

PlexBright[®] Light Measurement Kit Guide



PlexBright® Light Measurement Kit Guide

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Introduction

This document will provide a description of the PlexBright® Light Measurement Kit components and instructions for proper usage with the PlexBright Optogenetic Stimulation System (PlexBright System). Plexon provides the PlexBright Light Measurement Kit, containing the THORLABS PM100D Optical Power and Energy Meter (PM100D Power Meter) and S140C Integrating Sphere Photodetector (S140C Photodetector). This kit also includes adaptor pieces required to interface the S140C Photodetector with PlexBright LED Modules and PlexBright Optical Patch Cables. If you have already purchased the S140C Photodetector and a matching PM100D Power Meter, then you only need to purchase the necessary photodetector adaptor kit from Plexon. (See Appendix for more information about why PlexBright photodetector adaptor pieces are critical for accurate readings.)

This guide will provide a basic overview and describe components, hardware set-up, measuring steady-state light outputs, dynamic/pulsed light measurements, and includes an Appendix on avoiding light-clipping with PlexBright Photodetector Adaptors.

Overview

It is often useful to measure light outputs from the PlexBright System. For example, light output measurements can validate proper functioning of a PlexBright LED Module and proper connection of any attached PlexBright Optical Patch Cable and PlexBright Fiber Stub Implant. Also, because of variations between PlexBright LED Modules, PlexBright Optical Patch Cables and PlexBright Fiber Stub Implants, expected light outputs for a given supply current are only approximate. Light output measurements enable the precise control of optical stimulation that is often required in optogenetics experiments.

Light output measurements typically require a photodetector and power meter. The photodetector transduces incident light into an electrical signal, which the power meter processes and converts into a reading of light intensity. Different power meter/photodetector combinations will enable measurements of PlexBright light outputs, but the wrong components or even the incorrect use of the right components may lead to inaccurate measurements.

To take measurements of light output from the PlexBright System, Plexon highly recommends use of the PM100D Power Meter and S140C Photodetector along with specially designed PlexBright Photodetector Adaptor pieces for the most accurate readings. Standard photodetector adaptors are often not designed to anticipate the wide output angle of light emitted by the high performance PlexBright System. Thus, the resulting readings are likely to under represent the true output. Using the PlexBright Light Measurement Kit as described on the following pages will ensure you have the right equipment and techniques to make the most accurate measurements.

Components

The PlexBright Light Measurement Kit contains the following light measurement hardware from THORLABS as well as custom Plexon adaptors required for accurate and simple measurements of light output from PlexBright LED Modules, PlexBright Optical Patch Cables or PlexBright Fiber Stub Implants.

THORLABS Light Measurement Hardware

A - THORLABS PM100D Optical Power and Energy Meter



B - THORLABS S140C Integrating Sphere Photodetector



C - SMA-to-BNC Adaptor for outputting dynamic power meter output to an oscilloscope



Plexon Photodetector Adaptors

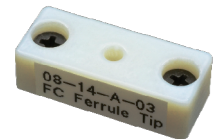
D - PlexBright LC Photodetector Adaptor (08-14-A-01) for use with the PlexBright Compact LED Modules or PlexBright Optical Patch Cables with an LC Ferrule Tip



E - PlexBright FC Connector Photodetector Adaptor (08-14-A-02) for use with the PlexBright Table-top LED Modules



F - PlexBright FC Ferrule Photodetector Adaptor (08-14-A-03) for use with the PlexBright Optical Patch Cables with an FC Ferrule Tip



Plexon can not guarantee the accuracy of any reading where different light measurement hardware has been substituted. Also, please note that there is not a photodetector adaptor identified for use with PlexBright Optical Patch Cables with a Bare Fiber Tip or PlexBright Fiber Stub Implants—that is because an accurate measurement can be made without the need for an adaptor.

