



Laser Power and Energy Meters



- *Widest Selection of Meters and Sensors*
- *NIST Traceable Calibration*
- *CE and ISO 9002 Certification*

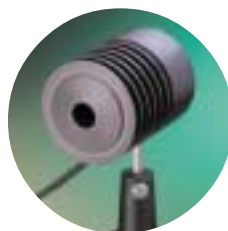
INSTRUMENTS

for Laser Power and
Energy Measurement





Laser Power and Energy Meters



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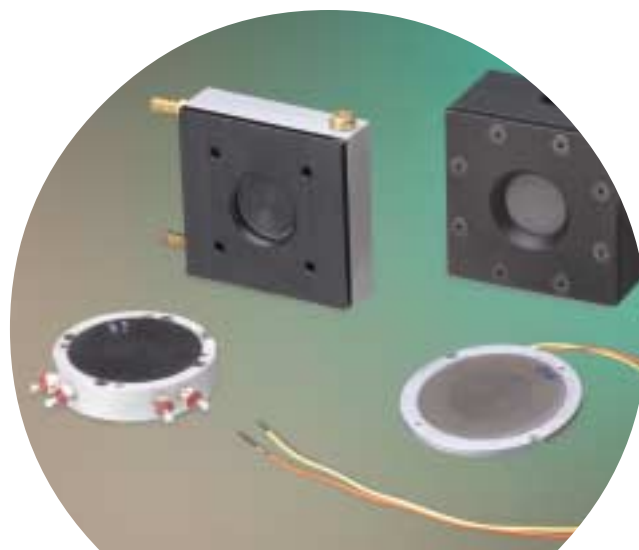
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Introduction to Laser Power and Energy Measurement



Radiometry of Laser Beams

Along with the development of the first lasers arose the need to develop instrumentation to measure the power and energy of the lasers. Traditional radiometers were too delicate and only suitable for measuring low power or energy beams. Therefore, Coherent introduced the **power meter** as a new class of device. These rugged instruments are optimized to measure laser beams. Such beams are typically parallel, or slowly converging or diverging, and 1-50 mm in diameter. The flow of laser radiation may be continuous (CW) in which case a power meter measuring in Watts (or mW, kW, dBm, etc.) is required, or the laser may be pulsed, when the total energy of a single pulse is most commonly measured in Joules (or mJ or dBJ) by an instrument which may be called an energy meter, a joulemeter or even a calorimeter. If the laser is repetitively pulsed, then some power meters can record the average flow of energy (as Watts).

Sensor Technology

Some lasers are CW and some are pulsed. They may have large diameter beams or

small beams. Some are high power, some are low power, and the wavelength can be from UV to the far IR. No one sensor type can measure all lasers; instead, three types of sensor technology are used based on the sensor material:

Thermal sensors measure the flow of energy through an array of thermoelectric cells. They are rugged and best for measuring medium and high power (CW) lasers. These sensors have an intrinsically flat spectral absorption from the UV to the far infrared, but there are some variations of surface reflection from the sensor, so each sensor is NIST traceably calibrated. Thus, accuracies of $\pm 2\%$ from 190 nm to 10.6 μm can be achieved. Typically, these sensors have a response time of 1-10 seconds, which is decreased to 0.5-2 seconds when matched with a Coherent readout console.

Semiconductor sensors are very sensitive detectors for the spectral regions 250 nm to 1.065 μm (silicon sensors) and 800 nm to 1.8 μm (germanium sensors). Semiconductor sensors are relatively rugged, but unfortunately their sensitivity

changes greatly with wavelength, so they must be combined with an appropriate readout console to achieve calibrated and accurate results ($\pm 5\%$). The semiconductor material typically saturates in the 10-50 mW range, so for linear operation up to a maximum of about 5 Watts a calibrated optical attenuator should be used. Such attenuators are also available from Coherent.

Pyroelectric sensors are used only to measure pulsed lasers. They do not respond to a CW optical input (unless it is chopped). Coherent offers pyroelectric sensors which measure single shot laser energies and repetitively pulsed lasers from 1-400 Hz.

Calibrated Accuracy

All Coherent power and energy meters with interchangeable sensors are supplied complete with National Institute of Standards and Technology (NIST) traceable Certificates of Calibration. Coherent maintains full re-calibration facilities in California, Europe, and Japan. (See page for 32 more details.)

Choosing a Measurement System

1 Select a sensor type based on laser wavelength, pulsed or CW operation and maximum power/energy.

Sensor Type	Primary Measurement Capabilities	Secondary Measurement Capabilities
Thermal	CW laser power ~1 mW to 5 kW	Single pulse energies (Ultima LabMaster™ and FieldMaster-GS™ only) and average power of repetitively pulsed lasers
Semiconductor	CW laser power ~1 nW to 5 W (250 nm to 1.8 μm)	Average power of repetitively pulsed lasers
Pyroelectric	Pulsed laser energies ~1 μJ to 100 J (190 nm to 20 μm)	Average power of repetitively pulsed lasers

2 Choose a readout console based on which sensor type(s) it works with, cost effectiveness, and how extensive a range of measurement capabilities and analytic features are needed.

Primary Application	Product Name	Thermal Sensors	Semiconductor Sensors	Pyroelectric Sensors	Major Benefits
Quick power checking	LaserCheck (page 4)		500 nW to 1 W		Inexpensive, pocket-sized
Medium and high power CW laser measurements	LaserMate™ (page 7)	0.3 mW to 150 W			Adjustable response, cost-effective, analog out
Low and medium power CW laser measurements	LaserMate-Q™ (page 5)		10 nW to 5 W		Cost-effective scope output
Pulsed energy measurements	LaserMate-P™ (page 6)			0.5 mJ to 10 J	Cost-effective, analog out joules, Watts, and Hz
Measurement of power and energy of all lasers	FieldMaster™ (page 8)	1 mW to 5 kW	10 nW to 5 W	0.5 mJ to 20 J	Extensive choice of SmartSensors™
Measurement and analysis of energy and power of all lasers	FieldMaster-GS™ (page 10)	1 mW to 5 kW 0.15 mJ to 95 J	10 nW to 5 W	1 μJ to 20 J	Choice of SmartSensors™, position, statistics, tuning, RS-232 and analog out
Complete measurement and analysis of energy and power of all lasers	Ultima LabMaster™ (page 12)	1 mW to 5 kW 0.15 mJ to 95 J	10 nW to 5 W	1 μJ to 20 J	Fully featured system, including SmartSensors™, position measurement, GPIB, RS-232, printer and analog out

3 Turn to the next few pages for more detailed information about the various instruments—from the simple hand held LaserCheck to the sophisticated systems such as the Ultima LabMaster™.

SmartSensors™

Both FieldMaster and LabMaster work with an extensive range of SmartSensors, which are fully described in the pages following the FieldMaster and LabMaster details. These SmartSensors are pre-programmed with linearity, wavelength and sensitivity factors during factory calibration, so they can be interchanged quickly and easily.



LaserCheck

Hand-held Laser Power Meter

- Auto ranging with peak sample-and-hold
- Power measurement from 0.5 μW to 1 W
- $\pm 5\%$ calibrated accuracy from 400-1064 nm



LaserCheck is a hand-held, inexpensive laser power meter specifically designed to provide power measurements in a small, light weight, self-contained package that can easily be stored in a pocket or tool kit. At higher powers the silicon sensor is protected from saturation with a built-in optical attenuator and all measurements are displayed on a clear LCD screen. LaserCheck is micro-processor controlled with wavelength correction, auto-ranging (μW or mW displayed), optical attenuator, power overload warning and automatic shutoff.

LaserCheck is ready to use. It is supplied complete with battery, integral pocket clip, storage case, CE certification and user instruction sheet. To initiate a measurement cycle press the Sample/Hold button to turn the LaserCheck on, center the beam on the sensor for >2 seconds and release the button to record a measurement of the power. Repeat the cycle to make another measurement or the LaserCheck will switch off automatically after 10 seconds.

Specifications

Sensor Disk: Silicon, 8 mm aperture

Power Range: 0.5 μW to 1 W

Accuracy: $\pm 5\%$

Max Power Density: 30 W/cm^2 with built-in ND attenuator, 0.5 W/cm^2 without attenuator.

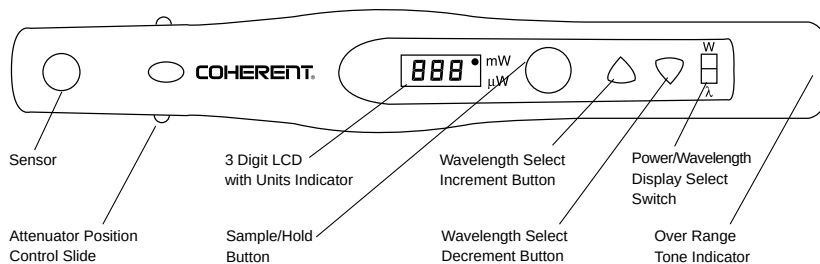
Wavelength Range: 400-1064 nm

Battery Life: 180,000 measurements at 12 sec/sample.

Overload Indication: "----" display and beep tone.

Size: 168 x 24 x 20 mm

Weight: 44 g



LaserCheck



Catalog Number	Description
33-1553	LaserCheck

ISO 9002 Certified



LaserMate-Q™

High-sensitivity Laser Power Meter

- Cost-effective precision CW low power measurement
- Range of three programmed sensors for 250 nm to 1.8 μm
- Power measurements from 10 nW to 50 mW (5 W with attenuator)



Analog and digital screen shown

LaserMate-Q™ is a high-sensitivity power meter for UV visible and near IR CW lasers. It combines both analog and digital displays. The digital readout provides high resolution and accuracy, while the analog meter provides the speed and real time feedback you need for laser tuning.

There is a choice of three semiconductor sensors, a silicon sensor for 400-1064 nm, a UV-enhanced silicon sensor for

250-400 nm and a germanium sensor for 800-1800 nm in the infrared. Sensors are quickly interchangeable and any sensor can be used with any LaserMate-Q readout unit. The readout downloads calibration information from the sensor when it is plugged in. Each sensor is individually calibrated and programmed, and the readout permits selection of the correct wavelength with resolution as fine as 1 nm. All sensors are air-cooled and are provided with a mounting base, adjustable-height post and connecting cable. If the laser power exceeds the maximum limit for the 400-1064 nm and 800-1800 nm sensors, then an optional optical attenuator is available to allow measurements up to 5 W. Further details of this attenuator can be found in

Accessories for Power and Energy Meters, page 26.

The readout is lightweight, compact (193 x 117 x 46 mm) and the adjustable-angle base folds across the face of the instrument to form a protective cover for transport. Battery operation is standard but an optional AC power adapter is available.

LaserMate-Q is CE certified and the design has been developed with low EMI noise sensitivity for use in real laser environments. Although the LaserMate-Q is designed to measure CW laser powers, it will also show an average power reading for a train of pulses provided the frequency is >20 Hz.

Power Waveform Viewing

The LaserMate-Q features an analog output that is a 0-1 VAC (uncalibrated) copy of the power waveform which allows pulse shape viewing on an oscilloscope etc. The bandwidth is 50 kHz, but is reduced for the more sensitive ranges:

Ranges	Frequency Response
≥ 1 mW	50 kHz
100, 300 μW	5 kHz
10, 30 μW	500 Hz
1, 3 μW	50 Hz
100, 300 nW	5 Hz

Readout Console Specifications

Power Subtraction: Offset of any reading to zero.

Display Response Time: <0.2 s

Battery: 9 V, >20 hours life

Display Backlighting: With AC operation only.

