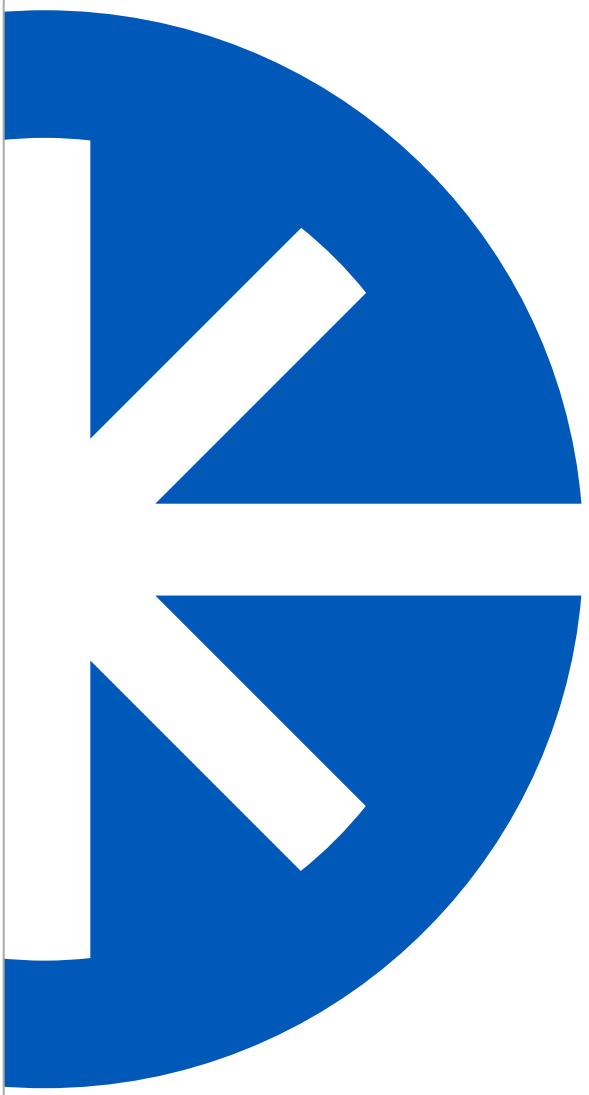

PowerMax®–Pro kW Sensor

User Manual

COHERENT®
Superior Reliability & Performance

POWERMAX®–PRO KW
USER'S MANUAL

5100 Patrick Henry Drive
Santa Clara, CA 95054 USA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

This documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.6 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z-535.3 and ISO 7010.

Anyone setting up or operating the PowerMax®-Pro kW sensor must first read and understand how safety information is presented prior to beginning any tasks.

This user information reported in this manual is in compliance with the following standards for Light-Emitting Products EN/IEC 60825-1 *"Safety of laser products – Part 1: Equipment classification and requirements"* 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 *"Performance standards for light-emitting products".*

Safety Warnings

This section provides information about signal words and safety symbols that you need to know before you begin to use the PowerMax-Pro kW sensor.

Signal Words

Four signal words are used in this documentation: **DANGER**, **WARNING**, **CAUTION** and **NOTICE**.

These signal words designate the degree or level of hazard when there is the risk of injury, as described in Table 1:

Preface Table-1. Signal Words

SIGNAL WORD	DESCRIPTION
DANGER	Indicates a hazardous situation that, if not avoided, WILL result in ***death or serious injury***. This signal word is to be limited to the most extreme situations.
WARNING	Indicates a hazardous situation that, if not avoided, COULD result in ***death or serious injury***.
CAUTION	Indicates a hazardous situation that, if not avoided, could result in ***minor or moderate injury***.
NOTICE	Indicates information considered important, but not hazard-related. The signal word "NOTICE" is used when there is the ***risk of property damage***.

Messages relating to hazards that could result in both personal injury and property damage are considered safety messages and not property damage messages.

Symbols

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level. The icons are intended to alert the operator as described in Table 2:

Preface Table-2. Safety Symbols

ICON	ALERTS THE OPERATOR TO…
	Important notes or instructions for operation and maintenance.
	Danger of exposure to hazardous visible and invisible laser radiation.
	Dangerous voltages when working with other equipment may be of sufficient magnitude to constitute a risk of electric shock.
	Danger of susceptibility to Electro-Static Discharge (ESD).

Export Control Laws

It is the policy of Coherent to comply strictly with export control laws of the United States of America (USA).

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations (ITAR).

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by laws in the USA, clarification must be obtained from Coherent or an appropriate agency of the U.S. Government.

For products manufactured in the European Union, Singapore, Malaysia, Thailand: These commodities, technology, or software are subject to local export regulations and local laws. Diversion contrary to local law is prohibited. The use, sale, re-export, or re-transfer directly or indirectly in any prohibited activities are strictly prohibited.

Declaration of Conformity

Declaration of Conformity certificates are available upon request.

SECTION ONE: SAFETY AND COMPLIANCE

This section describes requirements for safety for persons setting up or operating the PowerMax-Pro kW sensor, and includes:

- Laser Safety Hazards (p. 1-1)
  - Optical Safety (p. 1-2)
  - Laser back Reflection (p. 1-3)
  - Recommended Precautions (p. 1-3)
- Electrical safety (p. 1-4)

You must review these laser safety sections thoroughly BEFORE operating the PowerMax-Pro kW sensor. Carefully follow all safety instructions presented throughout this manual.

- Compliance with standards and regulations (p. 1-6)
  - Laser compliance (p. 1-6)
  - Environmental compliance (p. 1-7)

WARNING!
Use of controls or adjustments or performance of procedures other than those specified in this manual may result in exposure to hazardous radiation.

Laser Safety Hazards

Hazards associated with lasers generally fall into the following categories:

- Biological hazards from exposure to laser radiation that may damage the eyes or skin
- Electrical hazards generated in the laser power supply or associated circuits
- Chemical hazards resulting from contact of the laser beam with volatile or flammable substances, or released as a result of laser material processing

The above list is not intended to be exhaustive. Anyone operating a laser must consider the interaction with its specific working environment to identify potential hazards.

For the PowerMax-Pro kW sensor, hazards vary with the input angle and the laser beam.

WARNING—LASER RADIATION!
Always avoid eye or skin exposure to both DIRECT and SCATTERED radiation.

Optical Safety

Laser light, because of its optical qualities, poses safety hazards not associated with light from conventional light sources. The safe use of lasers requires all operators, and everyone near a laser, to be aware of the dangers involved. Users must be familiar with the instrument and the properties of coherent, intense beams of light.

The safety precautions listed below are to be read and observed by anyone working with or near the laser. At all times, ensure that all personnel who operate, maintain or service the laser are protected from accidental or unnecessary exposure to laser radiation exceeding the accessible emission limits defined in the laser safety standards.

WARNING!
Direct eye contact with the output beam from the laser may cause serious eye injury and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near a laser. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing, or combustible materials, even at some distance. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers, and photodiodes. Follow the control measures listed in "Recommended Precautions for Laser Safety" (p. 1-3).

Laser Safety Eyewear

Always wear appropriate laser safety eyewear for protection against the specific wavelengths and laser energy being generated.

The appropriate eye protection can be calculated as defined in the "EN 207 Personal eye protection equipment—Filters and eye-protectors against laser radiation (laser eye-protectors)", in other national or international standards (such as ANSI, ACGIH, or OSHA) or as defined in national safety requirements.

CAUTION!
Laser safety eyewear protects the user from accidental exposure to laser radiation by blocking light at the laser wavelengths.

However, laser safety eyewear may also prevent the operator from seeing the beam or the beam spot. Exercise extreme caution even while wearing safety glasses.

Viewing Distance

A laser produces optical power levels that are dangerous to the eyes and skin if exposed directly or indirectly. This product must be operated only with proper eye and skin protection at all times. Never view directly emitted or scattered radiation with unprotected eyes.

When viewing the laser during operation, the operator must maintain the Nominal Ocular Hazard Distance (NOHD) between the laser or scatter radiation and the operator's eyes. Check the Operator's Manual for the laser you are using.

Maximum Accessible Radiation Level

A laser produces visible radiation over the various wavelengths. See the Product Label on your laser for details about maximum emission levels.

Laser Back Reflection

Back reflection (also referred to as retroreflection) occurs when a part of the laser beam is sent back into the laser's exit aperture.

Back reflection can be caused by any object in front of the laser and can result in instability, noise, or damage to the laser. Damage from back reflection can be immediate, or it can be subtle and slowly decrease the service life of a laser. A laser that shows symptoms—such as low output power, no output power, over-current, or high noise—indicates a possibility of back reflection to the laser.

The low back-reflection design and coatings on the PowerMax-Pro kW Sensor reduce reflectivity and make set-up quicker and easier.

Recommended Precautions for Laser Safety

The following recommended precautions and guidelines to prevent damage to persons or property should always be observed. Laser beams can easily cause flesh burns or ignite clothing. These precautions also help to increase the operating life of the laser.

- Read and follow all safety precautions in the associated product manuals (whether Installation, Set-Up, Quick Start, Operator's or User Manuals).
- Set up the laser so that the beam height is either well below or well above eye level.
- Never look directly into the laser light source or at scattered laser light from any reflective surface, even when wearing laser safety eyewear. Never sight down the beam.
- Always wear appropriate eyewear for protection against the specific wavelengths and laser energy being generated. See "Laser Safety Eyewear" (p. 1-2) for more information.
- Watch where the reflections from objects are returning to make sure the reflections are not at or near the laser exit aperture. Change the objects to add an angle so the object is less reflective whenever possible. Add an optical isolator to those applications with laser exit aperture back reflections that cannot be corrected by angling the optics.
- Review any objects in front of the laser and make a note of which surfaces are a possible hazard for back reflections. Keep precautions in mind when moving objects that can create a back reflection in front of the laser.
- Avoid wearing watches, jewelry, or other objects that may reflect or scatter the laser beam.
- Block the beam before applying tools such as Allen wrenches or ball drivers to external optics.
- Provide enclosures for beam paths whenever possible.

- Stay aware of the laser beam path, particularly when external optics are used to steer the beam.
- Use appropriate energy-absorbing targets for beam blocking.
- Terminate the laser beam with a light-absorbing material. Laser light can remain collimated over long distances and therefore presents a potential hazard if not confined. It is good practice to operate the laser in an enclosed room.
- Decrease the power from any possible back reflections by starting the laser at lower output power—for example, 10% output power—before opening the laser shutter.
- Exercise extreme caution when using solvents in an area with any laser.
- Post laser warning signs in the area of the laser beam to alert those present.
- Limit access to the laser to trained and qualified users who are familiar with laser safety practices. When not in use, lasers should be shut down completely and made off-limits to unauthorized personnel.
- Advise all those working with or near the laser of these precautions.

Electrical Safety

The PowerMax-Pro kW sensor does not have dangerous voltages.

IMPORTANT!
The PowerMax-Pro kW sensor is designed to be operated as assembled; there are no user-serviceable components in the device. DO NOT disassemble the enclosure. ***The Warranty is void if the enclosure is disassembled!***

The most common ESD damage occurs when handling a device during installation or use. Take the necessary measures to protect the system from ESD.

Dry air and carpet also create a higher potential for ESD. Remember to take precautions or shielding not only for operations, but for demonstrations or trade show exhibitions.

CAUTION!
Electrostatic charges as high as 4000 volts easily collect on the human body and equipment and can discharge without detection.

Although the electronics features have input protection, permanent damage can occur on devices subjected to high-energy electrostatic discharges. You must take correct ESD precautions to prevent damage or performance degradation.

Electrical Safety Precautions

Everyone must observe the following precautions when working with potentially hazardous electrical circuitry:

WARNING!
When working with electrical power systems, the rules for electrical safety must be strictly followed. Failure to do so could result in the exposure to damaging levels of electricity.

1. Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
2. Do not short or ground the power supply output. Protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.

WARNING!
Normal operation of the sensor should not require access to the power supply circuitry. Removing the power supply cover exposes the user to potential electrical hazards. Contact an authorized service representative before attempting to correct any problem with the power supply.

3. Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
4. When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is touched accidentally.
5. Always use approved, insulated tools.

ESD Protection

The most common ESD damage occurs when handling the device during installation or use.

WARNING!
Damage can occur to the electronics features of the PowerMax-Pro kW sensor from Electrostatic Discharge (ESD).

Electrostatic charges easily collect on the human body, equipment, and facilities, and can discharge without detection. Dry air and carpet create a higher potential for Electrostatic Discharge (ESD).

Take necessary precautions or shielding to protect the system from ESD to prevent performance degradation or damage to the system.

When mobile equipment (a cart or table) is used as an ESD-protected workstation, connect it to ESD ground that meets ANSI/ESD S4.2 required limits for an ESD-protected workstation ($<1 \times 10^9$ ohms).

Compliance

This section describes compliance with various government requirements for safety, environmental regulations, and control law.

Laser Safety Standards

Following are sources for information about laser safety standards, as well as safety equipment and training.

Within the United States:

The applicable United States Government laser safety requirements are contained in 21 CFR Title 21 Chapter 1, Subchapter J, Part 1040 ("*Performance standards for light-emitting products")*. The text of this federal standard is available from:

U.S. Food and Drug Administration
Center for Devices and Radiological Health (CDRH)
Document Mail Center – WO66-G609
Sliver Spring, MD 20993-0002

Website: www.fda.gov

Outside of the United States:

For jurisdictions outside of the United States:

Safety of laser products - Part 1: Equipment classification and requirements
IEC 60825-1 / EN 60825-1

Safety of laser products - Part 14: A user's guide
IEC 60825-1 / EN 60825-1

Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use
IEC 61010-1 / EN 61010-1

Publications and Guidelines

International Electrotechnical Commission (IEC)
www.iec.ch

Safety of laser products - Part 1: Equipment classification and requirements
BS EN 60825-1
British Standard Institute
www.bsigroup.com

American National Standard for Safe Use of Lasers
ANSI Z136 Series
American National Standards Institute (ANSI)
www.ansi.org

A Guide for Control of Laser Hazards
American Conference of Governmental
and Industrial Hygienists (ACGIH)
www.acgih.org

Laser Safety Guide
Laser Institute of America
www.lia.org

CE Marking

The European Community requirements for product safety are specified in the Low-Voltage Directive (LVD) (published in 2014/35/EU).

This Directive requires that lasers comply with the standard EN 61010-1/IEC 61010-1 "Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use" and EN 60825-1/IEC 60825-1 "Safety of Laser Products". Compliance with the European requirements is certified by CE Marking.

Electromagnetic Compatibility

The primary issue for electromagnetic compatibility is to design covers, shielding, grounding, routing of electrical cable assemblies, and control elements with the proper safety features for a complete system.

The PowerMax-Pro kW sensor has been tested and shown to be compliant with the relevant requirements of the following directives for Electromagnetic Compatibility EN 61326-1_Ed2:2013 (IEC 61326-1_Ed2:2012) and EN 61000-3-2:2006.

Environmental Compliance

This section describes compliance with various environmental regulatory directives to identify hazardous substances.

Battery Directive

There is no battery in the PowerMax-Pro kW sensor.

EU REACH

Coherent products are classified as "articles" according to EU REACH definition, as follows:

> Article means an object which, during production, is given a special shape, surface or design that determines its function to a greater degree than its chemical composition. (REACH, Article 3(3))

Articles as defined by REACH regulations are exempt from registration as long as they are not intended to release a chemical substance.

To the best of our knowledge, all Coherent product meet the definition of "article" according to REACH.

In addition, to the best of our knowledge, Coherent products do not contain any Substances of Very High Concern (SVHC) above the legally mandated thresholds included in the REACH SVHC list, which is updated every six months. The current SVHC list is available on-line at https://echa.europa.eu/candidate-list-table.

RoHS Compliance

The European Union RoHS Directive EN 50581:2012 restricts the use of certain hazardous substances in electrical and electronic equipment. Coherent is in compliance with this Directive and can provide RoHS certification upon request. Compliance of this laser with the EMC requirements is certified by the CE mark.

China RoHS Compliance

This section details compliance with the China RoHS (Restriction of Hazardous Substances) Regulation SJ/T 11364-2014.

This Regulation restricts the use of certain hazardous substances in electrical and electronic equipment. The China RoHS Regulation applies to the production, sale, and import of products into the Peoples Republic of China.

Any hazardous substances in the PowerMax-Pro kW sensor are listed on the label, shown the example in Figure 1-1.

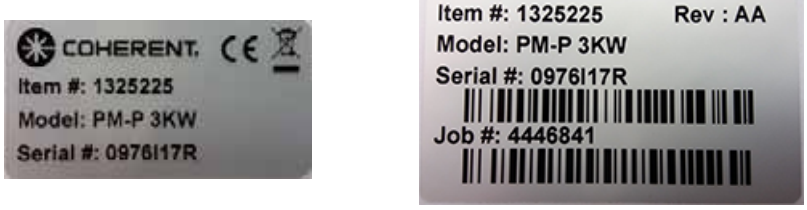
产品中有害物质的名称及含量							
部件名称 Part Name	有害物质 Hazardous Substances						
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)	
印刷电路板组装 Printed Circuit Board Assembly	X	O	O	O	O	O	
本表格依据 SJ/T 11364 的规定编制 O: 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。 X: 表示该有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572 规定的限量要求。							

Figure 1-1. China RoHS Label

The table shows that Lead (Pb) may be found in components of the PowerMax-Pro kW sensor. The environmental-friendly use period is 20 years, indicated by the number 20 inside the circle.

