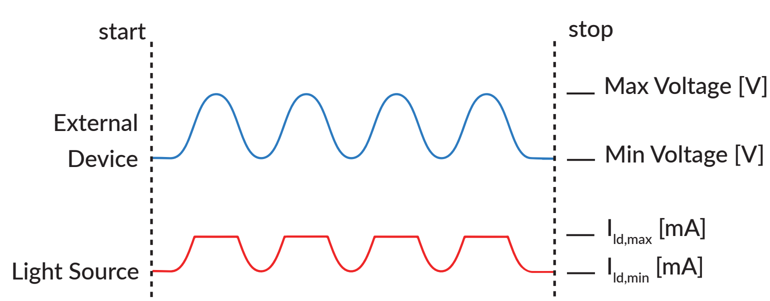


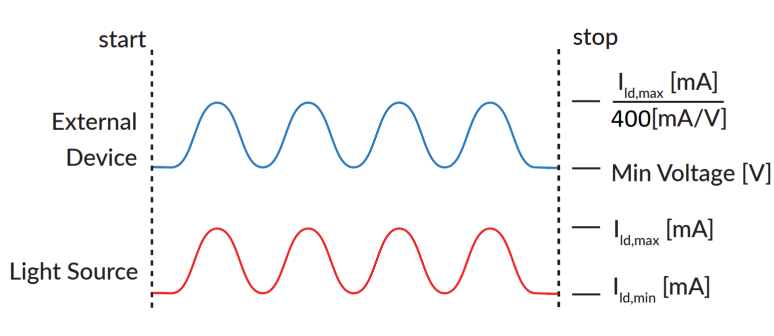
Figure 4.14: *Driver Signal Response to External Source in External TTL Mode*

External Analog

The **External Analog** mode is similar to the **External TTL**, except that the driving current is proportional to the voltage applied to the BNC input connector (Fig. 4.15b). On the input BNC, a maximum voltage signal corresponds to a maximum of 400 mA current. Most laser light sources have a maximum current below this value which could result in a clipping to the output signal (see Fig. 4.15a).



(a) *Clipping of light source current output*



(b) *Adjusted tension to maximum current*

Figure 4.15: *External Analog output is proportional to the External Device voltage*

To avoid this clip on the output waveform the maximum voltage setting must be equal to the maximal current divided by 400 mA/V (the value of the relationship between current and input voltage) (Fig. 4.15b). For square modulations, it is preferable to use External TTL mode instead of External Analog mode.