Hardware Set-up

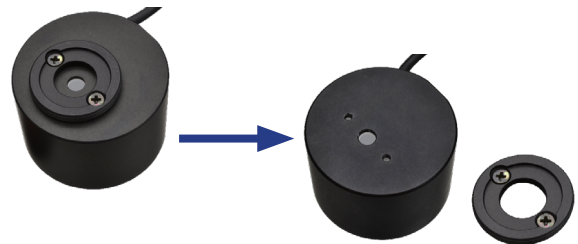
First Time Equipment Set-up

THORLABS System Equipment

1. Unpack the S140C Photodetector from the storage case.



2. Use a Phillips screwdriver (not included) to remove any non-Plexon adaptors from the S140C Photodetector, returning them to the storage case for possible future use.



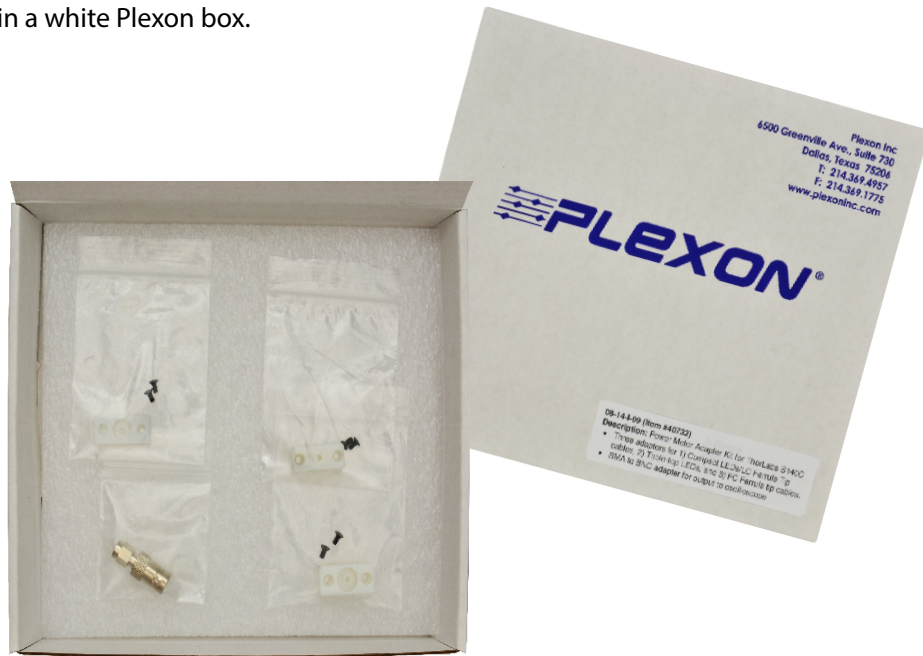
3. Unpack the PM100D Power Meter from its storage case.



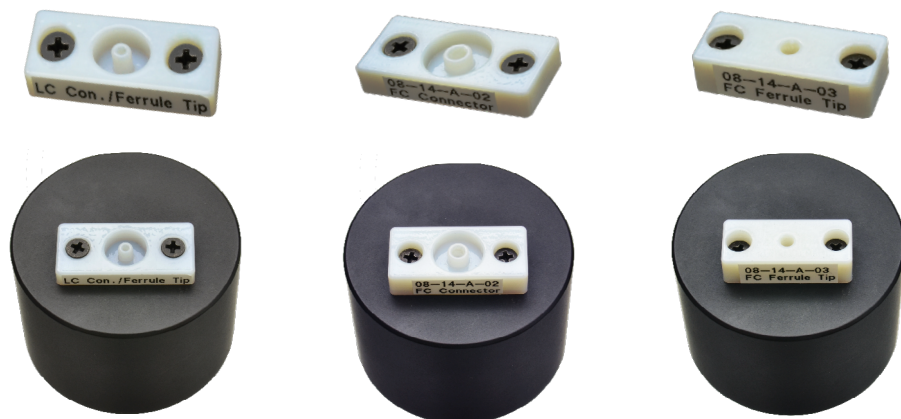
4. Plug in the PM100D Power Meter using the included power supply or select to run from battery.
5. Firmly attach the connector of the S140C Photodetector into the port on the the PM100D Power Meter marked "sensor".

