doric

Ce:YAG + LED/LD Fiber Light Source

User Manual

Version 2.2.1

Contents

1 Important Safety Information

1.1 General Safety Information

The *Ce:YAG + LED/Laser Optical Head* is a new type of optical source which, in addition to the laser-pumped Ce:YAG crystal fluorescence output, can also include standard LED or laser diode outputs. This type of hybrid light source is not specifically considered by international safety committees such as the IEC[1] and the FDA[2]. Consequently, the user should follow all safety procedures related to the worst case scenario, either in working or failure condition. Considering the power level of the fluorescence output of the *Ce:YAG + LED/Laser Optical Head*, this means following Class 3B laser product safety rules even though the output does not necessarily contain laser radiation, depending on the exact model and output filter. The next section on laser safety information should thus be **read and carefully followed**.

1.2 Laser Safety Information

If you are not familiar with laser light sources, ask for advice to qualified personnel **BEFORE FIRST USE** and **READ CAREFULLY** the application note ***Important Laser Safety Information*** that can be found on the USB key. You can also contact directly Doric Lenses by email (sales@doriclenses.com) to obtain a copy of this application note.

DANGER!
The *Laser Diode Module* is a Class 3B laser product.
Read the application note *Important Laser Safety Information*
BEFORE FIRST USE.

The *Ce:YAG + LED/Laser Optical Head* is a Class 3B laser product emitting visible light at sufficiently high power levels to **PERMANENTLY DAMAGE THE EYES. NEVER LOOK** directly into the optical beam exiting from the output FC connector or from any optical fiber connected to the output FC connector. **NEVER LOOK** directly at specular or diffuse reflections of the output beam. It is important to **WEAR LASER SAFETY GLASSES** (goggles) certified for the wavelength and power level of the light source. Also follow all safety procedures to protect anyone working in the area. Even when wearing laser safety glasses, **NEVER LOOK** directly into the beam or any specular reflection of the optical beam exiting from the *Ce:YAG + LED/Laser Optical Head* or from any optical fiber connected to its output FC connector. The *Ce:YAG + LED/Laser Optical Head* is provided with a safety interlock connector on the rear panel. When the interlock circuit is shorted and the power key is inserted, the driver is enabled (see Section 2.2). For a safe use of the *Ce:YAG + LED/Laser Optical Head*, the safety interlock connector should be connected to the laser safety interlock circuit of the laboratory. You should contact the laser safety officer (LSO) of your institution or company to set a proper laser safety interlock circuit for your application and laboratory installation. The *Ce:YAG + LED/Laser Optical Head* emits light spanning over a large bandwidth in the visible light spectrum. Since the output spectrum depends on the exact model and optional output filter, the output power level and the according safety procedures are specific to each application.

[1] International Electrotechnical Commission
[2] Food and Drug Administration

1.3 Safety Labels

The laser class labels are provided with the system and the laser aperture is clearly identified by laser warning label and/or the text *LASER APERTURE*.

(a) *Laser Classification Label Example*

(b) *Laser Warning Label*

LASER APERTURE

(c) *Laser Aperture Identification*

Figure 1.1: *Safety Labels*

1.4 Activation Safety Features

The drivers for all Doric Lenses light sources come with a number of safety features. These are built into the driver circuits, as shown in the block diagram (Fig. 1.2).

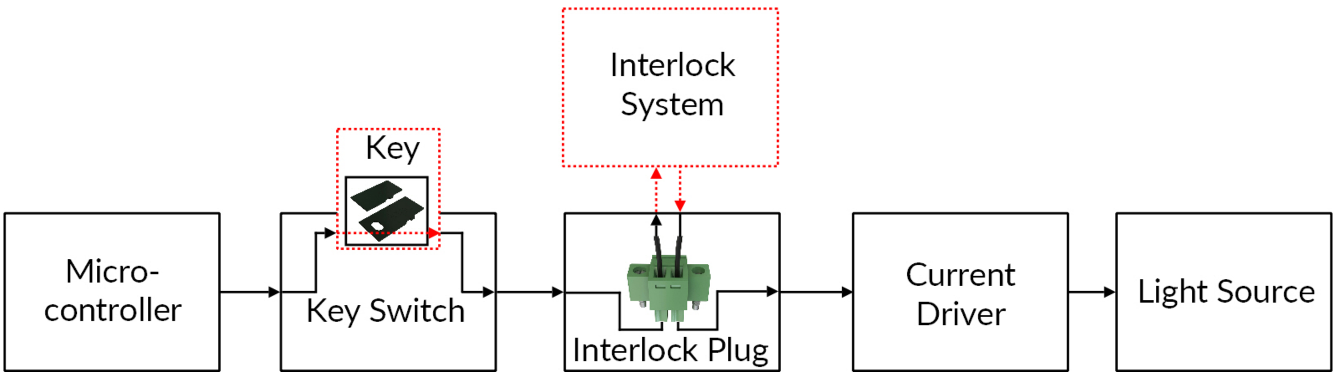
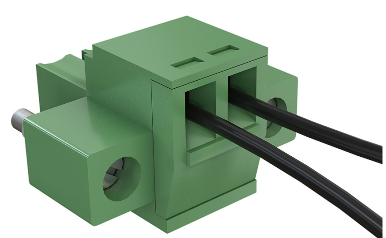


Figure 1.2: *Safety feature block diagram*

- The **Micro-controller**, **Key Switch**, **Interlock Plug** and **Current Driver** are connected in series. This means that if any single safety feature is not properly in place, the light source cannot be activated.
- The **Micro-controller** is used to control the light source driver.

(a) *Key Switch*



(b) *Interlock Plug*

Figure 1.3: *Safety Feature Elements*

- The **Key Switch** (Safety feature 1) (Fig. 1.3a), 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. 1.3b) 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.

1.5 Emission Indicator

For light sources emitting invisible laser radiation, a dedicated LED indicator is ON when the driver is outputting an electrical current. When the driver is outputting current, the light source will emit light from the aperture.

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Overview

2.1 Operating Principle

The Doric *Ce:YAG* light source is inspired by the "white" LED concept. LEDs (Light Emitting Diodes) are solid state light sources emitting light by the direct conversion of an electric current passing through a semiconductor junction. LEDs are now available at many central wavelengths and bandwidths. Properly speaking, no LEDs can emit over the entire visible spectrum to produce white light. Many so-called "white" LEDs are in fact a combination of a blue LED and a fluorescent crystal. A part of the blue LED light is absorbed by a Cerium doped Yttrium Aluminum Garnet crystal (shortly: Ce:YAG crystal) which, after absorption of blue light, spontaneously re-emits over a significant part of the visible spectrum, mostly green, yellow and red light. The combination of the green-yellow-red fluorescence and the unabsorbed blue light from the pumping LED results in white light.

"White" LEDs are designed for energy efficient white lighting applications. For scientific applications involving optical fiber coupling, high spectral brightness (W/mm^2/sr/nm) sources are required. In order to increase the spectral brightness, the "white" LED operating principle must be scaled in term of pump power. The power scaling first requires a higher brightness pump source emitting blue light. In the Doric *Ce:YAG* light source, high power blue laser diodes (LDs) emitting at 450 nm are used to provide a much smaller pumped volume of the Ce:YAG crystal. Such a direct power scaling of the pumping source leads to thermal failures. Indeed, a high brightness pumping leads to a local heating of the Ce:YAG crystal. When the crystal temperature locally reach about 400°C, a phenomenon called "temperature quenching" leads to a significant drop of the fluorescent emission due to non radiative relaxation of blue-light excited Ce^{3+} ions. The temperature increase ultimately leads to a catastrophic failure of the crystal. Heat generated by high brightness pumping thus have to be managed properly using passive/active cooling and crystal geometry.

The *Ce:YAG* light source emits over a broad and continuous visible light spectrum. A typical fluorescence spectrum of a Ce:YAG crystal is shown in Fig. 2.1. The source thus provides a speckle-free light beam at the output of multimode optical fibers. Also, direct modulation of the emitted light intensity is easily achieved through the modulation of the injection current of all pump laser diodes, and this, without any detrimental spiking like with diode-pumped solid-state (DPSS) laser systems.

