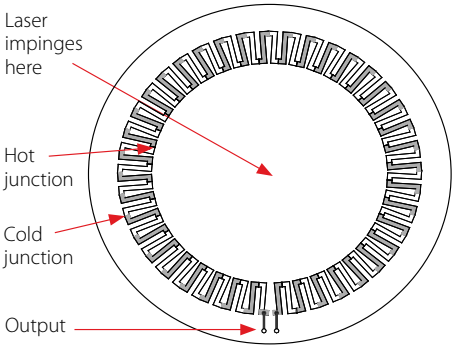
Power sensors

1.1 Power Sensors

Thermal Sensors

As described in the general introduction, the thermopile sensor has a series of bimetallic junctions. A temperature difference between any two junctions causes a voltage to be formed between the two junctions. Since the junctions are in series and the «hot» junctions are always on the inner, hotter side, and the «cold» junctions are on the outer, cooler side, radial heat flow on the disc causes a voltage proportional to the power input. Laser power impinges on the center of the thermopile sensor disc (on the reverse side of the thermopile), flows radially and is cooled on the periphery. The array of thermocouples measures the temperature gradient, which is proportional to the incident or absorbed power. In principle, the reading is not dependent on the ambient temperature since only the temperature difference affects the voltage generated and the voltage difference depends only on the heat flow, not on the ambient temperature. Since all the heat absorbed flows through the thermocouples (as long as the laser beam is inside the inner circle of hot junctions), the response of the detector is almost independent of beam size and position. If the beam is close to the edge of the inner circle, some thermocouples become hotter than others but since the sum of all of them is measured, the reading remains the same. Generally, Ophir specifies ±2% uniformity of reading over the surface or better.

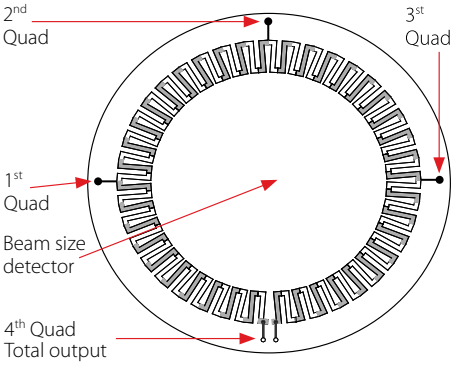


Using Power Sensors to Measure Single Shot Energy

Although Ophir thermal power sensors are used primarily to measure power, they can measure single shot energy as well, where they integrate the power flowing through the disc over time and thus measure energy. Since the typical time it takes for the disc to heat up and cool down is several seconds, these thermal sensors can only measure one pulse every several seconds at most. Thus they are suitable for what is called "single shot" measurement. Although the response time of the sensor discs is slow, there is no limit to how short the pulses measured are since the measurement is of the heat flowing through the disc after the pulse.

BeamTrack Power / Position / Size sensors

Ophir now has the new BeamTrack thermal sensor that can measure beam position and beam size as well as power. This innovative device provides an additional wealth of information on your laser beam – centering, beam position and wander, beam size as well as power and single shot energy. The BeamTrack sensor is illustrated schematically here and works as follows: the signal coming from the sensor is now divided into 4 quadrants so by measuring and comparing the output from the 4 sections we can determine the position of the center of the beam to a high degree of accuracy. In addition to the 4 quadrants, there is now a special proprietary beam size detector. After processing outputs from these various detectors, the user is presented with the beam position as well as beam size. Note that the beam size is calibrated only for a Gaussian beam of >3mm but for other beams it will give relative size information and will indicate if the beam is changing size. For more information on the BeamTrack sensors, please see section 1.1.3



Types of Thermopile Discs

There is no single absorber which meets the needs of all applications. Ophir has developed several types for different applications, such as long pulses (0.1-10ms), short pulses (<1µs) and continuous radiation. Absorbers optimized for long pulses and CW are characterized by thin, refractory materials, since the heat can flow through the coating and into the disc during the pulse. On the other hand, heat cannot flow during short pulses, and all the energy is deposited in a thin (typically 0.1µm) layer near the surface. This causes vaporization of the surface which ruins the absorber. Instead, a volume absorber that is partially transparent and absorbs over a distance of 50µm -3mm is used. This spreads the heat over a larger volume allowing much higher energies.