Plexon Photodetector and SMA-to-BNC Adaptors Box

1. Unpack the Plexon Photodetector Adaptor Equipment contained in a white Plexon box.



2. Use a Phillips screwdriver (not included) to attach the desired PlexBright Photodetector Adaptor to the S140C Photodetector with the included screws (review "Plexon Photodetector Adaptors" options in previous Components section).



Preparing PlexBright Equipment to be Measured

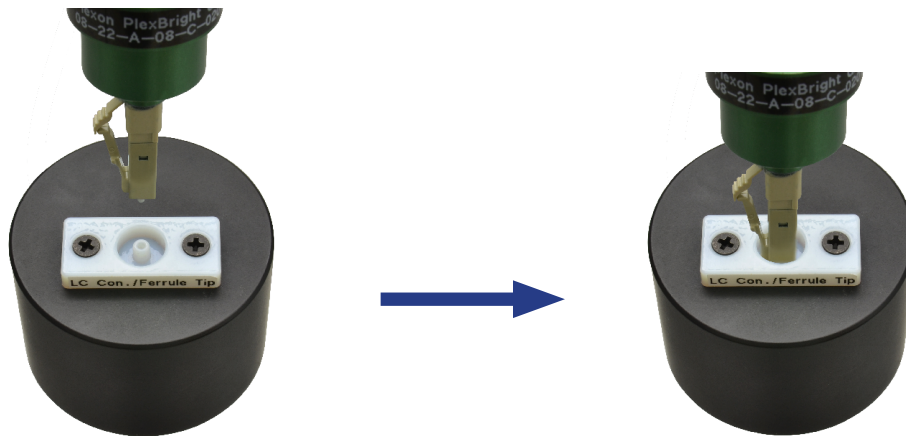
The PlexBright Photodetector Adaptors are designed to easily and accurately interface PlexBright LED Modules and PlexBright Optical Patch Cables to the THORLABS S140C Photodetector. PlexBright Photodetector Adaptors will be necessary for accurate measurements of output from PlexBright LED Modules or PlexBright Optical Patch Cables with either an LC or FC Ferrule tip.

NOTE: Measuring output from PlexBright Optical Patch Cables with a Bare Fiber Tip or from PlexBright Fiber Stub Implants does not require the use of an adaptor.

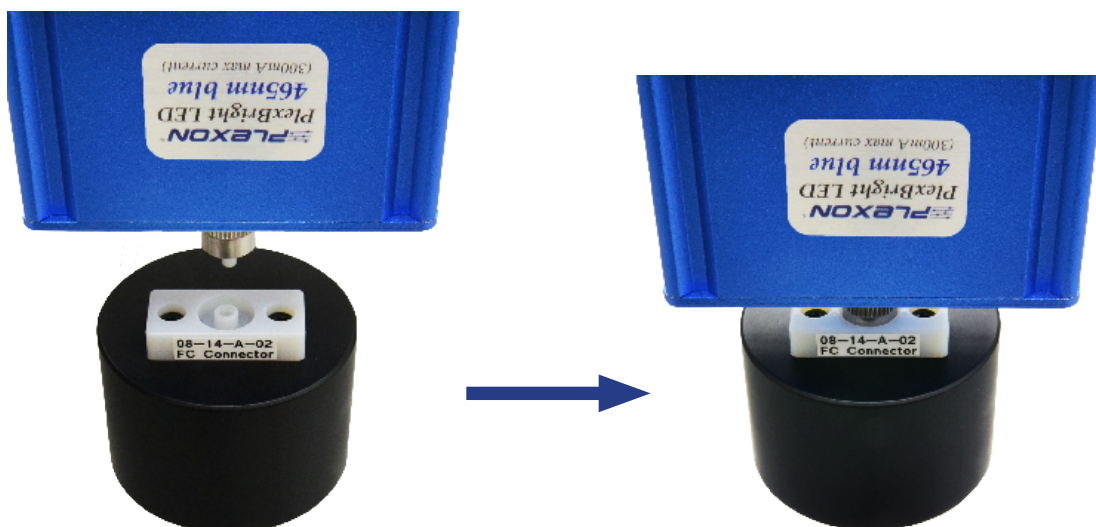
Preparing PlexBright LED Modules

To measure light output directly from a PlexBright LED Module:

1. Clean and dry the ferrule tip first (ideally using the PlexBright Optical Fiber Cleaning Kit).
2. Place the ferrule of the PlexBright LED Module into the opening on the appropriate PlexBright Photodetector Adaptor:
 - For PlexBright Compact LED Modules, the LC Photodetector Adaptor (08-14-A-01) should already be attached (see "Plexon Photodetector SMA-to-BNC Adaptors Box" section under "Hardware Setup").