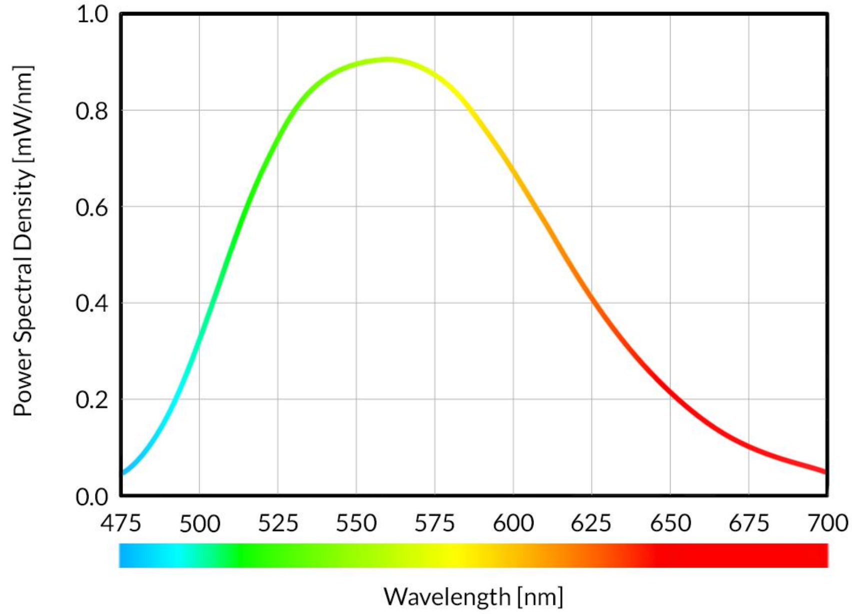


Figure 2.1: *Output Power Spectral Density of a Ce:YAG Optical Head using 200 µm, 0.53 NA Fiber*

2.2 Overview

The *Ce:YAG + LED/LD Fiber Light Source* includes two main components: the **Ce:YAG Optical Head** (Fig. 2.2) and the **Ce:YAG + LED/LD Driver** (Fig. 2.4).

2.2.1 Ce:YAG + LED/LD Optical Head

The Doric *Ce:YAG + LED/LD Optical Head* includes a laser or LED light source combined with the Ce:YAG light source (Fig. 2.2a). The light from both sources are mixed using an optical combiner. The *Ce:YAG + LED/LD Optical Head* is considered a Class 3B laser product. It is critical to follow the safety instructions stated in this manual. The light source has the following elements.

- The **Beam Aperture** 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 optical head to block the output light beam in absence of optical fiber.
- The **Fan Grids** are found on the top, rear and side of the light source. They must be kept clear at all times to avoid overheating the system.
- The **Removable Filter Holder** is used to insert an optical bandpass filter in the system, allowing the selection of a narrow part of the broad Ce:YAG spectrum of emission. The filter holder can accept any filter up to a 25.4 mm diameter and a maximum 5 mm thickness.
- The **HDB15 Connector** links the driver to the light source using a *HDB15* cable. This cable uses a custom pinout; **other *HDB15* cables should not be used with this system**[1].

(a) *Ce:YAG + LED/LD Light Source* (b) *Ce:YAG Optical Head without LED/LD Light Source*

Figure 2.2: *Ce:YAG Optical Head*

2.2.2 Bandpass Filter for Ce:YAG

Considering the very broad spectrum of Ce:YAG fluorescence, it is often required to select a specific part of the output spectrum using an optical bandpass filter. The light source contains a **Removable Filter Holder** that can accept filters with an outside diameter of 25.4 mm and maximum thickness of 5 mm. The filter is placed between the Ce:YAG light source and the combiner, and is held in place magnetically. A wide variety of filters are available in our Catalog.

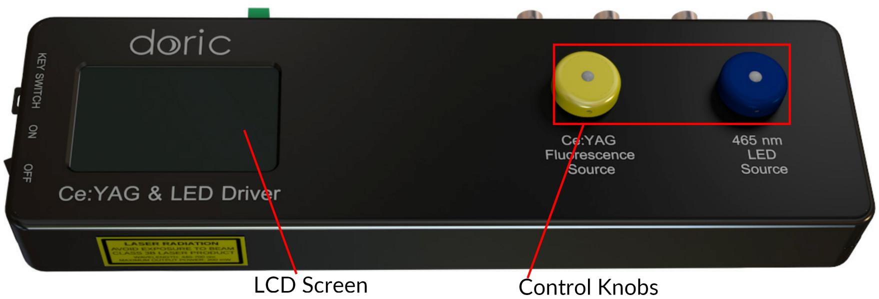
[1] Some models of Ce:YAG + LED/LD Light Source have a HDB9 Connector

Figure 2.3: *Bandpass Filter for Ce:YAG in its holder*

2.2.3 Ce:YAG + LED/LD Driver

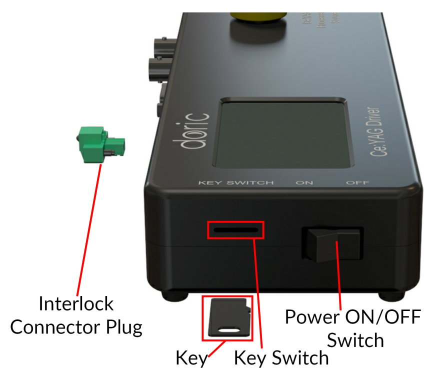
The *Ce:YAG + LED/LD Driver* (Fig. 2.4) is used to control the *Ce:YAG + LED/LD Fiber Optical Head*. The driver controls the Ce:YAG light source and the LED/LD light source independently, if applicable. The drivers have the following elements, as shown on Fig. 2.4.

- The **LCD Screen** (Fig. 2.4a) displays driver information (operating mode, status, etc.)
- The **Control Knobs** are used to control the driver in stand-alone mode, as well as setting the maximum or present light source current in all modes.
- The **12 V** (Fig. 2.4b) port connects the driver to its 12 VDC power supply.
- The **HDB15 Connector** links the driver to the light source using a *HDB15* type cable. This cable uses a custom pinout; **other *HDB15* cables should not be used with this system**.
- The BNC **Input Ports** allow the use of external analog signals to control the driver.
- The BNC **Output Ports** are used to monitor current on each light source .
- The **USB** port allows the user to connect the driver to a computer using a USB-A/USB-B cable. This allows the driver to be controlled using *Doric Neuroscience Studio*.
- The **Interlock** connector plug allows the user to connect the driver to a safety interlock system. It is recommended to connect the interlock plug to a laboratory interlock system (See chapter 1).
- The **Power On/Off** (Fig. 2.4c) switch turns on/off the driver.
- The **Key Switch** must be in place to enable light emission. Note that, despite its similar form factor, 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 **Key Switch**.



(a) *Front*

(b) *Back*



(c) *Side*

Figure 2.4: *Ce:YAG + LED/LD Driver*

3

Operations Guide

3.1 Getting Started

The procedure below should be followed carefully. There are several safety measures to take into account to ensure safe and proper use of the *Ce:YAG + LED/LD Optical Head* and the *Ce:YAG + LED/LD Driver*.

WARNING!

The *Ce:YAG + LED/LD optical head* is sensitive to electrostatic discharges (ESD), wear a properly grounded wrist strap when handling the optical head

1. Connect the **Interlock plug** to the driver. The system CANNOT be operational if the safety interlock circuit is open.
    - When unpacking, a temporarily shorted interlock plug is already secured in place. It is highly recommended to remove the shorting electrical wire and connect the interlock plug to a proper interlock circuit of the laboratory.
    - See the Important Safety Information section (Section 1) for more information.

WARNING!

Be aware that a shorted interlock plug DISABLES this safety feature AT YOUR OWN RISKS. A proper safety interlock circuit is highly recommended.

2. Ensure that the **ON/OFF switch** of the driver is set to OFF.
3. Connect the **Power supply** to the Ce:YAG + LED/LD Driver.

WARNING!

DO NOT OPEN the enclosure of the driver. Electrical hazards may result. The driver does not contain any user-serviceable components

4. The optical head is sensitive to electrostatic discharges, use proper grounding techniques.
5. Verify that the power switch of the driver is set to OFF.
6. Connect the *Ce:YAG + LED/LD Optical Head* to the *Ce:YAG + LED/LD Driver* using the *HDB15 Cable*[1].
7. Ensure that a proper laser beam block is ready at the output of the optical fiber.
8. Unscrew the metal safety cap from the **Beam aperture**.
9. Connect the *Optical fiber patch-cord* to the *Ce:YAG + LED/LD optical head*.