Ophir thermopiles can measure from tens of microwatts to Kilowatts. Nevertheless, the thermal range of operation of the discs is limited. If the difference between the hot and cold junction temperature exceeds tens of degrees, the constant heating/cooling of the junctions can cause premature failure in the junctions. In order to accommodate different power ranges, discs of different thicknesses and sizes are used, thick ones for high powers and thin ones for low powers.

The response time of the discs is dependent on their size and shape: larger diameters and thicker discs are slower than thin small diameter ones. The response time is in general dependent on the mass of material which has to heat up in the thin absorber region of the disc vs. the speed the heat flows out of the same region. The response time is approximately proportional to the aperture, i.e. a 50mm aperture disc is three times as slow as an 18mm aperture disc.

Thermal Surface Absorbing Sensors

A surface absorber typically consists of an optically absorbing refractory material deposited on a heat conducting substrate of copper or aluminum. When a long pulse of several hundred µs or a continuous laser beam falls on such a surface absorber, the light is absorbed in a very thin layer of the surface – typically 0.1 – 1µm thickness (see illustration A). Although the light is absorbed in a thin layer and there converted into heat, the pulse is long enough so that while energy is being deposited into the surface layer, heat is also flowing out into the heat conducting substrate and therefore the surface does not heat up excessively. Ophir standard surface absorbers can stand up to 10 Joules/cm^2 for 2ms pulses and up to 28kW/cm^2 for low power continuous lasers.

Surface Absorbers for High Power Lasers and Long Pulses

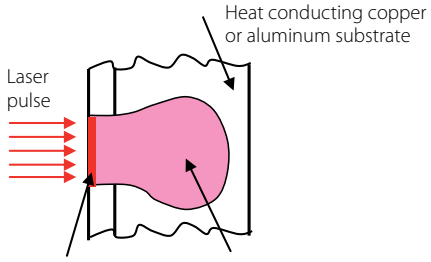
The traditional surface absorbers have a much lower damage threshold at > 1000W, where they can damage at 2-3 kW/cm^2. Ophir has developed coatings that improve the damage threshold for high power lasers. These coatings are denser and have higher heat conductivity than previous coatings. This LP1 coating also has a much higher damage threshold for long pulses reaching power damage thresholds of up to 10kW/cm^2 and 200J/cm^2 for 10ms pulses. Surface absorbers are suitable for pulses longer than ~100µs.

Surface vs. Volume Absorbers

When measuring a laser with short pulses of tens of µs or less, the heat is deposited in a short time and cannot flow during the pulse (see illustration B below). Therefore a surface absorber which absorbs the energy in a thin surface layer is not suitable. All the energy is deposited in a thin layer and that layer is vaporized. In this case, volume absorbers are used. These have traditionally consisted of a neutral density glass thermally bonded to a heat-conducting metallic substrate. The ND glass absorbs the light over a depth of 1-3 mm instead of fractions of a micrometer. Consequently, even with short pulses where there is no heat flow, the light and heat are deposited into a considerable depth of material and therefore the power/energy meter with aa volume absorber is able to withstand much higher energy densities – up to 10 Joules/cm^2 (see illustration C). These ND glasses form the basis of the Ophir P type absorbers. In addition to the P absorbers, Ophir has PF and SV absorbers that can stand up to higher average powers and power densities as well as EX absorbers for the UV.

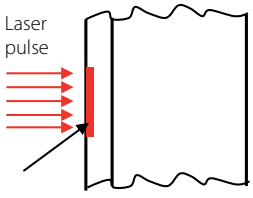
Long laser pulse (>100µs) or continuous

(A) Surface absorber



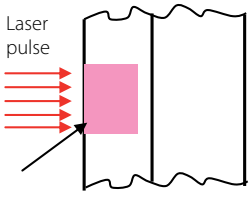
Short laser pulse <10µs

(B) Surface absorber



Depth of light penetration ~0.1-1µm. Light and heat concentrated same thin layer. Heat does not have a chance to flow during the short laser pulse duration.

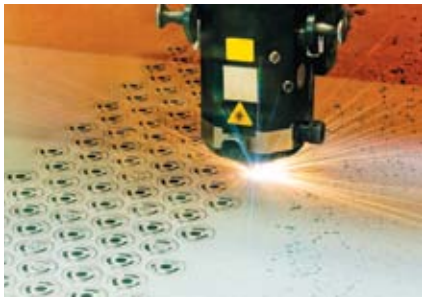
(C) Volume absorber



Light is absorbed gradually over thick partially transmitting layer. Heat is therefore generated over large volume even during short pulse with no heat flow.