The China RoHS Regulation also requires that the date of manufacture be identified. This is provided on the *Certificate of Calibration* shipped with each product.

Examples of product labels are shown in Figure 1-2.



Label on the Sensor Label on the Box

Figure 1-2. Examples of Product Labels

Waste Electrical and Electronic Equipment (WEEE, 2002)

The European Union Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU) is represented by a crossed-out garbage container label. The WEEE Directive applies to your product and any peripherals marked with this symbol.

Figure 1-3. WEEE Label

The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.

Do not dispose of these products as unsorted municipal waste. Contract your local distributor for procedures for recycling this equipment.

SECTION TWO: FEATURES AND SPECIFICATIONS

This section describes the PowerMax-Pro kW sensor, and includes:

Product Introduction

The PowerMax-Pro kW sensors offer kilowatt-class, continuous power measurement of laser beams.

The PowerMax-Pro kW sensors are compatible with the LabMax-Pro SSIM meter, with software available for both desktop and mobile platforms.

These sensors offer the following key features:

- Very fast 20 µsec response time
- Measures high average power to 3 kW
- Large 30 mm active area
- Unique optical design results in less than 1% back reflection
- QBH adapter available to contain 100% of the laser inside the enclosure

A variety of models are available for the PowerMax-Pro kW sensor, as shown in the following illustrations. Figure 2-1 shows the model for a PowerMax-Pro kW with Window.

Figure 2-1. PowerMax-Pro kW with Window

Figure 2-2 shows a PowerMax-Pro kW Free Space model (no Window):

The use of a Window or QBH Adapter is recommended to eliminate the chance of sensor contamination.

Figure 2-2. PowerMax-Pro kW Free Space model (no Window)

Figure 2-3 shows a PowerMax-Pro kW with optional QBH Adapter that replaces the front plate on either a Window model or the Free-Space model. The QBH Adapter is recommended for use with fiber lasers.

Figure 2-3. PowerMax-Pro kW with Optional QBH Adapter

The various models are more fully described in the lists of "PowerMax-Pro 1 kW Average Power Models" (p. 2-10) and "PowerMax-Pro 3 kW Average Power Models" (p. 2-10) and in the sections that follow.

Key Features

PowerMax-Pro detectors, first introduced in 2014, are based on Coherent's proprietary thin-film sensor technology. This combines the broad wavelength sensitivity, dynamic range, and laser damage resistance of a thermopile with the response speed of a semi-conductor photodiode.

Fast Response Time

PowerMax-Pro kW sensors are enhanced for multi-kW continuous power measurement of laser beams within microseconds, with the response speed nearing that of a semiconductor photodiode.

- The fast response time saves significant time for engineers, production, and QA staff. Taking kW measurements happens in real time without waiting a minute or longer for a single measurement.
- By embedding PowerMax-Pro kW sensors into processing equipment, system power and energy can be monitored more frequently. This improves throughput in the production line.

With no need to wait for the sensor to stabilize, the PowerMax-Pro kW sensors provide instant average power, as shown in the example in Figure 2-4:

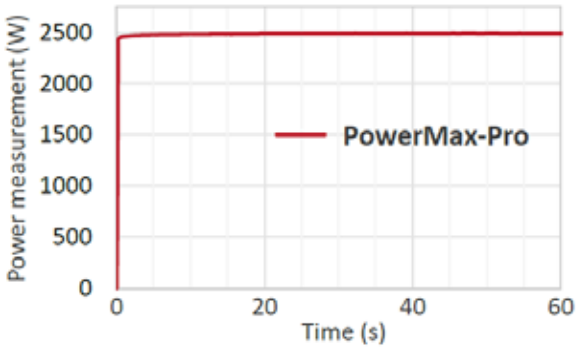


Figure 2-4. Instant Average Power

With a short heat flux path in the film, PowerMax-Pro kW sensors take a measurement within microseconds. These sensors provide a completely stabilized power reading in 0.0002 seconds, with no overshoot.

This is a significant performance advantage over traditional thermopile detectors and calorimeters, which typically take almost one minute to reach steady state before a measurement can be taken for a stable kilowatt power reading.

In addition, PowerMax-Pro kW sensors measure fast peak power. Figure 2-5 shows an example of firing a short duration burst of energy from a Continuous Wave laser to quickly measure power.

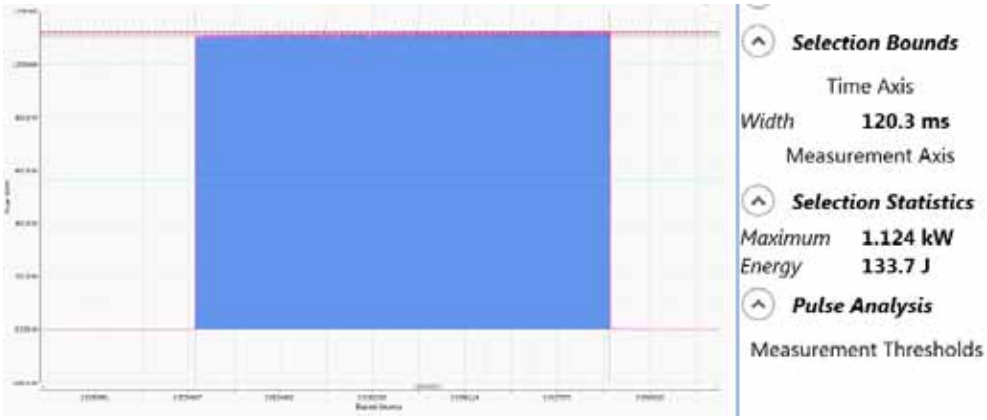


Figure 2-5. Fast Peak Power

kW Power Measurements

Using a metalized coating, most of the laser energy is reflected into a water-cooled heat sink inside the sensor. This allows the technology to achieve kW level measurements.

The new PowerMax-Pro kW sensors extend the average power handling capability up to 3 kW continuously and can handle modulated peak powers up to 5 kW.

Figure 2-6 shows an example of modulated laser pulse analysis. The energy in modulated pulses can be measured by integrating energy under the power curve in software of in meter hardware.

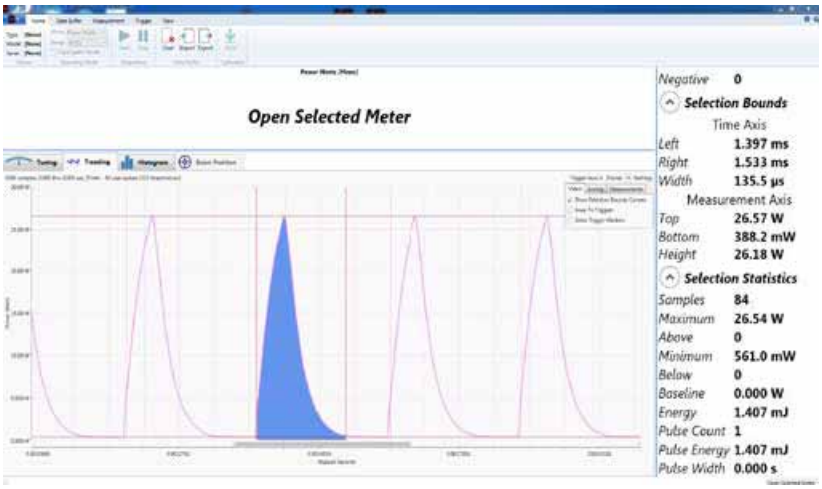


Figure 2-6. Modulated Laser Pulse Analysis

Significantly Reduced Back Reflection

Another important aspect of kilowatt class power measurements is dealing with back reflection from the detector.

Traditional thermopiles can reflect 10-15% back toward the source and must be a major consideration when setting up for a measurement.

The unique optical design of the Free Space and Window models of the PowerMax-Pro kW sensor traps >99% of the light entering the housing, resulting in less than 1% back reflection. The Window model may add another ~1% to reflected power above the <1% back reflection of the Free Space model.

When used with an optional QBH adapter mounting plate, 100% of the light is captured. This results in a a fully enclosed beam path with no back reflection.

Performance

Introduction of the PowerMax-Pro kW Sensor extends the average power handling capability. Power handling depends upon beam size.

The following charts plot power handling by beam size, beam divergence, and beam shape.

See "Section Three: Set Up the Sensor" (p. 3-1) for set-up instructions to accomplish the desired beam size.

NOTE:
Because not all beams are exactly Gaussian, to provide a margin of safety Coherent recommends a beam diameter of at least 20 mm for a 3 kW measurement.

Figure 2-7 shows the maximum average power the sensor can handle based upon beam diameter when exposed to a Gaussian beam profile. For example, with an 18 mm beam diameter, the sensor is capable of just under 3 kW continuous average power.

For diverging beams, the curve shown in the example in Figure 2-7 refers to the beam diameter at the absorber plane (114 mm from the front aperture).

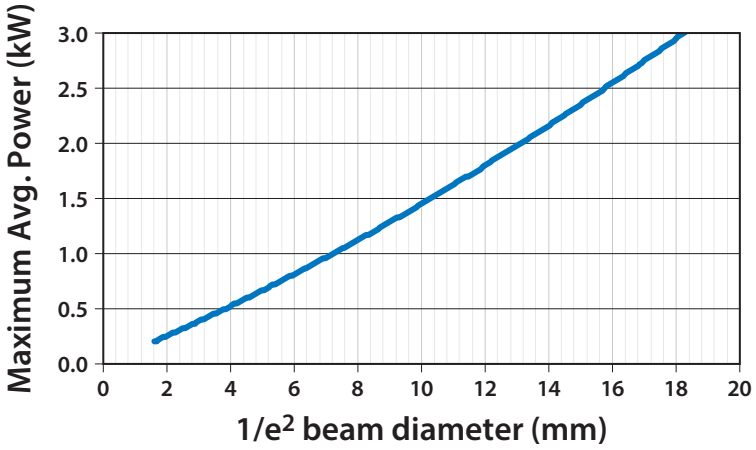


Figure 2-7. Maximum Average Power by Beam Diameter

Figure 2-8 shows the intermittent power handling capability at several different beam diameters. One purpose of this plot is to define the modulation pulse lengths that are possible for peak powers greater than 3 kW.

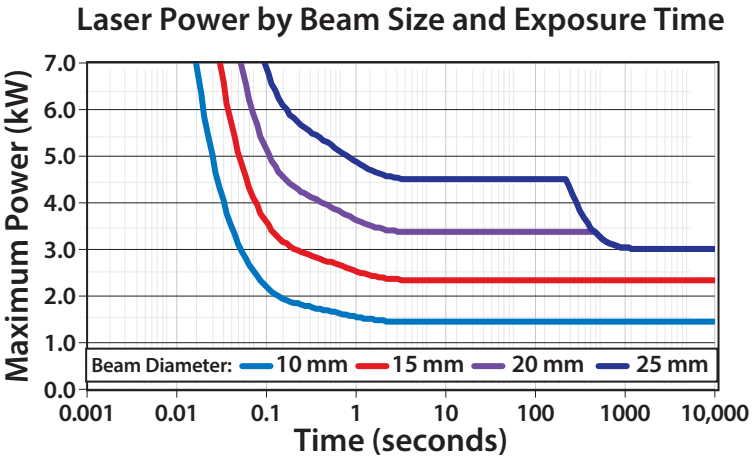


Figure 2-8. Laser Power by Beam Size and Exposure Time

Exposure to powers beyond the limits shown in these curves are likely to damage the heat sink coating.

Additionally, when used with beams >20 mm, short duration measurements greater than 3 kW are possible; with this technology, this is enough time to get a stable average power reading.

The sensor can be used above 3 kW intermittently for a minute or two with increasingly larger beams. See guidelines for 4 kW usage in the Application Note: *Using the PowerMax-Pro kW Sensor at Power Levels Above 3kW*.

CAUTION!
Take care to meet the beam size requirements and not exceed the duration limits. Otherwise, the housing can become too hot and the heat sink absorber can easily damage.

Table 2-1 lists examples of times it takes for the top front portion of the sensor enclosure to reach the stated temperature.

Table 2-1. Durations for Example Measurements

AVERAGE POWER	TEMPERATURE	TIME TO REACH TEMPERATURE
1 kW	51°C	Approximately 15 minutes.
2 kW	61°C	Approximately 15 minutes.
3 kW	83°C	Approximately 15 minutes.
4 kW	83°C	In only 2-3 minutes.

NOTES:

- With a 20mm diameter beam, this sensor can be used safely with modulated sources with peak powers up to 5 kW and pulse lengths up to 100 milliseconds.
- If care is taken to increase the beam size to 25mm, the sensor could be used with modulated peak power up to 7 kW for 100 milliseconds.
- These curves are for Gaussian beam profiles. Flatter beams can handle slightly higher powers (~5%) for longer lengths of time.
- For beams with hot spots or "super Gaussian" beams, the curves may be de-rated by up to 30%. Contacting Coherent LMC applications engineering for more detailed information.

Compatibility with Modes

Table 2-2 lists the different measurement modes supported by the PowerMax-Pro kW sensor and the compatible Coherent sensors and meters:

Table 2-2. Meter Compatibility Matrix

MODE	COMPATIBLE WITH
Basic, High-Speed, and Snapshot Measurement	LabMax-Pro SSIM
Basic Measurement	Legacy Meters: FieldMax, FieldMax II, LabMax-TOP
High-Speed Analog Signal on Oscilloscope	J-Power Pro

NOTE
Legacy meters do not support high-speed measurement modes, nor the extended wavelength compensation. While those legacy meters are compatible with the PowerMax-Pro kW sensor, those older meters are not recommended if they are very far from the calibration wavelengths due to spectral accuracy issues.

Applications

The high response speed of PowerMax-Pro kW sensors is particularly advantageous in commercial applications where it enables CW laser power and pulsed laser energy to be sampled more frequently, resulting in increased throughput and improved process control.

The high-power handling capability of the new PowerMax-Pro kW models are particularly useful for welding, cutting, drilling, and engraving with high-power fiber lasers, CO2 lasers, or solid state lasers.

Technology Comparison

The PowerMax-Pro kW sensors utilize a new version of the transverse thermoelectric thin-film HD sensor element introduced in earlier PowerMax-Pro models.

This type of thin-film detector combines a broad wavelength sensitivity, dynamic range, and laser damage resistance of a thermopile with the response speed of a semiconductor photodiode.

PowerMax-Pro kW sensors offers advantages over both:

- Thermopiles, used in numerous types of commercial applications
- Calorimeters, used by laser manufacturers and end users

Thermopile Sensors

For many years thermopiles have been the detector of choice for lasers used in commercial applications. These detectors operate on the thermoelectric principle in which thermal energy is converted into electrical energy.

The typical thermopile has a central, light absorbing disk, a series of thermocouples that surround the disk, and an annular heat sink around the ring of thermocouples. Figure 2-9 shows a conventional thermopile with radial heat flow (≥ 1s response time).

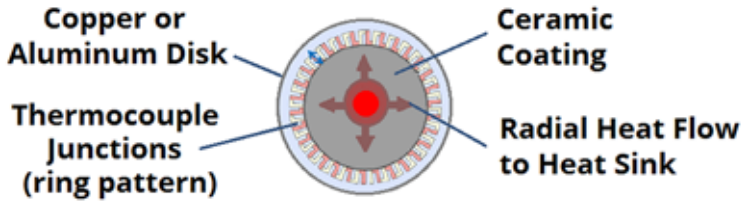


Figure 2-9. Traditional Radial Thermopile Physics

In operation, incident laser energy falls on the absorbing disk in the center of the detector and is converted into heat. This disk is typically coated with a material that absorbs light over a very broad wavelength range to increase sensitivity.

- The heat then flows across the width of the thermopile disk to the heat sink, which is held at a near constant ambient temperature by either air or water cooling, as shown in Figure 2-10.

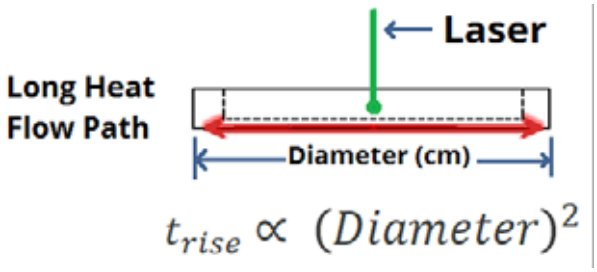


Figure 2-10. Traditional Thermopile – Long Heat Flow Path

- The temperature difference between the absorber and heat sink is converted into an electrical signal by the thermocouples.
- Calibrated electronics in the meter convert the electrical signal into a laser power reading.

Thermopile sensors have several advantages, including a very broad spectral range, an ability to work over a wide range of input powers, high laser damage resistance, and uniform spatial response (meaning insensitivity to changes in beam size, position or uniformity).

The limitation of the technology is that the transfer of heat across the width of the thermopile disk makes this technology inherently slow. It may take up to a minute before the heat flow caused by a kilowatt laser reaches equilibrium and the power measurement becomes stable on the display. Physically larger sensors take even longer to reach this stable state.

This slow response time makes thermopiles best suited for measuring CW laser power. For pulsed lasers, the best they can deliver is average power over a finite time interval, or total integrated energy from a long burst of pulses.

PowerMax-Pro Sensors

Coherent developed PowerMax-Pro technology to meet the growing need for a laser power sensor that offers the benefits of a thermopile, but with a fast response speed approaching that of a semiconductor photodiode.