[1] Some models of Ce:YAG + LED/LD Light Source use a HDB9-HDB15 cable.

DANGER!

The light beam exiting the *Ce:YAG + LED/Laser Optical Head* or any connected optical fiber should be confined properly BEFORE turning ON the driver.
Use a proper beam block. Read the application note *Important Laser Safety Information* BEFORE FIRST USE.

10. Ensure that all laser safety procedures are followed.
11. Insert the power key (see Fig. 2.4c for proper orientation) into its receptacle.
12. Set the power switch to ON.
13. The system is ready for stand-alone operation or software installation. See the Doric Neuroscience Studio Manual.

3.2 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. 3.1).

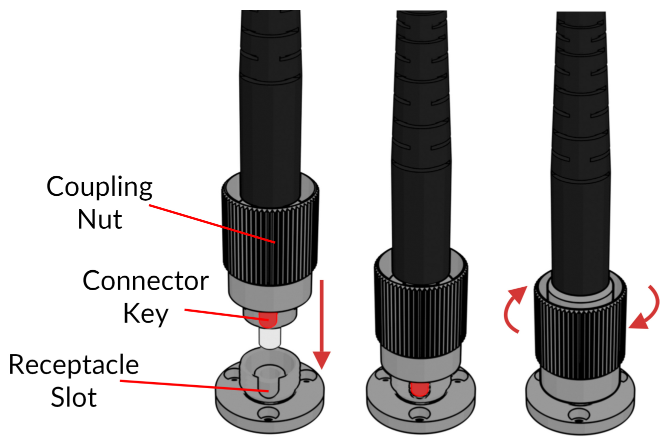


Figure 3.1: *FC connector, Fiber Installation*

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

3.3 Stand-alone Operation

The following sections details stand-alone operation of the driver. For installation of the light source in stand-alone mode, see section 3.1.

If the light source driver is used as a stand-alone device, 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**. 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.

3.3.1 Constant current (CW)

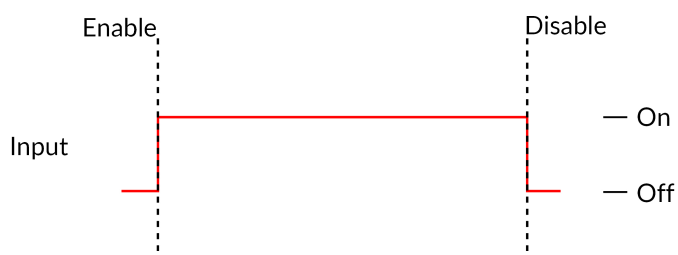


Figure 3.2: *Constant Current Mode Driver Signal*

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. 3.2).

3.3.2 External TTL (TTL)

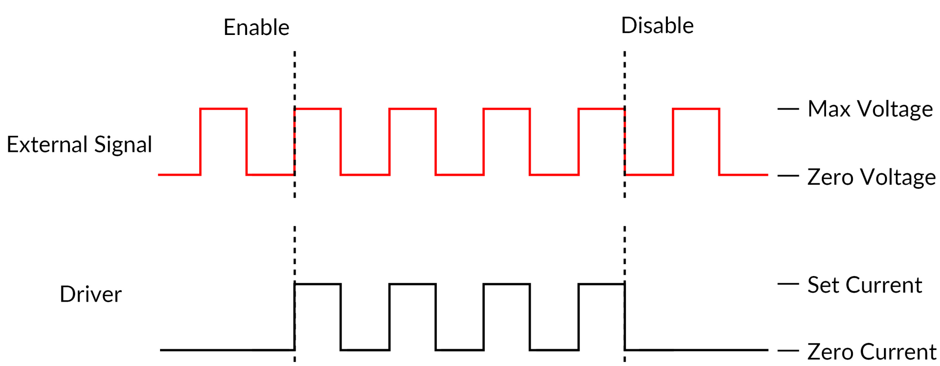
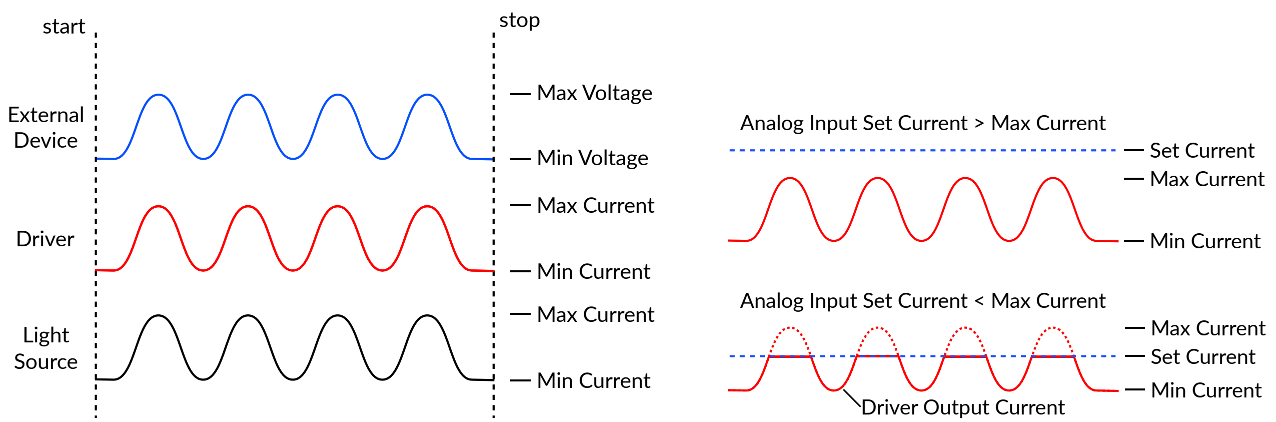


Figure 3.3: *Driver Signal Response to External Source in External TTL Mode*

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.

3.3.3 External Analog (Ext. Ana.)



(a) *External Analog output is proportional to the External Device voltage* (b) *External Analog output is dependent on the Set Current*

Figure 3.4: *External Analog Pulse Sequence Behavior*

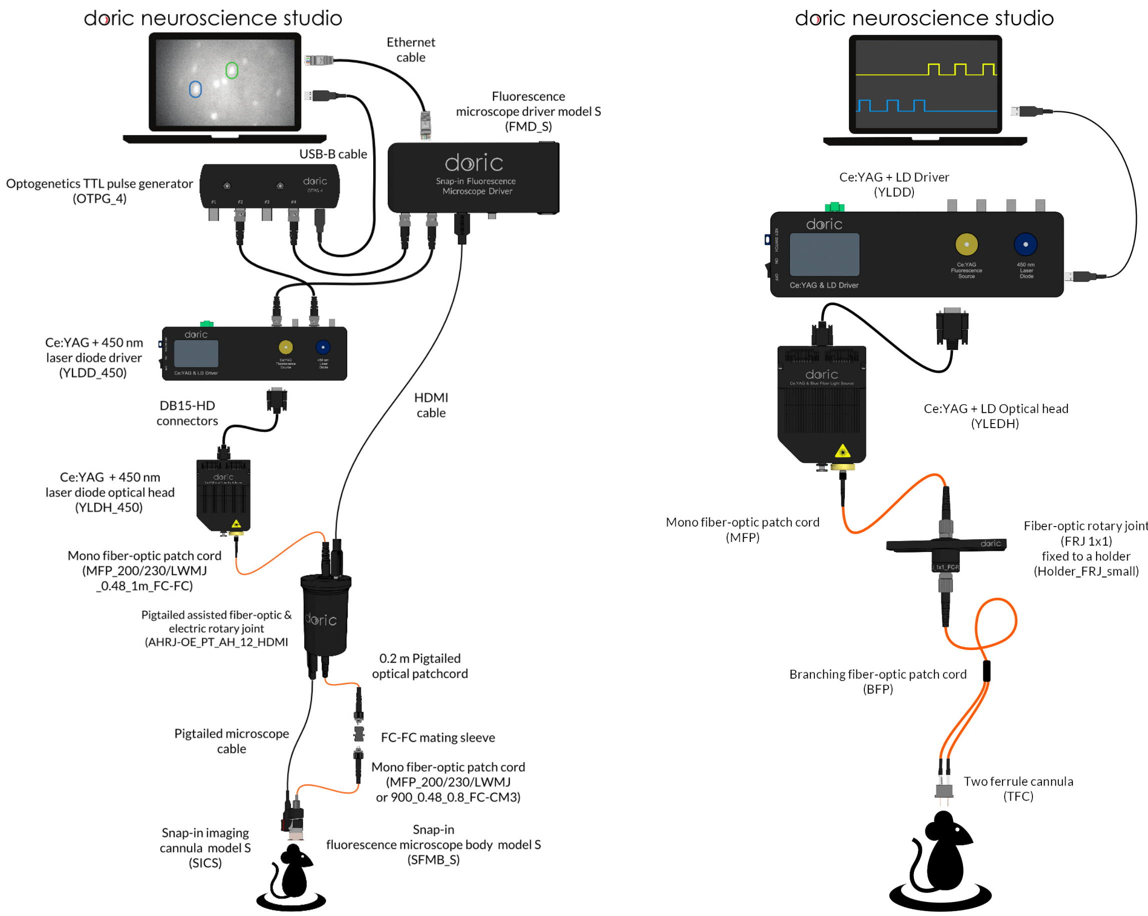
The External Analog mode is similar to the External TTL, except that the driving current is proportional to the voltage applied on the BNC input connector (Fig. 3.4a). On the input BNC, a maximum voltage signal corresponds to a maximum driver current. Should the current set on the light source be less than the maximum current, any voltage corresponding to a higher current will clip the output waveform (Fig. 3.4b, bottom). To avoid any clipping of the output waveform, the maximum current setting must be equal to or greater than the corresponding maximum analog input voltage (Fig. 3.4b, top). For square modulations, it is preferable to use External TTL mode instead of External Analog mode.