Surface absorbers work best when measuring power or energy for long laser pulses (A). Volume absorbers can measure pulses with much higher energies than surface absorbers (B), (C) can measure.

Introduction to High Power Water Cooled Sensors



Ophir has many years experience in supplying measurement systems for high power industrial lasers and has the highest power measuring equipment available on the market – up to 100 kilowatts. Ophir meters also have the highest damage threshold available – up to 10kW/cm^2 at full power. Ophir supplies water cooled sensors from 300W up to 120kW and air cooled sensors up to 500W.
All sensors supplied by Ophir have been tested at up to full power and their linearity verified over the entire power range. This is done deflecting a fraction of the power with a beam splitter into a lower power sensor whose linearity has previously been verified by NIST or PTB. In some cases, it is done by measuring the reading over the power range against a higher power sensor that has been previously measured. The accuracy, linearity and damage specifications have been carefully verified over many years of development and use by the largest existing user base. In addition to power meters for high powers, Ophir also has beam profilers, beam dumps and protective enclosures for industrial lasers.

Calibration Method and Estimated Accuracy for Ophir High Power Sensors

Ophir models 5000W, 10K-W, Comet 10K and 30K-W are calibrated using relatively low power lasers not exceeding 1000W. Using laser powers that are in many cases much lower than the power rating of the sensors being calibrated raises the question of calibration accuracy. The following explanation clearly demonstrates that these highest power sensors are indeed accurate to ±5% over their measurement range as specified. The 5000W, 10K-W and 30K-W sensors work on the thermopile principle, where the radial heat flow in the absorber disk causes a temperature difference between the hot and cold junctions of the thermopile which in turn causes a voltage difference across the thermopile. Since the instrument is a thermopile voltage generating device, it must be linear at low values of output. Therefore, if it has been shown to be linear up to full power – as it has - it will necessarily be linear at very low powers and if the calibration is correct at low powers, it will remain correct at high powers as well. On the other hand, although the output may be linear at low powers, there may be a zero offset that, due to the relatively low output at low powers, will cause an error in calibration.
For example, if calibration is performed at 200W and the output of the sensor is 10µV/W (a typical value) and there is a zero offset of only 1µV, this will cause a calibration error of 10%. Ophir's calibration method always measures the difference between the reading with power applied and without power applied, thus eliminating error due to zero offset. This measurement is taken several times to insure accuracy. The above measurement method assures that the calibration inaccuracy due to measurement errors is less than 1%, comparable to the expected errors in our lower powered sensors. In order to verify this, all of our high power sensors have been measured by comparison to various calibration standards. These measurements have shown Ophir sensors to be well within the claimed limits of linearity. The Comet 10K series measures the heat rise of the absorbing puck when irradiated by the laser for 10s. In order to calibrate the Comet 10K, we simply irradiate with a lower power laser for longer e.g. 150W for 60s. Thus the heating effect is similar to that of a higher power laser. Tests of the Comet calibrated by this method vs. NIST traceable high power sensors has shown that it is accurate and reproducible. For more information on calibration please consult our website at
www.ophiropt.com/calibration-procedure/tutorial

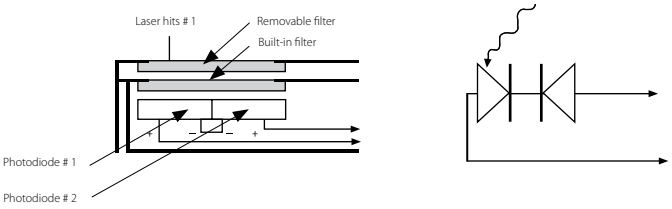
Photodiode Sensors

A photodiode sensor is a semiconductor device that produces a current proportional to light intensity and has a high degree of linearity over a large range of light power levels - from fractions of a nanowatt to about 2 mW. Above that light level, corresponding to a current of about 1mA, the electron density in the photodiode becomes too great and its efficiency is reduced causing saturation and a lower reading. Most Ophir PD sensors have a built-in filter that reduces the light level on the detector and allows measurement up to 30mW without saturation. Most sensors have an additional removable filter allowing measurement to 300mW or 3 Watts depending on the model.