The PowerMax-Pro sensor does preserve the primary benefits of a traditional thermopile architecture, including:

- Large active area (30 mm x 30 mm)
- Wide dynamic range (50 mW to 150W)

However, the PowerMax-Pro sensor is constructed and configured differently than a thermopile. In this device, the heat flows vertically through the detector. The electrical field that is generated moves perpendicular to the heat flow, as shown in Figure 2-11.

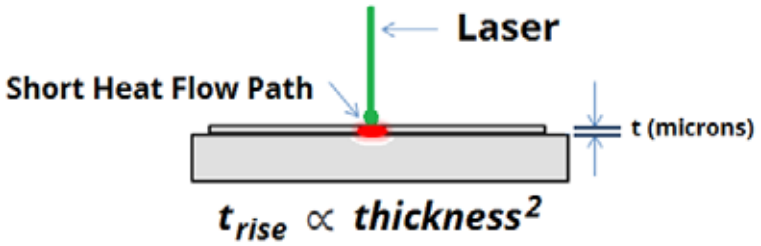


Figure 2-11. Transverse Thermoelectric Physics – Short Heat Path

The materials used in this sensor are a stack of films that have layer thicknesses on the order of microns, illustrated in Figure 2-12.

- Incident laser light is absorbed and generates heat that flows very quickly through these thin layers to the heat sink below the detector, where it is dissipated.

- The electrical signal from the thin-film layers moves laterally to the edges of the device, where it is measured by tapping into the sensor electrodes.

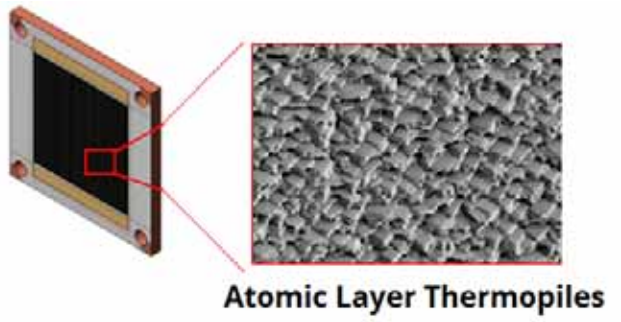


Figure 2-12. Transverse Thermoelectric Physics

Compared with the traditional radial-flow thermopile—which has a sensing time constant value of several seconds to a minute for kilowatt measurements—the time constant for the thin-film configuration is in the microsecond range. The sensor supplies an essentially instant power measurement without any overshoot, as shown in Figure 2-13.

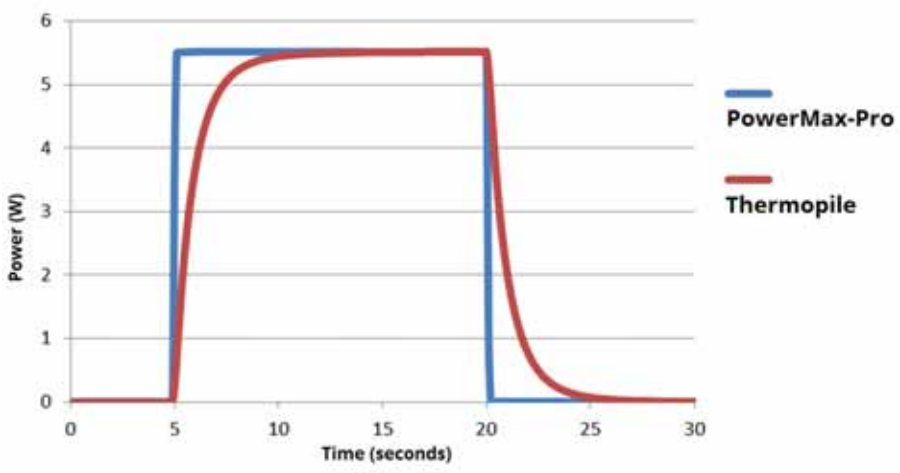


Figure 2-13. Rise Time – Thermopile vs. PowerMax-Pro

The response speed of PowerMax-Pro sensors lets users move beyond just measuring average power and enables visualization of the temporal pulse shape and peak power of modulated lasers with pulse in the 10's of microseconds or longer. These pulses can be integrated to calculate individual pulse energy.

For information about set-up requirements that differ from standard thermopiles, see "Step 6. Set Up Beam Size for Thin-Film Detectors" (p. 3-20). These requirements include considerations for:

- Beam size required to prevent laser damage and power handling limits
- Polarization sensitivity
- Wavelength sensitivity

Configurations Available

This section describes the various configurations available for both the 1 kW and 3 kW models of PowerMax-Pro kW sensors.

PowerMax-Pro 1 kW Sensor Models

Table 2-3 lists the wavelength and power ratings for the PowerMax-Pro 1 kW models:

Table 2-3. PowerMax-Pro 1 kW Average Power Models

P/N	DESCRIPTION	MAXIMUM AVERAGE POWER	MAXIMUM PEAK POWER
1324794	PowerMax-Pro – 1 kW, 810 nm (no window)	1 kW	1 kW
1334122	PowerMax-Pro – 1 kW, 810 nm (with Diode Laser Debris Shield Window)	1 kW	1 kW
1324796	PowerMax-Pro – 1 kW, 1070 nm (no window)	1 kW	1 kW
1325221	PowerMax-Pro – 1 kW, 1070 nm (with Fiber Laser Debris Shield Window)	1 kW	1 kW
1324795	PowerMax-Pro – 1 kW, 10.6 µm (no window)	1 kW	1 kW
1334121	PowerMax-Pro – 1 kW, 10.6 µm (with CO2 Laser Debris Shield Window)	1 kW	1 kW
1324797	PowerMax-Pro – 1 kW, 810 nm, 1070 nm and 10.6 µm (no window)	1 kW	1 kW

PowerMax-Pro 3 kW Sensor Models

Table 2-4 lists the wavelength and power ratings for the PowerMax-Pro 3 kW models:

Table 2-4. PowerMax-Pro 3 kW Average Power Models

P/N	DESCRIPTION	MAXIMUM AVERAGE POWER	MAXIMUM PEAK POWER
1325222	PowerMax-Pro – 3 kW, 810 nm (no window)	3 kW	5 kW
1334126	PowerMax-Pro – 3 kW, 810 nm (with Diode Laser Debris Shield Window)	3 kW	5 kW
1325224	PowerMax-Pro – 3 kW, 1070 nm (no window)	3 kW	5 kW
1325226	PowerMax-Pro – 3 kW, 1070 nm (with Fiber Laser Debris Shield Window)	3 kW	5 kW
1325223	PowerMax-Pro – 3 kW, 10.6 µm (no window)	3 kW	5 kW
1334125	PowerMax-Pro – 3 kW, 10.6 µm (with CO2 Laser Debris Shield Window)	3 kW	5 kW
1325225	PowerMax-Pro – 3 kW, 810 nm, 1070 nm and 10.6 µm (no window)	3 kW	5 kW

Note that the models listed with "Window Included" ship with a 30 mm diameter protective window to prevent contamination in harsh environments.

In general, the use of a protective window is always safer to avoid any debris in the environment from contaminating the reflective detector. These models are ***highly recommended*** when:

- The sensor is used in processing equipment
- Any environment were dust and debris is produced

If the window becomes contaminated or damaged, it can easily be replaced with the Replacement Window Assembly (P/N 1324793).

Standard Accessory

As a standard accessory, each sensor ships with the following:

- A base plate for mounting to an optical table or other surface
- A NIST-traceable calibration certificate
- Quick-disconnect water fittings

Optional Accessories

The front plate on free space models can be changed out in the field to provide direct compatibility with a variety of adapters. Coherent currently offer two optional user installable front plates for mounting QBH and for C-Mount threaded adapters.

A user-replaceable 1070 nm Window assembly is also available. This can be used to replace the protective debris shield window if it becomes damaged during use. These replacement windows are designed for specific laser wavelength bands and prevent contamination of the sensor element.

Table 2-5 lists the optional accessories available for the PowerMax-Pro kW sensors:

Table 2-5. PowerMax-Pro Optional Accessories

P/N	ACCESSORY	COMPATIBILITY NOTES
1325227	C-Mount Adapter Front Plate	Install onto any sensor by swapping front plate.
1319787	QBH Adapter Front Plate	Install onto any sensor by swapping front plate.
1325228	QBH Adapter Front Plate (includes QBH Adapter)	Install onto any sensor by swapping front plate.
1324793	Replacement Fiber Laser debris shield window (1030 nm–1120 nm; <0.5% absorption)	Threads into Window Mount Front Sensor cover P/N 1323853; provided with any sensor shipped with a window.
1331407	Replacement CO2 Laser debris shield window (9 µm–11 µm; <0.5% absorption)	Threads into Window Mount Front Sensor cover P/N 1323853; provided with any sensor shipped with a window.
1331408	Replacement Diode Laser debris shield window (780 nm–980 nm; <0.5% absorption)	Threads into Window Mount Front Sensor cover P/N 1323853; provided with any sensor shipped with a window.
1323853	Window Mount Front Sensor Cover	Required to retrofit a replacement window to a sensor model that has no window. Some models require recalibration.

Compatibility Matrix

Table 2-6 lists the optional accessories that can work with different models of both the PowerMax-Pro kW 1 kW and the 3 kW sensors. Notations in Table 2-6:

- "Yes" indicates the part is available to order.
- "Included" indicates that the part is shipped with the model ordered.

Note that some accessories also require that you order the Window Mount Front Sensor Cover (P/N 1323853). If that Front Sensor Cover is not included with the model you are using, then you must order the Window Mount Front Sensor Cover in addition to the optional Window accessory that you want to use.

Table 2-6. PowerMax-Pro kW Accessories Compatibility Matrix

Sensor Model	QBH Front Plate	C-Mount Plate	Window Mount Front Cover	Fiber Laser Window	Diode Laser Window	CO2 Laser Window
PowerMax-Pro kW – 810 nm (no window)	Yes	Yes	Yes	*Used with P/N 1323853*	*Used with P/N 1323853*	Recalibration Required
PowerMax-Pro kW – 810 nm (with Diode laser debris shield window)	Yes	Yes	**Included**	Recalibration Required	**Included**	Recalibration Required
PowerMax-Pro kW – 1070 nm (no window)	Yes	Yes	Yes	*Used with P/N 1323853*	*Used with P/N 1323853*	Recalibration Required
PowerMax-Pro kW – 1070 nm (with Fiber laser debris shield window)	Yes	Yes	**Included**	**Included**	Recalibration Required	Recalibration Required
PowerMax-Pro kW – 10.6 µm (no window)	Yes	Yes	Yes	Recalibration Required	Recalibration Required	*Used with P/N 1323853*
PowerMax-Pro kW – 10.6 µm (with CO_2 Laser debris shield window)	Yes	Yes	**Included**	Recalibration Required	Recalibration Required	**Included**
PowerMax-Pro kW – 810 nm, 1070 nm and 10.6 µm (no window)	Yes	Yes	Yes	*Used with P/N 1323853*	*Used with P/N 1323853*	*Used with P/N 1323853*

Specifications

This section lists various specifications for the PowerMax-Pro kW sensor.

Power Specifications

Table 2-7 lists the power specifications for the PowerMax-Pro kW:

Table 2-7. Power Specifications

SPECIFICATION	PMP 1 kW	PMP 3 kW
Average Power Range (continuous); see power handling curve for beam size requirements (p. 2-4)	1 kW to 1 kW	1 kW to 3 kW
Maximum Pulsed Peak Power	1 kW	5 kW
Noise Equivalent Power: Standard Mode (10 Hz) High-Speed Mode (20 kHz) Snapshot Mode (625 kHz)	< 50 mW < 0.5W < 1.5W	
Maximum Power Density (kW/cm^2)	5.0 at 1 kW average power	2.4 at 3 kW average power
Power Linearity (%)	±3	
Rise Time	< 20 µs	
Fall Time	< 20 µs	

General Specifications

Table 2-8 lists general specifications for the PowerMax-Pro kW:

Table 2-8. General Specifications

SPECIFICATION	PMP 1 kW	PMP 3 kW
Active area		
Horizontal Axis	30.0 mm	
Vertical Axis	27.5 mm	
Detector	57 mm from front plate	
Minimum Beam Size	10 mm at 1 kW average power	20 mm at 3 kW average power
Wavelength Range	Fixed calibration point ± 50 nm	
Back Reflection	< 1 %	
Back Reflection when used with QBH Adapter	0	
Calibration Wavelength	810 nm, 1070 nm, 10.6 µm Wavelengths typical; model dependent	
Calibration Uncertainty (k=2)	± 2.5 %	
Cooling Method (1 gpm water flow with less than 10 PSI back pressure)	Water	
Cable Type	DB25	
Cable Length	3m (9.8 ft.)	
Temperature for usage and storage	5°C to 40°C	
Operating environment	Non-condensing humidity	

Dimensions

This section provides dimensions for product models, mounting options, and optional accessories.

PowerMax- Pro 1 kW and 3 kW Models

Dimensions are included for the following product models:

- PowerMax-Pro 1 kW and 3 kW Free-Space
- PowerMax-Pro 1 kW and 3 kW with Window

Free-Space Sensors

The dimensions for the Free-Space models are the same for both PowerMax-Pro 1 kW and 3 kW Sensors. Figure 2-14 shows the Front view of the Free-Space models.

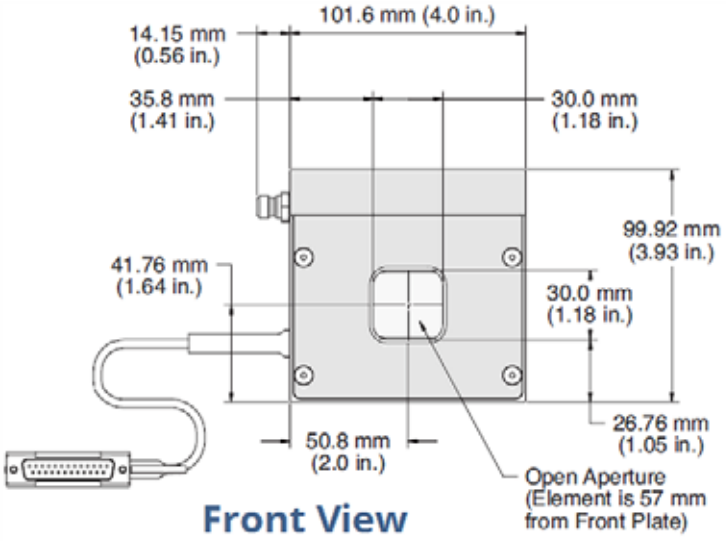


Figure 2-14. Dimensions – Front View of Free-Space Model

Figure 2-15 shows a side view of the Free-Space models. Note the position of the sensor plane.

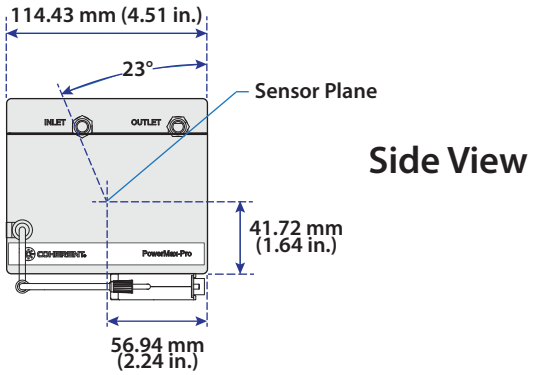


Figure 2-15. Dimensions – Side View of Free-Space Model

Models with Window

The following figures show the dimensions for the PowerMax-Pro 1 kW and 3 kW model with the protective front Window.

Figure 2-16 shows the side view with dimensions for the PowerMax-Pro kW with the protective front window. Note the position of the sensor plane.

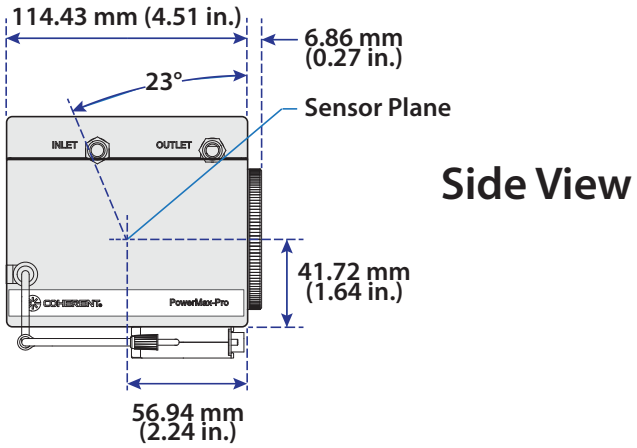


Figure 2-16. Dimensions – Side View of Window

Figure 2-17 shows the front view with dimensions for PowerMax-Pro kW with the protective front window.