LaserMate-Q Sensors

Catalog Number	Type	Wavelength Range (nm)	Power Max (mW) Min (nW)	Accuracy† $\pm$ % of Reading LSD	Maximum W/cm ²	Sensor Diameter (mm)
33-0233	UV	250-400	30 10	5.0 2	0.3	6
33-0241	VIS	400-1064	50 10	3.5 2	1.0	7.9
33-0258	IR	800-1800	10 10	5.0 2	0.5	5

See **Sensor Dimensional Drawings** for sensor head dimensions, page 20. † Including display.

LaserMate-Q Readouts

Catalog Number	Description
33-0332	LaserMate-Q Readout, Analog and Digital Displays
33-0324	LaserMate-Q Readout, Analog only Display
33-1298	1000:1 Optical Attenuator for 33-0241 and 33-0258
33-0639	AC Power Adapter 100-240 VAC 50/60 Hz
33-0555	Soft Carrying Case

All sensors and readouts supplied with NIST traceable calibration certificates.



LaserMate-P™

Pulsed Laser Energy Meter

- **Cost-effective precision pulsed energy measurement**
- **Measurements from 0.5 mJ-10 J, single shot and 1-50 Hz**
- **Displays Joules, average power, and repetition rate**
- **Large aperture, broadband sensor**



Analog only screen shown

High Energy Operation

Some laser pulses have a higher energy density than the maximum rating of 50 mJ/cm² (for 193 nm, 15 ns pulse) of the standard LaserMate-P. Coherent has available several beam attenuators and samplers which allow the density to be increased up to ~3.5 J/cm². See the Accessories section for further details (page 25).



Specifications

Sensor Disk: Pyroelectric, 43.2 mm aperture

Wavelength Range: 190 nm to 10.6 μm

Energy Range: 0.5 mJ to 10 J

Accuracy: ±5%

Maximum Average Power: 10 W

Maximum Energy Density: 50 mJ/cm² (for 193 nm, 15 ns pulse)

Pulse Rate: Single pulse or 1-50 Hz

Max Pulse Width: 1 ms

Response Time: <1 s

Battery: 9 V, >20 hours life

Analog Output: 0-1 V

Display Backlighting: With AC operation only.

LaserMate-P™ is a compact pulse energy meter with features which make it ideal for both lab and field use. It measures and displays pulse energies (0.5 mJ to 10 J) for single shots or pulse trains from 1-50 Hz. With pulse trains, the frequency can be displayed and also the averaged power in Watts. LaserMate-P is CE Certified and the design has been developed with low EMI noise sensitivity for use in real laser environments.

The crystalline pyroelectric sensor disc has a 43.2 mm aperture, a wide flat spectral response from 190 nm to 10.6 μm and a maximum energy density limit of 50 mJ/cm² (15 ns pulse at 193 nm). For operation at higher power densities, see the adjacent sidebar. The LaserMate-P

sensor heads are air-cooled and provided with a mounting base, adjustable-height post and connecting cable. Any LaserMate-P sensor head can be operated with any LaserMate-P readout.

The LaserMate-P energy meter combines both analog and digital displays. The digital readout provides high resolution and accuracy, while the analog meter provides the speed and real time feedback you need for laser tuning. It is lightweight, compact (193 x 117 x 46 mm) and the adjustable-angle base folds across the face of the instrument to form a protective cover for transport. Battery operation is standard, but an optional AC power adapter is available.

LaserMate-P



Catalog Number	Description
33-0316	LaserMate-P Readout, Analog and Digital Displays
33-0308	LaserMate-P Readout, Analog-only Display
33-0225	LaserMate-P Pyroelectric Sensor
33-0639	AC Power Adapter 100 - 240 VAC 50/60 Hz
33-0555	Soft Carrying Case

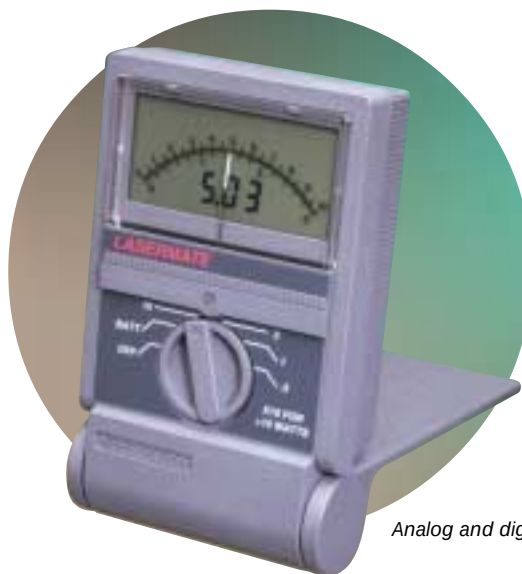
See **Sensor Dimensional Drawings** for sensor head dimensions, page 20. All sensors and readouts supplied with NIST traceable calibration certificates.



LaserMate™

Broadband Laser Power Meter

- Cost-effective precision CW power measurement
- Choice of sensors for 0.3 mW to 150 W power
- Sensors spectrally flat from 250 nm to 10.6 μm
- Adjustable needle response



Analog and digital screen shown

LaserMate™ is a simple multirange power meter for CW lasers and combines both analog and digital displays. The digital readout provides high resolution and accuracy, while the analog meter provides the speed and real time feedback you need for laser tuning.

There is a choice of seven separate thermal sensors, with maximum power ranges from 1-150 Watts. All sensors are air-cooled and (except for the 33-0183)

are provided with a mounting base, adjustable-height post and connecting cable. Sensors are quickly interchangeable and any sensor can be used with any LaserMate readout unit.

The readout is lightweight, compact (193 x 117 x 46 mm) and the adjustable angle base folds across the face of the instrument to form a protective cover for transport. Battery operation is standard, but an optional AC power adapter is available.

The LaserMate is CE Certified and the design has been developed with low EMI noise sensitivity for use in real laser environments. Although the LaserMate is designed to measure CW laser powers, it will also show an average power reading for a train of pulses, provided the frequency is >10 Hz.



LaserMate Sensors

Catalog Number	Power Max (W)	Power Min (mW)	Wavelength Range (μm)	Accuracy † % of reading	± LSD	Maximum W/cm ²	Sensor Diameter (mm)
33-0159	1	0.3	0.25-1.5	5	2	200	9.6
33-0167	3	10	0.25-10.6	5	2	200	17.8
33-0175	10	10	0.25-10.6	5	2	200	15.2
33-0183	20*	100	0.25-10.6	5	2	200	19.1
33-0191	30	100	0.25-10.6	5	2	200	19.1
33-0209	100	100	0.25-10.6	5	2	200	19.1
33-0217	150**	100	0.25-10.6	7	2	6000	19.1

* Requires customer supplied heatsink. ** Intermittent duty 2 Min @ 150 W, 5 Min @ 100 W, 20 Min @ 40 W. See **Sensor Dimensional Drawings** for sensor head dimensions, page 20. † Including display.

LaserMate Readouts

Catalog Number	Description
33-0290	LaserMate Readout, Analog and Digital Displays
33-0282	LaserMate Readout, Analog-only Display
33-0639	AC Power Adapter 100-240 VAC 50/60 Hz
33-0555	Soft Carrying Case

All sensors and readouts supplied with NIST traceable calibration certificate.



Readout Console Specifications

Response Time: <1 s, adjustable
Battery: 9 V, >200 hours life
Analog Output: 0-1 V
Display Backlighting: With digital display and AC operation only

ISO 9002 Certified



FieldMaster™

Laser Power and Energy Meter for use with SmartSensors™

- Choice of over 30 power and energy SmartSensors™
- CW power measurements from 10 nW to 5 kW
- Pulse energy measurements from 0.5 mJ to 20 J
- Sensors for wavelengths from 190 nm to 20 μm



FieldMaster™ is a versatile power and energy meter which supports thermal, pyroelectric and semiconductor photodiode sensor technologies and operates with a choice of over 30 Coherent SmartSensor™ detector heads. It measures virtually any pulsed or CW laser. CW beam powers can be measured with thermal and semiconductor sensors. The energies of pulsed beams can be measured with pyroelectric sensors from single shot up to 50 Hz with a display update rate of 0.3 Hz. The average power of repetitively pulsed beams (>10 Hz) can be measured and displayed as Watts with thermopile sensors.

FieldMaster combines both analog and digital displays. The digital readout provides high resolution and accuracy, while the analog meter provides the speed and real time feedback you need for laser tuning. The display features auto ranging for power or energy readings with the ability to select any range manually for ease of laser tuning. All ranges, except the top range, can be offset by one full range.

See the SmartSensors section (page 16) for the range of sensors available.

FieldMaster performs sophisticated internal corrections for wavelength, sensor linearity and operating conditions prior to displaying the measured value. When first using the FieldMaster with a new SmartSensor, simply scroll to the wavelength, then switch to the reading mode. Upon shutting off the meter, all of the customized settings that you have set are retained in the memory and reset upon turning on again. AC power operation (with screen backlighting) is standard, but internal batteries (~8 hours life) can be used for field use. There are visual and audible over range indicators, and FieldMaster will even warn you if the battery is running low.

FieldMaster is CE certified and has been developed with low EMI noise sensitivity for use in real laser environments. The design is lightweight, compact (193 x 117 x 46 mm) and the adjustable-angle base folds across the face of the instrument to form a protective cover for transport. The unit is built in Coherent's ISO 9002 Certified plant in the United States and is supplied complete with NIST-traceable Certificate of Calibration, AC power adapter and user manual.



SmartSensors™ for FieldMaster

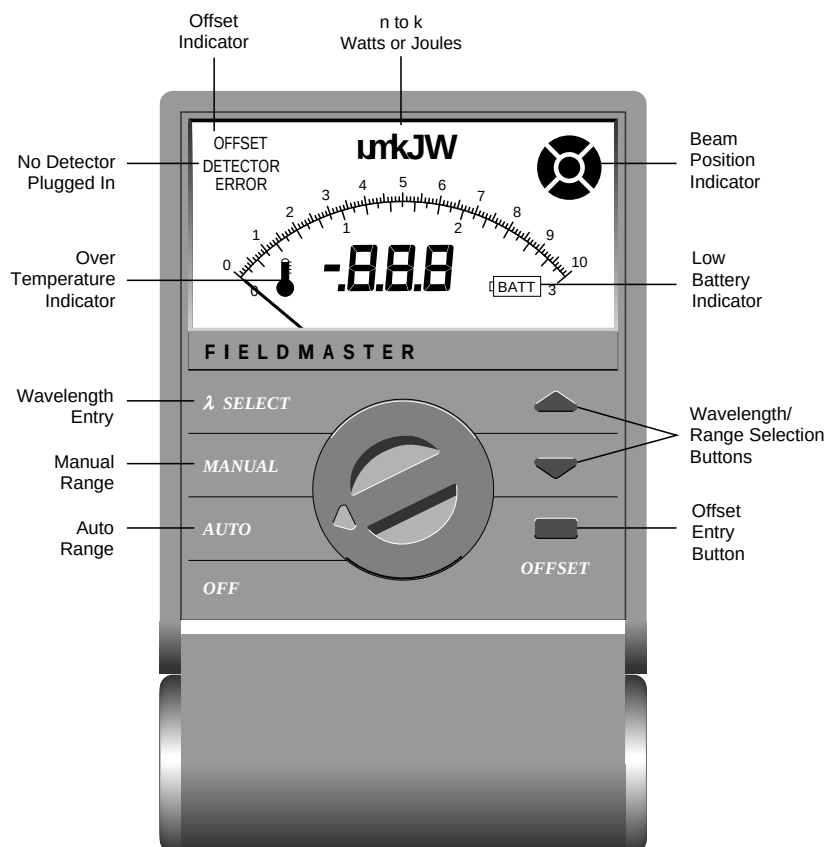
Setting up FieldMaster with any of over 30 SmartSensors is quick and completely automatic. Simply plug the SmartSensor into the FieldMaster display and scroll to the wavelength. FieldMaster does the rest. The SmartSensor technology automatically loads the ID of the chosen sensor, the wavelength correction, calibration factors, the range and alarm parameters. System accuracy is the sum of the readout accuracy (2%) and the % accuracy of the chosen SmartSensor.