Principle of Operation

When a photon source, such as a laser, is directed at a photodiode detector, a current proportional to the light intensity and dependent on the wavelength is created. Since many low power lasers have powers on the order of 5 to 30mW, and most photodiode detectors saturate at about 2mW, the PD300 sensor has been constructed with a built-in filter so the basic sensor can measure up to 30mW without saturation. With the removable extra filter, the PD300 sensors series can measure up to 300mW or 3W depending on the model.
The Ophir power meter unit amplifies this signal and indicates the power level received by the sensor. Due to the superior circuitry of the Ophir power meters, the noise level is very low and the PD300 series sensors with Ophir power meter have a large dynamic range from picowatts to watts. The PD300 is shown schematically below. The PD300 and PD300-3W have the exclusive patented dual detectors connected back to back which eliminate any signal illuminating both detectors equally (background light).

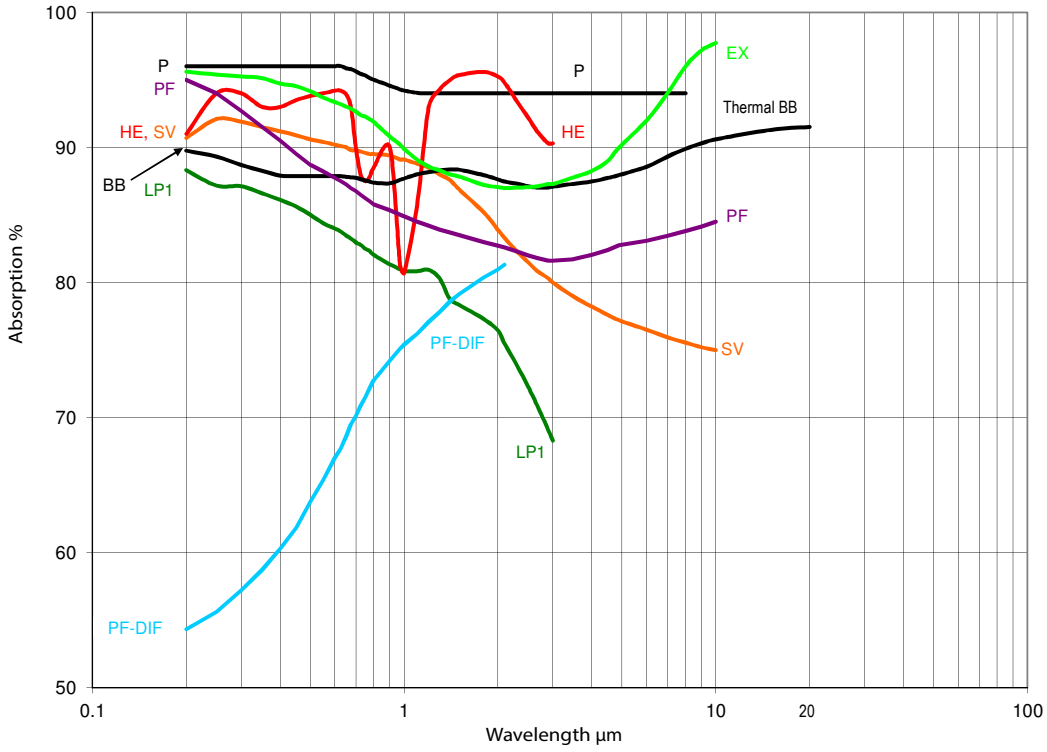
Calibration and Accuracy



The sensitivity of various photodiode sensors varies from one sensor to another as well as with wavelength. Therefore, each PD300 sensor is individually calibrated against a NIST standard, which has been calibrated at several nm intervals over the entire spectral range. The calibration is done over the entire spectral range against the NIST standard using a computer-controlled monochromator. Since the instruments are calibrated against NIST standards, the accuracy is generally ±3% over the wavelength range the calibration has been performed. The linearity of the photodiode detector is extremely high and errors due to this factor can be ignored, as long as saturation intensity is not approached. For more information on calibration accuracy please see our website at:
www.ophiropt.com/calibration-procedure/tutorial