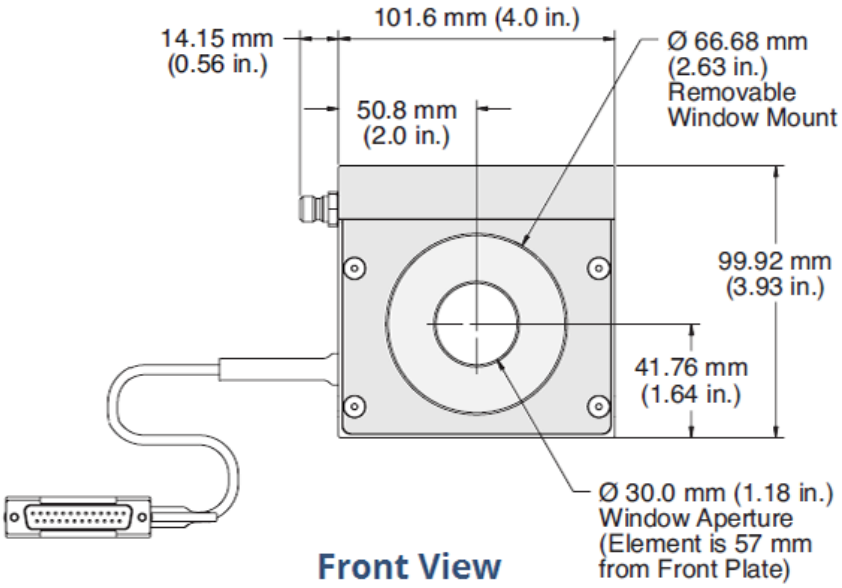


Figure 2-17. Dimensions – Front View of Window

Mounting Options (Base Plate)

Dimensions are provided for the following standard mounting options for the base of the PowerMax-Pro kW sensor:

- Mounting features on rear of all PowerMax-Pro kW sensors
- Mounting Plate Accessory (included with all models)
- Custom Mounting Plate (to rotate the sensor)

Mounting Base Features

The Mounting Plate may be attached to the PowerMax-Pro kW either on the side or on the bottom using pre-drilled holes, which aid in exact alignment of the sensor.

Figure 2-18 shows the dimensions for the mounting features on the back of all PowerMax-Pro kW Sensors.

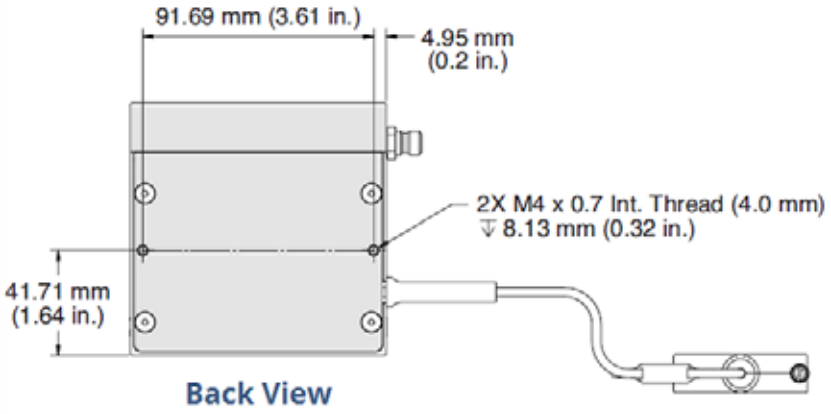


Figure 2-18. Dimensions – Mounting Features (View on Back of Sensor)

Figure 2-19 shows a view from the bottom of the sensor for mounting.

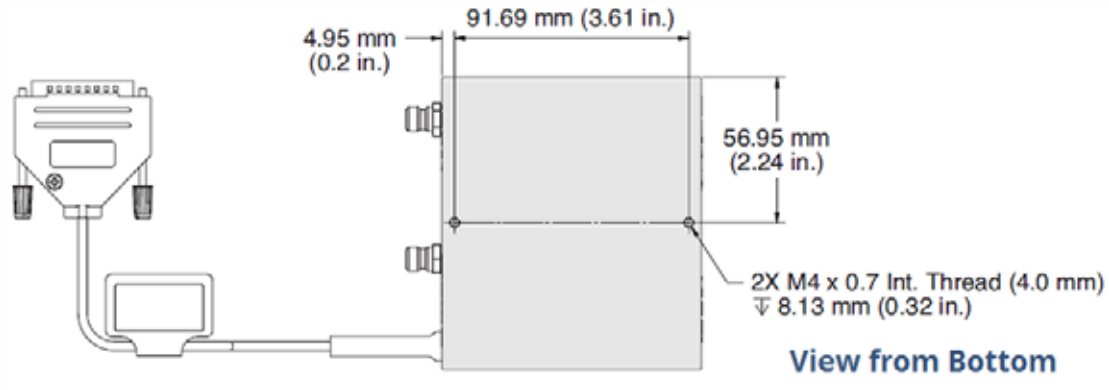


Figure 2-19. Dimensions – Mounting Features (View from Bottom of Sensor)

Mounting Base Plate Accessory

Figure 2-20 shows the dimensions for the Mounting Plate Accessory. This mounting plate is included with all PowerMax-Pro kW models as a standard accessory. See p. 3-5 for instructions about how to attach the Mounting Plate.

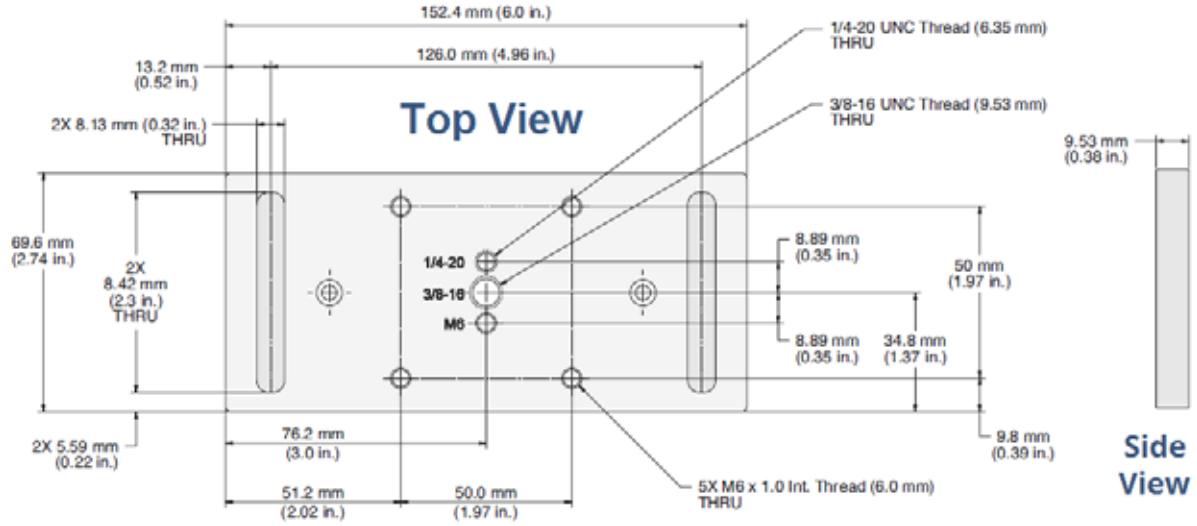


Figure 2-20. Dimensions – Mounting Plate Accessory

Custom Mounting Base Plate

Figure 2-21 shows the dimensions for the Custom Mounting Base Plate (Coherent P/N 1336448). This Custom Mounting Base Plate can be used to rotate the sensor or to compensate for polarization. For more detailed information, see "Custom Mounting Plate" (p. 3-6).

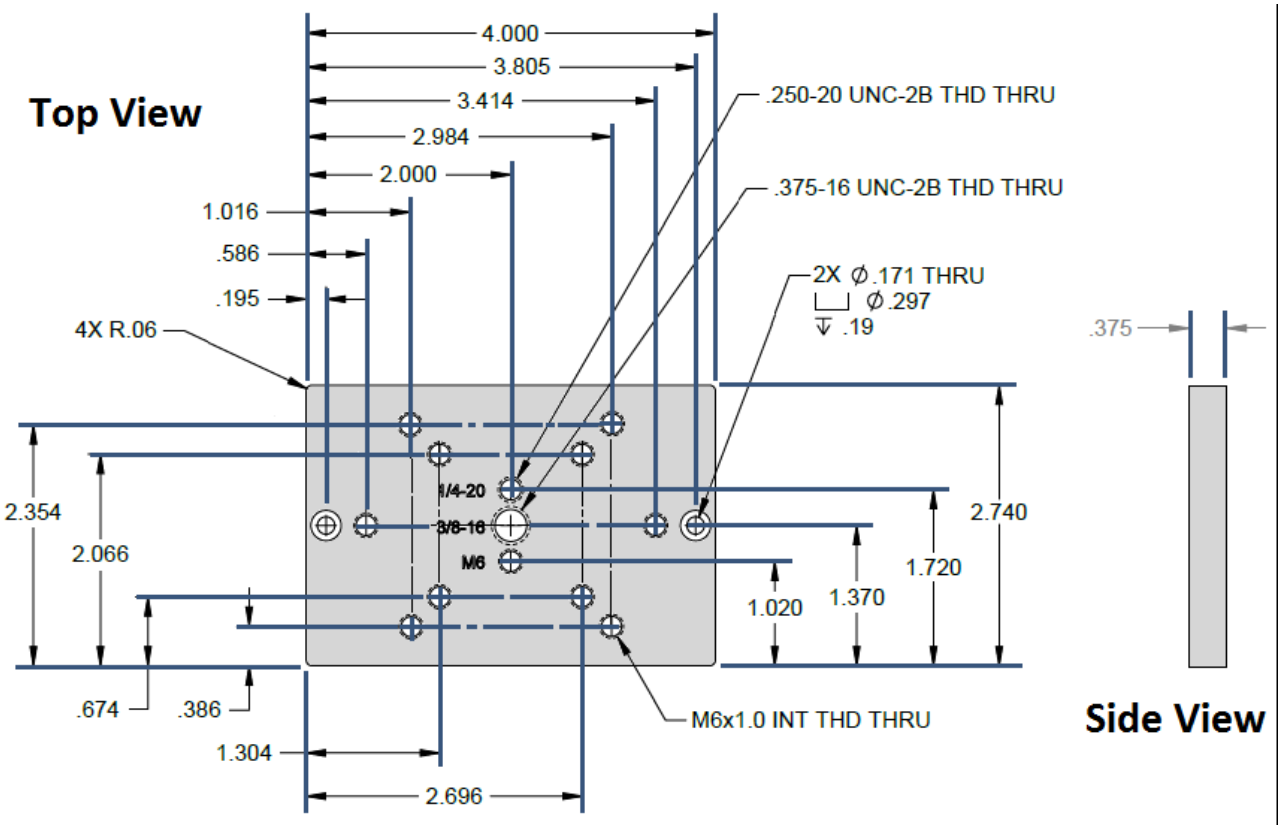


Figure 2-21. Dimensions – Custom 45-Degrees Base Mounting Plate

Optional Mounting Accessories

Dimensions are provided for the following:

- C-Mount Front Plate (for use with free-space models)
- QBH-Mount Front Plate (for use with free-space models)

C-Mount Front Plate

Figure 2-22 shows the dimensions for the C-Mount Front Plate. This optional accessory is used with PowerMax-Pro kW Free-Space models.

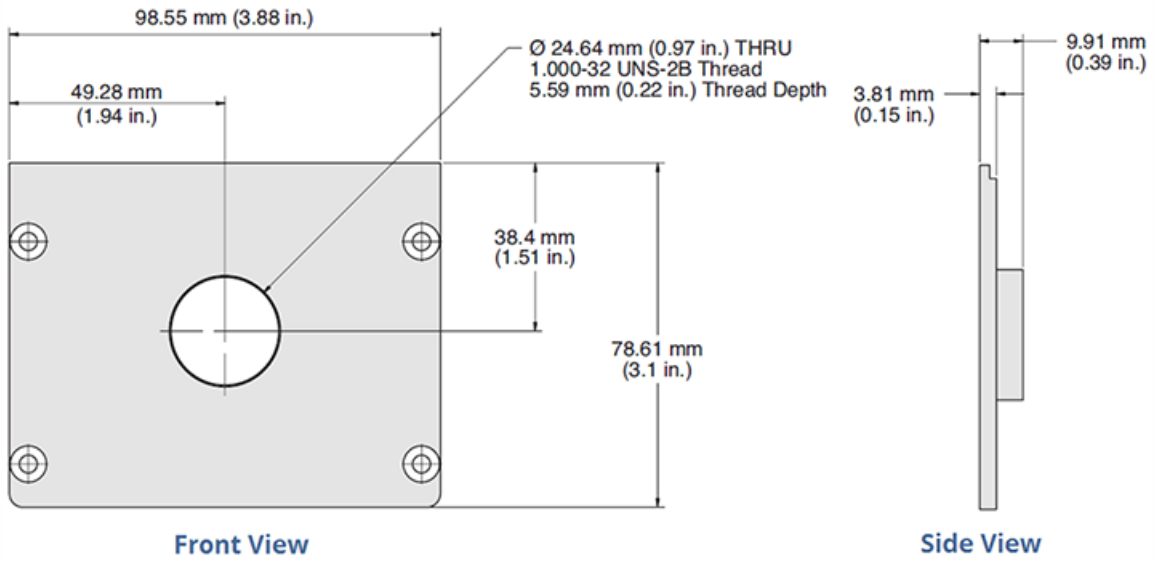


Figure 2-22. Dimensions – Optional C-Mount Front Plate

QBH-Mount Front Plate

Figure 2-23 shows the dimensions for the QBH-Mount Front Plate. This optional accessory is used with PowerMax-Pro kW free-space sensors.

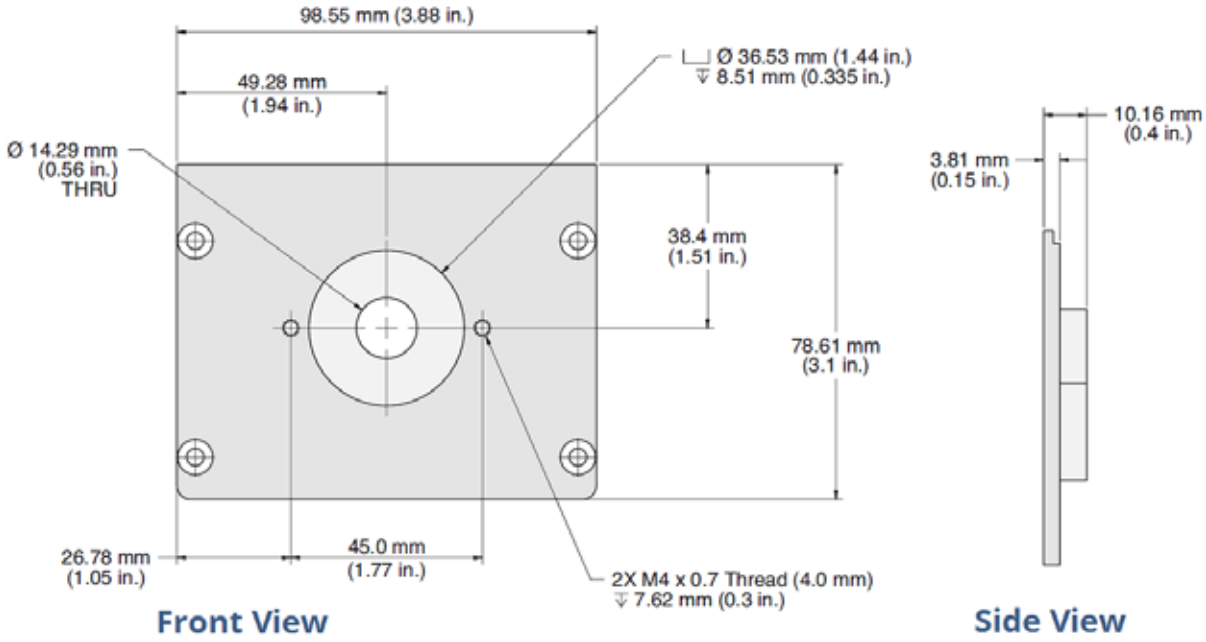


Figure 2-23. Dimensions – Optional QBH-Mount Front Plate

Replacement Window Assembly

Figure 2-24 shows the dimensions for the Replacement Window Assembly for PowerMax-Pro kW sensors. Periodically replacing the window helps prevent contamination in harsh environments.

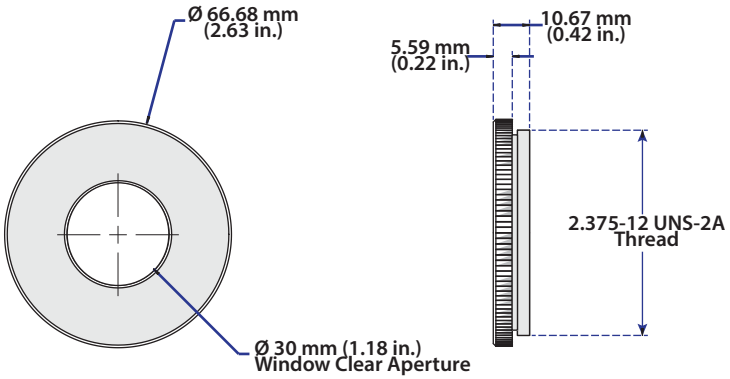


Figure 2-24. Dimensions – Replacement Window Assembly

Protective Dust Cover

The use of a Protective Dust Cover is critical for maintaining the sensitivity of the sensor and accuracy of measurements.

This section describes the Protective Dust Cover for both the Free-Space and the Windows model. There is also a plug on the QBH adapter for a Protective Dust Cover.

CAUTION!
Keep the Protective Dust Cover in place at all times when the sensor is not in use! Any dust or particulates that come into contact with a laser beam can cause damage if they are burned onto the surface of the sensor.

Protective Dust Cover — Free Space

Figure 2-25 shows the dimensions for the Protective Dust Cover that is shipped with the Free Space models of the PowerMax-Pro kW sensor. Note the tabbed edges on all four sides that fit the surface like a cap.