Square Sequences

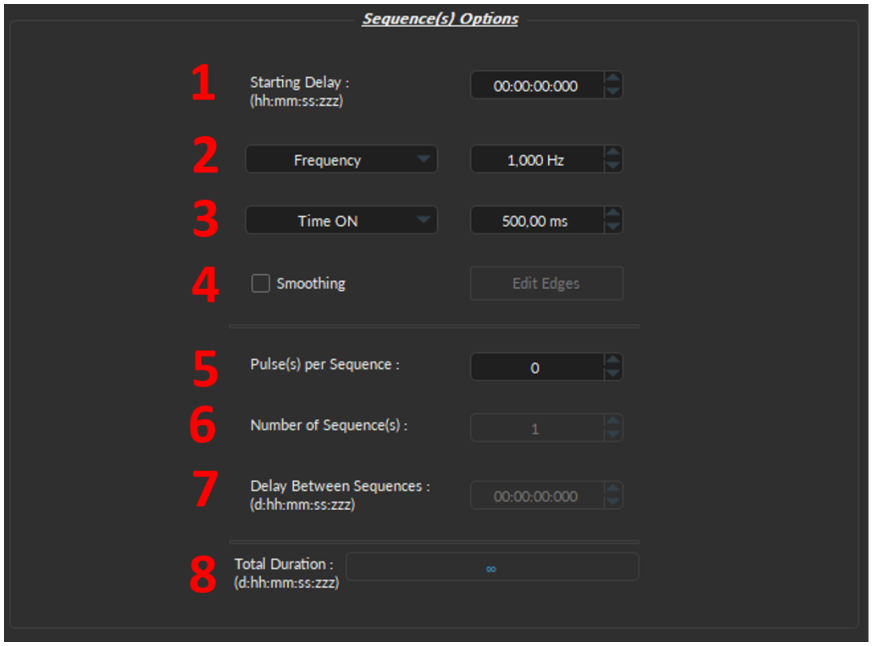


Figure 4.16: *Light Source Channel Configuration Window, Square Sequence Options*

The **Square Sequences** mode has the light source following a square pulse sequence.

1. The **Starting Delay** (Fig. 4.16) sets the delay (in hh:mm:ss:zzz format) before the first pulse.

2. The **Frequency/Period** (Fig. 4.16) sets the frequency (in Hz) or period (in ms) for the pulse sequence. For example, a signal at 10 Hz (frequency) will output one pulse every 100 ms (period), whereas a pulse sequence at 0.5 Hz (frequency) will output one pulse every 2000 ms (period).

3. The **Time ON/Duty Cycle** (Fig. 4.16) sets the time (in ms) or the duty cycle (in %) for each pulse. The **Time ON** must be lower than (1/frequency)+0.005 ms, while the **Duty cycle** must be below 100 %. These squares will appear red should an impossible **Frequency**/**time ON** be selected. Should the **Smoothing** option be selected, this feature becomes inaccessible.

4. The **Smoothing** option is used to change the pulse slope in square pulse sequences. The **Edit Edges** button opens the **Smoothing Edge(s)** window (Fig. 4.17).

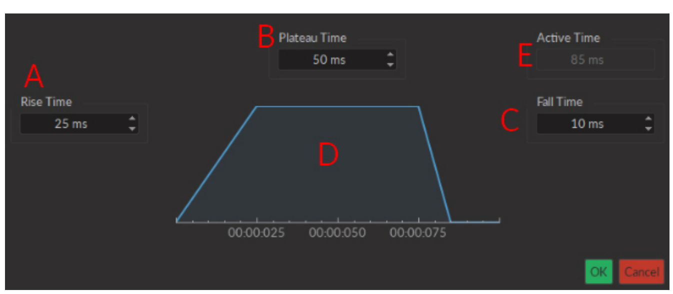


Figure 4.17: *Light Source Smoothing Edge(s) Window*

a) The **Rise Time** box is used to define the duration to rise from 0 to the pulse maximum.
b) The **Plateau Time** box is used to define the duration the pulse is at its maximum value.
c) The **Fall Time** box is used to define the duration to descend from the pulse maximum to 0.

d) The **Pulse Graph** displays the pulse shape.

e) The **Active Time** box displays the total duration of the pulse. While the **Smoothing** option is active, the **Time ON** is fixed at this value.

5. The **Pulses per sequence** (Fig. 4.16) sets the number of pulses per sequence. If it is set to 0, the pulse will be repeated indefinitely.
6. The **Number of sequences** (Fig. 4.16) sets the number of times that the sequence will be repeated. If it is set to 0, the sequence will be repeated indefinitely.
7. The **Delay between sequences** (Fig. 4.16) sets the delay (in hh:mm:ss:zzz format) between each sequence if the **Number of Sequences** is greater than 1.
8. The **Total Duration** (Fig. 4.16) displays the total time of the experiment. The different values can be *Inf* for infinite, a valid time value or *Err* if the **Time ON** value is greater than 1/frequency.

Complex Sequences

The **Complex Sequences** mode allows the design of complex pulse sequences. Multiple sequences can be combined to create a more elaborate pulse sequence. These are displayed in a spreadsheet format.