See the **SmartSensors** section (page 16) for the range of sensors available.

Extended Function Module

The Analog-out Module provides a 0-1 Volt analog output proportional to the laser power for any of the thermal sensors (except for 33-0928). These thermal sensors have a quadrant configuration and the module "combines" the signals from the four elements to give a total power reading.



Specifications

Accuracy: $\pm 2\%$ ± 2 LSD meter only. Net accuracy with any head is head accuracy plus instrument accuracy. See SmartSensor™ section.

Display: Three digit liquid crystal display (LCD) and conventional moving coil meter. Contrast can be adjusted via push buttons.

Power Requirements:

AC Operation:

115 VAC 50/60 Hz	230 VAC 50/60 Hz
10 VA Maximum	7.5 VA Maximum
1.5 VA Typical	1.5 VA Typical

DC Operation:

Uses two standard 9 V transistor radio batteries. Unit is fully functional with one battery. Use two batteries for maximum working life before battery change. Low battery condition is indicated at 5% of battery life remaining.

Working life of batteries:

8 hours with two each Duracell MN1604 or ID1604.

4 hours with one each Duracell MN1604 or ID1604.

Memory: Retains configuration information when turned off (wavelength correction values, display contrast etc.).

Operating Temperature: 5 °C to 40 °C

Safety Features: Visual and audible sensor over-temperature and sensor over-range alarms. Has protective cover which doubles as a base. Also, an optional soft carrying case is available.

Size: 190 x 117 x 46 mm

Weight: 737 grams with batteries

FieldMaster



Catalog Number	Description
33-0506	FieldMaster Readout with AC Adapter
33-0555	Soft Carrying Case
33-0548	Analog-out Module for FieldMaster



FieldMaster-GS™

Laser Power and Energy Analyzer for Use with SmartSensors™

- Choice of over 30 SmartSensors™ for wavelengths from 190 nm to 20 μm
- CW power measurements from 10 nW to 5 kW
- Pulse energy measurements from 1 μJ to 95 J
- 70 x 60 mm digital display with analog tuning needle
- Beam statistics and position displays
- RS-232 control and analog out



The FieldMaster-GS™ is the newest Laser Power and Energy Analyzer from Coherent. This analyzer can be used with over 30 SmartSensors™ allowing measurement and analysis of the output of virtually any laser. With detector specific data stored in each SmartSensor and setup data retained in the FieldMaster-GS, ease of use is combined with features and reliability that set a new standard.

The FieldMaster-GS has a large graphical display and true analog tuning needle. When tuning or walking in a laser the analog needle swings in to view and the graphical display tracks the peak reading while autoranging as necessary. When not needed, the needle rests out of view so that the entire screen is available for display and analysis of the readings that are acquired.

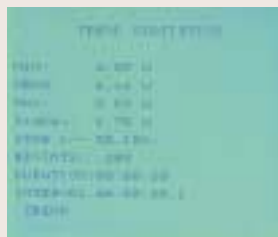
CW beam powers can be measured with thermal and semiconductor SmartSensors. The energies of pulsed lasers can be measured with both pyroelectric and thermopile sensors. With pyroelectric SmartSensors, the repetition rate can be as high as 400 Hz and thermopile SmartSensors can read single pulses, and average power of repetition rates greater than 8 Hz.

Beam Position



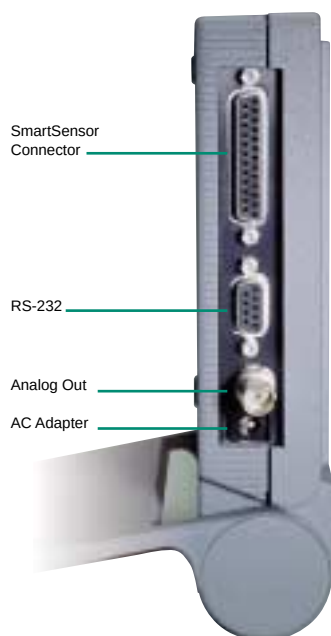
With the thermopile SmartSensors, obtaining beam alignment and position drift information is easy. Beam position stability can be tracked over time and displayed in both strip chart and polar graphs. For beam alignment, the sensor center (target) can be zoomed up to 32X with resolution to 0.01 mm.

Statistics



FieldMaster-GS displays powerful and easy to interpret information on pulse trains, CW stability and power drift in lasers. The interval for trending is selectable as time or pulse count with 200-2000 data points recorded, and can be viewed as tabular data, a strip chart graph or histogram.

While the FieldMaster-GS has many powerful analytic functions – statistics, position, stability – it is easy to use. The most common functions have “hot” keys on the front for HOME, TUNE, TREND, and MENU selections, while there are four “soft” keys for specific control within each screen. To move around in the control screens the cursor pad allows intuitive navigation. Designed and built from concept to completion with CE requirements for EMI and RFI, the



FieldMaster-GS delivers reliable and accurate measurements in all laser environments.

Connectivity

SmartSensors™ simply plug in and download all sensor parameters for instant set up and measurement capability. The FieldMaster-GS can extend the range and usefulness of SmartSensors with:

- Selectable averaging of 1-200 readings for accurate readings of noisy sources.
- Offset selection that allows the subtraction of background noise and signals that are not of interest.
- Programmable attenuation factors from 100,000:1 to 0.01:1 – for attenuators, beam splitters, etc.

The FieldMaster-GS has RS-232 communication and control for integration into test setups to record test results or provide feedback for laser system control.

The 0-1 volt analog out is software assignable to any manual range. It updates at a 5 Hz rate with $\pm 2\%$ accuracy over 4096 steps.

The AC power adapter comes supplied with plugs for US, UK, Europe, Australia and Japan. The adapter auto switches for any worldwide voltage or frequency. In addition to powering the FieldMaster-GS, the AC adapter also charges the internal high energy Ni-Cd battery.

Specifications

Accuracy:

Display Unit: $\pm 1\%$ of reading ± 2 LSD.

System Accuracy: sum of display and sensor accuracies.

Pulse Capture Rate: 10 Hz max

CW Sample Rate: 10 Hz max

Tuning Needle Rate: 10 Hz

Digits Update Rate: 2 Hz

Size: 190 x 117 x 46 mm

Weight: 784 g

Operating Temp: 5 °C to 40 °C

Analog Out: 0-1 V $\pm 2\%$, 5Hz

Battery Life: 8 hours of continuous use (4 hours with backlight).

FieldMaster-GS with SmartSensors

SmartSensors contain calibration, wavelength and linearity data in a memory chip. This allows quick setup with over 30 sensors that are available off the shelf to meet your specific measurement needs. Additionally, Coherent is developing new SmartSensors as laser measurement requirements change. Please refer to the SmartSensors section (page 16) for details.

FieldMaster-GS



Catalog Number	Description
33-0498	FieldMaster-GS*
33-0555	Soft Case

* Supplied with Battery, AC adapter, User Manual, Certificate of Calibration and one year warranty.

ISO 9002 Certified



Ultima LabMaster™

Laser Power and Energy Analyzer System for SmartSensors™

- Single or dual channels with choice of over 30 power and energy SmartSensors™
- CW power measurements from 10 nW to 5 kW
- Pulse energy measurements from 100 µJ to 95 J
- Sensors for wavelengths from 190 nm to 20 µm
- Ratio/difference, RMS noise and beam position measurements



Ultima LabMaster™ is a comprehensive power and energy measuring and analyzing system for CW, single pulse and repetitive pulse laser measurements. LabMaster supports thermopile, pyroelectric and semiconductor photodiode sensor technologies and operates with a choice of over 30 Coherent SmartSensor™ detector heads. CW beam powers can be measured with thermopile and semiconductor sensors. The energies of pulsed beams can be measured for single shot events (pyroelectric and thermal sensors) and for repetition rates up to 400 Hz (pyroelectric sensors) with a display update rate of 3 Hz. The average power of repetitively pulsed beams can be measured and displayed as Watts with thermopile sensors (>10 Hz), and pyroelectric sensors (1-400 Hz).

Data can be displayed on the large screen with digital, strip chart and analog-bar presentations and logged to memory, a printer, or the RS-232 and IEEE 488 ports. LabMaster features a complete statistics package for power and energy analysis, including minimum, maximum,

median, standard deviation, two sigma, trending, histogram and RMS noise.

SmartSensors are pre-programmed with linearity, wavelength and sensitivity factors during factory calibration so that they can be interchanged quickly and easily. Any two power or energy SmartSensors can be used at the same time with the two channel Ultima LabMaster. The readings of the two sensors can be displayed together, separately, added, subtracted or as a ratio. The position of the beam on the sensor can be displayed (thermal sensors only) and alarms can be set to monitor the power/energy and beam position. Signal offsets may be set to eliminate background signal or allow the monitoring of small fluctuations of a larger signal.

Ultima LabMaster is CE certified and has been developed with low EMI noise sensitivity for use in real laser environments. The unit is built in Coherent's ISO 9002 certified plant in the United States and is supplied complete with NIST-traceable Certificate of Calibration, internal rechargeable

battery pack (4 hours operation), AC power adapter and user manual.

High Visibility Interactive Display

LabMaster has a high speed, high contrast 256 x 128 pixel liquid crystal display. The large (124 mm x 64 mm) display has been optimized for wide-angle viewing and observation at a distance across a laboratory. There is software control of screen backlighting, contrast and normal/reverse display. There is a straightforward menu and soft-button system of controls. Most screens contain information in digital form, but strip charts are available and some screens feature bar-graph displays for convenient real-time feedback for laser tuning.





2-channel Home Screen

This shows the Ultima LabMaster home screen display for two-channel operation using a combination of a CW and a pulsed sensor. Most of information is in digital form, but analog bar-graphs are available for fast real-time feedback for laser tuning and the “bullseye” target shows the location of the laser beam on the thermal CW detector.



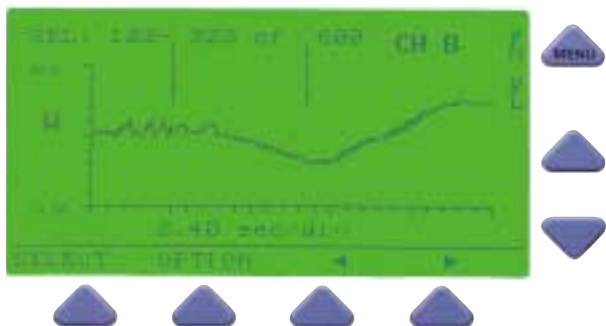
Ratios and Differences

Not only can Ultima LabMaster display the energy or power from two separate detectors, it can also calculate and display the difference (CH A - CH B) and the ratio CH A/B. Note the analog bar for tuning in the top left of the screen.



Statistical Analyses

Ultima LabMaster's statistical package eliminates the need for a separate computer to calculate statistical information such as minimum and maximum values, standard deviation and two sigma variance. The analyses are available for both energy and power measurements and the frequency of pulsed sources can be monitored.



Strip Chart “Trend” Displays

The change of power and energy values with time can be conveniently displayed in strip chart form and logged to memory or a printer. Data from either or both of two channels may be displayed and a zoom control used to magnify the data from selected time intervals.

Datalogging and External Control



The standard interface for Ultima LabMaster is the display screen, but on some occasions it is desirable to record the data internally or externally, or control the operation of the machine via an RS-232 or IEEE-488.2 interface. This section explains the interfaces and capabilities available.

Any screen can be accurately reproduced by a **printer** (Epson, HP Deskjet, HP Laserjet or IBM ProPrinter) connected to the printer port by selecting the **print screen** command.