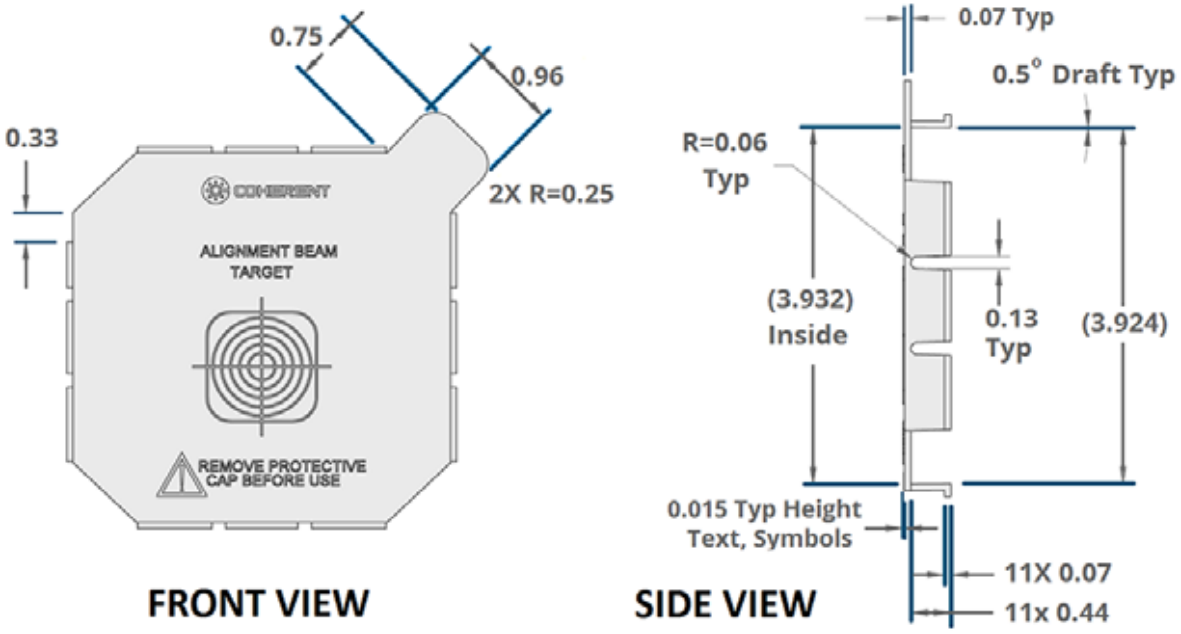


Figure 2-25. Dimensions – Protective Dust Cover (Free Space Model)

Protective Dust Cover — Window

Figure 2-26 shows the dimensions for the Protective Dust Cover (P/N 1323853) that is shipped with the Window models of the PowerMax-Pro kW sensor.

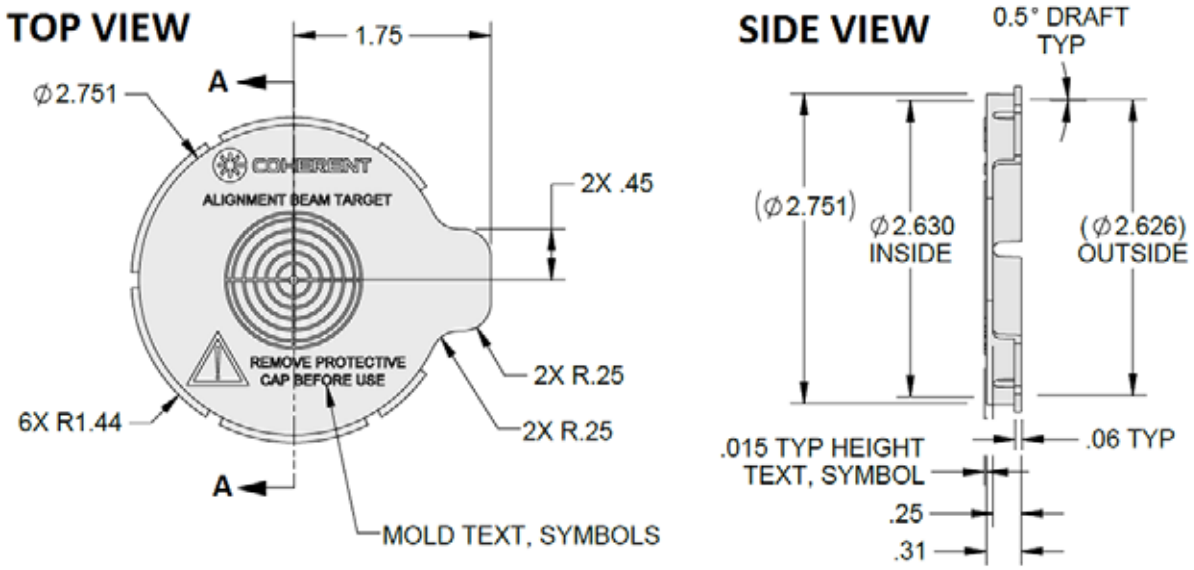


Figure 2-26. Dimensions – Protective Dust Cover (Window Model)

SECTION THREE: SET UP THE SENSOR

This section how to set up the PowerMax-Pro kW sensor so you can:

- Correctly set up minimum beam sizes
- Ensure accurate measurement
- Avoid damage to the sensor

Set-up activities should be done in a clean environment under normal humidity and temperature conditions (see Table 2-8 for specifications).

Instructions include the following steps:

In addition, remember to periodically check the sensor for dust and contaminants; see "Inspect and Clean the Sensor" (p. 3-26).

WARNING—LASER RADIATION!
Always use precautions to avoid eye or skin exposure to both DIRECT and SCATTERED radiation.

Refer to "Section One: Safety and Compliance" (p. 1-1) to learn about required safety precautions when working with lasers.

Before You Begin

Before you begin set-up, first gather the necessary tools and equipment, then inspect the shipping box and unpack the contents. Ensure that the environment is clean and free of dust and particulates.

IMPORTANT!
There are no user-serviceable components inside the PowerMax-Pro kW sensor. The sensor is designed only to have the interchangeable front plate removed and replaced as desired; otherwise, DO NOT disassemble the enclosure itself. ***The Warranty is void if the enclosure is disassembled!***

Tools and Equipment Required

Gather the following items that are not shipped with the PowerMax-Pro kW sensor.

- Both a 2 mm and a 3 mm hex driver
- Additional M6 or 1/4-20 screws used to attach
  - The Mounting Plate via the extended slots to an optical table or other flat surface
  - Optical post + post holder + base
- Water hoses (1/4" interior dimension) appropriate hose clamps
- A source for compressed clean, dry air or compressed nitrogen to clean dust or particulates off of the sensor element

Receive and Inspect the Shipping Box

After you receive your order, immediately inspect the shipping boxes for any indication of damage.

NOTE:
The exact contents of the shipping box vary, depending on model ordered; see "Configurations Available" (p. 2-10) for list of available sensors and accessories.

If you see any damage, document these discrepancies on the packing list. Also immediately contact both the shipping carrier and either an authorized Coherent representative or the Coherent Order Administration Department, as follows:

- Inside the USA: 1-(800)-367-7890
- Outside the USA: 1-(408)-764-4557

Step 1: Unpack the Shipping Box

This section provide general instructions about how to unpack the shipping box.

NOTICE!
After unpacking the sensor and any options or accessories, save the shipping box and all packing materials. These materials are required later for safe transport of the sensor back to the factory for annual calibration; see "Appendix A: Service and Support" (p. 5-1) for details.

To unpack the shipping box:

1. Open the shipping box and remove the documentation inserted in the top foam layer, shown in Figure 3-1.

   Documentation includes the following important information that you need to retain for your records. Please make note of the Calibration Interval & Due Date.

   - Certificate of Calibration, with the date of manufacture and a China RoHS2 compliance sticker
   - Supplemental Sensor Information
   - Coherent Calibration Interval & Due Date Policy
   - *Quick Set-Up Guide*

Figure 3-1. Unpack the Shipping Box – Remove Top Layer

2. Notice all packaging for contents of the shipping box, shown in Figure 3-2. The packing arrangement for different models may vary.

   As you unpack components, retain all shipping materials for times you may need to ship the unit to another location or return to Coherent for annual calibration.

Figure 3-2. Unpack the Shipping Box – Contents

3. Place components on a clean surface.

CAUTION: Immediately check to ensure that the Protective Dust Cover is intact and covering the window area!

Keep the Protective Dust Cover in place at all times when the sensor is not in use. Any dust or particulates can damage the sensor by being burned onto the sensor element when hit by a laser beam.

The contents of the shipping box vary by the model that is ordered. All orders include the following components:

- PowerMax-Pro kW sensor with internal heat sink, installed brass quick-disconnect fittings (for water hoses), and an attached DB-25 connector
- Two (2) female quick-connect sockets with a barb for an 0.25” hose I.D. (interior dimension)
- Mounting plate with socket-head M4 hex screws
- (Optional) User-installable Front Plates to mount either a QBH or C-Mount threaded adapter

Various models of the PowerMax-Pro kW are shipped with different forms of protection for the front plate of the sensor:

- A Free-Space model (open square aperture) is shipped with a square cap that covers the entire front of the sensor
- A Window model is shipped with a round cap covering the window
- A QBH-connector includes a plug that acts as a protective dust cover

---

CAUTION!
It is critical to prevent dust, debris, and other contamination from getting inside the sensor cavity and onto the sensor element. Never touch the sensor element, which can deposit natural oils from your fingertips onto the surface.

Such contamination can cause changes in sensitivity to the sensor or become burned onto the surface of the sensor element.

To prevent damage, keep the protective dust cover in place when not in use. Remove the cover only for the few moments in which you take measurements.

The square Protective Dust Cover (shown in Figure 3-3) is shipped with the Free-Space of the PowerMax-Pro kW sensor.

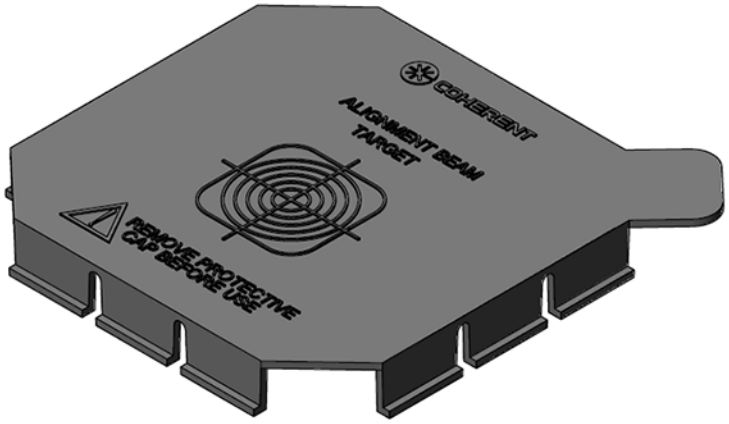


Figure 3-3. Protective Dust Cover — Free-Space Model

For the correct orientation, set the tab at the top right side of the sensor as you face the area for the sensor window.

The round Protective Dust Cover (shown in Figure 3-4) is shipped with the Window model of the PowerMax-Pro kW sensor.

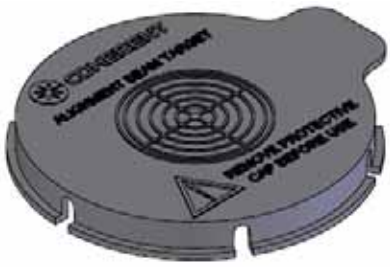


Figure 3-4. Protective Dust Cover — Window Model

Step 2: Attach a Mounting Base Plate to the Sensor

This section describes how to attach a Mounting Base Plate to the PowerMax-Pro kW sensor.

There are different Mounting Base Plate options that are available, as follows:

- Standard Mounting Plate, shipped with all products (described next)
- A Custom Mounting Plate with additional drill holes at a 45-degree angle. Order this option if you want to rotate the sensor and change its orientation (see p. 3-6)

The desired Mounting Base Plate should be attached now to the sensor body; otherwise, the two counter-bored M4 mounting through-holes can become hidden when the Mounting Plate is attached to other hardware.

Note that there are also options for Front Plates for the PowerMax-Pro kW sensor; see Table 2-5 (p. 2-11) for more information.

Standard Mounting Base Plate

The standard Mounting Base Plate (shown in Figure 3-5) is shipped with all models.

Figure 3-5. Standard Mounting Plate

The standard Notice the pre-tapped holes in the Mounting Plate, used as follows:

- The tabs on each side of the Mounting Plate protrude beyond the width of the sensor, with slots to accommodate M6 or 1/4-20 screws for bench mounting on 50mm centers on an optical table.
- The two holes near the open slots on either end of the Mounting Plate are used to attach the Mounting Plate to the sensor. You can attach the Mounting Plate to either the back or bottom side of the PowerMax-Pro kW sensor.
- The three tapped holes in the center are used to attach a post stand to the sensor. This accommodates 1/4”-20, 3/18”-16, and M6 threads that are in line with the optical axis.
  - The 3/8”-16 tapped hole on the mounting plate corresponds with the center point of the sensor element.

    The 3/18”-16 UNC female thread in the center of the Mounting Plate can be used to mount the sensor on Coherent’s PSH-1 Post and Stand Assembly (P/N 1111302).
  - The marked 1/4”-20 and M6 threaded hole can be used with optical post mounts.
  - Use M6 threaded holes with square bolt pattern for mounting.

- The four female threads are designed in a square 2" grid pattern at the top and bottom horizontal edges of the Mounting Plate, with 50 mm spacing between holes. This spacing allows the sensor to be attached to an optical table or other pre-drilled flat surface, such as inside a system enclosure or on a robot arm.

To attach the standard Mounting Base Plate to the sensor:

1. Place the Mounting Plate onto either the back or side of the PowerMax-Pro kW sensor, and align the holes for the bolts.

   The two M4 tapped mounting holes on the bottom and rear of the sensor housing are in-line with the sensor element center for ease of alignment. Insert the center mounting bolts into the holes.

2. Tighten the screws using a hex wrench (torque screws at 25-in lbs.). The plate is aligned, as shown in Figure 3-6.

Figure 3-6. Standard Mounting Plate Attached to Sensor

To mount the sensor on either a flat surface (such as an optical table) or a post and stand holder, go to the section, "Step 3: Attach the Sensor" (p. 3-11).

Custom Mounting Plate

If you want to rotate the sensor or to compensate for polarization, instead attach the custom mounting plate (Coherent P/N 1336448, purchased separate. The custom mounting plate is shown in Figure 3-7.

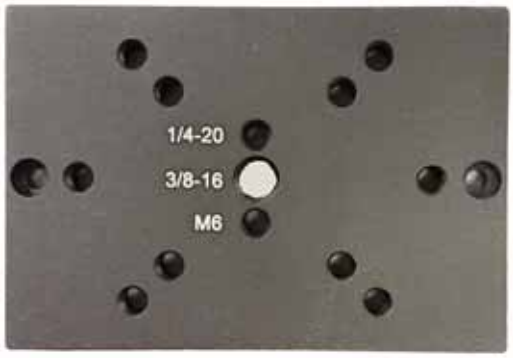


Figure 3-7. Custom 45-Degrees Mounting Plate

Notice the additional mounting holes in the custom adapter plate. These mounting holes allow the PowerMax-Pro kW sensor to be fastened with a 45-degree relative to the mounting surface.

To mount the PowerMax-Pro kW sensor at an angle, see instructions to "Attach Sensor in a 45-Degree Orientation" (p. 3-13).

Step 2b (Optional): Replace Window or Front Plate

Depending on your application, you can select from various options to replace the front plate of the sensor (see Table 2-5 for the current list). This section describes how to replace the front plate with one of the following:

- Replacement front window assembly (on a Window model)
- A C-Mount Front Plate
- A QBH Adapter with Front Plate

For information about dimensions for each of these options, see "Dimensions" (p. 2-14).

CAUTION!
When removing and installing screws, place the sensor in a horizontal position so that screws do not fall into the sensor enclosure. Any objects falling into the enclosure can strike the element and cause permanent damage.

Replace the Front Window Assembly

Replacement windows are available for the PowerMax-Pro kW sensor in the event that the protective debris shield window becomes damaged during use.

To replace the window assembly, order the appropriate replacement window (listed in Table 3-1) based on the requirements for the laser you are using.

Table 3-1. Replacement Windows

P/N	DESCRIPTION	WAVELENGTH	REFLECTANCE
1324793	Replacement Fiber Laser debris shield window	1030 nm–1120 nm	<0.5%
1331407	Replacement CO2 Laser debris shield window	9 µm–11 µm	<0.5%
1331408	Replacement Diode Laser debris shield window	780 nm–980 nm	<0.5%

These replacement Window assemblies thread into the front plate for the Window Mount Front Sensor (P/N 1323853), which is part of any Window model of a PowerMax-Pro kW sensor.

The example in Figure 3-8 shows a breakout of the parts included in one of the Window assemblies:

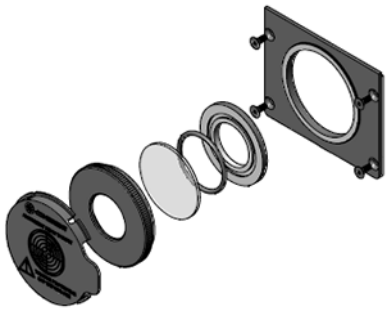


Figure 3-8. Example — Window Replacement Assembly

To replace the window:

1. Remove the replacement window from its packaging in an environment that is clean and free of dust and contaminants.
2. Remove the damaged window assembly that is currently installed on the sensor. To do so, hand-turn the assembly counter-clockwise and gently lift off of the front of the sensor.
3. Install the new window assembly by aligning it with the opening on the front of the sensor and rotating the assembly clockwise.
4. Carefully hand-tighten the new window assembly in the front cover threads.