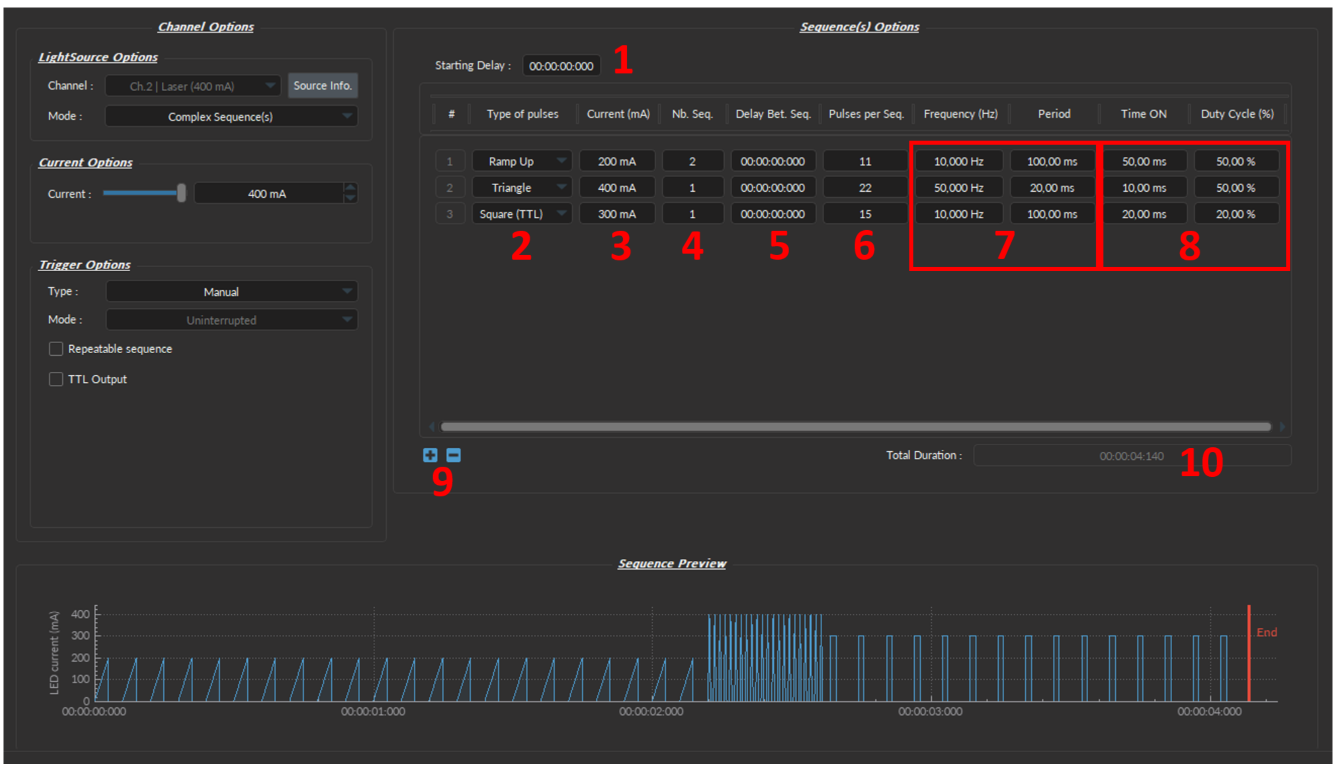


Figure 4.18: *Complex Sequences Window*

1. The **Starting Delay** (Fig. 4.18) sets the delay (in hh:mm:ss:zzz format) before the first pulse sequence.
2. The **Types of pulses** (Fig. 4.18) sets the pulse type. Pulses can be **Square**, triangular (**Triangle**), **Ramp up Ramp down** or **Delay**. The **Delay** pulse type is used to create a delay between different sequences.
3. The **Max Current** (Fig. 4.18) sets the maximum current (in mA) for the given sequence.
4. The **Number of sequences** (Fig. 4.18) sets the number of times that the sequence will be repeated, with a minimum of 1.
5. The **Delay between sequences** (Fig. 4.18) sets the delay (in hh:mm:ss:zzz format) between each sequence if the **Number of Sequences** is greater than 1.

