

# PlexBright<sup>®</sup> LD-1 Single Channel LED Driver

Part of the PlexBright Optogenetic Stimulation System



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# PlexBright LD-1

## Single Channel LED Driver

Part of the PlexBright Optogenetic Stimulation System

User Guide

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# Publication History

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**March 2020**

The requirement to use the Plexon supplied insulated BNC cable for connecting the LD-1 Driver to the LED Module was emphasized.

The explanation and instructions for setting the current limit were clarified.

**February 2017**

The relationship between the analog input and the current output was clarified. See Section 7.

**April 2016**

A typographical error was corrected in Sections 10 and 11. The value of TTL latency is shown correctly now on both pages (150  $\mu$ s).

**February 2014**

This is the first issue of the user guide for PlexBright LD-1 Single Channel LED Driver.

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# Contents

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Publication History	iii
Introduction	1
LD-1 LED Driver Capabilities	1
LD-1 LED Driver Components	2
Typical Set-up of the LD-1 LED Driver	3
Using the Output Display	4
Using the TTL Input	4
Using the Analog Input	4
Using the PlexBright Series-Y Cable for Control of Two LEDs	5
Setting the Current Limit	6
Temporal Response of the LD-1 LED Driver	9
Specifications for LD-1 LED Driver	10

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## 1 Introduction

Thank you for considering the Plexon® PlexBright® Optogenetic Stimulation System for your optogenetics applications. This manual explains the proper usage of the PlexBright LD-1 Single Channel LED Driver (LD-1 LED Driver). If you have further questions related to LD-1 LED Driver or would like to upgrade your system to 4-Channel Optogenetic Controller with Radiant™ software, please feel free to contact your Plexon Technical Support Expert by telephone at +1 214-369-4957 or by email at [support@plexon.com](mailto:support@plexon.com).



PlexBright LD-1 LED Driver

## 2 LD-1 LED Driver Capabilities

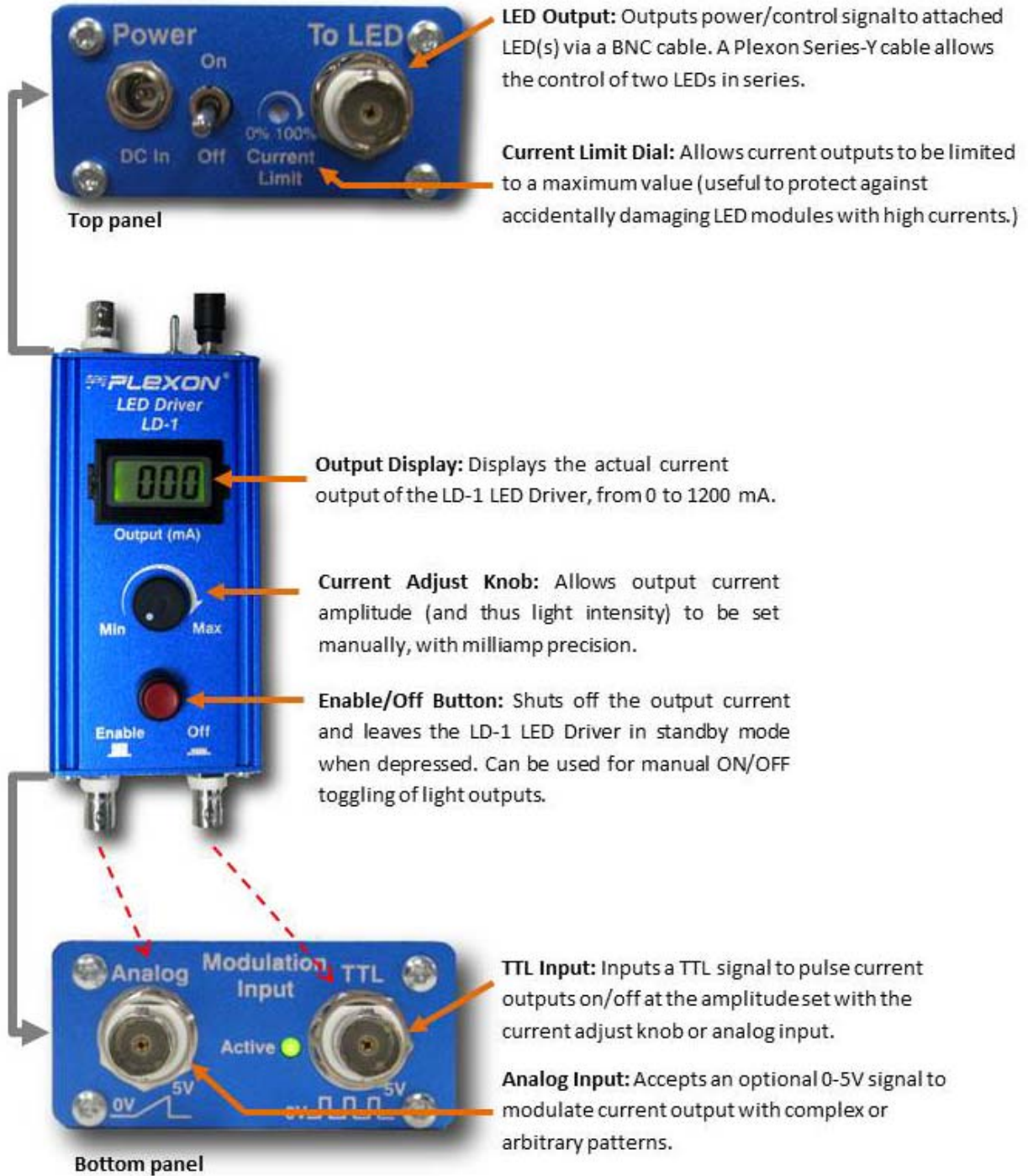
The LD-1 LED Driver provides an economical solution for controlling a single LED Module or two LED Modules in series, as for bilateral stimulation. The LD-1 LED Driver is equipped with a **Current Adjust Knob** and **LCD Output Display**, which together can be used to precisely set the LED supply current, and thus the light output intensity. Once the desired intensity has been set, the LD-1 LED Driver can accept a digital (TTL) input signal from another device to generate a temporally precise output pattern, consisting of rectangular pulses at the set intensity. Alternatively, the LD-1 LED Driver can also accept a 0-5V analog input signal encoding complex and arbitrary output patterns, such as ramps, sine waves, or simulated LFPs (local field potentials).