The **Auxiliary I/O** socket provides eight 0-5 V TTL-compatible outputs which can be set as alarms for any chosen high- or low-level for two channels of positional (with position-measuring thermal sensors only) and two channels of power/energy information.

This socket also provides two standard 0-1 V (5 Hz) bandwidth analog outputs for the power/energy reading in each channel and two 0-1 V fast analog outputs which provide outputs with 50 kHz bandwidth (less on the most sensitive ranges) for the power when semiconductor sensors are in use.

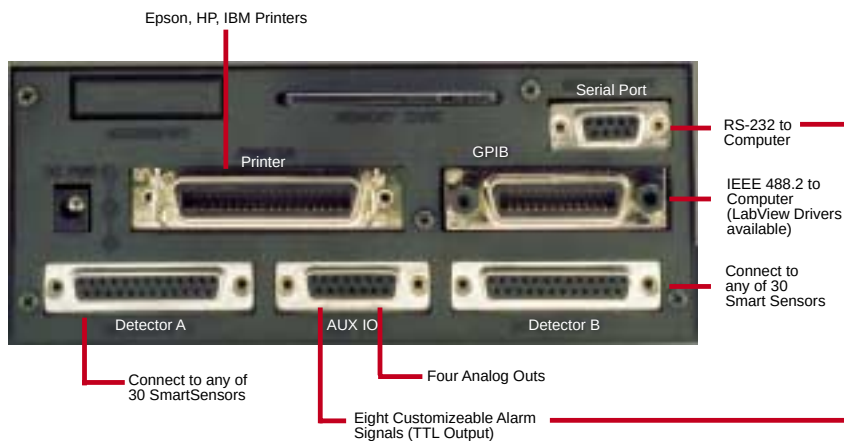
Two-thousand points (interpoint time selectable from 0.1 sec to 30 min) of power, energy, position and frequency information can be recorded internally by selecting the **trend** command. The same information can be sent to a printer via the printer port, using the **print trend data** command. Longer periods of power/energy data can be collected by the **Ultima Connection** (Ultima/Windows connection kit, 33-0670) which includes a 3 m cable, adapters, manual and Windows software with Visual Basic source code for the RS-232 interface. Alternatively, more extensive standard software can be used with the **RS-232** (300-9600 baud) or **IEEE-488.2** ports to establish the Ultima LabMaster set-up conditions, control the data acquisition and transfer the data to a PC computer.

SmartSensors™ for LabMaster

Setting up LabMaster with any of over 30 SmartSensors is quick and completely automatic. Simply plug the SmartSensor cable into the LabMaster display console, select the **channel setup** screen and enter the wavelength and the value of the attenuation factor of any filter in use with that sensor. LabMaster does the rest. The SmartSensor technology automatically loads the ID of the chosen sensor, the wavelength correction, linearity with power, temperature linearity and sensitivity data, and range and alarm parameters. System accuracy is the sum of the readout accuracy (1%) and the % accuracy of the chosen SmartSensor.



See the **SmartSensors™** section (page 16) for the range of sensors available.

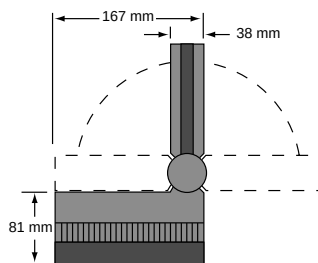
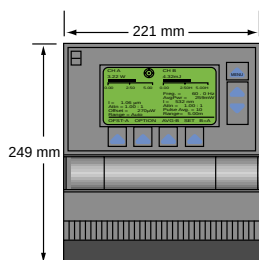


ALARMS - ON			
CH A		CH B	
1. H 1.23E-05 W		1. P 0.12E-02 M	
2. H 0.05E-05 W		2. P 0.21E-02 M	
*3. L 0.17E-06 W		3. N	
4. P 0.02E-03 M		4. N	
SET UP - CHANNEL A			
SET UP - CHANNEL B			
DONE	RESET	SET UP	OFF



Power/Energy Histograms

Power and energy data which has been collected to display as a strip chart, can for statistical analysis be displayed in histogram form.



Beam Position and Alignment

With Coherent thermal SmartSensors™, Ultima LabMaster can display information about the position of the incident beam on the sensor disk. This information allows the user to safely and precisely align the sensor head and the beam being measured. This is particularly useful for non-visible beams. Usually a simple "bullseye" representation is displayed, but exact information about the centroid of the beam position and the beam size can be displayed (as here). This information can also be displayed in strip chart form, for one or two sensors.

Typical SmartSensors™ available, see following page.



Specifications

Display Type: High speed, high contrast liquid crystal display. Wide viewing angle, 256 x 128 pixels.

Display Options: Software control of contrast, normal or reverse display and screen backlighting.

Update Rate: <1 second

Display Accuracy: $\pm 1\% \pm 2$ LSD (Must be added to detector accuracy for total system accuracy.)

Interfaces: RS-232 (300, 1200, 4800, 9600 baud), GPIB (IEEE-488.2)*

Analog Out*: 0-1 V, $\pm 2\%$

Computer Correct: 5 Hz

Full Bandwidth: 50 kHz (optional, for Semiconductor detectors only)

Printer*: Parallel, compatible with Epson, IBM ProPrinter, HP inkjet printers.

Auxiliary Out (alarm signals): 0-5 V, TTL compatible

Pulse Sensor (maximum pulse capture rate):

500 Hz dual channel,

1 kHz single channel

Semiconductor Sensor*

RMS Noise Measurement:

5% accuracy, 20 Hz-50 kHz bandwidth with a crest factor of 6.

Selectable reading averaging:

10 Hz or 100 Hz

Trend: 2000 points per channel Pulse or Time acquisition modes.

Real Time Statistics: 10 Hz acquisition for CW detectors. Up to 500 Hz acquisition for pulse dual channel. Up to 1 kHz acquisition for pulse single channel.

Power Requirements

AC Operation: 100-240 VAC, 50/60 Hz

DC Operation: 9 VDC, 1 A

* Note: Features not available with single channel LabMaster Ultima without the Performance Package.

Ultima LabMaster



Catalog Number	Description	Channels	Analog Output	Computer Connections
33-0647	Ultima LabMaster 1 Channel*	1	Standard	RS-232
33-0621	Ultima LabMaster 1 Channel Enhanced*	1	Standard & Fast	RS-232, Printer, IEEE-488
33-0613	Ultima LabMaster 2 Channel Enhanced*	2	Standard & Fast	RS-232, Printer, IEEE-488
33-0670	Ultima/Windows Connection Kit See "Datalogging and External Control," page 14			
33-0704	Soft case for Ultima LabMaster See Accessories section, page 27			
33-0712	Small hard case for Ultima LabMaster See Accessories section, page 27			
33-0720	Large hard case for Ultima LabMaster See Accessories section, page 27			

* Supplied with internal battery, AC adaptor, user manual, certificate of calibration and one year warranty.

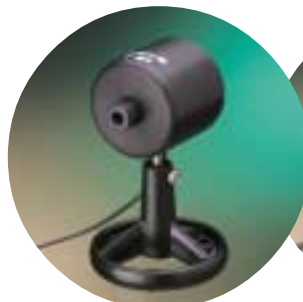
ISO 9002 Certified



SmartSensors™

For Use with FieldMaster™, FieldMaster-GS™ and Ultima LabMaster™

- Sensors for power and average power measurements
- Sensors for single pulse and repetitive pulse energy
- Sensors for RMS noise and beam position measurements



LM-1



LM-45 HTD



LM-10 HTD

SmartSensors™ are laser power and energy sensors that have been developed for quick and convenient use with the FieldMaster, FieldMaster-GS and Ultima LabMaster measurement system readouts. The SmartSensors are factory programmed with NIST traceable calibration, an identification key, detector responsivity, variation of sensitivity with wavelength, linearity with power, temperature sensitivity and transient data. The data is stored in a flash memory inside the connector and automatically downloaded into the readout whenever the system is initialized. The readout then uses this information and the signals provided from the sensor to deliver accurate readings.

This special calibration and stored data allow you to interchange sensors and readouts. When the Ultima LabMaster or FieldMaster detect a new sensor, data is exchanged from the smart connector to the readout. Then, within seconds, the readout is programmed with all of the information that it needs to deliver accurate readings to you.

Three types of sensor technology – thermal, semiconductor and pyroelectric – are used for the range of SmartSensors. These technologies are explained in the adjacent sidebar.

Sensor Technology

No one sensor type can measure all laser types. Instead, three types of sensor technologies are used based on the sensor material:



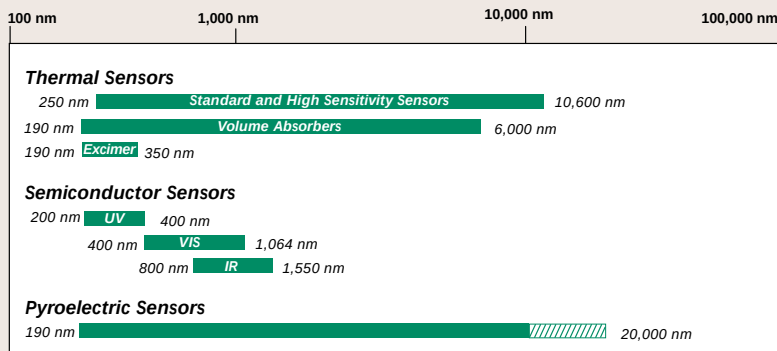
Thermal sensors measure the flow of energy through an array of thermoelectric cells. They are rugged and best for measuring medium and high power (CW) lasers. These sensors have an intrinsically flat spectral absorption from the UV to the far infrared, but there are some variations of surface reflection from the sensor, so each sensor is NIST traceably calibrated.

Thus, accuracies of $\pm 2\%$ from 190 nm to 10.6 μm can be achieved. Typically, these sensors have a response time of 1-10 seconds, which is increased to 0.5-2 seconds when matched with a Coherent readout console.

Semiconductor sensors are very sensitive detectors for the spectral regions 250 nm to 1.065 μm (silicon sensors) and 800 nm to 1.8 μm (germanium sensors). Semiconductor sensors are relatively rugged, but unfortunately their sensitivity changes greatly with wavelength, so they must be combined with an appropriate readout console to achieve calibrated and accurate results ($\pm 5\%$). The semiconductor material typically saturates in the 10-50 mW range, so for linear operation up to a maximum of ~5 Watts, a calibrated optical attenuator should be used. Such attenuators are also available from Coherent (see page 26).

Pyroelectric sensors are used only to measure pulsed lasers. They do not respond to a CW optical input (unless it is chopped). Coherent offers pyroelectric sensors which measure single shot laser energies and pulsed lasers from 1-400 Hz.

Wavelength Ranges of SmartSensors™



Selecting a SmartSensor™

- 1 Select the appropriate technology for your type of laser output from the table below.

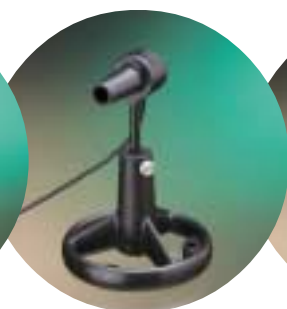
Measurement Requirement	Measurement Range	Sensor Type	Notes
CW Laser Power	1 mW to 5 kW 10 nW to 5 W	Thermal Semiconductor	
Average Power of Pulse Train >10 Hz >30 Hz 1-400 Hz	1 mW to 5 kW 10 nW to 5 W 1 μ W to 10 W	Thermal Semiconductor Pyroelectric	Ultima LabMaster only Ultima LabMaster and FieldMaster-GS
Single Shot Pulse Energy	0.15 mJ-50 J 100 μ J-20 J	Thermal Pyroelectric	Ultima LabMaster and FieldMaster-GS 0.5 mJ minimum on FieldMaster
Pulse Train Pulse Energy 1-400 Hz Pulse Repetition Rate 1-400 Hz with max 10 Hz sampling 1-50 Hz with max 0.3 Hz sampling	100 μ J-20 J 100 μ J-20 J 0.5 mJ-20 J	Pyroelectric Pyroelectric Pyroelectric	Ultima LabMaster only FieldMaster-GS FieldMaster
Beam Position	See Below	Thermal	Ultima LabMaster and FieldMaster-GS
RMS Noise	See Below	Semiconductor	Ultima LabMaster only

- 2 Determine the specific individual sensor from the selection charts on the following pages. These charts include details of other parameters essential to a correct choice, such as the power/energy range, the appropriate wavelength and the sensor aperture size.