3.3.4 Temperature regulation

The *Ce:YAG + LED/LD optical head* requires efficient temperature regulation to function properly. When using the driver in **Stand-alone mode**, the status indicator of the *Ce:YAG + LED/LD optical head* will show the temperature inside the head.

- The temperature should remain stable at approximately 20-21°C.
- A safety feature will shut down the light source if the crystal temperature is outside the appropriate range.
- Ensure that both driver and optical head are in a well ventilated area to avoid overheating.

3.4 Connected to Doric Neuroscience Studio Software



(a) *OSFM Setup* (b) *Optogenetics Setup*

Figure 3.5: *Systems using a Ce:YAG + LED/LD light source system*

1. Connect the Ce:YAG + LED/LD Driver to the power outlet with the included 12 V AC-DC adapter and turn the Driver switch ON. **Always power the Ce:YAG + LED/LD Driver before connecting the USB cable to the computer for a proper driver installation.**
2. Install the Doric Neuroscience Studio Software on the computer. Double-click on the setup_DoricStudioX.X.exe file located on the Doric USB memory stick supplied with the Ce:YAG + LED/LD Driver and follow the on-screen instructions.
3. Connect the **USB-A/USB-B cable** between the driver and the computer.
4. If needed, connect an external device to the Ce:YAG + LED/LD Driver by using the modulation input BNC. In this configuration, the driver will wait the signal from another device, consequently the light source will be triggered. To follow an external device, select the external TTL or the external analog mode for the desired channel.
5. If needed, connect a data acquisition system or an external device to the Driver by using the monitoring output BNC of the desired channel. A data acquisition system enables the viewing and the recording of the signal generated by an external device connected to the Driver. The output BNC can also be used to connect an external device that will be triggered by the light source.

4

Doric Neuroscience Studio

4.1 Channels

Doric Light Sources can be controlled by the Doric Neuroscience Studio. These include *LED Modules*, *Laser Diode Modules* and *Ce:YAG Fiber Light Source*. The interface is separated into two main sections, **Control & settings** and the **Acquisition View**. Each light source driver has a number of **Channels**, each one controlling a light source of its given type. These channels, accessible using the **Add Channel** will be the first detailed.

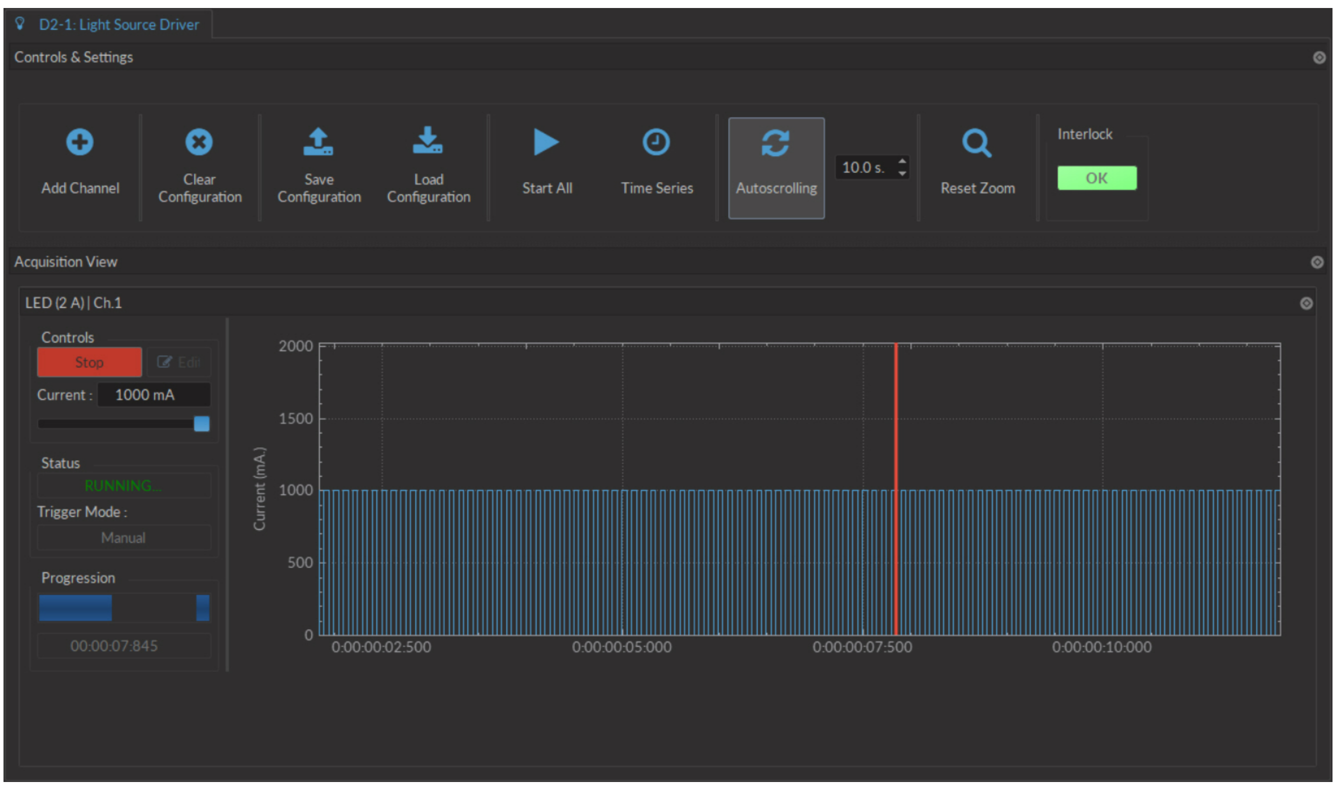


Figure 4.1: *Light Source Driver Tab*

Each light source driver is separated into a number of **Channels**. Each channel controls a single light source. While each channel can be controlled in **Stand-alone** mode by the driver, additional functions can be accessed for these channels when the driver is connected to the Doric Neuroscience Studio. These function are used through the **Channel Configuration** window (Fig. 4.2).