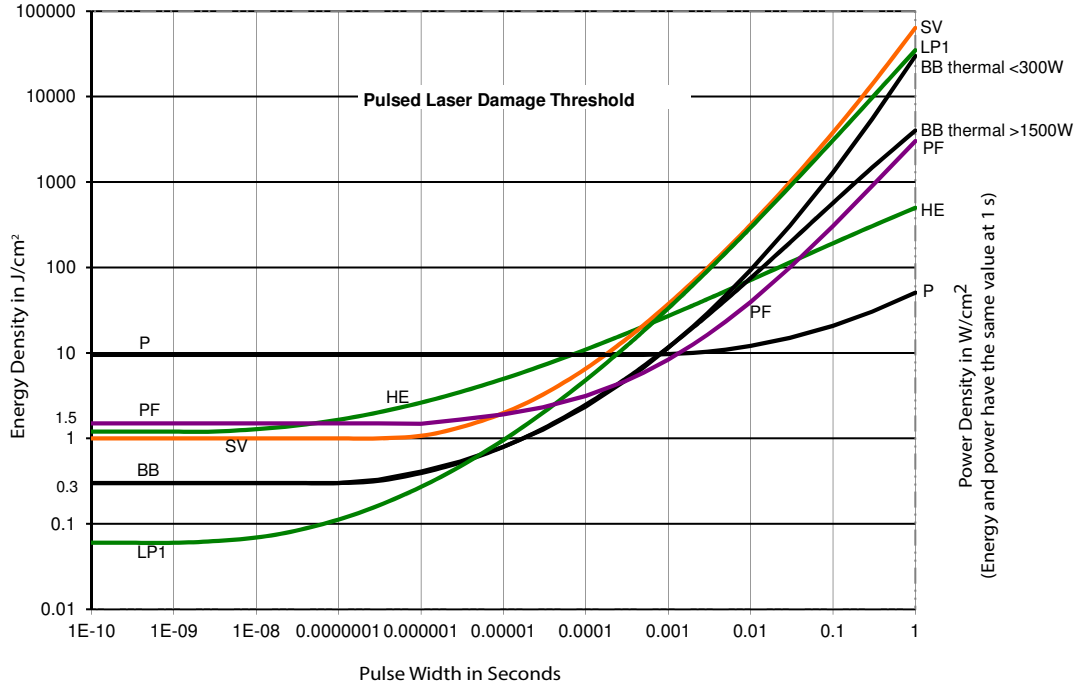
Absorption and Damage Graphs for Thermal Sensors

Absorption vs. Wavelength



Damage Threshold vs. Pulse Width

Note: The CW power damage threshold in W/cm² is found on the right hand side of the table at the 1s pulse width value.



1.1.1 Photodiode Power Sensors

1.1.1.1 Standard Photodiode Sensors

50pW to 3W

Features

- Very large dynamic range
- Swivel mount for hard to measure places
- Comes with filter in / filter out options
- Patented automatic background subtraction
- Fiber optic adapters available

PD300 with filter off

PD300 with filter installed

PD300-TP Mounted on stand

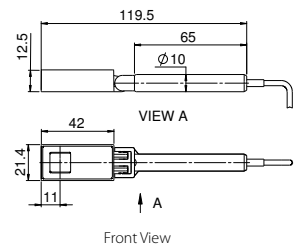
Model	PD300			PD300-1W			PD300-3W			PD300-TP		
Use	**General**			**Powers to 1W**			**Powers to 3W**			**Thin profile for tight fit**		
Detector Type	silicon			silicon			silicon			silicon		
Aperture	10x10mm			10x10mm			10x10mm			10x10mm		
Filter mode	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in	Filter out		Filter in
Spectral Range nm	350-1100		430-1100	350-1100		430-1100	350-1100		430-1100	350-1100		400-1100
Power Range	500pW to 30mW		200µW to 300mW	500pW to 30mW		200µW to 1W	5nW to 100mW		200µW to 3W	50pW to 3mW		20µW to 1W
Power Scales	30mW to 30nW and dBm		300mW to 30mW and dBm	30mW to 30nW and dBm		1W to 30mW and dBm	100mW to 300nW and dBm		3W to 30mW and dBm	3mW to 3nW and dBm		1W to 3mW and dBm
Resolution nW	0.01		NA	0.01		NA	0.1		NA	0.001		1
Maximum Power vs. Wavelength	nm	mW	mW	nm	mW	mW	nm	mW	mW	nm	mW	mW
	<488	30	300	<488	30	1000	<488	100	3000	350-400	3	NA
	633	20	300	633	20	1000	633	100	3000	400-500	3	1000
	670	13	200	670	13	1000	670	100	2000	600	2.5	1000
	790	10	100	790	10	600	790	100	1200	700	2	500
	904	10	100	904	10	700	904	100	1200	800-950	1.5	300
	1064	25	250	1064	25	1000	1064	100	2200	1064	3	500
Accuracy (including errors due to temp. variations)												
% error vs Wavelength nm	±10	360-400	NA	±10	360-400	NA	±10	360-400	NA	±7	350-400	NA
	±3	400-950	±5 430-950	±3	400-950	±5 430-950	±3	400-950	±5 430-950	±3	400-950	±5 400-950
	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100	±5	950-1100	±7 950-1100
Damage Threshold W/cm²	10		50	10		10 [(a)]	10		100	10		50
Max Pulse Energy µJ	2		20	2		100	20		500	1		100
Noise Level for filter out pW	20			20			200			±2		
Response Time with Meter s	0.2			0.2			0.2			0.2		
Beam Position Dependence	±2%			±2%			±2%		±3%	±2%		
Background Subtraction	95-98% of background is cancelled automatically under normal room conditions, even when changing continuously						N.A.			N.A.		
Fiber Adapters Available (see page 68)	SMA, FC, ST, SC			SMA, FC, ST, SC			SMA, FC, ST, SC			N.A.		
Version							V1					
Part Number	**7Z02410**			**7Z02411A**			**7Z02426**			**7Z02424**		