- 3 Check the high power/energy operation section for operational damage limits.



LM-P10



LM-2



LM-P-209

RMS Noise

When using Semiconductor SmartSensors, Ultima LabMaster can be used as a sensitive noisemeter. LabMaster measures noise from 10 Hz to 50 kHz. Average power is measured and divided into measured RMS power to calculate and display the noise as % RMS.

Beam Position and Alignment

The full range of Thermal SmartSensors (with the exception of catalog number 33-0928 and 33-7956) can be used with Ultima LabMaster and FieldMaster-GS to display information about



the position of the incident beam on the sensor disk. This allows the user to safely and precisely align the sensor head and the beam being measured. This is particularly useful for non-visible beams. See the Ultima LabMaster and FieldMaster-GS sections for further details.

Thermal SmartSensors

See pages 20-21 for sensor dimensions.

Catalog Number	Name	Power			Aperture (mm)	Notes	Spectral Range (μm)	Accuracy (± %)	For Single Shot Use with Ultima and FieldMaster-GS			Sensor Coating (note m)
		Max (W)	Min (W) (note f)	Resolution (W)					Max Pulse Length (s)	Max Joules	Min Joules	

Standard Thermal Sensors: 6000 W/cm² maximum CW power density (see page 22 for details)

33-7832	LM-200XL HTD	200	1.0	0.1	55	c	0.25-10.6	4	0.34	95	0.50	HTD
33-7857	LM-200 HTD	200	0.2, 0.1	0.01	19	k	0.25-10.6	5	0.12	10	0.07	HTD
33-7840	LM-200 HTD	200	0.2, 0.1	0.01	19	t	0.25-10.6	5	0.12	10	0.07	HTD
33-7865	LM-200B HTD	200	0.2, 0.1	0.01	19	c, w	0.25-10.6	5	0.12	10	0.1	HTD
33-7873	LM-150 FS HTD	150	0.1	0.01	19	r	0.25-10.6	5	0.12	10	0.07	HTD
33-7881	LM-100XL HTD	100	1.0	0.1	40		0.25-10.6	4	0.34	50	0.50	HTD
33-7899	LM-100 HTD	100	0.1	0.01	19		0.25-10.6	2	0.12	10	0.07	HTD
33-0472	LM-100B HTD	100	0.1	0.01	38	c, w	0.25-10.6	4	0.34	50	0.1	HTD
33-7915	LM-45 HTD	45	0.1	0.01	19		0.25-10.6	2	0.12	10	0.07	HTD
33-7923	LM-10 HTD	10	0.01	0.001	16		0.25-10.6	2	0.11	10	0.05	HTD
33-7931	LM-3 HTD	3	0.01	0.001	19		0.25-10.6	2	0.11	10	0.05	HTD

High Power Thermal Sensors: 2500 W/cm² maximum CW power density (see page 22 for details)

33-1132	LM-5000	5000	300	1.0	55	a, e, g	0.25-10.6	5	0.34	95	1.0	H
33-1124	LM-2500	2500	150	1.0	55	a, e, g	0.25-10.6	5	0.34	95	1.0	H
33-1116	LM-1000	1000	2.0, 1.0	0.1, 1.0	38	b, g	0.25-10.6	5	0.18	45	0.25	H

Volume Absorbers for High Peak Power: 1 GW/cm² at 10 ns maximum peak power density (see page 22 for details)

33-1017	LM-80V	80	0.5, 0.1	0.01	38	h	0.19-6.0	4	0.4	45	0.25	V
33-0993	LM-30V	30	0.1	0.01	19	h	0.19-6.0	3.5	0.17	10	0.07	V

Excimer Special Coated Sensors: 2000 W/cm² maximum power density (see page 22 for details)

33-1108	LM-200XLE	200	1.0	0.1	55	c	0.19-0.35	4	0.24	45	0.50	UV
33-1033	LM-100E	100	0.5, 0.1	0.01	40		0.19-0.35	5	0.34	50	0.25	UV
33-4508	LM-100EB	100	0.5, 0.1	0.01	38	c, w	0.19-0.35	5	0.34	50	0.25	UV

High Sensitivity Thermal Sensors: 400 W/cm² maximum power density (see page 22 for details)

33-0928	LM-1	1.0	0.015	0.0001	9		0.25-2.5	5	0.11	1.0	0.15 mJ	P
33-7956	LM-1 IR	1.0	0.015	0.0001	9		1.0-10.6	5	0.11	1.0	0.15 mJ	P

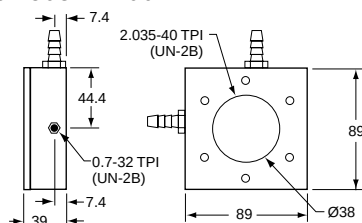
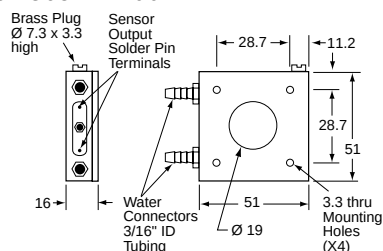
Special Purpose Sensors: 2500 W/cm² maximum CW power density (see page 22 for details)

33-1215	Beam Finder	1000	2.0	0.1	35	b, d, e	0.3-10.6	5	0.6	45	0.25	H
33-7907	LM-20 HTD	20	0.1	0.01	19	p	0.25-10.6	2	0.12	10	0.07	HTD

All SmartSensors are supplied with a 1.8 m (6 ft) cable (unless otherwise noted), stand and NIST traceable Calibration Certificate.

- (a) 7.5 liter/min cooling water required. Maximum temperature deviation 3%/min. Maximum flow deviation 2%/min.
- (b) 4 liter/min cooling water required. Maximum temperature deviation 3%/min. Maximum flow deviation 2%/min.
- (c) 1 liter/min cooling water required. Maximum temperature deviation 3%/min. Maximum flow deviation 2%/min.
- (d) Designed for system integration for measurement of power and position, for use on the Ultima only (supplied with 6 m [20 ft] cable and cooling hoses).
- (e) Supplied with 6 m (20 ft) cable.
- (f) Value to the left is for Ultima LabMaster and FieldMaster-GS, value to the right is for FieldMaster.
- (g) Single shot pulse readings only available on Ultima LabMaster.
- (h) Damage limit: Pulse 1 GW/cm², measured at 1.06 μm, (10 ns pulse). Varies with wavelength, derate by 50% 0.26-0.35 μm, by 90% below 0.26 μm, Maximum Average Power Density 30 W/cm².
- (k) Must be used with 110 VAC power for internal fan cooling for powers above 50 Watts.
- (m) See coating specifications and maximum power density limits on page 22.
- (p) Designed for system integration, must be mounted to a heat sink.
- (r) Intermittent duty (2 min @ 150 W; 5 min @ 100 W; 20 min @ 40 W). See page 24 for further details.
- (t) Must be used with 220 VAC power for internal fan cooling for powers above 50 Watts.
- (w) See sensor drawings at top of next page. These sensors require water cooling to operate at the maximum specified power ratings. They can also be operated using convection and conduction cooling methods. See details on cooling methods and associated power ratings in the OEM sensor section, pages 28-31.

ISO 9002 Certified

33-0472 LM100B HTD**33-4508 LM100EB****33-7865 LM-200B HTD**

All dimensions shown in mm unless otherwise indicated.

**Semiconductor SmartSensors**

See pages 20-21 for sensor dimensions.

Catalog Number	Name	Power			Aperture (mm)	Spectral Range (μm)	Accuracy (±%) (note f)	Maximum Power Density (W/cm²)	Max Power with Attenuator (W)
		Max (mW)	Min (μW)	Resolution (nW)					
33-0951	LM-2 UV	30	0.01	1.00	6.0	0.25-0.4	8, 5	0.3	NA
33-0936	LM-2 VIS	50	0.01	1.00	7.9	0.4-1.064	5, 3	1.0	5.0
33-0944	LM-2 IR	10	0.5 z	1.00	5.0	0.8-1.55	4.5, 2	0.5	5.0

All SmartSensors are supplied with a 1.8 m (6 ft) cable, stand and NIST traceable Calibration Certificate.

(f) Value to the left is for Ultima LabMaster and FieldMaster-GS, value to the right is for FieldMaster.

(z) 1 μW for FieldMaster.

Pyroelectric SmartSensors

See pages 20-21 for sensor dimensions.

Catalog Number	Name	Energy			Power		Aperture (mm)	Spectral Range (μm)	Accuracy (±%)	Notes	Maximum Pulse Width (ms)	Maximum Repetition Rate (Hz)
		Max	Min (note v)	Resolution	Average Power Max	Min						

High Sensitivity

33-1140	LM-P-209	3 mJ	1.0 μJ	0.1 μJ	2 W	100 μW	9.0	0.19-10.6	5	y	0.10	200
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Large Aperture

33-1173	LM-P10i	10 J	0.5 mJ	10 μJ	10 W	0.5 mW	43.2	0.19-10.6	5 q	e, x	1.00	50
33-1165	LM-P10	20 J	0.7 mJ	10 μJ	10 W	0.7 mW	50.8	0.19-20	5 q	x	2.30	10
33-1199	LM-P10LP	20 J	0.7 mJ	10 μJ	10 W	0.7 mW	50.8	0.19-20	5 q	x	2.30	10

Standard Aperture

33-1157	LM-P5	5 J	0.5 mJ	10 μJ	5 W	0.5 mW	25.4	0.19-20	5 q	x	0.60	40
33-1181	LM-P5LP	5 J	0.5 mJ	10 μJ	5 W	0.5 mW	25.4	0.19-20	5 q	x	0.60	40
33-1207	LM-P5HR	5 J	0.5 mJ	10 μJ	5 W	0.5 mW	25.4	0.19-20	5 q	y, #	0.04	400

All Pyroelectric SmartSensors are supplied with a 1.8 m (6 ft) cable, stand, damage test slide and NIST traceable Calibration Certificate.

(q) ±7% from 0.19-0.30 μm.

(v) 10x Amp available, (catalog number 33-0480), please call for details.

(y) For use with the Ultima LabMaster and FieldMaster-GS only.

(#) No test slide supplied.

(e) Max of 1 Joule for FieldMaster.

(x) Max pulse width is 0.3 ms for FieldMaster.

Further information on SmartSensor™ specifications can be found at <http://catalog.CoherentInc.com> or by calling your local Coherent sales representative.

Sensor Dimensioned Drawings

33-1132 LM-5000 33-1124 LM-2500 33-7832 LM-200XL HTD 33-1108 LM-200XLE	33-1116 LM-1000	33-7857 LM-200 HTD (110 VAC) 33-7840 LM-200 HTD (220 VAC)
33-1033 LM-100E 33-7881 LM-100XL HTD 33-1017* LM-80V	33-7873 LM-150FS HTD 33-0217 LaserMate 150	33-7899 LM-100 HTD 33-0209 LaserMate 100
33-7907 LM-20 HTD 33-0183 LaserMate 20	33-7915* LM-45 HTD 33-0993 LM-30V 33-0191 LaserMate 30	33-1215 Beamfinder

All dimensions in mm unless indicated otherwise.