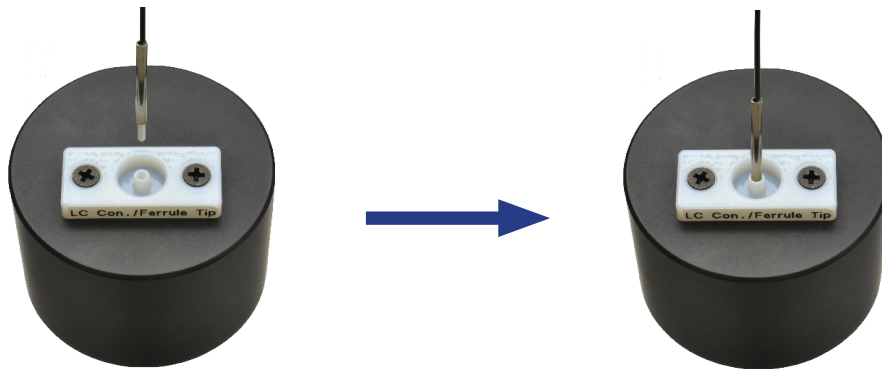
- For PlexBright Table-top LED Modules, the FC Connector Photodetector Adaptor (08-14-A-02) should already be attached (see "Plexon Photodetector SMA-to-BNC Adaptors Box" section under "Hardware Setup").



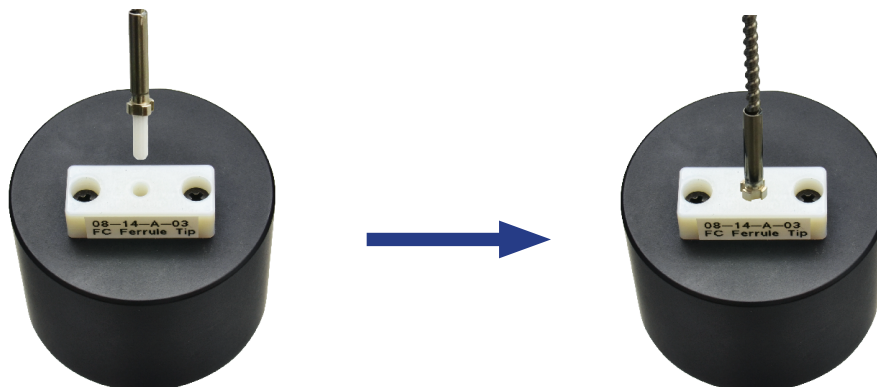
Preparing PlexBright Optical Patch Cables

To measure light output from a PlexBright Optical Patch Cable with an LC or FC Ferrule tip connected to a PlexBright LED Module:

1. Separate the module from the patch cable.
2. Clean and dry the fiber exiting the module, and the fiber tips at both ends of the patch cable (ideally using the PlexBright Optical Fiber Cleaning Kit).
3. After reattaching the module to the patch cable, make sure the patch cable is properly and firmly attached to the module.
4. Place the exposed ferrule of the PlexBright Optical Patch Cable into the opening on the appropriate PlexBright Photodetector Adaptor already fixed to the photodetector:
 - For PlexBright Optical Patch Cables with an LC Ferrule Tip, the LC Photodetector Adaptor (08-14-A-01) should already be attached (see "Plexon Photodetector SMA-to-BNC Adaptors Box" section under "Hardware Setup").

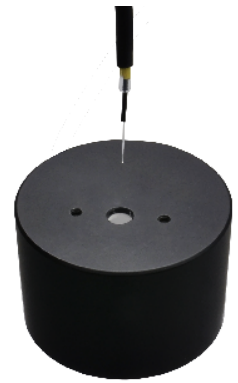


- For PlexBright Optical Patch Cables with an FC Ferrule Tip, the FC Ferrule Photodetector Adaptor (08-14-A-03) should already be attached (see "Plexon Photodetector SMA-to-BNC Adaptors Box" section under "Hardware Setup").