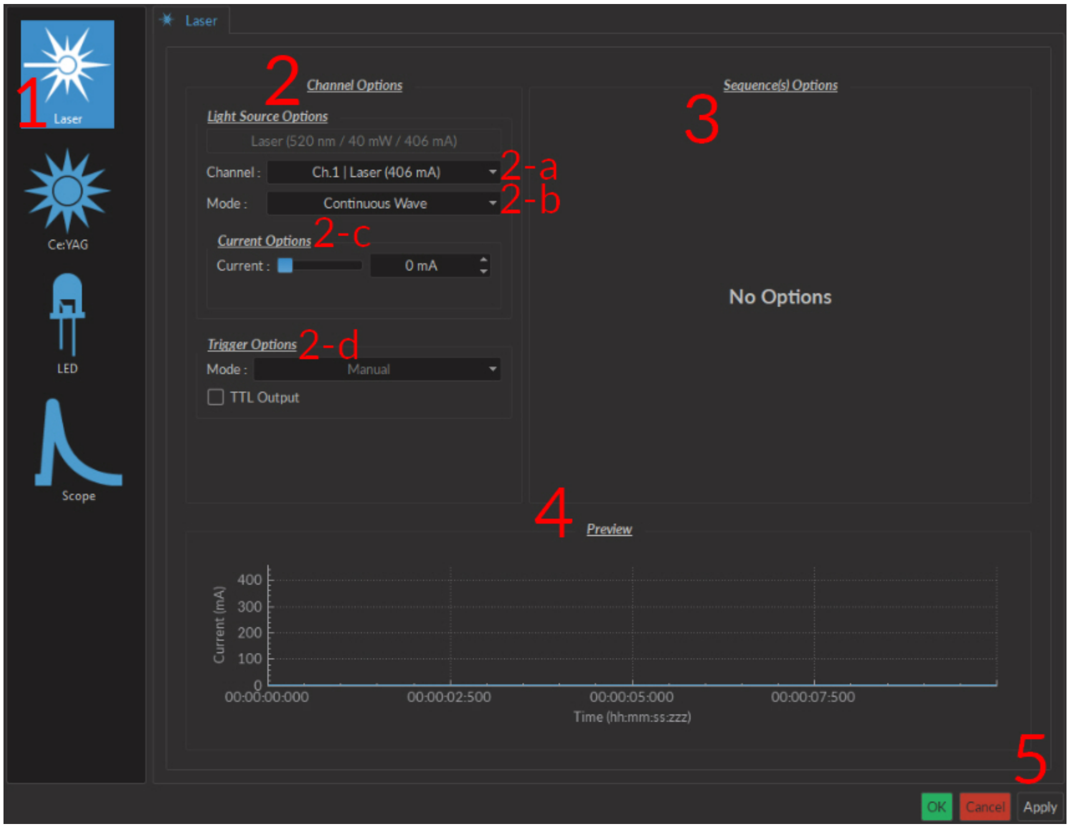


Figure 4.2: *Light Source Channel Configuration Window*

1. The **Channel Types** (Fig. 4.2) are displayed on the left side of the window. These include **Laser** light sources, **Ce:YAG** light sources and **LED** light sources, as well as the **Scope** to measure signal using the driver.

2. The **Channel Options** box (Fig. 4.2) includes **Light Source Options** and **Trigger Options** for the given channel.

   a) The **Channel** (Fig. 4.2) drop-down list identifies which driver channel is currently being edited, assuming a driver with multiple channels.

   b) The **Mode** (Fig. 4.2) drop-down list includes each possible driver mode. These are used to control the pulse sequences emitted by the light source. The options related to this mode are detailed with the **Sequence Options**.

   c) The **Current Options** (Fig. 4.2) includes the slider used to control the current sent to the light source.

      - When using a *LED Driver* module, the **Overdrive** checkbox will appear. 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 *LEDD*, the **Low-Power** checkbox will appear. When selected, this allows reduced-power signaling for the same voltage. This mode is only available for *CLED* modules. This allows low-power signals to be more stable in time. The maximal current is reduced to one tenth of light source's normal maximal current. If the **BNC Output** is used, the voltage of the signal 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). The **BNC output** of the driver will still relate LED current with a 400 mA/V conversion factor.

   d) The **Trigger Options** (Fig. 4.2) allow the selection of a number of trigger modes to activate a pulse sequence.

      - The **Manual** trigger mode is standard, and allows direction activation by the user.
      - The **Triggered** trigger mode is active when an input greater than 4 V is detected on the BNC input. Following input pulses will be ignored while the sequence is running. The sequence will restart with the arrival of the first input pulse after the sequence has finished.

- The **Gated** trigger mode is active as long as there is a high TTL signal (4 V or more) on the input modulation BNC. This signal comes from a different light source or device driver. When the TTL signal is low (0.4 V or less), the sequence stops and waits for another high TTL signal to continue.
- If the **TTL Output** option is checked, the output BNC channel can 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.

3. The **Sequence options** box (Fig. 4.2) is where sequence options are defined depending on the mode. The **Continuous wave, External TTL** and **External Analog** modes have no additional sequence options.

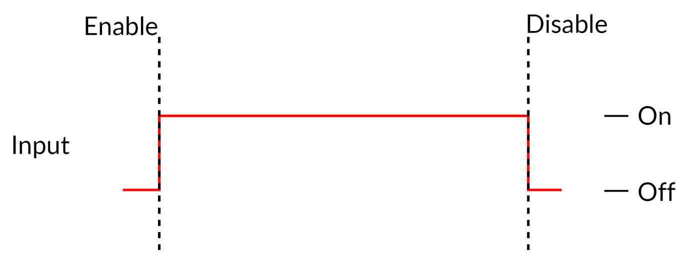


Figure 4.3: *Constant Current Mode Driver Signal*

a) The **Continuous Wave** mode (Fig. 4.3) 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.

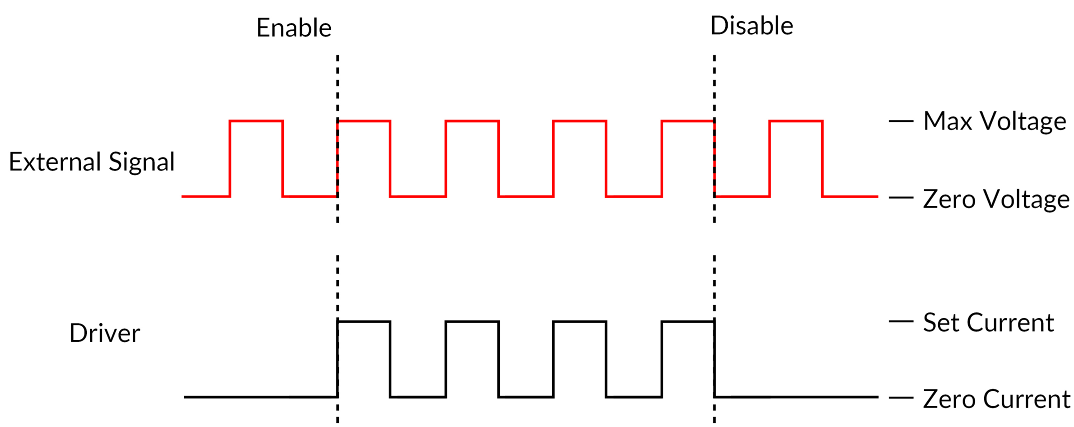


Figure 4.4: *Driver Signal Response to External Source in External TTL Mode*

b) The **External TTL** mode (Fig. 4.4) 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 **TTL** under **MODE**. This mode has no additional sequence options.

c) The **External Analog** mode (Fig. 4.5) is similar to the External TTL, except that the current will be set by the voltage on the BNC input (Fig. 4.5 top). On the input BNC, a maximum voltage signal corresponds to a maximum driver current. Should the current set on the light source be less than the maximum current, any voltage corresponding to a higher current will clip the output waveform (Fig. 4.5 bottom). To avoid any clipping of the output waveform, the maximum current setting must be equal to or greater than the corresponding maximum analog input voltage. See the corresponding light source manual to find the voltage/current relationship. This mode has no additional sequence options.