6. The **Pulses per sequence** (Fig. 4.18) sets the number of pulses per sequence, with a minimum of 1.
7. The **Frequency/Period** (Fig. 4.18) sets the frequency (in Hz) or period (in ms) for the pulse sequence. These two values are linked, and when one is changed the other will adjust automatically. For example, a signal at 10 Hz (frequency) will output one pulse every 100 ms (period), whereas a pulse sequence at 0.5 Hz (frequency) will output one pulse every 2000 ms (period).
8. The **Time ON/Duty Cycle** (Fig. 4.18) sets the time (in ms) or the duty cycle (in %) for each pulse. These two values are linked, and when one is changed the other will adjust automatically. The **Time ON** must be lower than (1/frequency)+0.005 ms, while the **Duty cycle** must be below 100 %.
9. The **Sequence controls** (Fig. 4.18) allow the addition (**+**) or removal (**-**) of sequences to the spreadsheet.
10. The **Total Duration** (Fig. 4.18) displays the total time of the experiment. The different values can be *Inf* for infinite, a valid time value or *Err* if the **Time ON** value is greater than 1/frequency.

Custom File Sequence(s)

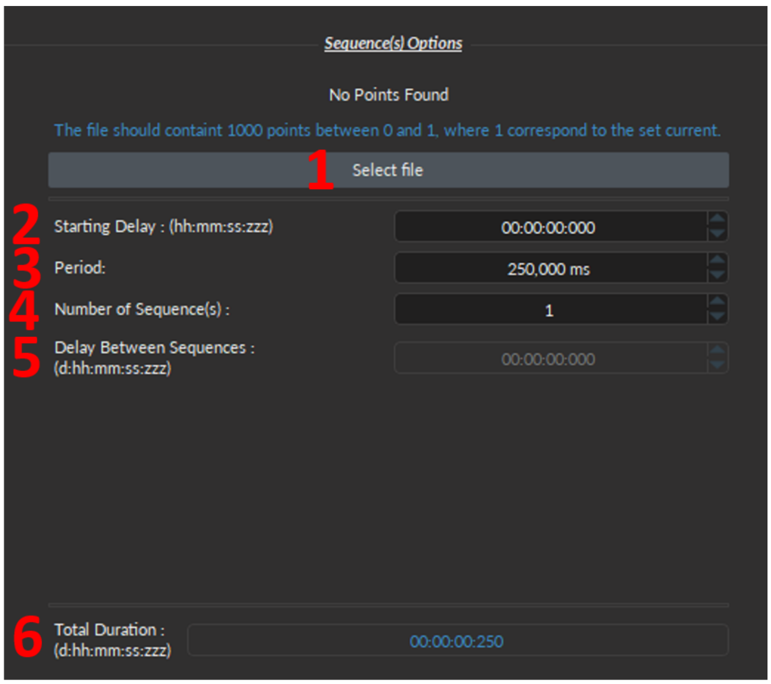


Figure 4.19: *Light Source Channel Setup Window, Custom Sequence File Mode*

1. The **Select file** button allows to import a CSV file with 1000 values between 0 and 1 contained in one column.

   Notes:

   - If the file contains less than 1000 values, the missing data will be replaced by 0 to reach the 1000 values.
   - If the file contains more than 1000 values, the extra values will be ignored.
   - If the file contains negative values, they will be set to 0.
   - If the file contains values greater than 1, they will be reduced to 1.
2. The **Starting Delay** (Fig. 4.19) sets the delay (in hh:mm:ss:zzz format) before the first pulse sequence.
3. The **Period** (Fig. 4.19) sets the period (in ms) for the pulse sequence contained in the file.
4. The **Number of Sequences** (Fig. 4.19) sets the number of times that the sequence will be repeated, with a minimum of 1.