To measure light output from a PlexBright Optical Patch Cable with a Bare Fiber tip connected to a PlexBright LED Module:

1. Separate the module from the patch cable.
2. Clean and dry the fiber exiting the module, and the fiber tips at both ends of the patch cable (ideally using the PlexBright Optical Fiber Cleaning Kit).
3. After reattaching the module to the patch cable, make sure the patch cable is properly and firmly attached to the module.
4. No PlexBright Photodetector Adaptor is needed. Simply fix the PlexBright Optical Patch Cable over the direct center of the S140C Photodetector's aperture with a stabilizing device rather than freely holding it.



Preparing PlexBright Fiber Stub Implants

No Photodetector Adaptor is required to measure light output from a PlexBright Fiber Stub Implant (connected to a PlexBright Optical Patch Cable and a PlexBright LED Module). To measure light output from a bare fiber at the end of a PlexBright Fiber Stub Implant:

1. Remove any adaptor from the S140C Photodetector.
2. Separate the module, the patch cable and the fiber stub implant (if applicable).
3. Clean and dry the ferrule exiting the module, and the fiber tips at both ends of the patch cable and/or the fiber stub implant (ideally using the PlexBright Optical Fiber Cleaning Kit).

NOTE: Be careful not to damage the fragile glass tip of the fiber stub when cleaning or positioning.

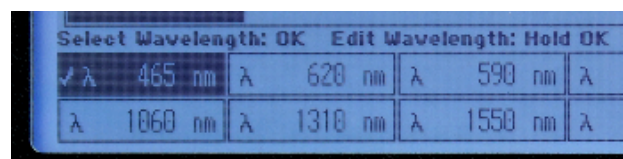
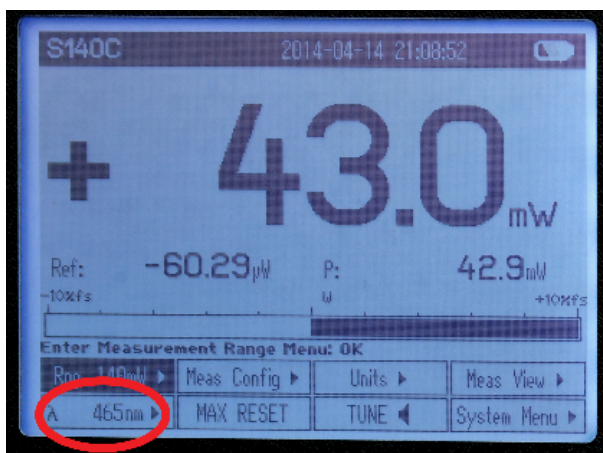
4. No PlexBright Photodetector Adaptor is needed. Simply fix the PlexBright Fiber Stub Implant over the direct center of the S140C Photodetector's aperture

Measuring Steady-state Light Outputs

The PM100D Power Meter provides a simple push-button interface that displays the measured light power. Typical units of measurement are milliwatts (mW).

1. Configure the PM100D Power Meter for the wavelength being measured. The current wavelength setting is displayed in the lower left corner of the screen. Press the λ button to access the "Wavelength" menu. Use the arrow keys to select one of the default wavelengths, or if necessary customize one of the defaults by pressing and holding the OK button to enter editing mode. In edit mode, use the arrow keys to set the desired wavelength and then press OK.

NOTE: Failure to set the appropriate wavelength will result in faulty readings of light output.



Select the wavelength of the light being measured

2. Make sure the tip of the PlexBright LED Module or PlexBright Optical Patch Cable with a Ferrule tip is clean and fully inserted into the appropriate PlexBright Photodetector Adaptor.

NOTE: If measuring output from a PlexBright Optical Patch Cable with a Bare Fiber Tip or a PlexBright Fiber Stub Implant, a Photodetector Adaptor is not necessary. Use a manipulator to fix the optical fiber tip just inside the direct center of the S140C Photodetector's aperture.