Note that in order to deliver quickly changing patterns such as fast pulse trains, an external device is required to generate a standard TTL or 0-5V analog signal encoding the desired output pattern. This control signal is then converted by the LD-1 LED Driver into the supply current required by the LED Module(s).

See <http://www.plexon.com> for additional product information about the PlexBright Optogenetic Stimulation System.

### 3 LD-1 LED Driver Components

The LD-1 LED Driver features a backlit **Output Display** of the current output, manual controls for modulating and slowly pulsing current outputs, a **TTL Input** for precise dynamic control over quickly pulsed LED patterns, and an **Analog Input** (0-5V) for precise dynamic modulation of arbitrary output current waveforms.



## 4 Typical Set-up of the LD-1 LED Driver

In its most basic use, the LD-1 LED Driver can be powered with its included power supply cable, and connected to a PlexBright Table-top LED Module with the included BNC cable. Plexon provides an insulated BNC cable that prevents the outer contacts from touching. The circuit that sets the current output relies on measuring the return current. If the outer BNC contact were uninsulated, and if this uninsulated contact were then shorted to ground through accidental contact with another object (a metal table for example), the output current would go to unexpectedly high values.

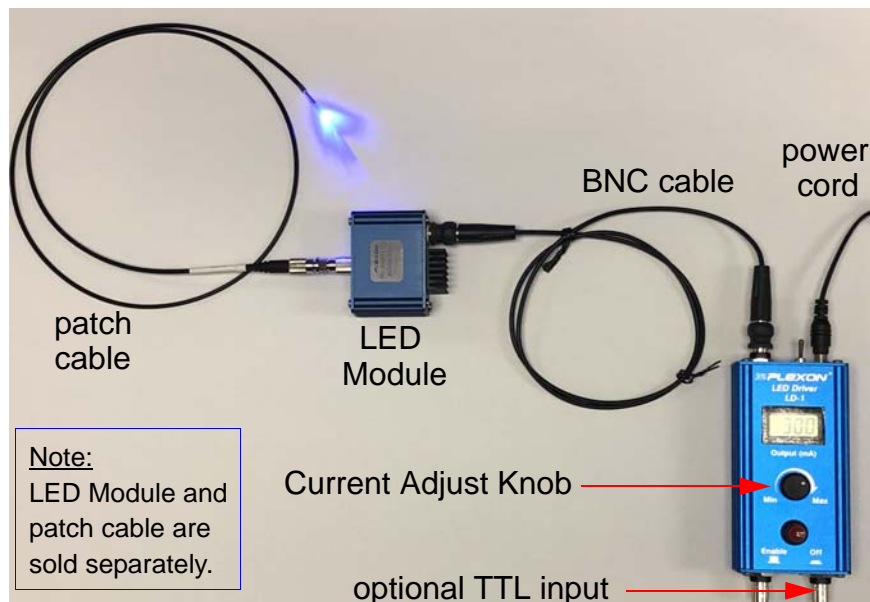


### CAUTION

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

The typical set-up is shown in the image below. After the maximum allowable current is set with the **Current Limit Dial** (shown on the previous page), turning the **Current Adjust Knob** will adjust the current supplied to the LED Module, and thus the amount of light the LED Module outputs. (The separate **PlexBright Light Measurement Kit** should be used to precisely measure LED Module / patch cable outputs at given supply currents.) The LD-1 LED Driver **Output Display** screen shows the actual current applied to the LED Module (in milliamps).

Once the desired current has been set with the **Current Adjust Knob**, a TTL signal can then be sent to the **TTL Input** connector via a BNC cable to pulse the LED ON/OFF. Note that although the LCD **Output Display** updates more slowly than the **TTL** or **Analog Input**, the LD-1 LED Driver keeps up with the quickly changing inputs to control the attached LED Module with precise, sub-millisecond resolution. (See [Section 10, “Temporal Response of the LD-1 LED Driver,”](#) on page 9.)



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The LD-1 LED Driver can also power PlexBright LED Modules (specifically the Compact LED Modules) through any PlexBright Dual LED Commutator. In a basic configuration, the LD-1 LED Driver connects to channel 1 of any PlexBright Dual LED Commutator via the included BNC cable. In a more advanced configuration, such as for bilateral stimulation, the LD-1 LED Driver connects to channels 1 and 2 of any PlexBright Dual LED Commutator via the Series-Y BNC cable (available separately from Plexon). For additional information about using two LEDs, see [Section 8, “Using the PlexBright Series-Y Cable for Control of Two LEDs,”](#) on page 5.

## 5 Using the Output Display

The LD-1 LED Driver **Output Display** shows the current (in milliamps) being output to the LED Module. If no LED Module is attached, the **Output Display** screen will read “000,” because regardless of the **Current Adjust Knob** setting, no current is actually being output from the LD-1 LED Driver.

The **Current Adjust Knob** and **Output Display** should be used to set current output levels while the output is continuously on (for example, not pulsed with the **TTL Input**). The LCD **Output Display** updates fairly quickly, but is not intended for tracking rapidly changing signals. The display will lag behind rapidly changing signals or show the average value of rapidly pulsed outputs.

## 6 Using the TTL Input

After setting the output current level, a TTL digital (ON/OFF) signal can be input via a BNC cable to pulse the attached LED with a desired ON/OFF pattern. If no **TTL Input** cable is attached, the LD-1 LED Driver is by default in the “on” state, as indicated by the “**Active**” green indicator LED on the bottom panel of the device. Once a BNC cable delivering a TTL signal is attached, a low input TTL signal (<~0.7V) turns off the current output. A high input TTL signal (>~2.0V) turns on the current output. The **Enable/OFF Button** red push-button can be pushed to override the TTL signal, shutting off all current output when depressed. The green LED indicator light illuminates when the TTL input is high, unless the **Enable/OFF Button** is depressed.

## 7 Using the Analog Input

The **Analog Input** can be used to output arbitrary or complex signals of time-varying intensities. To use the **Analog Input**, use a BNC cable to input an analog 0-5V signal generated by an external device.