33-7923 LM-10 HTD 33-0175 LaserMate 10	33-7931* LM-3 HTD 33-0167 LaserMate 3	33-0928 LM-1 33-7956 LM-1 IR 33-0159 LaserMate 1
33-0951 UV 33-0936 VIS 33-0944 IR 33-0233 33-0241 33-0258	33-1140 LM-P-209	33-1181 LM-P5LP
33-1165* LM-P10 33-1157 LM-P5 33-1207 LM-P5HR	33-1199 LM-P10LP	33-1173 LM-P10i 33-0225 LaserMate P

All dimensions in mm unless indicated otherwise.

Sensor Damage Avoidance and Cooling

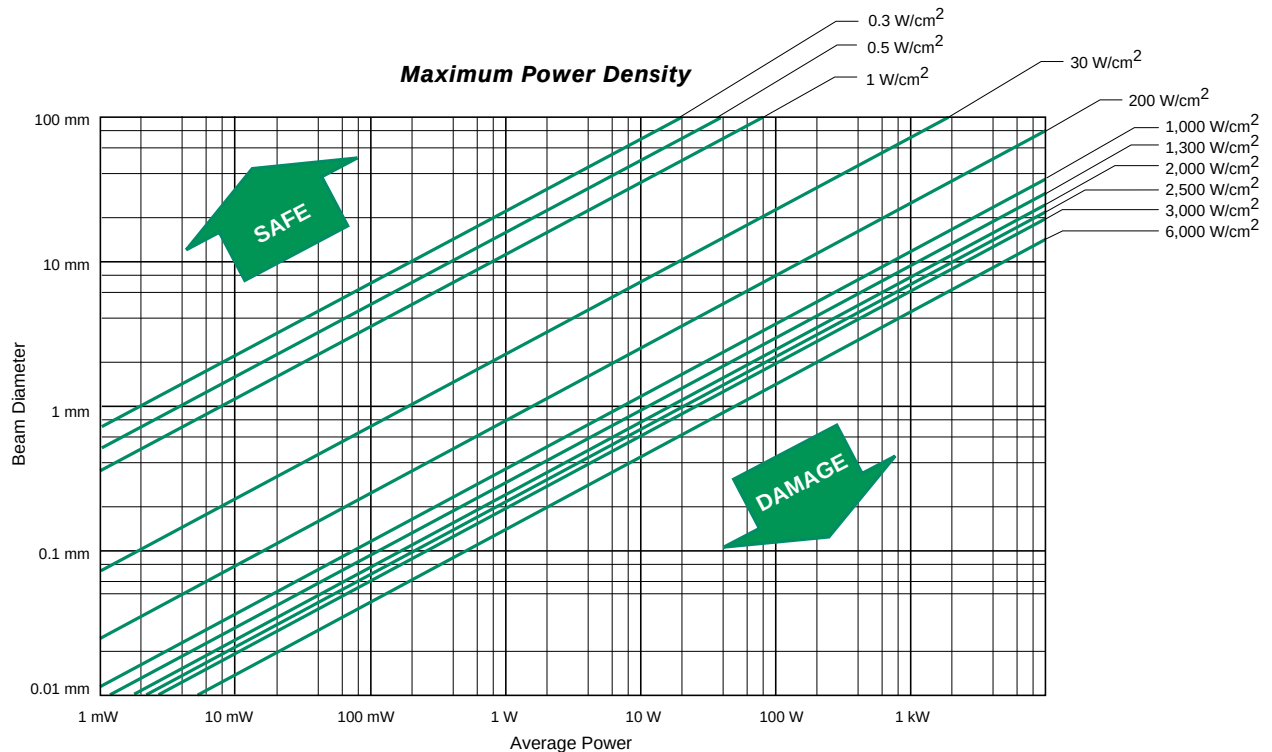
High Power/Energy Operation and Avoidance of Sensor Damage

The various sensors are each designed to operate over a specified range of powers or energies. It is normally safe to operate up to the maximum value of the specified measurement range, but each sensor type has additional limits, expressed as the

maximum value for the power density (Watts/cm²) or energy density (Joules/cm²) at the sensor surface. The following details describe these limits for the different sensor types.



LM-10 HTD



Variation of beam diameter and power for average power densities of thermal and semiconductor sensors. Safe operating limit above damage threshold lines.

Coherent Thermal Sensor Coatings

See page 18 to determine the coating used on a specific sensor.

		HTD	H	UV	P	V
Maximum CW Power Density^a						
Uniform distribution at 10 Watts	(W/cm ²)	6000 ^d	2500	2000	400	30
TEM ₀₀ distribution over 1/e ² area at 10 Watts	(W/cm ²)	3000 ^d	1300	1000	200	15
Maximum Energy Density						
	(J/cm ²)	1.75	1.1	0.5	3.3	10
Maximum Peak Power Density (Single Shot)						
1064 nm 20 ns FWHM	(MW/cm ²)	87 ^c	43 ^e	–	–	1000 ^a
Wavelength Range						
	(nm)	200-11,000	200-11,000	200-350	200-20,000	190-6000

(a) Measured with 10 ns FWHM pulse width derate by 50% at 351 and 90% <260 nm.

(b) Measured per ISO 1012 single shot.

(c) 37 MW/cm² at 20 Hz.

(d) Derate by 80% at 3500 Watts.

(e) Derate by 45% at 532 nm.

Thermal Sensors

To avoid damage to the sensor surface keep the average CW power density below the maximum power density limit specified for that sensor. This limit is dependent on the absorptive surface coating used on that sensor. The sensor selection chart on page 18 shows the surface coating type for each thermal sensor and the chart on the bottom of page 22 shows the maximum CW power density limit. Use the appropriate line on the graph on page 22 to translate the power density limit (W/cm^2) to a power limit (W) and the beam diameter for your laser. If you might exceed the limit, use a beam splitter or beam expander. If the thermal sensor is to be used for pulsed measurements, then keep the energy in any pulse below the limit shown in the sensor coating chart on page 22 and the peak power density below $43 \text{ MW}/\text{cm}^2$ (measured with a 20 ns $1.064 \mu\text{m}$ pulse). This peak power density varies with wavelength, derate it by 44% for 532 nm . If the peak power density might exceed this limit, then use one of the Volume Thermal Absorbers (see page 24). Note that the high sensitivity LM-1 thermal sensors (33-0928 and 33-7956) have a

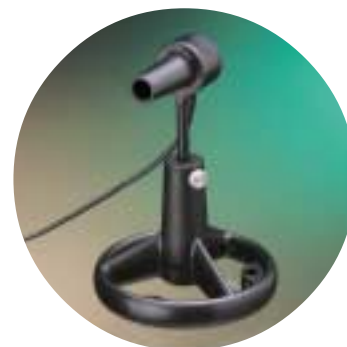
peak energy density rating, not a peak power density rating. This limit is the same as that for the pyroelectric sensors (see graph below).

Semiconductor Sensors

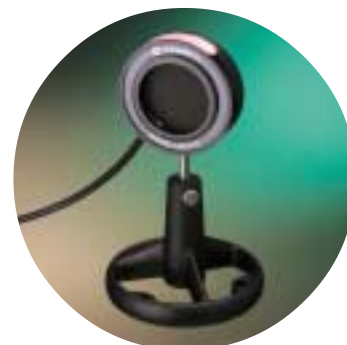
To avoid damage to the sensor surface, keep the CW power density below the maximum power density shown in the semiconductor sensor selection chart on page 19 and on the graph located on page 22. Use the appropriate line on the graph to translate the power density limit (W/cm^2) to a power limit (W) for your beam diameter. If you might exceed the limit, use a beam expander, beam splitter or attenuator.

Pyroelectric Sensors

To avoid damage to these sensors, only operate them with pulsed radiation and keep below the maximum average power limit as shown in the selection chart (on page 19). Also keep the energy density below the limit shown in the graph below. If your energy density might exceed the limit, use an attenuator or beamsplitter, as shown on page 25. A sensor damage test slide is also available (see page 27).



LM-2 UV

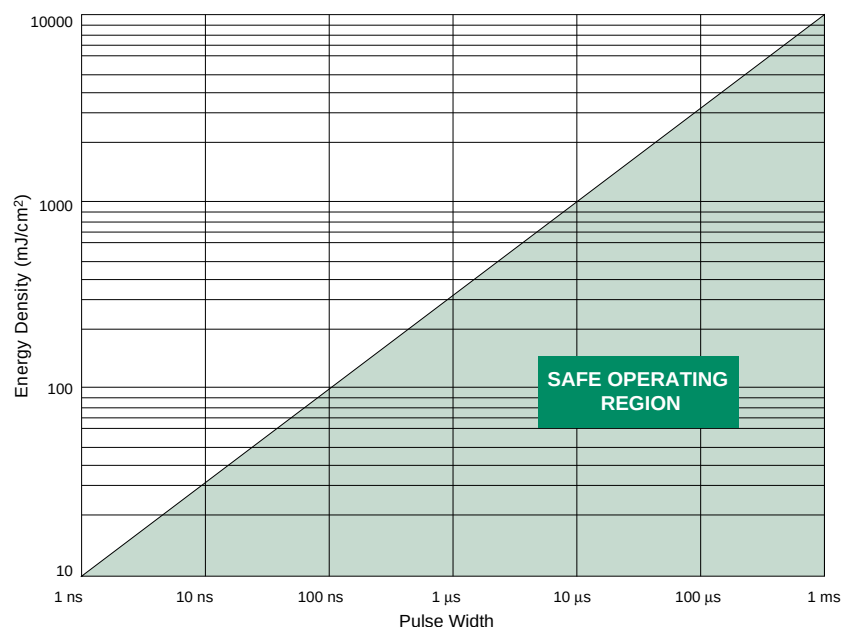


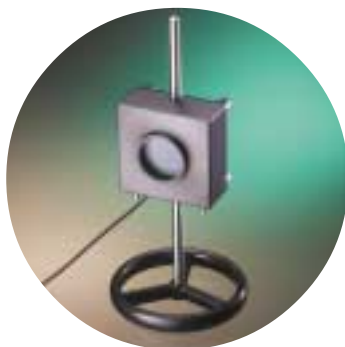
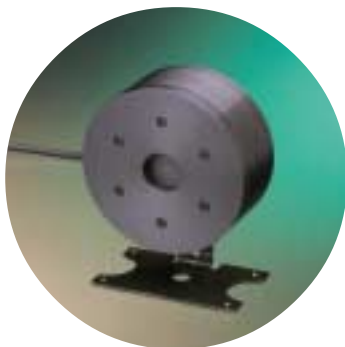
LMP-10i

Thermal Sensor Glow

When operated close to their maximum power range, some thermal sensors may glow red hot from the absorbed laser radiation. This is normal, and the point that the sensors will "glow" is dependant on the sensor coating type (see the chart on bottom of page 22). The HTD coated sensors will glow well before they reach the damage threshold and can be operated in the "glowing mode" continuously. The H coated sensors will lightly glow within about 20% of its damage threshold and can be operated this way continuously. The UV and P coated sensors can glow within 5% of their damage thresholds and glowing should be a warning sign that damage is about to occur.

Energy Density Damage Thresholds for Pyroelectric Sensors



**LM-80V****LM-5000****LM-200 HTD****LM-150 FS HTD**

Volume Thermal Absorbers

If the peak power density of your laser exceeds the limit for the standard thermal sensors (43 MW/cm^2), then the volume absorbers (see selection chart on page 18) may be the solution. These have a few-mm thick disk of absorbing glass attached to the sensor surface and a peak power density rating of 1 GW/cm^2 (measured with a 10 ns, $1.064 \mu\text{m}$ pulse). This peak power density limit varies with wavelength, derate it by 50% below $0.35 \mu\text{m}$ and 90% below $0.26 \mu\text{m}$. The sensors are supplied with all three absorbing disks. There is a diffuser kit (33-1249) for the 33-0993 LM-30V SmartSensor™ that will increase the rating to 10 GW/cm^2 at 1064 nm .