3. Observe the output reading from the PM100D Power Meter.

4. To obtain units of mW/mm² at the tip of optical fiber, divide the mW measurement by the cross-sectional area of the fiber core.

- For any PlexBright Optical Patch Cable, the core radius is 0.1mm. Therefore, the cross sectional area is 0.0314mm².
- For PlexBright Fiber Stub Implants with the larger optical fiber (200/230µm), the core radius is 0.1mm. The cross sectional area is 0.0314mm² (same as above).
- For PlexBright Fiber Stub Implants with the smaller optical fiber (110/125µm), the core radius is 0.055mm. Therefore, the cross sectional area is 0.0095mm².

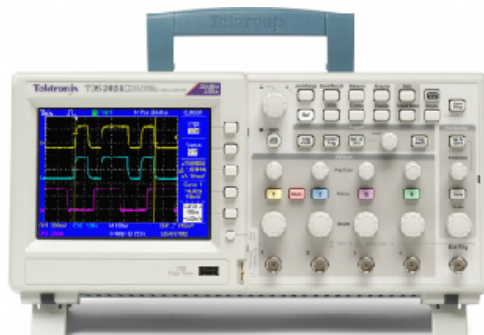
For example, a PlexBright Optical Patch Cable generating a reading of 25mW would be converted to mW/mm² as follows:

$$25\text{mW} / (0.0314\text{mm}^2) = 796 \text{ mW/mm}^2$$

Dynamic/Pulsed Light Measurements

The display on the PM100D Power Meter is not suitable for visualizing quickly changing light outputs. However, the PM100D Power Meter provides an analog output signal that can be routed to an oscilloscope to characterize dynamic light outputs. The following materials are required:

- ♦ SMA-to-BNC Adaptor (included)
- ♦ Standard female-to-female BNC cable (not included)
- ♦ Standard oscilloscope (not included)



Sample Oscilloscope

To measure quickly changing light outputs take the following steps:

1. Attach SMA-to-BNC Adaptor firmly to the "ANALOG OUT" of the PM100D Power Meter.

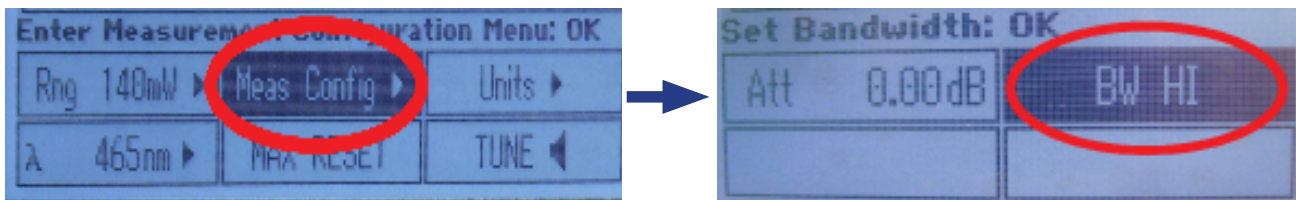


2. Attach a standard BNC cable from the SMA-to-BNC Adaptor to the oscilloscope input.

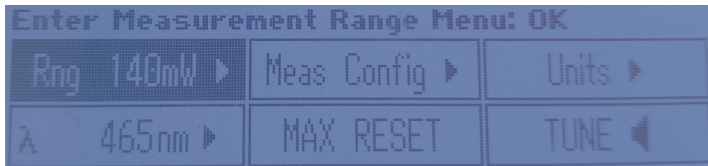


3. Select the wavelength being measured as described in the Measuring Steady-state Light Outputs section.

4. Under the "Measurement Configuration" menu of the PM100D Power Meter's push button interface, select the "BW HI" (high bandwidth) option. This option will enable high frequency outputs.



5. Under the “Rng” menu, disable the autoranging feature by selecting from the drop down list the maximum light output to be measured. This step is important to keep the scaling of the output signal constant. Take note of this



maximum range value (e.g. 140mW).