Note: (a) Maximum power density above which sensor may not read correctly. There will be no permanent damage until 50W/cm²

* For graphs see page 26-27

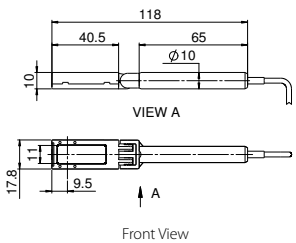
* For PD300-3W drawing see PD300-UV/PD300-IR drawing on page 23

PD300/ PD300-1W filter installed



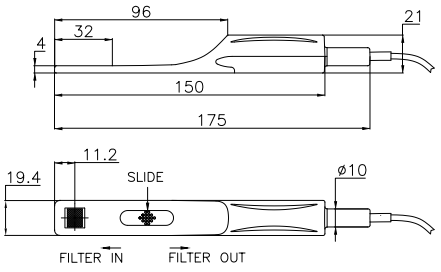
Front View

PD300/ PD300-1W filter off



Front View

PD300-TP



1.1.1.1 Standard Photodiode Sensors

10pW to 300mW

Features

- Spectral range including UV and IR
- Very large dynamic range
- Swivel mount for hard to measure places
- Comes with filter in / filter out options
- Fiber optic adapters available

PD300-UV/PD300-IR with filter off

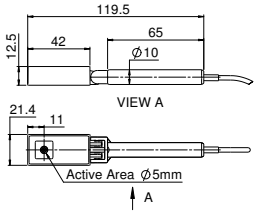
PD300-UV/PD300-IR with filter installed

PD300-IRG with fiber input

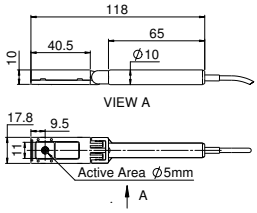
Model	**PD300-UV/ PD300-UV-193**				**PD300-IR**				**PD300-IRG**			
Use	**Lowest powers from 200-1100nm**				**Low powers from 700-1800nm**				**Telecom wavelength fiber and free space measurements**			
Detector Type	silicon				germanium				InGaAs			
Aperture	10x10mm				Ø5mm				Ø5mm for free space beams			
Filter mode	Filter out		Filter in		Filter out		Filter in		Filter out		Filter in	
Spectral Range nm	200 -1100		220 -1100		700-1800		700-1800		800 - 1700		950 - 1700	
Power Range	20pW to 3mW		2µW to 300mW		5nW to 30mW		200µW to 300mW		10pW to 800µW		20µW to 150mW	
Power Scales	3mW to 3nW and dBm		300mW to 300µW and dBm		30mW to 30nW and dBm		300mW to 30mW and dBm		800 µW to 800pW and dBm		300mW to 3mW and dBm	
Resolution nW	0.001		100		0.01		NA		0.0001		1	
Maximum Power vs. Wavelength	nm	mW	mW		nm	mW	mW		nm	mW	mW	
	250 - 350	3	300		800	12	120		<1000	0.8	100	
	400	3	300		1000-1300	30	300		1100	0.8	30	
	600	3	300		1400	30	250		1200	0.8	50	
	800 - 950	2.5	150		1500	25	80		>1300	0.8	150	
	1064	3	300		1600	30	100					
					1800	30	300					
Accuracy (including errors due to temp. variations)												
% error vs Wavelength nm	±6	200-270	±10	220-400	±5	700-900	±7	700-900	±3	1000-1650	±6	1000-1650
	±3	270-950	±5	400-950	±4	900-1700	±6	900-1700	±5	<1000 & >1650	±8	<1000 & >1650
	±5	950-1100	±7	950-1100	±7	1700-1800	±9	1700-1800				
Damage Threshold W/cm²	10		50		10		50		5		50	
Max Pulse Energy µJ	0.4		15		0.3		3		1		100	
Noise Level for filter out pW	±1				200				±300fW at 1550 nm and 1s average			
Response Time with Meter s	0.2				0.2				0.2			
Beam Position Dependence	±2%				±2%				±1% over 80% of aperture			
Fiber Adapters Available (see page 68-69)	SC, ST, FC, SMA				SC, ST, FC, SMA				FC, FC/APC, SMA			
Version									V1			
Part Number	**PD300-UV: 7Z02413** **PD300-UV-193: 7Z02413A** (same as above with additionaly calibration point at 193nm accuracy ±6%)				**7Z02412**				**7Z02402**			