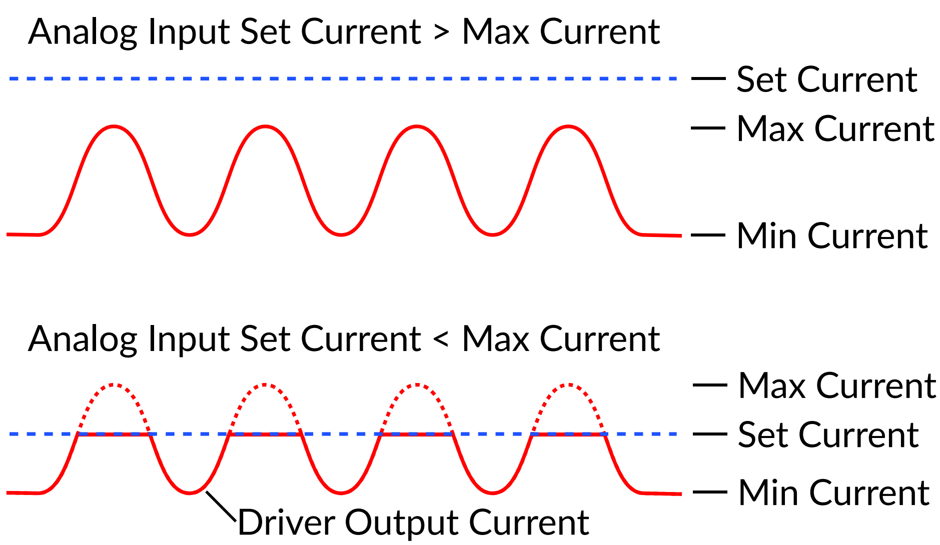


Figure 4.5: *Driver and Light Source in External Analog Mode*

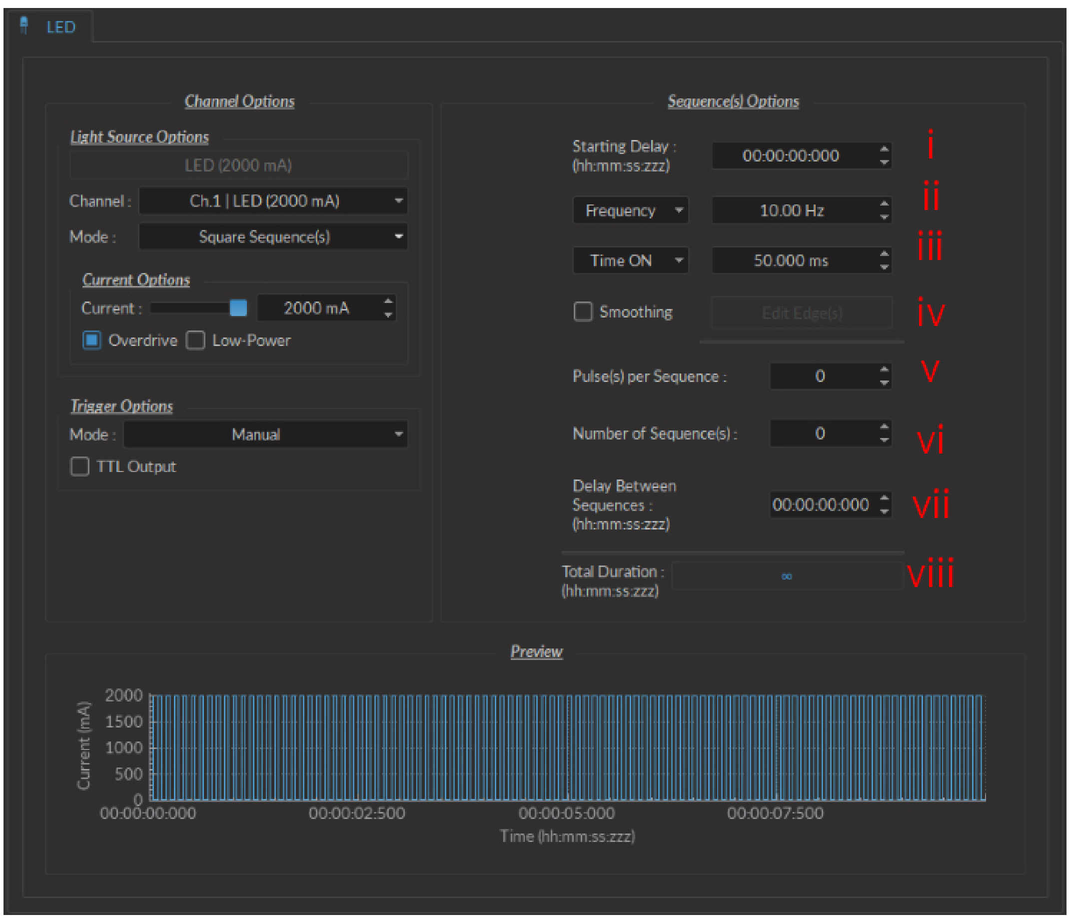


Figure 4.6: *Light Source Channel Configuration Window, square sequence options*

d) The **Square sequences** mode has the light source follow a square pulse sequence.

i. The **Starting Delay** (Fig. 4.6) sets the delay (in hh:mm:ss:zzz format) before the first pulse.

ii. The **Frequency/Period** (Fig. 4.6) 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).

iii. The **Time ON/Duty Cycle** (Fig. 4.6) 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.

iv. 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. 4.7).

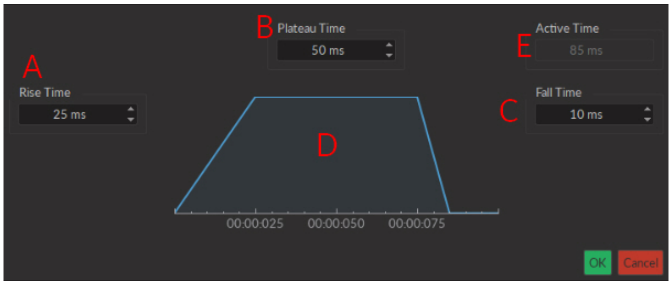


Figure 4.7: *Light Source Smoothing Edge(s) Window*

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 defined 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.

v. The **Pulses per sequence** (Fig. 4.6) sets the number of pulses per sequence. If it is set to 0, the pulse will be repeated indefinitely.

vi. The **Number of sequences** (Fig. 4.6) sets the number of times that the sequence will be repeated. If it is set to 0, the sequence will be repeated indefinitely.

vii. The **Delay between sequences** (Fig. 4.6) sets the delay (in hh:mm:ss:zzz format) between each sequence if the **Number of Sequences** is greater than 1.

viii. The **Total Duration** (Fig. 4.6) 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.

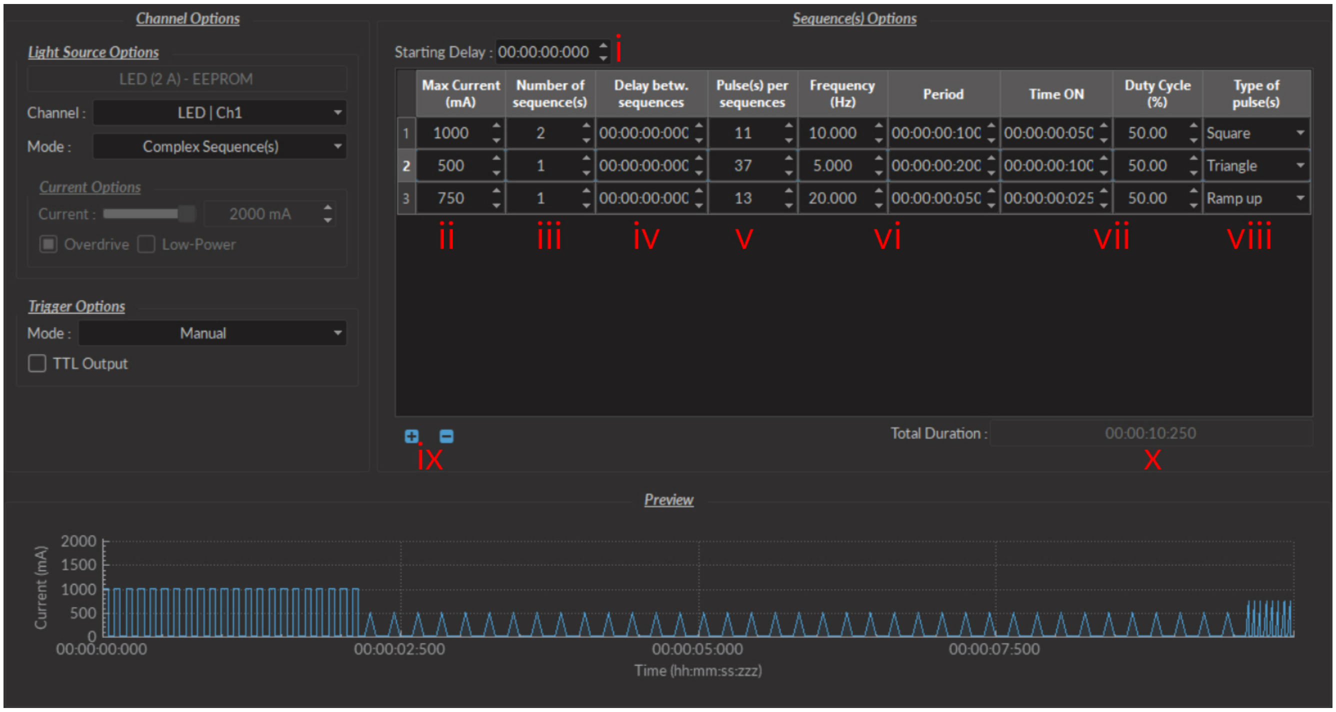


Figure 4.8: *Complex Sequences Window*

e) The **Complex Sequences** mode 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.

   i. The **Starting Delay** (Fig. 4.8) sets the delay (in hh:mm:ss:zzz format) before the first pulse sequence.
   ii. The **Max Current** (Fig. 4.8) sets the maximum current (in mA) for the given sequence.
   iii. The **Number of sequences** (Fig. 4.8) sets the number of times that the sequence will be repeated, with a minimum of 1.
   iv. The **Pulses per sequence** (Fig. 4.8) sets the number of pulses per sequence, with a minimum of 1.
   v. The **Delay between sequences** (Fig. 4.8) sets the delay (in hh:mm:ss:zzz format) between each sequence if the **Number of Sequences** is greater than 1.
   vi. The **Frequency/Period** (Fig. 4.8) 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).
   vii. The **Time ON/Duty Cycle** (Fig. 4.8) 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 %.