When no BNC cable delivering an analog 0-5V signal is attached to the **Analog Input** port, the level of current output is controlled by the **Current Adjust Knob**. An attached **Analog Input**, however, will override the settings of the **Current Adjust Knob** and control the output linearly according to the analog voltage input.

When the signal applied to the **Analog Input** is 0V, the current output of the LD-1 will be zero milliamps. As the **Analog Input** voltage is increased, the

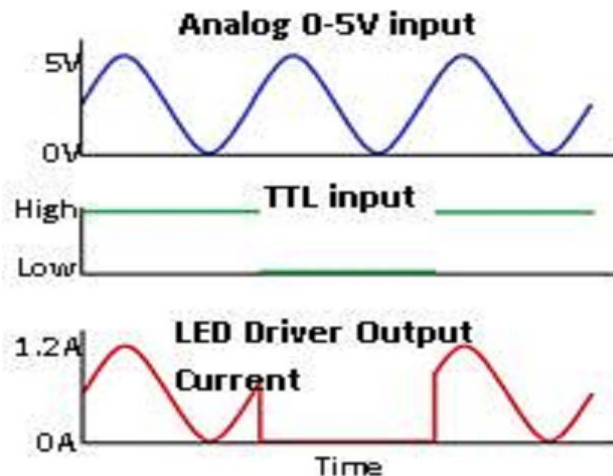


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current output will remain zero until the **Analog Input** exceeds a threshold value. This threshold value depends on the setting of the **Current Limit Dial**. Typical threshold values will be ~100mV when the **Current Limit Dial** is set to 1000 mA and ~1000 mV when the **Current Limit Dial** is set to 100 mA. After the **Analog Input** exceeds the threshold limit, the current output increases linearly with the applied **Analog Input**. A 5V **Analog Input** corresponds to *limited* current output of the device as determined by the setting of the **Current Limit Dial**. Exceeding 5V on the **Analog Input** will cause the current output to exceed the limit set by the **Current Limit Dial** and is not recommended.

Before using the **Analog Input**, first empirically determine the threshold value, the minimum **Analog Input** voltage required to turn the LED on. Then modulate the LD-1 with an **Analog Input** that ranges between this threshold value and 5V.

The **Analog** and **TTL Input** signals can be used together to create complex patterns. For example, an analog input consisting of a 0-5V sine wave would cyclically power and dim an attached LED Module, oscillating between 0% and to 100% of the maximum light output. By attaching an additional, simultaneous **TTL input**, the sinusoidal current/light output could be shut on or off. This is illustrated in the diagram below.



## 8 Using the PlexBright Series-Y Cable for Control of Two LEDs

The LD-1 LED Driver has a single output channel for LED control. In some cases, it is useful to control multiple LEDs simultaneously with the same signal. For example, in bilateral stimulation experiments, the same region in both hemispheres of the brain is stimulated simultaneously. To control two LEDs with the output of a single LD-1 LED Driver, a PlexBright Series-Y cable must be used to route the LD-1 LED Driver output to two LEDs.

**Note:** The Series-Y Cable is **not** the same as a standard BNC T-connector. A standard BNC T connects two devices in parallel and makes the voltage but not the current the same. The Series-Y cable ensures that the same full output current will be delivered simultaneously to both LED Modules.

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Both LED Modules must be attached to the Series-Y cable, or an open-circuit will result, and no current will be delivered to any one attached module. To control two commutator-mounted Compact LED Modules, the Series-Y cable would attach to both input ports on the commutator body.

## 9 Setting the Current Limit



### CAUTION

**SET THE CURRENT LIMIT EVERY TIME YOU CHANGE THE LED MODULE!**

The LD-1 LED Driver typically comes with the Current Limit Dial preset to 300mA, matched to the maximum inputs of the most common blue LED Modules. This preset limit might need to be adjusted up or down for LED Modules with lower or higher maximum current limits.

The maximum current for each LED Module is listed on its label. Be sure to follow the instructions in the section "[Procedure—Setting the current limit](#)" (below).

Understanding the Current Limit Dial

The **Current Limit Dial** sets an upper limit on the current output from the LD-1 LED Driver. This upper limit protects LED Modules from being overdriven with currents higher than their rated values. For example, with no current limiting, the LD-1 LED Driver can output a maximum current of 1200mA, whereas a PlexBright blue LED Module runs at a maximum allowable current of 300mA. Limiting the LD-1 LED Driver output to 300mA ensures that the LED Module will not be inadvertently damaged by overdriving it with currents higher than the rated value.