The glass disks can be damaged by irregular and non-circular beams, so the user can replace the glass with the aid of a convenient disk replacement kit.

Volume Absorber Disk Replacement Kits

Catalog Number	Description
33-1462	Disk Replacement Kit for 33-0993 LM-30V (UV $0.19\text{-}0.35 \mu\text{m}$)
33-1470	Disk Replacement Kit for 33-0993 LM-30V (VIS $0.35\text{-}1.1 \mu\text{m}$)
33-1488	Disk Replacement Kit for 33-0993 LM-30V (IR $1.0\text{-}6.0 \mu\text{m}$)
33-1249	Diffuser Kit for 33-0993 LM-30V
33-1496	Disk Replacement Kit for 33-1017 LM-80V (UV $0.19\text{-}0.35 \mu\text{m}$)
33-1504	Disk Replacement Kit for 33-1017 LM-80V (VIS $0.35\text{-}1.1 \mu\text{m}$)
33-1512	Disk Replacement Kit for 33-1017 LM-80V (IR $1.0\text{-}6.0 \mu\text{m}$)

Cooling Thermal Sensors

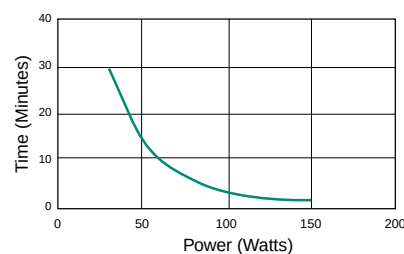
Most of the thermal sensor heads are adequately cooled by naturally convected air for continuous operation, but some of the higher power thermal sensors require water cooling (5 kW LM-5000, 33-1132; 2.5 kW LM-2500, 33-1124; 1 kW LM-1000, 33-1116; and 200 W LM-200XL HTD, 33-7832). See notes on page 18 on water flow requirements for these sensors.

Two thermal sensors (LM-200 HTD) have fan cooling (200 W, 33-7857 for 110 VAC and 200 W, 33-7840 for 220 VAC).

The compact portable limited duration test head 33-7873 LM-150 FS HTD can be used at the full 150 W rating for only ~2 minutes (100 W ~5 minutes, 40 W ~20 minutes). See the chart at right for other durations.

The compact Special Purpose Thermal Sensors 33-1215 (1 kW) and 33-7907 (20 W) have been designed for system integration, the 33-1215 requires water cooling and the 33-7907 must be attached to a heat sink.

**LM-150 FS HTD
Power vs Duration**





Accessories for Power and Energy Meters

Attenuators for Pyroelectric Sensors

These 5:1 (uncalibrated) attenuators are excellent accessories for pyroelectric sensors. There is a standard attenuator available in both 25 mm and 50 mm apertures and a special 50 mm attenuator for excimer laser operation.

The standard attenuator is a sandwiched alumina and UV-grade frosted silica diffuser with an attenuation of approximately 5:1 from 0.35-2.5 μm . These attenuators simply replace the face plate by threading on the body of the 33-1157, 33-1207, 33-1165 sensors, but with the 33-1173 and 33-0225 an adapter ring is required. These attenuators are rated at 20 W maximum average power with a maximum energy density (for a 10 ns pulse) of 3.5 J/cm² at 1.06 μm (derated to 2.4 J/cm² at 0.532 μm and 0.54 J/cm² at 0.355 μm).

The 50 mm aperture excimer attenuator is a metal mesh screen and UV-grade frosted silica diffuser with an attenuation of approximately 5:1 from 0.19 to 3.0 μm . It can be used with pyroelectric sensors 33-0225, 33-1173, 33-1165, 33-1157 and 33-1207 by slipping over the body of the sensor and being held with a set screw. The excimer attenuator has a maximum energy density of 400 mJ/cm² at 0.266 μm (temporally insensitive) and can withstand 20 Watts of average power.



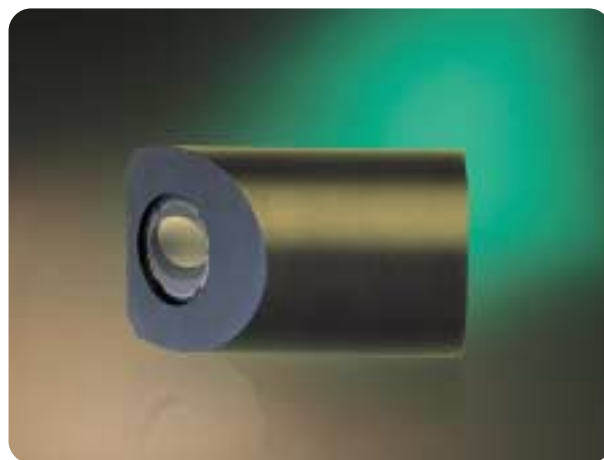
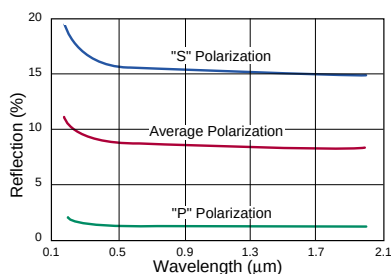
50 mm Attenuator

Attenuators for Pyroelectric Sensors

Catalog Number	Description
33-1306	25 mm Aperture Standard Attenuator
33-1314	50 mm Aperture Standard Attenuator
33-1322	Adapter for Sensors 33-1173 and 33-0225
33-1348	50 mm Excimer Attenuator

Beamsplitter for Pyroelectric Sensors

The beamsplitter for the 33-1140 LM-P-209 high sensitivity pyroelectric sensor is a laser-quality quartz pick-off optic held at a 45 degree angle to the sensor in a metal housing. The beamsplitter covers the range of 0.193 to 2.0 μm , and has a pick-off percentage of between 2 and 20% depending on wavelength and polarization (see chart). The beamsplitter has a 12 mm aperture and mounts to the sensor body by replacing the face ring.



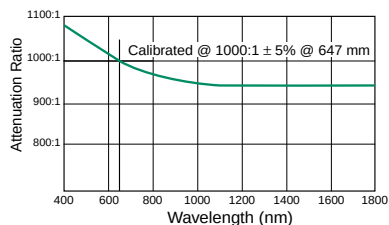
Beamsplitters for Pyroelectric Sensors

Catalog Number	Description
33-1405	Beamsplitter for High Sensitivity Sensor 33-1140

ISO 9002 Certified

1000:1 Attenuator for Semiconductor Sensors

This attenuator for the semiconductor sensors allows the visible and infrared sensors to be used at 5 Watts and 3 Watts respectively. The attenuator threads into the sensor in place of the light shield and provides from 1100:1 to 950:1 attenuation (please refer to graph). Each attenuator is calibrated for 1000:1 $\pm 5\%$ at 647 nm in our laboratory and supplied with a certificate of calibration. The useful spectral range of the attenuator is 400-1800 nm. The attenuator can be used with power densities as high as 100 MW/cm².



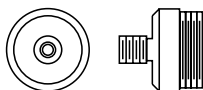
1000:1 Attenuator for Semiconductor Sensors

Catalog Number	Description
33-1298	1000:1 Attenuator for Semiconductor Sensors

Fiber Optic Connector Adapters

Fiber optic adapters are available for connecting common fiber terminations to the 3/4-32 threads around the entrance apertures of the semiconductor or 3, 10 and 150 Watt thermal sensors.

33-1413 SMA Connector



33-1421 DIN Connector



33-1439 FC/PC Connector



Fiber Optic Connector Adapters

Catalog Number	Description
33-1413	SMA Type Connector
33-1421	DIN 2106 Type Connector
33-1439	FC/PC Type Connector

ISO 9002 Certified

Carrying and Storage Cases

Two soft sided and two hard sided cases are available. The small soft case fits LaserMates (LaserMate, LaserMate-P, LaserMate-Q) and FieldMaster readouts, and the Ultima LabMaster soft case fits the Ultima LabMaster readout. The hard cases, with their custom cutout foam sections, can be used with any readout. The large hard case will hold a readout and two large sensors (100-5000 W) and one small sensor (less than 50 W size). The small hard case will hold any readout and two sensors of less than 50 W size.



Carrying and Storage Cases

Catalog Number	Description
33-0712	Small Hard Case
33-0720	Large Hard Case
33-0704	Ultima LabMaster Soft Case
33-0555	FieldMaster and LaserMate Soft Case

Pyroelectric Sensor Test Slides

For protection of your sensor when measuring unknown beams, the test slide is inserted into the beam and then examined for damage. These test slides are coated with the same matte black absorbing coating as the pyroelectric sensors. If coating damage is visible then attenuation is required before measuring the beam.



Pyroelectric Sensor Test Slides

Catalog Number	Description
33-1389	Pyroelectric Test Slides (package of three)

ISO 9002 Certified



OEM Laser Power Sensors

- Easy mounting
- Compact and reliable
- Interchangeable
- Replaceable sensors



The OEM sensors shown in this section represent a small selection of standard configurations. Coherent can custom design an OEM sensor solution to meet your specific requirements. Please call your local Coherent representative to discuss your application and needs.

Coherent offers a wide selection of OEM and custom Laser Power Sensors. These sensors are ideal for applications and laser systems requiring built-in power monitoring.

The OEM Laser Power and Energy Sensors are configured for mounting into an assembly that will provide support, and excess heat removal. There are three basic styles: the Serviceable

Blocks, the Monolithic Sensors and the Chassis Mountable Sensor Disks. Depending on the sensor, the output is via a BNC connector, a set of 0.9 mm pins or as a SmartSensor™ connection. Typically, the linear range of power or energy that can be sensed is 100:1, but is dependent on the mounting, heat sinking and environment. They are rated for natural convection, conduction and active water cooling where applicable.

Heat sinking

The mounting of the conduction cooled sensors must be to a structure that can absorb and dissipate the power that is incident on the sensor. This heat must be dissipated while maintaining a maximum of 100 degrees Centigrade temperature at the sensor. In a simplified analogy, the designer can consider the sensor as a heat source (such as a resistor) that cannot exceed 100 degrees Centigrade. If the steady state of the heat flow is changed either by an increase in heat being dumped into the heat sink by another device or by a intermittent cooling, then the readings may reflect this. Aluminum is the recommended mounting substrate for

all sensors. A general rule for thickness of mounting substrate is a minimum of 1/8" for up to 10 Watts, and a minimum of 1/4" for up to 200 Watts.

The water cooled sensors have a minimum required water flow per Watts of heat, and a maximum change in time of water flow and temperature. If the water flow or temperature varies more than the maximum allowed per minute, then the readings will reflect this as an increase or decrease in power.

Further information on OEM Sensor specifications can be found at <http://catalog.CoherentInc.com> or by calling your local Coherent sales representative.

Serviceable Blocks

- Replaceable sensors
- Adjustable outputs
- Interchangeable

Serviceable blocks are available in three power ranges from 10-200 Watts. The blocks are factory calibrated and supplied with NIST traceable calibration certification. These sensors are constructed in the same way as the standard Coherent thermal sensors, but packaged in a chassis mountable case. The sensitivity can be re-calibrated at our service centers or in situ within a 10% range.