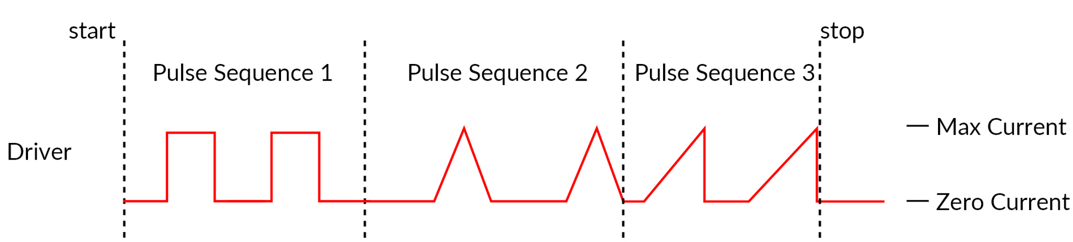


Figure 4.9: *Internal Complex Mode Pulse Sequences*

   viii. The **Types of pulses** (Fig. 4.8) sets the pulse type. Pulses can be **Square**, triangular (**Triangle**), **Ramp up Ramp down** or **Delay** (Fig. 4.9). The **Delay** pulse type is used to create a delay between different sequence

ix. The **Sequence controls** (Fig. 4.8) allow the addition (**+**) or removal (**-**) of sequences to the spreadsheet.
x. The **Total Duration** (Fig. 4.8) 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.

f) The **Scope** mode allows the measurement of electrical signal using the driver (Fig. 4.10). The signal is received by the Input BNC of the chosen channel on the light source driver.

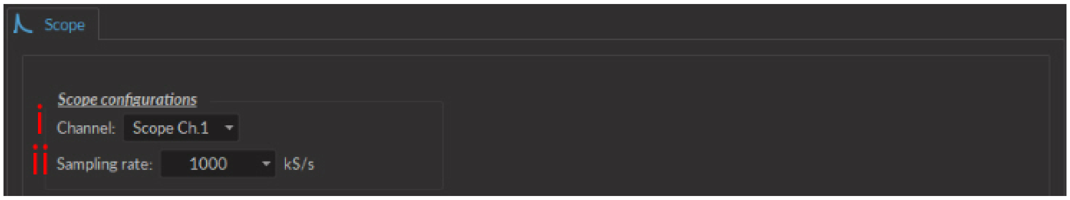


Figure 4.10: *Scope*

i. The **Channel** drop-down list indicated which driver channel will be used to receive signal. The chosen can be used to drive a light source while serving as a scope.
ii. The **Sampling Rate** drop-down list allows the selection of the rate (in kilosamples per second) at which measurements are taken.

4. The **Preview** box (Fig. 4.2) displays a preview of the chosen sequence while in the **Continuous Wave**, **Square Sequences** and **Complex Sequences** mode.

5. The **Apply** button (Fig. 4.2) will generate the defined channel OR update an already configured channel with any changes.

4.2 Control & Settings

The **Control & settings** sections is used to control the light source. It includes the following elements.

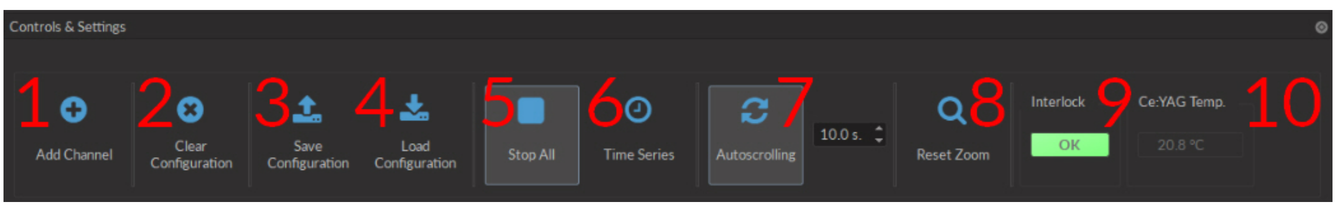


Figure 4.11: *Control & Settings*

1. The **Add channel** button (Fig. 4.11) opens the **Channel Configuration** window 4.2. See section 4.1 for more details.

2. The **Clear Configuration** button (Fig. 4.11) clears all configuration channels. Cleared channels cannot be recovered unless previously saved.

3. The **Save configuration** button saves all currently configured channels in **.doric** format.

4. The **Load configuration** button loads a file in **.doric** format that contains a previously saved set of configured channels.

5. The **Start All** button (Fig. 4.11) starts all currently configured channels.

6. The **Time Series** button opens the **Time Series** window. This tool allows all channels to share the same timing.

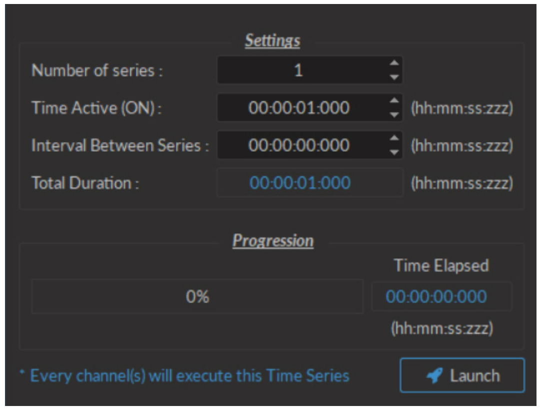


Figure 4.12: *Control & Settings, Time Series Window*

- The **Number of series** (Fig 4.12) sets the number of times that the sequence will be repeated, with a minimum of 1.
- The **Time Active** sets the duration of each series in hh:mm:ss:zzz format. If the **Time series** is used in combination with a sequence, the **Time Active** should be greater than the sequence **Total Time** If the **Time Active** is shorter, the sequence will be stopped after the **Time Active**.
- The **Interval between series** sets the duration between each series in hh:mm:ss:zzz format.
- The **Total Duration** displays the total duration of the sequence in hh:mm:ss:zzz format.
- The **Progression** bar displays the progression of the sequence in %, while the **Time Elapsed** counter displays the progression in hh:mm:ss:zzz format.
- The **Launch** button starts the sequence.

7. The **Autoscrolling** button activates the autoscroll function. When active, the **Graph** in the **Acquisition View** will follow a section as wide as the time defined beside the button.
8. The **Reset Zoom** button resets the axes in the **Graph** to their standard values.
9. The **Interlock** indicator displays OK when the interlock is correctly connected, and OPENED when disconnected.
10. The **Ce:YAG Temp** indicator displays the temperature of the *Ce:YAG source* in real time. This indicator will only appear when a *Ce:YAG driver* is connected to the computer. Should the temperature be too high the temperature will appear in red. Should the temperature be too low, the temperature will appear in blue.

4.3 Experiment View

The **Experiment 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.