* For graphs see page 26-27

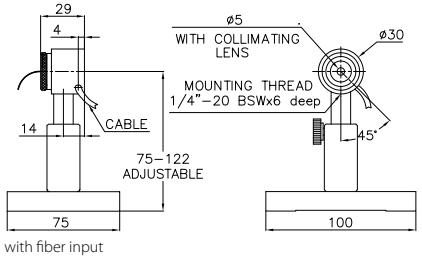
PD300-UV/PD300-IR filter installed
(Ø5mm for PD300-IR only)



PD300-UV/PD300-IR filter off
(Ø5mm for PD300-IR only)



PD300-IRG



with fiber input

1.1.1.2 Round Photodiode Sensors

20pW to 3W

Features

- Round geometry for easy centering
- Threaded to fit standard SM1 bench equipment
- Same performance as standard PD300 sensors
- Comes with removable filter as standard
- Fiber optic adapters available

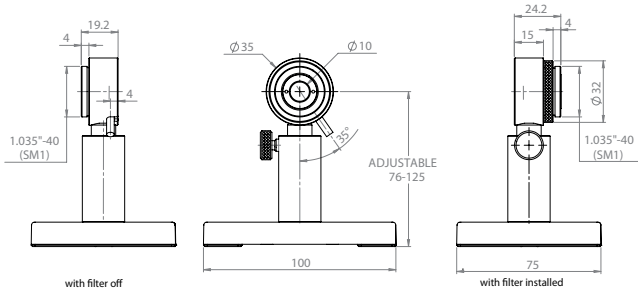
PD300R Filter Off

PD300R Filter installed

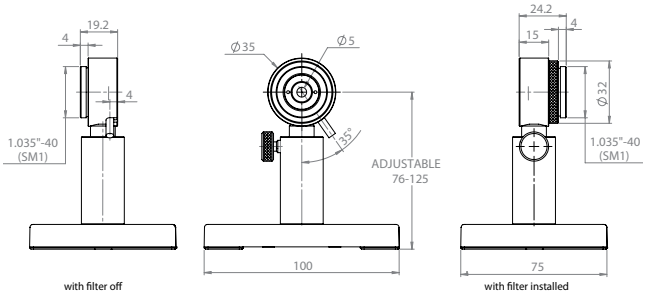
Model	PD300R		PD300R-3W		PD300R-UV		PD300R-IR	
Use	**General**		**Powers to 3W**		**Lowest powers from 200-1100nm**		**IR wavelengths 700-1800nm**	
Detector Type	silicon		silicon		silicon		germanium	
Aperture	Ø10mm		Ø10mm		Ø10mm		Ø5mm	
Filter mode	Filter out	Filter in	Filter out	Filter in	Filter out	Filter in	Filter out	Filter in
Spectral Range nm	350-1100	430-1100	350-1100	430-1100	200 -1100	220 -1100	700-1800	700-1800
Power Range	500pW to 30mW	200µW to 300mW	5nW to 100mW	200µW to 3W	20pW to 3mW	2µW to 300mW	5nW to 30mW	200µW to 300mW
Power Scales	30mW to 30nW and dBm	300mW to 30mW and dBm	100mW to 300nW and dBm	3W to 30mW and dBm	3mW to 3nW and dBm	300mW to 300µW and dBm	30mW to 30nW and dBm	300mW to 30mW and dBm
Resolution nW	0.01	NA	0.1	NA	0.001	100	0.01	NA
Maximum Power vs. Wavelength	nm mW	mW	nm mW	mW	nm mW	mW	nm mW	mW
	<488 30	300	<488 100	3000	250 - 350 3	300	800 12	120
	633 20	300	633 100	3000	400 3	300	1000-1300 30	300
	670 13	200	670 100	2000	600 3	300	1400 30	250
	790 10	100	790 100	1200	800 - 950 2.5	150	1500 25	80
	904 10	100	904 100	1200	1064 3	300	1600 30	100
	1064 25	250	1064 100	2200			1800 30	300
Accuracy (including errors due to temp. variations)								
% error vs Wavelength nm	±10 360-400	NA	±10 360-400	NA	±6 200-270	±10 220-400	±5 700-900	±7 700-900
	±3 400-950	±5 430-950	±3 400-950	±5 430-950	±3 270-950	±5 400-950	±4 900-1700	±6 900-1700
	±5 950-1100	±7 950-1100	±5 950-1100	±7 950-1100	±5 950-1100	±7 950-1100	±7 1700-1800	±9 1700-1800
Damage Threshold W/cm²	10	50	10	100	10	50	10	50
Max Pulse Energy µJ	2	20	20	500	0.4	15	0.3	3
Noise Level for filter out pW	20		200		±1		200	