General Specifications

Accuracy: $\pm 5\%$ for 8 mm beam centered on the sensor area

Certification: NIST traceable calibration certificate provided

Output impedance: 2.5 k Ohms max

Response time (to 90%): < 3 seconds

Maximum operating temp: 100 °C

Required water flow: 1 liter/minute (for water cooling)

Pressure drop at specified flow: 1.4 kg/cm² (20 psi)

Max water pressure: 100 psi

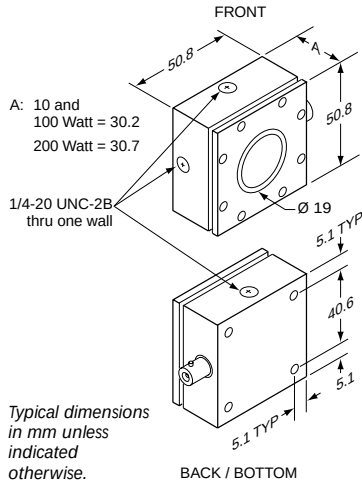
Max water flow deviation: 3%/min

Max water temp deviation: 2%/min

33-0407 10 Watt Sensor

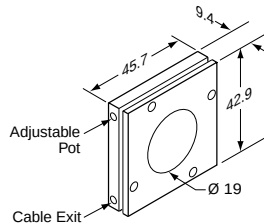
33-0415 100 Watt Sensor

33-0423 200 Watt Sensor



10, 100, 200 Watt Sensor

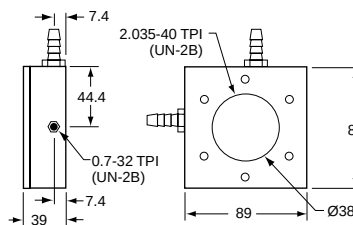
33-0456 10 Watt Thin Case Sensor



10 Watt Thin Case Sensor

33-0472* 100 Watt HTD Sensor

33-4508** 100 Watt Excimer Sensor



100 Watt HTD and Excimer Sensor

Serviceable Blocks

Catalog Number	Type	Power Handling per Cooling Method			Output (mV/W)	Weight (g)	Termination	Sensor Coating
		Convection (W)	Conduction (W)	Water (W)				
33-0407	10 Watt Sensor	3	10	10	1	168	BNC	HTD
33-0415	100 Watt Sensor	3	80	100	0.4	168	BNC	HTD
33-0423	200 Watt Sensor	3	80	200	0.4	168	BNC	HTD
33-0456	10 Watt Thin Case	2	10	—	1	112	Wire Cable	HTD
33-0472*	100 Watt HTD Sensor	15	100	80	—	645	SmartSensor™	HTD
33-4508**	100 Watt Excimer Sensor	15	100	80	—	645	SmartSensor™	UV

* Same as LM-100B HTD SmartSensor™, see page 18. ** Same as LM-100EB SmartSensor™, see page 18



Monolithic Sensors

- **Compact**
- **Easily Mounted**
- **Interchangeable**

Monolithic sensors are constructed so that the heat transfer structure and the sensor area are one continuous piece. This allows a more compact form for tighter environments. They are available in power ranges from 10-1000 Watts. All of the sensor outputs are terminated in 0.9 mm solderable pins except 33-7865 which is a SmartSensor™ version of 33-7964.

General Specifications

Accuracy: $\pm 3\%$ for beam centered on the sensor area.

Certification: NIST traceable calibration certificate provided.

Output impedance: 2.5 k Ohms typical

Maximum operating temp: 100 °C

Pressure drop at specified flow: 1.4 kg/cm² (20 psi)

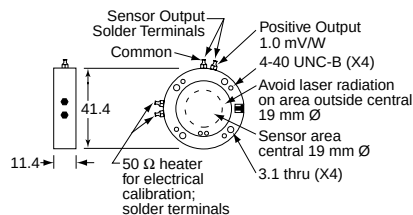
Max water pressure: 100 psi

Max water flow deviation: 3%/min

Max water temp deviation: 2%/min

33-1751/33-1769

10 Watt Monolithic Sensor



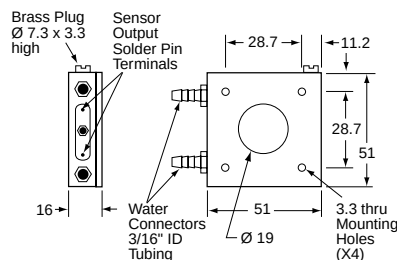
Typical dimensions in mm unless indicated otherwise.



10 Watt Monolithic Sensor

33-7964/33-7865*

200 Watt Water Cooled Sensor



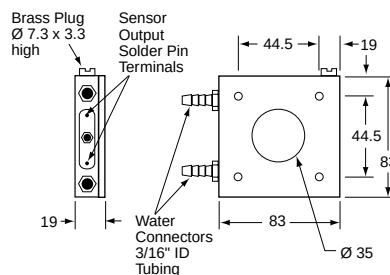
Typical dimensions shown in mm (dimensions will vary with sensor power capability).



200 Watt Water Cooled Sensor

33-0654

1000 Watt Water Cooled Sensor



Typical dimensions in mm unless indicated otherwise.

Monolithic Sensors

Catalog Number	Type	Power Handling per Cooling Method				Response Time	Impedance Typ (k Ohms)	Weight (g)	Termination	Sensor Coating
		Conduction (W)	Water (W)	Output (W)	Required Flow (liter/min)					
33-1751	10 Watt Sensor	10	—	1	—	3	2.5	15	Solder Pin	P
33-1769	10 Watt Self Cal	10	—	1	—	3	2.4	15	Solder Pin	P
33-7964	200 Watt Sensor	20	200	0.4	1	10	2.5	50	Solder Pin	HTD
33-7865*	200 Watt Sensor	20	200	—	1	2	—	50	SmartSensor™	HTD
33-0654	1000 Watt Sensor	200	1000	0.05	4	20	5	771	Solder Pin	H

* Same as LM-200B HTD SmartSensor™, see page 18.

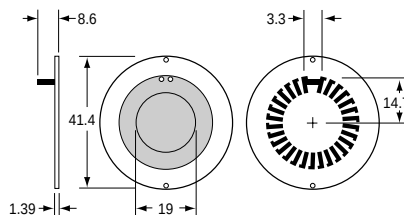


Chassis Mountable Sensor Disks

- **Most integratable**
- **Smallest Form Factor**

33-0779/33-7949

10 and 100 Watt Sensor Disks

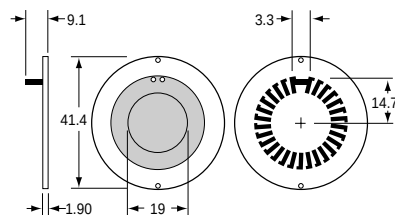


Typical dimensions shown in mm (dimensions will vary with sensor power capability)



10, 100 or 200 Watt OEM Sensor

33-1801 200 Watt Sensor Disk

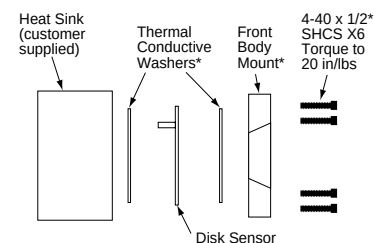


Typical dimensions shown in mm (dimensions will vary with sensor power capability)

Chassis Mountable Sensor Disks are provided for those OEMs that require the most compact installation. They are rated for a maximum power, but to realize that level, great care must be taken in correct mounting to an adequate heat sink. The mounting must be able to continuously extract the incident energy while maintaining less than 100 °C on the sensor edge. For further information and specifications, please call your local Coherent sales representative to discuss your system requirements. All of the sensors are terminated with 6 inches of 28 AWG kynar wire.

Mounting of

10/100/200 Watt Sensor Disks



* Installation Kit includes: two Thermal Conductive Washers, four 4-40 Screws and a Front Body Mount.

For the Chassis Mountable Sensor Disks, a mounting installation kit (33-1835) is available that includes two special heat sinking washers, a front body mount and four 4-40 machine screws. Full instructions and product information is available and can be faxed to you by calling your Coherent sales representative.

Chassis Mountable Sensors

Catalog Number	Type	Output Minimum (mV/Watt)	Impedance Typ (k Ohms)	Sensor Coating
33-0779	10 Watt Sensor Disk	0.4	2.5	HTD
33-7949	100 Watt Sensor Disk	0.4	2.5	HTD
33-1801	200 Watt Sensor Disk	0.4	3.5	HTD
33-1835	Sensor Disk Installation Kit*			



Service and Calibration

Coherent Auburn Division is committed to customer service. Our technicians are trained to handle calibration, repair, part requests and upgrades.

Laser power/energy meters normally degrade with time. Usage and environmental factors can have an adverse effect on accuracy and also results in wear and/or damage to parts critical to optimum performance. Maintaining a competitive edge in today's marketplace demands that capital equipment be maximized to reduce expenditures.

To maintain the accuracy and longevity of your laser power/energy meters, a regular schedule of calibration and preventative maintenance is required. Coherent, using the best equipment and personnel available, has been calibrating and repairing laser power/energy meters for over 30 years.

The Coherent Calibration Lab has a full spectrum of light sources from 193 nm to 10,600 nm, with powers ranging from nanowatts to kilowatts. By duplicating the actual environment of the user, Coherent can calibrate, verify or certify all laser power/energy meters.

Are you exceeding the power density of your detector head?

To preserve the accuracy and life of your sensor disk, it is important to know and operate within the power densities specified for each detector. Exceeding specified power densities physically wears sensor disks, changing spectral responses and power readings. See pages 22-24 for further details on power density limits.



ISO 9002 Certified and NIST Traceable

The Coherent Calibration Lab is ISO 9002 Certified and will calibrate or verify each device to the highest level of accuracies with traceability to National Institute of Standards and Technology (NIST) Laboratories in Boulder, Colorado and Gaithersburg, Maryland.

We provide certification

The Coherent Lab provides certification of calibration to ISO 10012-1, ANSI Z540-1 and MIL-STD 45662-A.

What about power meters not manufactured by Coherent?

The Coherent Lab can verify power and energy meters that are made by other manufacturers. Call for more information.

Calibrate once a year

To optimize performance and longevity, Coherent recommends that power/energy meters be calibrated at least once a year.

For Calibration:

United States Service: 530/888-5062
FAX: 530/889-5262
Japan Service: 813 5635 8680
FAX: 813 5635 8681
Germany Service: 49 6071 9680
FAX: 49 6071 968499

Please have ready:

- Model Number
- Serial Number
- Purchase Order Number

In the US ship to:

Coherent Auburn Group
Attn: **RMA Number***
2303 Lindbergh Street
Auburn, CA 95602-9595

*RMA stands for **Return Material Authorization**. This will be issued with a cost estimate when you call. Following this procedure will shorten the time you are without your instrument.

How long will it take?

Turn around time is normally six calendar days. A three day or 24 hour service is available for an additional charge.



Doing Business with Coherent



We accept orders online at <http://catalog.CoherentInc.com>, by phone, fax, e-mail or mail. When confirming an order which has already been placed, please indicate "confirming" on the order.

Prices indicated are current at the time of publication, but we reserve the right to change these without notice. Prices are FOB our warehouse and do not include freight, duty or any applicable taxes.

Export prices are 10% higher than those quoted domestically.

Terms of payment for domestic orders are cash with order, credit card, COD or Net30 with prior approval of credit.

Export terms are strictly letter of credit, cash in advance or credit card.

Shipment means are at the discretion of Coherent, but we will attempt to meet your special requests. We do not take responsibility for any delays or damage caused by the shipper.

Returns are accepted only after a return authorization number has been obtained from Coherent and credit will be allowed for goods returned under authorization in good condition.

Cancellation of orders will incur a termination charge of not less than 10% of the order value and Coherent reserves the right to charge for all costs incurred in support of any cancelled order.

Goods are warranted to be free from defects and to work in the manner specified for a period of 12 months from date of shipment.

Specifications are current at the time of publication, but Coherent reserves the right to change these without prior notice.

Technical information provided in this catalog is intended to be helpful in the application of Coherent products, but we do not accept responsibility for its use.

Terms and Conditions of Sale
Terms and Conditions of Sale are specific to each country in which Coherent operates. They are supplied with all quotations and invoices and can be sent by fax or mail on request. Nothing in the foregoing statements modifies the Terms and Conditions in effect for each country of operation.