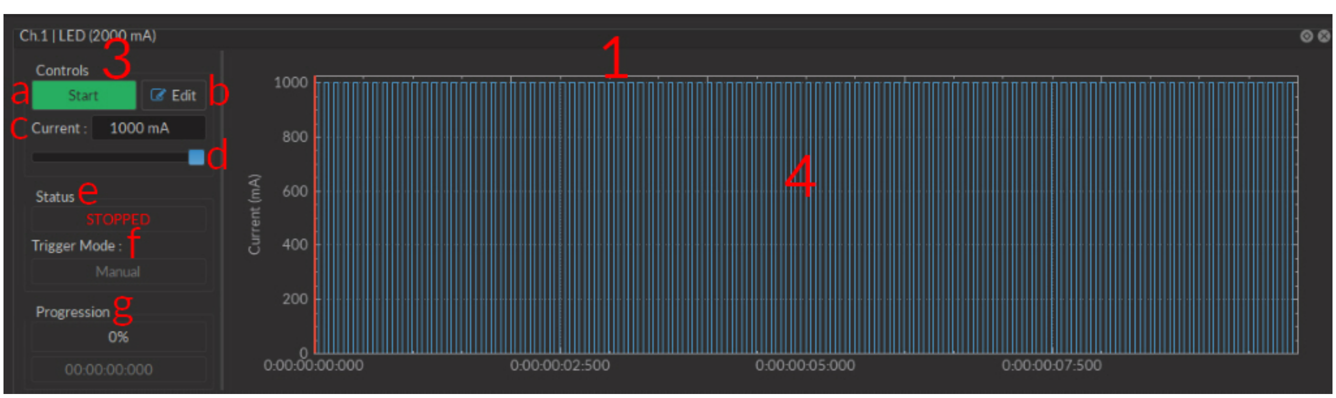


Figure 4.13: *Experiment View, Light Source Channel*

1. The **Light Source Channel** box (Fig. 4.13) contains all elements related to a single light source channel.
2. The **Scope Channel** box (Fig. 4.14) is used to control and configure an active **Scope**.

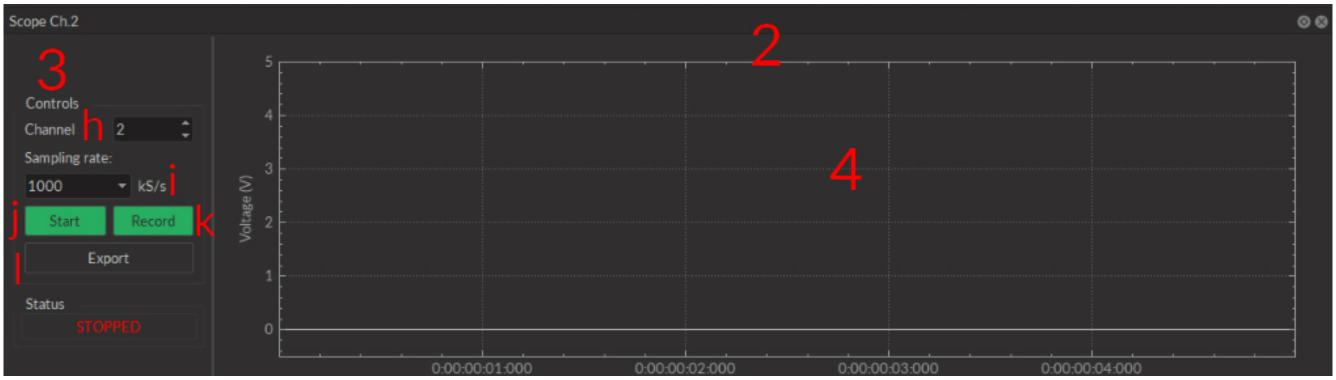


Figure 4.14: *Experiment View, Scope Channel*

3. The **Controls View** displays all elements to control/configure the channel.
   a) The **Start/Stop** button activates/deactivates the light source connected to the **Light Source Channel**.
   b) The **Edit** button opens the **Channel configuration** window to edit the pulse sequence. This button is only accessible when the channel is deactivated.
   c) The **Current Box** box allows the current to be changed exactly (in mA).
   d) The **Current Slider** allows the light source current to be adjusted.
   e) The **Status** box displays the status of the channel (**Light source** or **Scope**). The **Status** will display RUNNING... when active and STOPPED when deactivated.
   f) The **Trigger Mode** of the light source is displayed in this box.
   g) The **Progression** box displays the progression of the pulse sequence.The advancement of the sequence is displayed % on the **Progression bar**, and in hh:mm:ss:zzz format on the **Time Elapsed** box.
   h) The **Channel** drop-down list is used to chose the channel used as a scope.
   i) The **Sampling Rate** drop-down list allows the selection of the rate (in kilosamples per second) at which measurements are taken.
   j) The **Start** scope channel button activates a live measurement sequence. Important measurements should not be made as a live measurement, as these only conserve a small amount (60 s) of data.
   k) The **Record** scope channel button starts a recorded measurement sequence.
   l) The **Export** scope channel button allows the recording of a live measurement sequence on the scope.
4. The **Graph View** displays either a preview of the pulse sequence for **Light Source Channels** or the received signal for the **Scope Channel**.

5

Specifications

Table 5.1: *Electronic Specifications of the Ce:YAG + LED/LD Driver*

Specification	**Value**	**Note**
Power supply	110 - 240 VAC, 50 - 60 Hz	
DC Power supply	12 VDC	150 W
Mass	935 g	Approximate
Dimensions		
Width	30 cm	Including connectors
Depth	10 cm	Including connectors
Height	5.5 cm	Including connectors
TTL input voltage	0 to +5 V	
Display current accuracy	2% @ maximum rated current	Error increases at lower current.
Ce:YAG Analog input voltage	270 mA/V (typical)	See data sheet
Ce:YAG Monitor output voltage	3.7 V/A (typical)	See data sheet
Ce:YAG Maximum output current range	1200 mA	See data sheet
Ce:YAG Maximum forward voltage	32 V	Typical; see data sheet
Ce:YAG Minimum output current	40 mA	
Ce:YAG Rise/Fall time	<10 µs	
LED Analog input voltage	400 mA/V light source current	Standard 1 A LED Driver
	40 mA/V light source current	Low power mode enabled
LED BNC output voltage	2.5 V/A	
LED Maximum output current range	200, 2000 mA	
LED Maximum forward voltage	7 V	
LED Minimum output current	2.5 mA	Low power mode enabled
LED Rise/Fall time	<10 µs	Typical
LD Analog input voltage	80 mA/V light source current	If applicable: see datasheet
LD BNC output voltage	12.5 V/A	If applicable: see datasheet
LD Maximum output current range	LD Model dependent	If applicable: see datasheet
LD Maximum forward voltage	10 V	-
LD Minimum output current	25 mA	Model dependent; see data sheet
LD Display current accuracy	2% @ maximum rated current	Error increases at lower current.
LD Rise/Fall time	<10 µs	Typical

Table 5.2: *Software Specifications for the Ce:YAG + LED/LD Driver*

Specification	**Value**	**Note**
Current adjustment steps	1 mA	
Modulation minimum frequency	0.01 Hz[1]	Internal complex mode : 0.000054 Hz
Modulation maximum frequency	50 kHz	-3 dB attenuation
Minimum ON or OFF time	0.005 ms[1]	Internal complex mode : 2 ms
Maximum ON or OFF time	100 s[1]	Internal complex mode : 5 h
Maximum number of pulses per sequence	16.68 millions[1]	Internal complex mode : 65 535
Maximum number of sequences	4.2 billions[1]	Internal complex mode : 65 535
Minimum step increments	39 µsec[1]	Internal complex mode only
Number of steps per period	128[1]	Internal complex mode only
Scope acquisition speed	10 kS/s	Single channel

Table 5.3: *General Specifications of the Ce:YAG + LED/LD Optical Head*

Specification	**Value**	**Note**
Electrical connector	HDB15	Non-standard cable
Mass	1300 g	Approximate
Dimensions		
Width	10 cm	Including connectors
Depth	15 cm	Including connectors
Height	8.5 cm	Including connectors
Output NA	0.63	
Output Optical Fiber Core Size	<600 µm	Power scales up to this core size

Table 5.4: *Recommended Environmental Specifications*

Specification	**Operation**	**Storage**
Use	Indoor	Indoor
Temperature	20 °C to 30 °C	-20 °C to 60 °C
Humidity	40 - 60 % R.H., non condensing	40 - 60 % R.H., non condensing

[1] For all operation modes, except the internal complex mode

6 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 Contact us

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

Phone 1-418-877-5600

Email sales@doriclenses.com

doric

357 rue Franquet - Quebec, (Quebec)
G1P 4N7, Canada
Phone: 1-418-877-5600 - Fax: 1-418-877-1008
www.doriclenses.com