Install a C-Mount Front Plate

The optional C-Mount Front Plate is available as a standard universal thread mount that can be used to attach various fiber adapters or other threaded mounts to the front of the sensor.

To replace the C-Mount Front Plate:

1. Remove the C-Mount Front Plate from its packaging in an environment that is clean and free of dust and contaminants.
2. Remove the Protective Dust Cover from the sensor.
3. Using a 2 mm Allen wrench, remove the four (4) corner screws on the existing front plate of the sensor, and set aside.
4. Align the new C-Mount Front Plate assembly on the opening of the sensor.
5. Attach the plate using the four (4) screws that you removed earlier, and carefully hand-tighten the new front plate with torque at 12 in lbs.

Install a QBH Adapter with Front Plate

The PowerMax-Pro kW sensor can be configured in multiple ways. One option is to use the QBH Adapter (P/N 1325228), shown in Figure 3-9, to replace an existing front plate on either a Free Space model or a Window model.

The QBH Adapter includes a QBH fiber connector and an attached mounting plate. The attached two wires can be connected with interlocks to ensure a laser-safe environment.

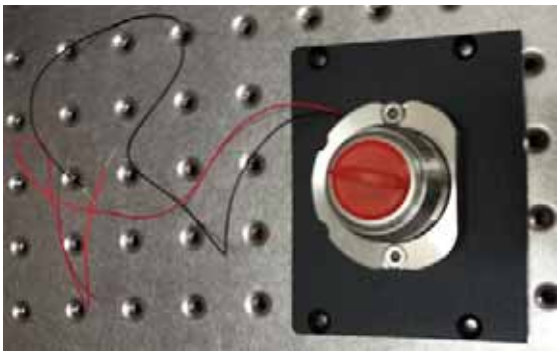


Figure 3-9. QBH Adapter with Attached Wires and Mounting Plate

This optional QBH Adapter securely fastens a QBH pig-tailed fiber optic cable to a specific depth and can eliminate errors from angular sensitivity or polarization. Polarization errors may still occur, depending on the orientation of the polarization out of the QBH fiber (if, for some reason, there is a definite polarization state).

IMPORTANT!
If you plan to use a QBH fiber optic cable on a PowerMax-Pro kW sensor that is not equipped with the QBH Adapter, there are critical set-up issues about distance and angle. Follow instructions to minimize errors and avoid damage.

To install the QBH Adapter on the sensor:

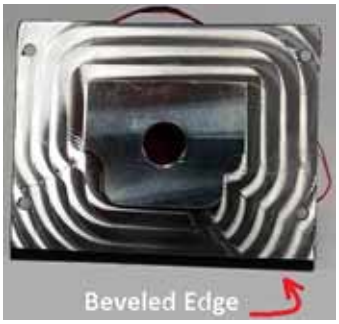
1. Ensure that the Protective Dust Cover or dust cap is in place on the existing sensor.
2. Turn off any power to the sensor.
3. Remove the QBH Adapter from its packaging in an environment that is clean and free of dust and contaminants.

IMPORTANT!
When working with a QBH Adapter, do NOT touch any laser fiber output. Always use Nitrile gloves whenever you handle fiber output.

4. Remove the Protective Dust Cover on the sensor. Using a 2 mm Allen wrench, remove the four (4) corner screws on the existing front plate of the sensor and set aside.
5. Quickly remove the existing front plate and replace it with the QBH Adapter. The attached mounting plate on the QBH Adapter bolts onto the front of the PowerMax-Pro kW enclosure to replace any existing front plate.

   Notice the beveled edge on the lower back side of the front plate (shown in Figure 3-10). This ensures the correct orientation of a front plate into the sensor enclosure.

FRONT PLATE FOR FREE SPACE MODEL



FRONT PLATE FOR QBH ADAPTER

Figure 3-10. Beveled Edge on Back Side of Front Plates

CAUTION!
Do NOT exceed specifications for torque (12 in lbs.) to ensure that screws are removable for future calibrations.

6. Attach the mounting plate for the QBH Adapter with the four (4) screws that you removed earlier, as shown in Figure 3-11.

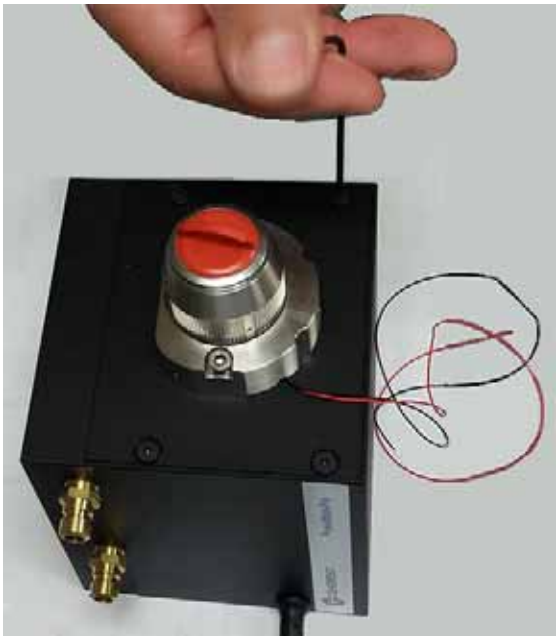


Figure 3-11. Attach QBH Adapter Mounting Plate to Sensor

7. Tighten using the Allen wrench.
8. Mount assembled sensor to post or other stable surface.
9. Attach the two wires to the interlock, if you have any in place.
10. Insert the fiber cables, and twist and lock.

For information about setting the beam size when using a fiber optic cable, see "Using the QBH Adapter" (p. 3-22).

Step 3: Attach the Sensor

Now that you have attached the desired mounting plate to the sensor, you can set up the PowerMax-Pro kW sensor in several ways:

- Directly attach the sensor to a flat surface, such as a bench or optical table.
- Mount the sensor on a post in a vertical orientation.
- Mount the sensor in a 45-degree angle orientation.

CAUTION:
Due to the size and weight of the PowerMax-Pro kW sensor, Coherent strongly recommends that you fasten the sensor on a stand to a bench or optical table.

Directly Attach Sensor to a Flat Surface

To attach the Mounting Plate to an optical table or other flat surface:

1. Place the Mounting Plate on an optical table and align the four mounting holes to the matching holes in an optical table.
2. Insert the M6 or 1/4-20 screws through the Mounting Plate into the holes in the optical table.
3. Tighten to secure.

Attach Sensor in a Vertical Orientation

This section describes how to attached the PowerMax-Pro kW sensor to a post and stand in a vertical orientation.

Notice three holes in the center of the Mounting Plate on the sensor housing. These tapped mounting holes accommodate different sizes of posts. Each hole is a different size to accommodate a variety of posts.

The design of the sensor housing is such that the tapped mounting holes in the Mounting Plate on a Post is in exact alignment with the center line of the sensor. See Figure 2-15 or Figure 2-16 for a view of the position of the sensor plane in the enclosure.

An example of an optical post and stand assembly is shown in Figure 3-12.

Figure 3-12. Post and Stand Assembly

NOTE:
A post stand is not provided with the PowerMax-Pro kW Sensor and must be purchased separately. An example product that you can order from Coherent is the PSH-1 Post and Stand Assembly (P/N 1111302).

To attach a post to the Mounting Plate on the sensor:

1. Select the appropriate size post for the stand.
2. Attach the post to the sensor, as shown in Figure 3-13, and hand tighten.

Figure 3-13. Attach Post to Sensor

IMPORTANT:
Due to the size and weight of the sensor, Coherent recommends that you fasten the stand to a bench or optical table.

To mount the sensor onto the post holder:

1. Attach the post holder to the stand.
2. Attach the base of the stand to an optical table using screw mounts.
3. Holding the assembly of the sensor and post firmly, insert the post into the post holder on the stand, as shown in Figure 3-14.
4. Tighten the set screw on the post holder to secure the inner post and stabilize the sensor.

Figure 3-14. Insert Sensor into Post Holder

Attach Sensor in a 45-Degree Orientation

This section describes how to fasten the PowerMax-Pro kW sensor to the post assembly, adjust its height, and rotate the sensor to a 45-degree angle.

You must first purchase some additional hardware, such as the examples of standard off-the-shelf hardware available from Edmund Optics listed in Table 3-2. Similar hardware from other vendors (such as Thorlabs) may also be available.

Table 3-2. Hardware Required to Rotate the Sensor

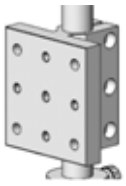
EDMUND OPTICS PART NUMBER	DESCRIPTION	PHOTO
P/N 54-262	Breadboard Adapter, 3/4-inch, with four (4) M6 x 22mm Socket-Head Cap Screws. Attaches the post assembly to an optics table.	
P/N 39-351	Stainless Steel 12-inch vertical post, 3/4-inch diameter, with collar.	
P/N 56-665	3/4-inch Post Clamp with Bracket. Allows for vertical movement and 360° rotation.	

Figure 3-15 shows a parts breakout of the rotated assembly using the parts listed. Note that the Socket-Head Cap Screws listed are included with the parts.

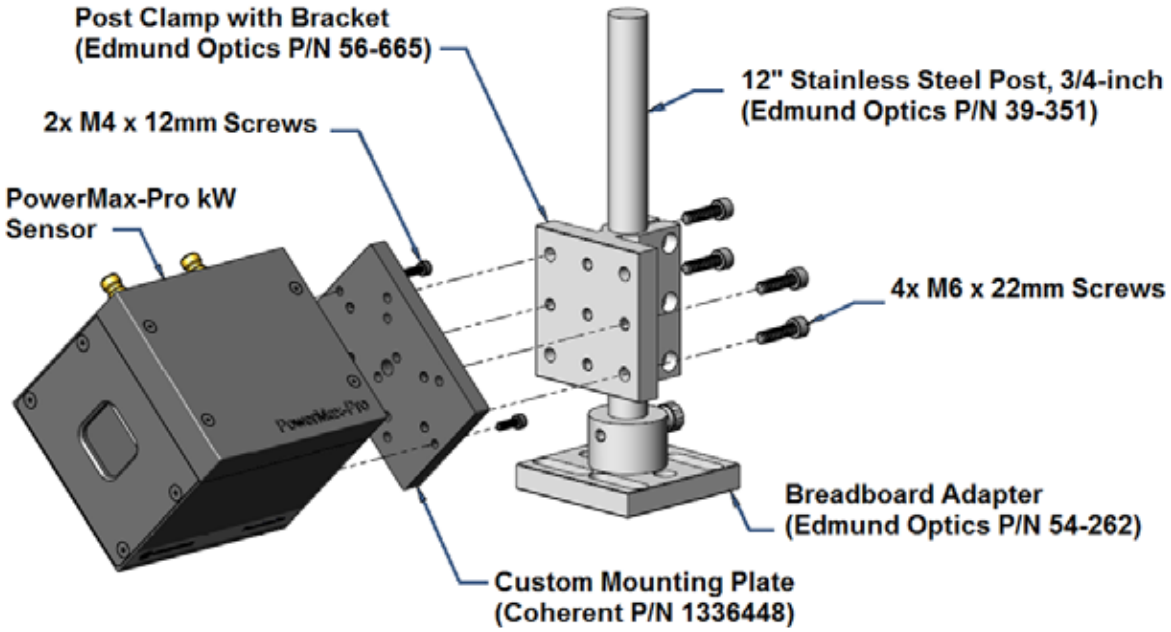


Figure 3-15. Parts Breakout — Rotated Sensor Assembly

To mount the sensor in a 45-degree position:

1. Attach the Coherent custom 45-degree mounting plate to the PowerMax-Pro kW sensor, using the two (2) M4 x 12 mm long Socket-Head Cap Screws.
2. Set aside the Sensor while you assemble and attach the post and stand.
3. Using 1/4-20" Socket-Head Cap Screws, attach the Breadboard Adapter to an optics table through the holes and/or slots in the Adapter.
4. Insert a 12-inch x 3/4-inch Stainless Steel Post into the Breadboard Adapter.
5. Tighten the #8-32 Locking Screw on the post ring at the base of the Breadboard Adapter to firmly connect the post.
6. Move the collar on the Stainless Steel Post to the desired vertical position and tighten.
7. Attach the Post Clamp with Bracket to the Stainless Steel Post using 1/4" Socket-Head Cap Screws. (The required 1/4" Socket-Head Cap Screws are included with each part.)
8. Holding the Sensor assembly, attach the custom mounting plate to the Post Clamp Bracket. Due to the weight of the Sensor, it is recommended that you use all four (4) M6 x 22mm Socket-Head Cap Screws screws to attach the custom mounting plate to the Post Clamp Bracket.
9. Hand-rotate the Sensor assembly to a 45-degree orientation. Use one screw to pivot the Post Clamp Bracket and one screw to lock it into position.

Figure 3-16 shows a completely assembled PowerMax-Pro kW with the custom mounting plate, attached to and rotated on the post:

Figure 3-16. Rotating Adapter Plate

Step 4: Set Up Water Cooling

The heat sink integrated in the PowerMax-Pro kW sensor is water cooled.

Before you activate the sensor and take any measurements, you must first set up water cooling for the internal heat sink.

WARNING!
Failure to provide water cooling can cause immediate damage to the sensor.

Without water cooling, the laser beam can burn up the sensor housing (given the right amount of power over even a short period of time).

This section provides the following information and describes how to set up water cooling:

- Precautions when working with water
- Requirements for coolant
- Specifications for fittings
- Sensor flow rates

Precautions When Working with Water

Always maintain water cooling to the sensor. Always ensure there is water cooling to the PowerMax-Pro kW sensor before taking any measurements.

While working with water connections, avoid getting water on the surface of the sensor element. Water corrodes the coating on the sensor surface and causes damage.

If water does come in contact with the sensor surface, the best way to quickly remove the water is to use a blow dryer to evaporate the water to keep it from soaking into the coating.

Contaminants that might be left after water evaporates could be deposited on the surface of the sensor element and cannot be blown off. These contaminants can often be more difficult to remove than dust particles and cause damage to equipment.

Any contaminants on the sensor element can change the sensitivity of the detector and impact accurate measurements.

Requirements for Coolant

Following are requirements for coolant for the PowerMax-Pro kW sensor:

- Tap or distilled water is recommended.
- The exact temperature of the water is not critical as long as the temperature is relatively stable. The water can be supplied from a chiller or local tap.
- The use of deionized (DI) water will provide cooling, but prolonged use has been known to slowly reduce or dissolve ions in aluminum and brass. If you choose to use deionized (DI) water for coolant, schedule regular inspection of any fittings.
- Ethylene Glycol may be used, up to a 10% maximum in the mixture.
- Allow sufficient time for the water flow and sensor head to reach equilibrium. The water flow should run through the sensor for at least a couple of minutes before zeroing the meter and beginning the measurement.
- Ensure that the total power load for the cooling system also accommodates requirements for heat disposition from the sensor. Inadequate flow rate in the sensor can cause erroneous measurements.

Flow Rates

The specifications for water cooling require a flow rate of at least 1 GPM (Gallon per Minute) and that the sensor drops no more than 10 PSI from Inlet to Outlet.

The flow rates are minimums for proper heat transfer from these sensors.

- Water flow should be maximized when using these products near the upper limit of their power specifications.
- Higher water flow rates can be used if the pressure is not significant. However, too much pressure in line can damage (leaks) even though sensor housing is sealed.
- The damage threshold on these sensors drop as they heat up.

If you have any questions about the maximum power limits or power density specifications, refer to the catalog specifications or contact Coherent; see "Appendix A: Service and Support" (p. 5-1).

Fittings for PowerMax-Pro kW Water-Cooled Sensors

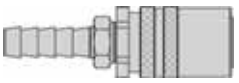
Specifications for water-cooled PowerMax-Pro kW sensors are as follows:

- Water port threads: 1/8" NPT
- Minimum water flow rate: 1 GPM (Gallons per Minute) or
  4 LPM (Liters per Minute)

Water Fittings Shipped with Sensor

It is recommended that you use the water fittings supplied by Coherent with the PowerMax-Pro kW sensor, listed in Table 3-3. These are brass quick-connect fittings for a hose size of 1/4" ID (Inside Dimension), available from Foster Manufacturing (see http://www.couplers.com).

Table 3-3. Fitting Specifications for Sensor

DIAMETER (ID = INSIDE DIMENSION)	PART NUMBER	ILLUSTRATION
Straight-Thru Sockets (Straight Hose Stem)		
1 /4 ID	FS204 | FS204P	
Plugs (Male Thread)		
1 /8 I.D.	FP251	

Replace Water Fittings

The brass fittings (male; long-female) for the water lines are attached to the sensor. Users may remove these and replace with fittings in a push-to-connect style. The Inlet and Outlet for water cooling are indicated on the sensor housing.

Should you choose to replace the water couplings shipped with the sensor, install fittings into 1/8" NPT pipe threads in the sensor assembly.

To REMOVE existing fittings:

1. Gently twist the existing water fittings counter-clockwise to loosen.
2. Gently clean away the threads of any old Teflon tape from the fittings.