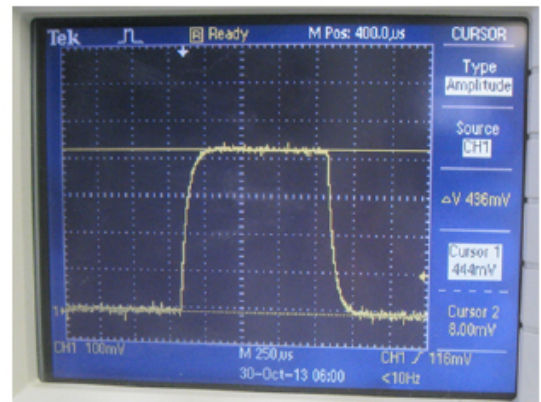
6. The analog output displayed on the oscilloscope (volts) must be converted to a light measurement (watts), taking into account the maximum range value, which in turn depends on the set wavelength:

$$\text{Oscilloscope Reading (mV)} / 2000 \text{ (mV)} * \text{Maximum Range Value (mW)} = \text{Light Output (mW)}$$

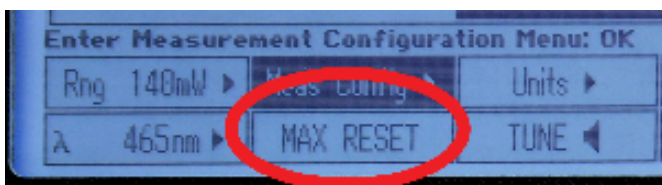
For example, if the oscilloscope reading of light output is 400mV, with the PM100D Power Meter set to measure a wavelength of 465nm and the maximum range value selected to be 140mW, then the light output is:

$$400/2000 * 140 = 28\text{mW}$$

7. To visualize and measure short pulses or quickly changing signals, use the trigger setting on the oscilloscope.

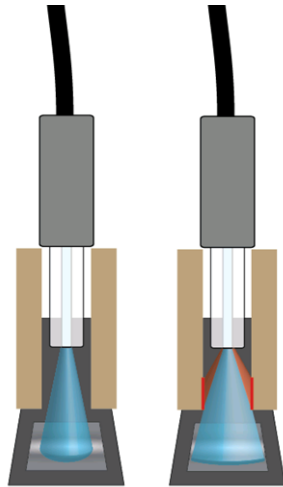


When an oscilloscope is not available, the maximum value reading on the front display of the light meter (MAX RESET) may be used to capture the peak value of quickly changing light pulses. For further information, consult Section 5.3: Power Measurement of Pulsed Signals in the THORLABS PM100D Operation Manual.



Appendix: Avoiding Light-clipping with PlexBright Photodetector Adaptors

Photodetectors often come with adaptors designed to mate with standard fiber-optic connectors. However, these adaptors are often not designed to anticipate the wide output angle of light emitted by the high performance PlexBright System. As a result, these standard adaptors can clip the light output from PlexBright devices, causing artificially low measurements. To avoid this, use the appropriate PlexBright Photodetector Adaptor when possible. (An adaptor is not necessary when measuring output from PlexBright Optical Patch Cables with a Bare Fiber Tip or PlexBright Fiber Stub Implants.) The emitting tip of the PlexBright LED Module or PlexBright Optical Patch Cable can also be manually positioned by hand or with a manipulator to avoid light clipping.



Left) The adaptor is designed to measure a narrow output cone of light. Right) Wider angle light is clipped by the same adaptor and never reaches the photodetector surface.

About Plexon Inc

Plexon is a pioneer and leading innovator of custom, high-performance data acquisition, behavior and analysis solutions specifically designed for scientific research. We collaborate with and supply thousands of customers including the most prestigious neuroscience laboratories around the globe driving new frontiers in areas including basic science, brain-machine interfaces (BMI), neurodegenerative diseases, addictive behaviors and neuroprosthetics. Plexon offers integrated solutions for in vivo neurophysiology, optogenetics, and behavioral research – backed by its industry-leading commitment to quality and customer support. For more information, please visit www.plexon.com.

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If after reviewing this document, you would still like to access Plexon's Technical Support, we are available via several communication channels. You are invited to reach us through email or on the phone.

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