Follow the detailed procedure on the next page to set the current limit.

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## Procedure—Setting the current limit

Use the following steps to set the **Current Limit Dial** to a desired maximum value. Do not turn the **Current Limit Dial** beyond the safe value for the attached LED.

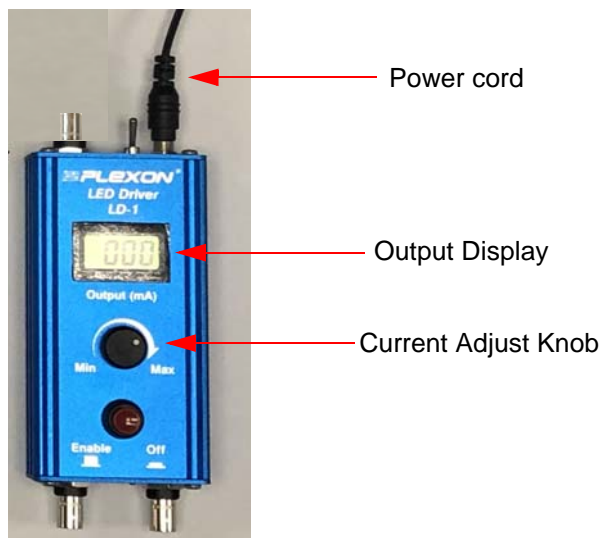


### CAUTION

**Damage to the LED Module from setting the Current Limit Dial to an unsafe value will void the warranty.**

- 1 Ensure the **Enable/Off** button on the LD-1 LED Driver is in the “Enable” position.
- 2 Turn the **Current Limit Dial** fully counterclockwise with a small flat-head screwdriver (not included with the LD-1 LED Driver). This limits the output to zero, and will protect any LED Module that will be attached in a later step in this procedure.
- 3 Connect the power cord to the LD-1 LED Driver and turn the LD-1 LED Driver power on.
- 4 Use your fingers to turn the black **Current Adjust Knob** on the front of the LD-1 LED Driver clockwise to 100% output.

**Note:** The **Output Display** should read “000” at this time, because the **Current Limit Dial** was turned fully counterclockwise in [Step 2](#).



- 5 Attach an LED Module (as shown in the image below) using the Plexon supplied BNC cable. Make sure that the outside of the BNC connector is not touching other external objects. The cable that came with your LD-1 LED Driver system is insulated for this reason.



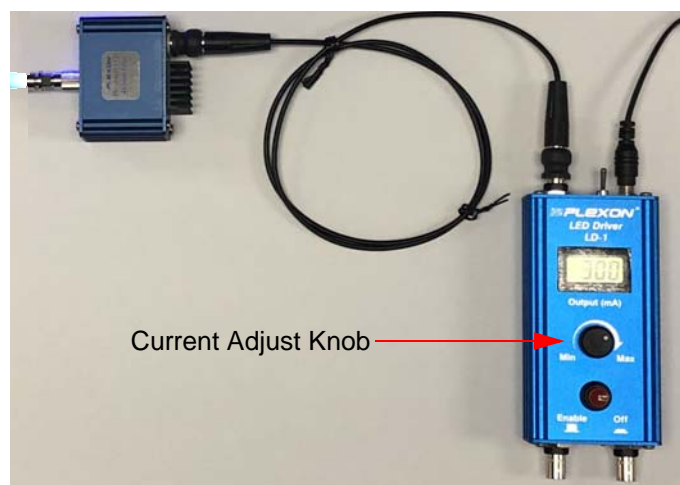
### CAUTION

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

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- 6 Use the screwdriver to slowly turn the **Current Limit Dial** clockwise up to the desired maximum allowable current associated with the attached LED Module, for example, 300mA for the Plexon blue table-top LED Module. The current value output in mA will be readable on the LD-1 Driver display.