To REPLACE fittings with push-to-connect fittings:

1. Carefully wrap Plumbing Tape around Brass fittings, making 1-1/2 to 2 turns around threads of the Brass Fittings.
2. Install the Brass Fittings to the heat sink.
3. Finger Tighten only.
4. Use a wrench to tighten the fittings two (2) full turns after finger tightening.

CAUTION:
Use care when removing and replacing water fittings. *Do not over tighten!* Over-tightening the fittings can cause damage to threading on the fittings, creating water leaks and damage to the sensor.

Steps to Set Up Water Cooling

Water hoses are not included with the PowerMax-Pro kW sensor. You can clamp a hose directly to the fittings shipped with the sensor or, if you want to use something other than connectors shipped with the sensor, there are a variety of hoses connectors available in the marketplace.

WARNING!
The sensor is designed to contain > 99% of the laser power into the cavity. It is critical that water flow is established through the sensor before laser power is introduced.

Damage will occur to he device if power is put into the sensor cavity without proper cooling flow.

To set up water cooling for the PowerMax-Pro kW sensor:

1. Gather the necessary tools and parts, including water hoses of sufficient length to reach the cooling system or chiller. Use water hoses that support the specifications listed in Table 2-8 (p. 2-13), such as those shown in Figure 3-17:

Figure 3-17. Water Hoses

2. Attach the water hoses to the appropriate INLET and OUTLET coupling or fittings on the PowerMax-Pro kW sensor, shown in Figure 3-18. This example also shows the cable for the DB-25 connector that is attached to the sensor.

Figure 3-18. Attach Water Hoses to Sensor

3. Tighten the hose clamps using to secure the hoses to the fittings.

4. Turn on the water supply now to test the pressure and flow. (See “Flow Rates” (p. 3-16) for requirements.) Water lines must have flow; otherwise the sensor housing could melt when a laser beam is aimed at the sensor.
5. Check any in-line flow gauge or flow meter to ensure that water is flowing at the specified pressure of 1 GPM (Gallons per Minute) or 4 LPM (Liters per Minute).

Step 5. Connect the Sensor to a Meter

Coherent recommends using the PowerMax-Pro kW sensor with the LabMax-Pro SSIM meter, shown in Figure 3-19.

Figure 3-19. LabMax-Pro SIMM Meter

This combination provides “instant” power readings on, and allows you to view temporal pulse shapes > 100 µsec pulse width and > 10 kHz PRF. For more information, see:

https://www.coherent.com/measurement-control/measurement/laser-power-and-energy-meters/labmax-pro-ssim

The PowerMax-Pro kW is an amplified sensor that requires power, which is sent to the sensor from a meter through the DB-25 connector. The cord for the DB-25 connector is fixed (permanently secured to the PowerMax-Pro kW sensor). This cable and connector cannot be removed or unplugged from the Sensor, and has a strain relief section where the cable is attached to the sensor.

To connect the sensor to the meter:

1. Attach the DB-25 connector from the PowerMax-Pro kW sensor to the LabMax-Pro SSIM meter, as shown in Figure 3-20.

Figure 3-20. Connect the Sensor to the Meter

2. Gently tighten the thumb screws to secure the connector to the meter.

Optional Mobile App

There is also a Mobile App for the LabMax-Pro SSIM meter that can be used with tablets or mobile phones with the PowerMax-Pro kW sensor, shown in Figure 3-21.

Figure 3-21. LabMax-Pro Mobile App on Android Tablet (WiFi Adapter Available)

When used with the Mobile App, you can connect using USB, WiFi, or a corporate WiFi network and view high-resolution snapshot data. In addition, these tools and applications allow you to save, import, and export data. For more information, see:

https://www.coherent.com/measurement-control/measurement/labmax-pro-mobile-app

Connect to Legacy Meters

Legacy meters includes meters such as the FieldMax II, FieldMate, LabMax TOP, J-Power Pro and others.

However, Coherent recommends using the PowerMax-Pro kW sensor with the LabMax-Pro SSIM meter. Legacy meters cannot access newer features now available in the software nor cover the range of wavelengths. This may result in increased errors associated with the lack of spectral table depth.

For example, a legacy J-Power Pro meter is a compact sensor adapter that powers the active sensor circuit in DB-25 PowerMax-Pro sensors and passes the raw output voltage of the sensor directly to the BNC connector.

The peak voltage of the output (as referenced from the baseline voltage) is then measured using an oscilloscope or other analog-to-digital input device. The calibrated peak voltage represents the integrated energy of the laser pulse.

Step 6. Set Up Beam Size for Thin-Film Detectors

The requirements to set up a sensor with a thin-film detector differs from standard thermopiles. The following details and additional laser parameters are not typically considered when using a more traditional thermopile:

- Wavelength sensitivity
- Distance and beam divergence to determine spot size
- Polarization sensitivity
- Angular sensitivity

Information about each of these factors and how to adjust the sensor are described more fully in the sections that follow.

Wavelength Sensitivity

Different models of the PowerMax-Pro kW sensor measure different wavelengths, as listed in Table 3-4.

Table 3-4. Wavelength Range by Sensor Model

MODEL	LASER	WAVELENGTH RANGE
Free space	All	640 nm to 11 µm
Window	The anti-reflective coating on the window reduces the range of wavelengths that can be measured, depending on the laser:	
	CO2 lasers	9 µm to 11 µm
	Diode lasers	780 nm to 1 µm (980 nm)
	Fiber lasers	1000 nm to 1400 nm

NOTE:
The mechanical design of the PowerMax-Pro kW absorbs >99% of the reflected light within the enclosure.

Set Beam Size

As the average power goes up, minimum beam sizes are required. Because the absorption surface is deep within the sensor, it is not obvious where the beam size focuses.

Adjusting the beam size (diameter and power) is required to prevent laser damage and to achieve power handling limits. This is critical when dealing with non-collimated laser beams.

WARNING!
Damage occurs if the sensor is not set up correctly. Also, using the device in a manner that exceeds specifications is not covered under the Warranty. Any damage to the sensor requires that you ship the sensor to the factory for repair or replacement.

Beam Propagation

Figure 3-22 shows a cross-section diagram of how a 25 mm laser beam hits the sensor.

Table 3-5 lists the measurements to be considered in this example:

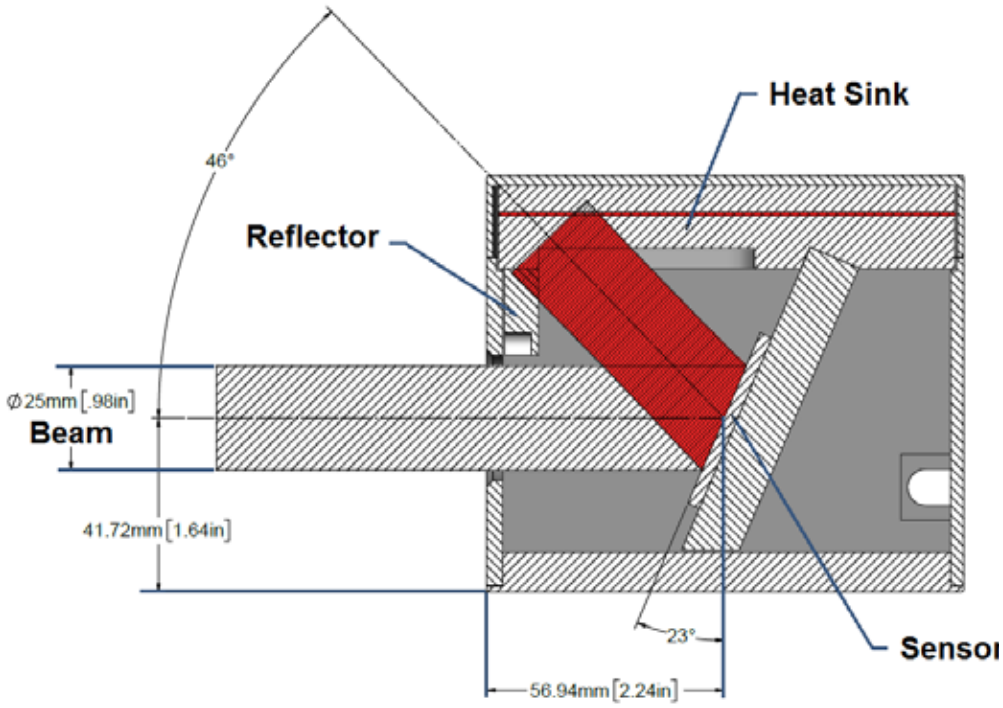


Figure 3-22. Cross-Section of Beam Hitting Sensor

Table 3-5. Measurement of Beam Hitting Sensor

DESCRIPTION	MEASUREMENT
Distance from aperture to center of sensor element	59.94 mm (2.24 in.)
Distance from center of sensor element to absorber in the direction of the reflection	41.72 mm (1.64 in.)
Effective maximum beam size on the element	25 mm (0.98 in.)

Using the QBH Adapter

The PowerMax-Pro kW sensor can be configured in multiple ways. See "Configurations Available" (p. 2-10) for a list of options, including the Free-Space model, a Window model, or a laser-safe QBH Adapter.

When using Fiber Optic cables, it is strongly recommended that you order the QBH Adapter and install it on the sensor to ensure a secure worry-free connection. The QBH Adapter ensures that a QBH laser cable is fastened to a specific depth; this also eliminates angular errors.

Should you choose not to use the QBH Adapter, you must determine the Fiber End Point (FEP) on the cable and take the necessary steps to correctly set the distance. The QBH Adapter specifies that the FEP of the fiber cable should be 7.0±0.3 mm from the face of the PowerMax-Pro kW sensor.

IMPORTANT!
The proper spacing from the FEP to the sensor surface is critical.

Setting the QBH cable to the correct distance ensures that the entire beam is captured on the surface of the sensor and is not absorbed into the housing nor produce unwanted reflections. Setting the QBH cable to the correct distance also results in error-free measurements.

To minimize errors induced by angular sensitivity of the PowerMax-Pro kW sensor, the QBH fiber optic cable from the laser should be:

- Fastened securely.
- Set up to correctly reference the housing of the sensor.

Figure 3-23 shows a cross-section diagram when using a QBH Adapter with a Fiber Optic cable (NA 0.2 beam).

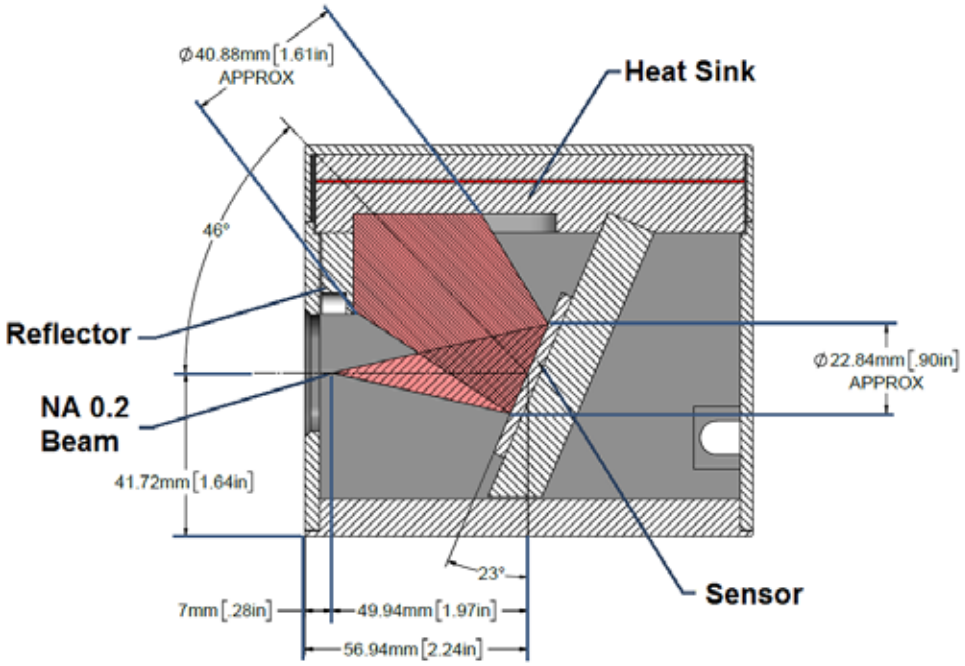


Figure 3-23. Cross-Section of Beam Hitting Sensor Using a QBH Adapter

Table 3-6 lists the measurements to be considered for fiber termination in this example for an NA 0.2 beam when using a QBH Adapter:

Table 3-6. Reflection When Beam Hitting Sensor

DESCRIPTION	MEASUREMENT
Distance from aperture to center of sensor element	59.94 mm (2.24 in.)
Distance from focus of beam entering inside aperture to center of sensor element	49.94 mm (1.97 in.)
Distance from center of sensor element to absorber in the direction of the reflection	41.72 mm (1.64 in.)
Divergence of beam off of sensor element	40.88 mm (1.61 in.)
Effective maximum beam size on the element	22.84 mm (0.90 in.)
FEP of the fiber cable from the face of the sensor	7.0±0.3 mm

See “Performance” (p. 2-4) for general information about power handling by beam size, beam divergence, and beam shape.

Polarization Sensitivity

This section describes how to use PowerMax-Pro kW sensors to compensate for error in measurements created by polarization.

The design of the PowerMax-Pro kW sensor uses a reflective gold mirror surface that is placed at a relatively high incidence angle. The reflectivity between polarization states is significant at this angle, which reduces the accuracy of the final power measurement.

The PowerMax-Pro kW sensors are calibrated at several wavelengths for improved spectral accuracy. At all of those wavelengths except CO2 (described below), the lasers are randomly polarized. This calibration results in minimal error for circularly and randomly polarized lasers.

When the sensor is used with a vertically or horizontally polarized laser, or a polarization at some other fixed angle, some method of correction is required. The measurement can either be corrected using polarization correction factors, or the sensor can be rotated 45 degrees to the linearly polarized laser. There methods are described next.

Quantitative Polarization Correction Factor

PowerMax-Pro kW sensors that contain CO2 laser calibrations also contain polarization calibration information.

> NOTE: PowerMax-Pro kW models calibrated at only 810 nm or 1070 nm do not contain polarization correction information. A triple wavelength calibrated model is required to get polarization data for use at non-CO2 laser wavelengths.

These particular PowerMax-Pro kW models are calibrated with a polarized CO2 laser beam to characterize each detector's response to polarized light. The sensor is tested in the horizontal, vertical, and 45-degree polarization states. The 45-degree polarization calibration is loaded into the sensor, and the other data is used to provide correction factors.

A series of correction factors for 0 to 90-degree polarization states in 15-degree increments is published in the Supplemental Sensor Information data sheet (shown in the example in Figure 3-24). This supplement is attached to each *Certificate of Calibration* shipped with the product. Use this information to correct for polarized measurements in the Gain function (Measurement tab in the LabMax-Pro PC software).

Polarization Angle	Correction Factors Factor
0°	1.0843
15°	1.0717
30°	1.0396
45°	1.0000
60°	0.9646
75°	0.9410
90°	0.9328
Circular	1.0000

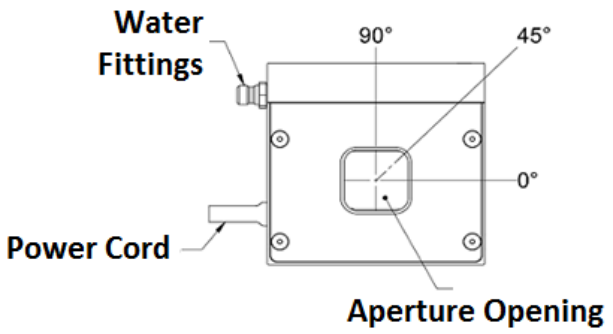


Figure 3-24. Polarization Calibration

Physical Polarization Correction

Vertically and horizontally polarized lasers can be measured without any polarization error by rotating the sensor to a 45-degree angle around the Z-axis with respect to the optical table, as shown in Figure 3-25.

Figure 3-25. Rotating Adapter Plate

See “To mount the sensor in a 45-degree position:” (p. 3-14) for instructions and mounting recommended hardware.

For other fixed polarization angles, simply rotate the sensor 45 degrees to the fixed polarization angle.

Gain Adjustment

Gain Adjustment is intended to allow a bias “offset” to be created to allow for things such as:

- Correcting for polarization effects when using PowerMax-Pro kW sensors with polarized beams
- Compensating for optical losses in the beam path leading up to the measurement point
- Aligning two different measurement systems

Gain Adjustment does not affect calibration.

To adjust for gain, click the check box for the Gain option in the Measurement toolbar of the LabMax-Pro PC software as shown in Figure 3-26.

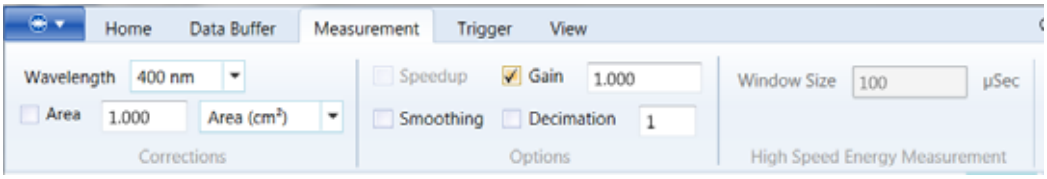


Figure 3-26. Software — Gain Adjustment

Step 7: Take a Test Measurement

For highest accuracy, the measured beam should be aligned so that it is centered in the front aperture of the sensor and perpendicular to the front aperture plate surface. The alignment target on the protective dust cap and the geometry of the sensor mount can be used to square and center the beam.