5. The **Delay Between Sequences** (Fig. 4.19) sets the delay (in hh:mm:ss:zzz format) between each sequence if the **Number of Sequences** is greater than 1.

6. The **Total Duration** (Fig. 4.19) displays the total time of the experiment. The displayed values can be *Inf* for infinite or a valid time value.

4.2.4 Preview

The **Preview** box (Fig. 4.6, number 4) displays a preview of the chosen sequence while in the **Continuous Wave**, **Square Sequences**, **Complex Sequences** and **Custom File Sequence(s)** mode.

4.3 Acquisition view

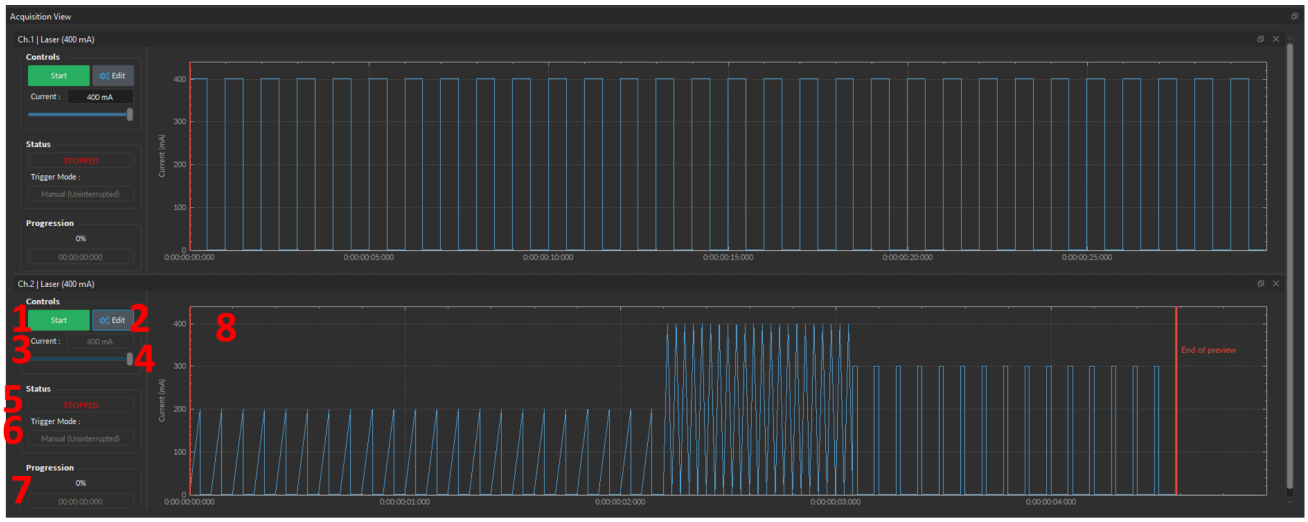


Figure 4.20: *Acquisition View, Light Source Channel*

The **Acquisition View** box is used to display information related to the usage of each channel. This section allows limited control of the light source while it is active. The elements displayed to control and configure the channels are explained below.

1. The **Start/Stop** button activates/deactivates the light source connected to the **Light Source Channel**.

2. The **Edit** button opens the **Channel configuration** window to edit the pulse sequence. This button is only accessible when the channel is deactivated.

3. The **Current** box allows the current to be changed exactly (in mA).

4. The **Current Slider** allows the light source current to be adjusted.

5. The **Status** box displays the status of the channel. The **Status** will display RUNNING... when active and STOPPED when deactivated.

6. The **Trigger Mode** of the light source is displayed in this box.

7. The **Progression** box displays the progression of the pulse sequence. The advancement of the sequence is displayed in % on the **Progression bar**, and in hh:mm:ss:zzz format on the **Time Elapsed** box.