**Example**

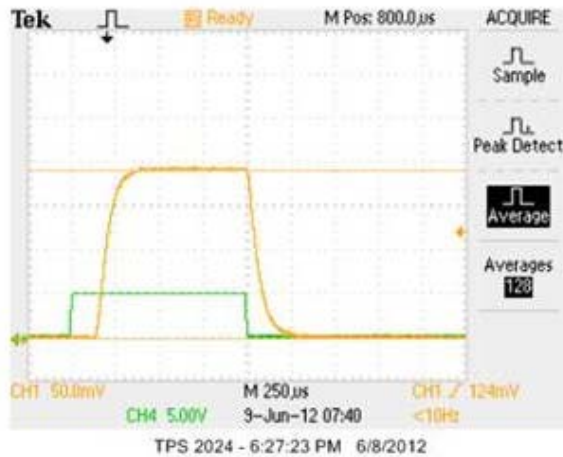
If the **Current Limit Dial** starts in the fully counterclockwise position and is then rotated with a screwdriver 25% in the clockwise direction, the maximum current output of the LD-1 LED Driver will be increased from 0mA to 300mA (that is, 25% of the driver's maximum possible output of 1200mA). After making this adjustment, turning the manual **Current Adjust Knob** on the front of the LD-1 LED Driver fully clockwise will result in an output of 300mA. Likewise, applying the full 5V to the Analog Input will now result in an output of 300mA.



- 7 Once the maximum output is set by the steps above, you can use the **Current Adjust Knob** to make fine adjustments to the current output value.
- 8 When you are ready to begin an experiment, connect an appropriate patch cable to the LED Module. It is strongly recommended that you use the PlexBright Light Measurement Kit (sold separately) to precisely measure LED Module / patch cable outputs at given supply currents.

## 10 Temporal Response of the LD-1 LED Driver

As described in the sections above, the LD-1 LED Driver can input **Analog** or **TTL** signals to precisely control LED output patterns with high temporal resolution. The two relevant parameters regarding the temporal resolution of the output are 1) onset latency (time between control signal onset and onset of LED light output), and 2) the rise time of the LED Module output (time to ~80% of the final light output value). This is shown in the diagram below.



**Measured light output from a Blue PlexBright LED (yellow trace) at the full current of 300mA, during a 1ms pulse, triggered with the TTL input (green trace).**

The onset latency is significantly shorter when controlling with the **Analog Input**. Also, note that the onset latency can be accounted for ahead of time and compensated for in some experiments. In this case, the approximate 100µs rise time of light onset translates into achievable pulse widths of less than 500µs, and maximum pulse frequencies higher than 1kHz.

Input Type	Latency from control signal input to light onset (microseconds)	Rise time from light onset to ~80% of final light output (microseconds)	Total latency from control signal input until ~80% LED output (microseconds)
TTL Input	150 µs	100 µs	250 µs
Analog Input	60 µs	100 µs	160 µs

## 11 Specifications for LD-1 LED Driver

<b>General</b>		
Dimensions	2.6 cm x 5.5 cm x 10.5 cm (1.0 in x 2.2 in x 4.1 in)	
Weight	250 g (0.55 lbs)	
Power requirements	100–240 VAC, 50/60 Hz, 0.7 A	
Compatibility with LED Modules	All PlexBright LED Modules	
Number of LED Modules controlled simultaneously	1 or 2 (Use with 2 LED Modules requires accessory)	
Compatibility with commutators	PlexBright Dual LED Commutator, or PlexBright Dual LED + 16 Channel Commutator	
<b>Inputs</b>		
Input modes	Voltage (Analog and TTL) signals from external source(s)	
Maximum input voltage	5 V	
Digital input levels (TTL)	Low < 0.7V, High > 2.0V	
<b>Outputs</b>		
Maximum current	1200 mA (can be set to a lower value with <b>Current Limit Dial</b> )	
Current adjustment	Manual (with <b>Current Adjust Knob</b> )	
<b>Response Latency</b>	<b>TTL Input</b>	<b>Analog Input</b>
Latency from control signal input to light onset	150 $\mu$ s	60 $\mu$ s
Rise time from light onset to ~80% of final light output	100 $\mu$ s	100 $\mu$ s
Total latency from control signal input to ~80% LED output	250 $\mu$ s	160 $\mu$ s
<b>Accessories (optional)</b>		
Cable	PlexBright Series-Y BNC Cable	

# PlexBright™ LD-1

## Single Channel LED Driver

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