WARNING!
Do not remove the Protective Dust Cover and cover the sensor at all times (except when taking a measurement).
Failure to do so could cause damage to the sensor element.

To take a test measurement:

1. Direct the laser beam so that it is perpendicular to the PowerMax-Pro kW sensor. That is, the incoming beam should be perpendicular to the front aperture plate surface.
2. Center the beam in the front aperture on the sensor.
3. Remove the Protective Dust Cap.

CAUTION!
While you can test an alignment beams with the Protective Dust Cover still on the sensor, you must remove the Cover before firing the laser beam at the sensor.

4. Take the measurement.
5. Immediately replace Protective Dust Cap. Remember to keep the Protective Dust Cap intact while checking measurements.
6. Review the results of the measurement, and repeat as necessary.

Go to "Section Four: Measurement Modes" (p. 4-1) for instructions about how to take a basic power measurement as well as a high-speed or snapshot measurement.

Inspect and Clean the Sensor

This section applies primarily to the Free Space model for the PowerMax-Pro kW sensor. (The model with the Window covers and protects the sensor element, which offers some protection against contamination.)

Dust in the atmosphere can deposit onto the surface of the exposed sensor element. When irradiated by a high power beam, dust can burn and cause damage to the sensor surface.

Regularly inspect the sensor element to ensure there is no dust on the sensor element. Any dust or contaminants can result in damage to the sensor.

NOTE: A good rule is to inspect first and clean only if necessary!

To inspect the sensor element:

1. Always turn off any laser sources before you begin the inspection of the optical port and sensor element.

CAUTION!
Always wear the appropriate safety glasses when required in your area. Be sure that any laser safety glasses meet federal and state regulations and are matched to the lasers used in your environment.

2. Remove the Protective Dust Cap and store it in a clean resealable bag to avoid contamination of the Dust Cap.
3. If you notice any dust or particulate contamination rest on the surface of the element, lightly dust off the surface using compressed clean, dry air or compressed nitrogen.

ADDITIONAL NOTES:
Do not touch the sensor element with your finger or any object.
Do not use any dry products to clean the sensor element, including a tissue, swab, or cleaning fabric.
Do not use any wet products to clean the sensor element, including alcohol or any wet cleaning solution.

4. Replace the Protective Dust Cap as soon as possible.

Next Steps

Go to “Section Four: Measurement Modes” (p. 4-1) for descriptions of the various measurement modes (Basic, High-Speed, and Snapshot) and instructions about how to take those measurements.

SECTION FOUR: MEASUREMENT MODES

This section summarizes the following measurement modes available in the LabMax-Pro PC software:

- Basic Mode – A nearly instant average power reading at a 10 Hz sampling rate
- High-Speed Mode – A high-speed power reading streaming at 20 kHz
- Snapshot Mode – A burst of high-resolution power data sampled at 625 kHz or 1.6 microseconds per sample

Each of these modes are described in the next sections. The software application is compatible with PowerMax-Pro sensors, as well as with thermopile and optical power sensors.

For more information about these modes, as well as software set-up and tips, see the *LabMax-Pro PC Installation & Quick Start Guide* (P/N 1269225) or the LabMax-Pro PC v1.5 software Help files.

Basic Measurement Mode Overview

The Basic power measurement mode of the LabMax-Pro SSIM uses a typical 10 Hz sampling rate.

This mode is best used to measure the average power of either Continuous Wave (CW) lasers or the average power of high-repetition rate (pulsed) lasers.

- In10 Hz sampling mode, PowerMax-Pro sensors supply an almost instantaneous power reading, similar to a photodiode, while also taking advantage of the sensor's ability to directly read very high powers.

  However, because data is sampled every 100 milliseconds, temporal pulse information is not displayed. To view temporal information, use High-Speed Mode instead.
- When measuring the average power of high repetition rate, short-pulsed lasers such as picosecond, femtosecond, and nanosecond lasers, it is best to operate in Basic mode because:
  - Ultrafast and q-switched laser pulses are too fast for PowerMax-Pro to resolve temporal pulse information.
  - High-Speed Mode sampling rates tend to alias with the high kHz pulse repetition rates.

High-Speed Measurement Mode Overview

High-Speed Mode is compatible only with PowerMax-Pro sensors.

High-speed mode operates at a continuous data sampling rate of 20 kHz, permitting pulse shape analysis of modulated lasers with repetition rates up to 2.5 kHz.

These types of pulse trains are common in many laser-based material processing applications, such as micro welding. This mode can also be useful for viewing the settling times of Continuous Wave lasers after the laser is fired.

- A data point is sampled every 50 microseconds, making this mode very useful for real-time visualization of temporal shape of modulated lasers with pulse lengths hundreds of microseconds or longer. This mode also provides fast feedback about changes in power output from Continuous Wave sources.
- To avoid aliasing effects between the meter sampling rate and the laser pulses, High-Speed Mode cannot be used with lasers modulated at over 2.5 kHz pulse repetition frequency.

Figure 4-1 illustrates the type of detail collected in LabMax-Pro PC software for a CO2 laser when using High-Speed mode.

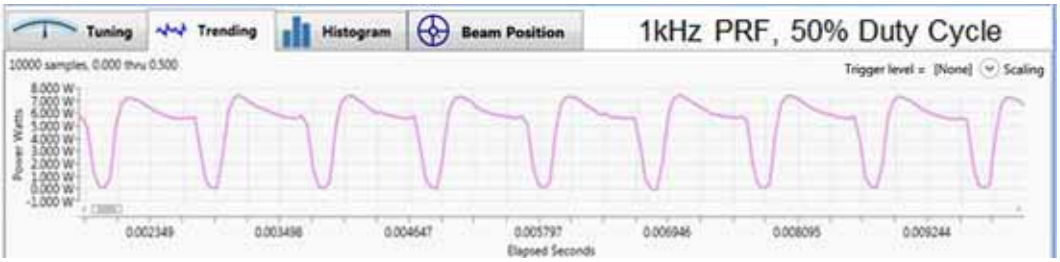


Figure 4-1. Example – Using High-Speed Mode

Snapshot Measurement Mode Overview

A faster high-speed sampling mode, called Snapshot Mode, provides burst sampling at a rate of 625 kHz for a maximum of 384 milliseconds.

This mode lets you see the temporal characteristics of modulated pulses used in commercial cutting, engraving and drilling applications.

The temporal detail in Snapshot Mode illustrates the true performance of the laser—previously masked by slow thermopiles— thereby providing more information to help set up process recipes and monitor system performance in manufacturing.

Figure 4-2 shows the data quality and high pulse shape fidelity that is achievable. This example is a snapshot based on:

- Modulated 10.6 µm CO2 Laser
- 50 µsec PW
- 8 kHz PRF
- 40% Duty Cycle

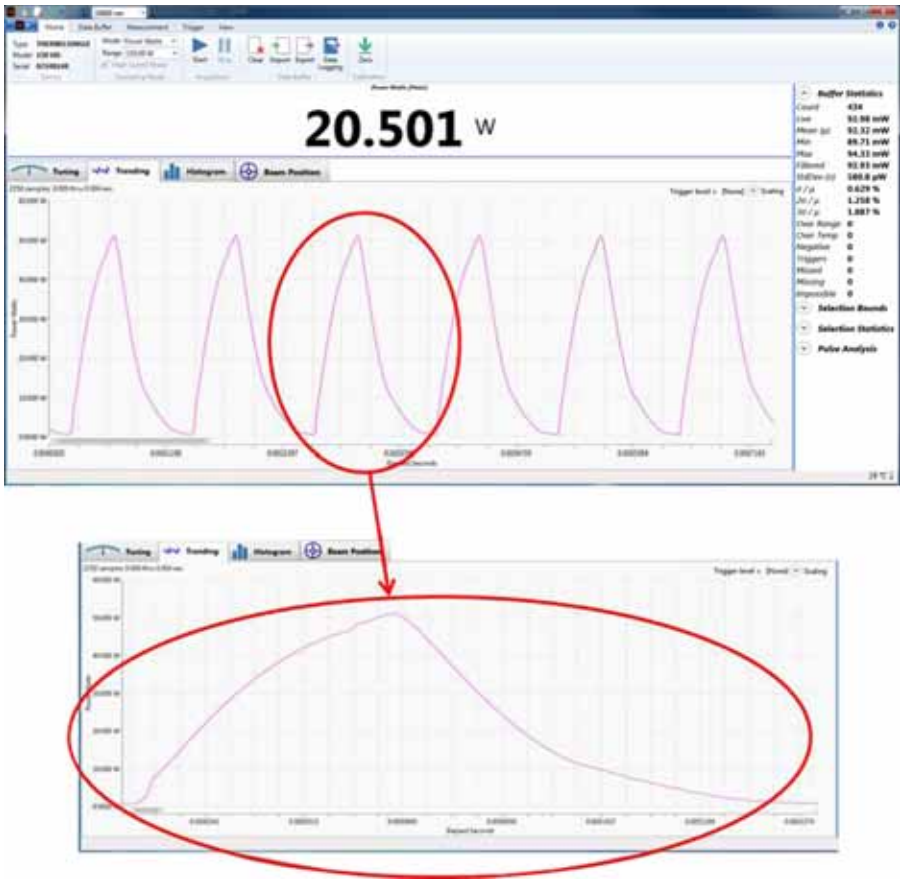


Figure 4-2. Example Using Snapshot Mode

For more details about the Snapshot process or other mode, see the *LabMax-Pro PC Installation & Quick Start Guide* (P/N 1269225) or the LabMax-Pro PC v1.5 software Help files.

APPENDIX A: SERVICE AND SUPPORT

This section provides information about:

- Calibration
- Obtaining service
- Product shipping instructions
- How to contact Product Support

Calibration

Coherent laser power and energy meters are precision instruments, capable of delivering very accurate measurements, as well as providing many years of useful service. To maintain this high level of performance, Coherent recommends that meters and sensors are serviced and re-calibrated once a year.

IMPORTANT!
There are no user-serviceable components in the PowerMax-Pro kW laser system. DO NOT disassemble the enclosure. The laser system is designed to be operated as assembled.
The Warranty is void if the enclosure is disassembled!

Any required service must be performed at Coherent's facility in Wilsonville, Oregon.

To arrange for warranty service or annual recalibration, contact your regional Coherent service center to obtain a Return Material Authorization (RMA) number.

Use the shipping box and packaging materials you retained to safely transport the sensor back to the factory for its annual calibration. See "Product Shipping Instructions" for details.

Should you experience any difficulties with the PowerMax-Pro kW sensor and need more assistance or technical information, contact LMC as described in the next sections.

Coherent Calibration Facilities

As the largest laser manufacturer in the world, Coherent has been able to build state-of-the-art calibration facilities containing the widest possible range of laser types and technologies. This enables us to perform instrument and sensor calibration under virtually any combination of wavelength, power, and operating characteristics.

Coherent is a registered ISO 9001:2000 company, our products are NIST traceable, and our calibration labs are fully ANSI Z540 compliant.

In addition to the technological advantage, we also strive to deliver the best service in the industry, with a knowledgeable and responsive staff, and rapid turnaround.

NIST Calibrated Standards

Sensors are calibrated against NIST-traceable working standard sensors which are, in turn, calibrated against NIST-calibrated golden standard sensors. These working and golden standards are maintained with the utmost care, recalibrated annually, and verified even more regularly. Coherent maintains multiple NIST-calibrated standards at many laser wavelengths to support growing calibration requirements.

Optical Calibration

Optical calibration is a core competency at Coherent, and we strive to continually improve our methods, precision, and repeatability.

Additionally, most of the calibrations are performed with highly automated systems, thus reducing the possibility of human error to nearly zero.

Strict quality inspections during many stages of calibration and testing assure a precise and accurate instrument that is NIST traceable and CE marked. The benefit is that instruments calibrated by Coherent consistently perform as expected under their actual use conditions.

Obtaining Service

To obtain service under warranty, Customer must notify the Company of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. The Company shall, in its sole discretion, determine whether to perform warranty service at the Customer's facility, at the Company's facility, or at an authorized repair station.

If Customer is directed by the Company to ship the product to the Company or a repair station, Customer shall:

- Package the product (to protect from damage during shipping) as instructed in "Product Shipping Instructions".
- Ship it to the address specified by the Company, shipping prepaid. The customer shall pay the cost of shipping the Product back to the Customer in conjunction with recalibration and recertification; the Company shall pay the cost of shipping the Product back to the Customer in conjunction with product failures within the first twelve (12) months of time of sale or during an extended 12-month warranty period.

You must include a Returned Material Authorization number (RMA) assigned by the Company on the outside of all shipping packages and containers. Items returned without an RMA number are subject to return to the sender. Detailed instructions to prepare a product for shipping are provided in the next section.

Product Shipping Instructions

To prepare a product for shipping to Coherent:

1. Contact Coherent Customer Service (see "Contact Product Support" in the next section) for a Return Material Authorization number.

2. Attach a tag to the product that includes the name and address of the owner, the person to contact, the serial number, and the RMA number you received from Coherent Customer Service. This tag should be packed inside the box.
3. Wrap the product with polyethylene sheeting or equivalent material.
4. Using the original shipping and packaging materials, pack the product. If the original carton and packing materials are not available:
   - Obtain a corrugated cardboard shipping carton with inside dimensions that are at least 6 in. (15 cm) taller, wider, and deeper than the product. The shipping carton must be constructed of cardboard with a minimum of 375 lb. (170 kg) test strength.
   - Cushion the instrument in the shipping carton with packing material or urethane foam on all sides between the carton and the product. Allow 3 in. (7.5 cm) on all sides, as well as the top and bottom.
5. Seal the shipping carton with shipping tape or an industrial stapler.
6. Add the RMA number you received from Coherent Customer Service to the shipping label for the box.
7. Ship the sensor to the following address:

   Coherent, Inc.
   Laser Measurement and Control, Attn: RMA #
   27650 SW 95th Ave.
   Wilsonville, OR 97070
   USA

Contact Product Support

Coherent provides telephone and web-based technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services.

Under no circumstances do these support services affect the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks (or safety features) defeated is always at the operator's own risk.

Please be prepared to provide the following information to the Support Engineer who responds to your request:

- Model or part number of your unit
- Serial number of your unit
- A description of the problem
- Any corrective steps you may have attempted

For the latest Customer Service information, refer to the company website:

www.Coherent.com

In the USA and North America

If you are shipping products from within the United States or North America, contact Coherent LMC Technical Support directly, either:

- By phone in North America: (800) 343-4912 or (408) 767-4042
- By e-mail: LMC.sales@coherent.com

Telephone coverage is available Monday through Friday (except during U.S. holidays). Inquiries received outside normal office hours are tracked by our automatic answering system and promptly returned the next business day.

International

If you are located in Europe, contact LMC Technical Support directly, as follows:

- Germany: +49–6071–968–0
- Japan: +813–5635–8680

For Coherent general Technical Support, contact your local Coherent Service Representative, or contact us as follows:

- By phone: 1-(408)-764-4557 or 1-(800)-367-7890
- By e-mail: Product.Support@Coherent.com
- To view a list of contact names, telephone numbers, and addresses worldwide, visit our website:

  www.Coherent.com

APPENDIX B: WARRANTY

This section provides information about:

- Limited warranty
- Extended warranty
- Warranty limitations

PowerMax-Pro kW sensors ship with a standard one-year warranty, described in this section.

The warranty is maintained throughout the lifetime of the sensor if it is returned annually for service and recalibration.

Limited Warranty

Coherent, Inc. (the "Company") warrants its laser power and energy meters and sensors products ("Products") to the original purchaser (the "Customer") that the product is free from defects in materials and workmanship and complies with all specifications, active at the time of purchase, for a period of twelve (12) months.

Coherent, Inc. will, at its option, repair or replace any product or component found to be defective during the warranty period. This warranty applies only to the original purchaser and is not transferable.

Extended Warranty

Coherent, Inc. (the "Company") offers original purchasers (the "Customer") purchasing laser power and energy meters and sensors products ("Products") an extended twelve (12)-month warranty program, which includes all parts and labor.

To qualify for this warranty, a Customer must return the Product to the Company for recalibration and recertification. The Company will re-certify the Product, provide software upgrades, perform any needed repairs, and recalibrate the Product for a fixed service fee (as established by the Company from time to time and in effect at the time of service).

If the product cannot be re-certified due to damage beyond repair, parts obsolescence, or other reasons, the Customer may be informed that an Extended Warranty program is not available for the Product.

If the Product fails and is returned to the Company within one year following the date of recalibration and recertification service, the Company will, at its option, repair or replace the Product or any component found to be defective. If the Product must be replaced and the Product is no longer available for sale, Coherent reserves the right to replace with an equivalent or better Product. This warranty applies only to the original purchaser and is not transferable.

Warranty Limitations

The foregoing warranties shall not apply, and Coherent reserves the right to refuse warranty service, should malfunction or failure result from:

- Damage caused by improper installation, handling or use.
- Laser damage (including sensor elements damaged beyond repair).
- Failure to follow recommended maintenance procedures.
- Unauthorized product modification or repair.
- Operation outside the environmental specifications of the product.

Coherent assumes no liability for Customer-supplied material returned with Products for warranty service or recalibration.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, ORAL, OR IMPLIED. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL THE COMPANY BE LIABLE FOR ANY INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS PRODUCTS.

Power-Max®–Pro kW Sensor — *User Manual*

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