8. The **Graph View** displays either a preview of the pulse sequence for **Light Source Channels**.

5 Specifications

5.1 General specifications

Table 5.1: *Recommended Environmental specifications*

SPECIFICATION	OPERATION	STORAGE
Use	Indoor	Indoor
Temperature	20°C to 30°C	-20°C to +60°C
Humidity	40-60 % RH, non condensing	40-60 % RH, non condensing

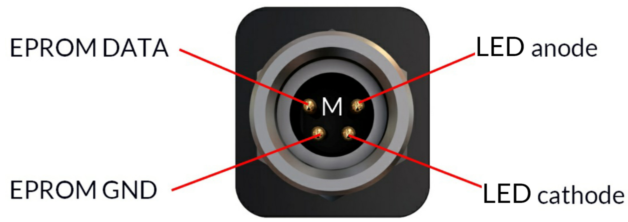


Figure 5.1: *M8 Male Pinout (light source)*

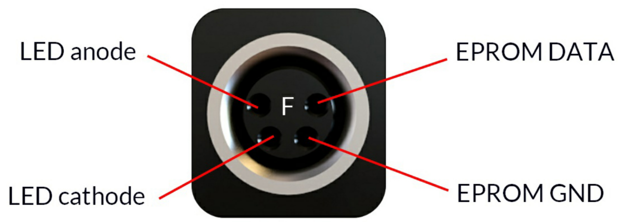


Figure 5.2: *M8 Female Pinout (LED Driver)*

Table 5.2: *General Specifications for Connectorized LEDs*

SPECIFICATION	VALUE	NOTE
Input Current	Min: 0 mA - Max: see Table 5.10	700 mA recommended for 1000mA max current LEDs
Forward Voltage	3.0 - 4 V Typical	
Dimensions	63 x 59 x 21 mm	Without cable, with baseplate
Mass	∼100 g	
CLED cable connector	M8-4pins - Male	See Fig. 5.1
Output NA	0.55	NA of up to 0.63 NA will slightly increase power
Output optical fiber core diameter	<960 µm	Power scales up to this core diameter
Maximum Output Power	See Datasheet	

Table 5.3: *General Specifications for Connectorized High Power LEDs*

SPECIFICATION	VALUE	NOTE
Input Current	Min: 0 mA - Max: see Table 5.9	2000mA max in overdrive
Forward Voltage	3.0 - 4 V Typical	
Dimensions	86 x 53 x 51 mm	Without cable, with baseplate
Mass	∼170 g	
CLED cable connector	M8-4pins - Male	See Fig. 5.1
Output NA	0.7	
Output optical fiber core diameter	<1500 µm	Power scales up to this core diameter
Maximum Output Power	See Datasheet	

Table 5.4: *General Specifications for Combined LEDs*

SPECIFICATIONS	VALUE	NOTES
Input current	Min: 0 mA - Max: see Table 5.8	700 mA recommended for 1000mA max current LEDs
Forward voltage	3.0 - 4.0 V typical	-
Emission power	See Datasheet	-
Emission wavelength	See Datasheet	-
LED connector	M8-4 Pins-Male	See Fig. 5.1
Dimensions		
2-LED model	42 x 98 x 110 mm	without holder
3- and 4-LED model	42 x 126 x 115 mm	without holder
Mass		
2-LED model	370 g	without holder
3-LED model	500 g	without holder
4-LED model	500 g	without holder
Output NA	0.5	-
Output optical fibre core diameter	<960 µm	Power scales up to this core diameter

Table 5.5: *General Specifications for LEDFRJ*

SPECIFICATIONS	VALUE	NOTES
Input Current	0-1000 mA	700 mA recommended for 1000mA max current LEDs
Forward Voltage	3.0-4.0 V typical	-
Emission Power	See Datasheet	-
Emission wavelength	See Datasheet	-
Start-Up Torque	<20 µN·m	-
Electrical connector	M8-4 pins-Male	-
Dimensions		
Single LED model	70 x 39 x 39 mm	without holder
2-LED model	102 x 127 x 135 mm	including holder
3- and 4-LED model	102 x 132 x 139 mm	including holder
Mass		
Single LED model	90 g	without holder
2-LED model	370 g	without holder
3-LED model	500 g	without holder
4-LED model	500 g	without holder
Output NA	0.5	-
Output optical fibre core diameter	<960 µm	Power scales up to this core diameter

Table 5.6: *General Specifications for LEDFLS*

SPECIFICATION	VALUE	NOTE
Power supply	110 - 240 VAC; 50 - 60 Hz	Power supply adapter included
DC power supply	12 VDC	36 W (1-2-ch), 60 W (4-ch)
Mass		
1-channel model	580 g (1.28 lbs)	
2-channel model	757 g (1.67 lbs)	
4-channel model	1155 g (2.55 lbs)	
Dimensions (L x H x D)		
1-channel model	183 x 58 x 105 mm	Including aperture
2-channel model	239 x 58 x 105 mm	Including aperture
4-channel model	357 x 58 x 105 mm	Including aperture
TTL input voltage	0 to +5 V	Min Hi Level: 2.8 V; Max Low Level: 2.3 V
Analog input voltage	400 mA/V light source current	
	40 mA/V light source current	Low power mode enabled
BNC output voltage	2.5 V/A	
Output Current	4 - 200 mA	Low Current Mode
	40 - 2000 mA	Normal Mode
Maximum forward voltage to LED	7 V	
Display current accuracy	2% @ maximum rated current	Error increases at lower current.
Current adjustment steps	1 mA	
Rise/Fall time	<10 µsec	Typical
Minimum Modulation Frequency	0.01 Hz	
Maximum Modulation Frequency	10 kHz	-3 dB attenuation
Minimum ON or OFF time	50 µs	
Maximum ON or OFF time	100 s	
Maximum of pulses per sequence	65535	
Maximum of sequences	65535	
Output NA	0.55	NA of up to 0.63 NA will slightly increase power
Output optical fiber core diameter	<960 µm	Power scales up to this core diameter

Table 5.7: *General specifications for LED Drivers*

SPECIFICATION	VALUE	NOTE
Power supply	110 - 240 VAC; 50 - 60 Hz	Power supply adapter included
DC power supply	12 VDC	36 W (1-2-ch), 60 W (4-ch)
Mass		
1-channel model	580 g (1.28 lbs)	
2-channel model	757 g (1.67 lbs)	
4-channel model	1155 g (2.55 lbs)	
Dimensions (L x H x D)		
1-channel model	185 x 58 x 105 mm	Including connectors
2-channel model	239 x 58 x 105 mm	Including connectors
4-channel model	357 x 58 x 105 mm	Including connectors
TTL input voltage	0 to +5 V	Hi Level>2.8 V; Low Level<2.3 V
Analog input voltage	400 mA/V light source current	Normal Mode 2000 mA LED Driver
	40 mA/V light source current	Low current Mode (*)
Analog input voltage range	Min: 0.1 V Max: 5 V	40 to 2000 mA
		4 to 200 mA (Low current Mode (*))
BNC output voltage	2.5 V/A	
Output current	4 - 200 mA	Low current Mode
	40 - 2000 mA	Normal Mode
Maximum forward voltage to LED	7 V	
Display current accuracy	2% @ maximum rated current	Error increases at lower current.
Current adjustment steps	1 mA	
Rise/Fall time	<10 µs	Typical
Minimum Modulation Frequency	0.01 Hz	
Maximum Modulation Frequency	10 kHz	-3 dB attenuation
Minimum ON or OFF time	50 µs	
Maximum ON or OFF time	100 s	
Maximum of pulses per sequence	65535	
Maximum of sequences	65535	

5.2 Power Tables

Table 5.8: *Typical Connectorized LED, LEDFRJ1 and LEDFLS Output Power vs Optical Fiber Core Diameter*

LED			**TYPICAL OUTPUT POWER @ Max current (mW)**			**Overdrive @2000 mA (pulsed)**
Central Wavelength (nm)	**Bandwidth FWHM (nm)**	**Bandwidth FWHM (nm)**	**Core 200 µm 0.57 NA**	**Core 400 µm 0.57 NA**	**Core 960 µm 0.63 NA**	
365	∼12	500	4.0	12	75	1
385	∼12	500	6.0	23	100	1
405	∼12	500	5.0	20	90	1
420	∼15	500	5.5	23	100	1
450	∼22	1000	8.0	23	100	x1.7
465	∼25	1000	8.5	30	140	x1.7
505	∼30	1000	3.0	16	70	x1.6
515	∼40	1000	3.0	9.5	40	x1.5
560	∼100	1000	2.0	10	60	-
595	∼15	1000	2.0	8.5	40	x1.2
625	∼17	1000	3.5	14	70	x1.6
635	∼20	1000	6.5	25	100	x1.6
850	∼30	1000	6.0	22	40	-
940	∼35	1000	5.0	20	40	-
5500K	-	1000	10	45	200	-

Table 5.9: *Typical Connectorized High Power LED vs Optical Fiber Core Diameter*

LED			**TYPICAL OUTPUT POWER @ Max current (mW)**			**Overdrive @2 A (pulsed)**
Central Wavelength (nm)	**Bandwidth FWHM (nm)**	**Maximum Current (mA)**	**Core 200 µm 0.57 NA**	**Core 400 µm 0.57 NA**	**Core 960 µm 0.63 NA**	
450	∼21	1500	12	50	250	x1.25
475	∼24	1500	10	40	230	x1.25
560	∼100	1500	10	40	220	x1.25

Table 5.10: *Typical Combined LEDs and Combine LED with Fiber-optic Rotary Joints Output Power vs Optical Fiber Core Diameter*

LED			TYPICAL OUTPUT POWER at max current (mW)		
Central Wavelength (nm)	**Bandwidth FWHM (nm)**	**Maximum Current (mA)**	**Core 200 µm 0.57 NA**	**Core 400 µm 0.57 NA**	**Core 960 µm 0.63 NA**
365	∼12	500	4.0	16	40
385	∼12	500	5.0	20	80
405	∼15	500	3.2	14	35
420	∼15	500	4.5	18	45
450	∼25	1000	6.0	24	70
465	∼25	1000	6.0	24	70
505	∼30	1000	2.5	10	35
515	∼40	1000	2.5	10	35
560	∼100	1000	1.5	6.0	20
595	∼20	1000	1.3	5.0	13
625	∼20	1000	2.8	10	50
635	∼20	1000	5.0	20	50
850	∼35	1000	5.0	18	30
940	∼35	1000	1.6	8.0	30

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Support

6.1 Maintenance

The product does not require any maintenance. Do not open the enclosure. Contact Doric Lenses for return instructions if the unit does not work properly and needs to be repaired.

6.2 Warranty

This product is under warranty for a period of 12 months. Contact Doric Lenses for return instructions. This warranty will not be applicable if the unit is damaged or needs to be repaired as a result of improper use or operation outside the conditions stated in this manual. For more information, see our Website.

6.3 Disposition

Figure 6.1: *WEEE directive logo*

According with the directive 2012/19/EU of the European Parliament and the Council of the European Union regarding Waste Electrical and Electronic Equipment (WEEE), when the product will reach its end-of-life phase, it must not be disposed with regular waste. Make sure to dispose of it with regards of your local regulations. For more information about how and where to dispose of the product, please contact Doric Lenses.

6.4 Contact us

For any questions or comments, do not hesitate to contact us by:

Phone 1-418-877-5600

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