Response Time with Meter s	0.2		0.2		0.2		0.2	
Beam Position Dependence	±2%		±2%	±3%	±2%		±2%	
Fiber Adapters Available (see page 69)	FC, ST, SC, SMA		FC, ST, SC, SMA		SC, ST, FC, SMA		SC, ST, FC, SMA	
Version								
Part Number	**7Z02436**		**7Z02437**		**7Z02438**		**7Z02439**	

* For graphs see page 26-27

PD300R/ PD300R-3W/ PD300R-UV



PD300R-IR



1.1.1.3 Special photodiode sensors

Features

- PD300-BB for broadband light sources - radiometry (PD300-BB-50mW option up to 50mW)
- PD300-CIE for eye adjusted Lux measurements
- BC20 for measuring scanned beams such as bar code light sources

BC20

PD300-BB/ / PD300-BB-50mW

PD300-CIE

Model	**PD300-BB**	**PD300-BB-50mW**		**PD300-CIE** [b]	**BC20** [b]
Use	**Radiometry-broad spectrum**	**Same as PD300-BB with removable attenuator for use to 50mW**		**Eye adjusted measurement in Lux**	**Scanned beams e.g. bar code**
Detector Type	Silicon with special filter	Silicon with special filter		Silicon with special filter	Silicon with peak and hold circuit
Aperture	10x10mm	10x10mm		Active area 2.4 x 2.8mm	10x10mm
Spectral Range nm	430 - 1000 (see graph)	430 - 1000 (see graph)		400 - 700 (see graph)	633, 650, 675 (others available)
Filter Mode		Filter out	Filter in		
Power Range	50pW to 4mW	50pW to 4mW	1nW to 50mW	20mLux to 200kLux	100µW to 20mW
Power Scales	4mW to 8nW and dBm	4mW to 8nW and dBm	50mW to 80nW and dBm	200kLux to 200 mLux	20mW to 2mW
Resolution nW	0.001	0.001	0.01	1 mLux	0.001
Accuracy	Maximum deviation from flat spectrum (see graph)	Maximum deviation from flat spectrum (see graph)		(see graph)	±3% for >10% of full scale. Deviation from calibration -3% at 30,000 inch/s scan rate on sensor.
	±10%	±10%	±12%		
Damage Threshold W/cm²	10	10	100	10	50
Max Pulse Energy µJ	1	1	10	1	NA
Noise Level pW	2	2	30	±1mLux	5µW
Response Time with Meter s	0.2	0.2	0.2	0.2	Two modes of operation: Hold: holds highest reading for 5s then updates. No Hold: updates reading 3 times per second.
Beam Position Dependence	±2% for broadband light sources	±2% for broadband light sources	±3% for broadband light sources	NA – source overfills detector	±2%
Background Subtraction	NA	NA	NA	NA	Background is automatically subtracted from both scanned and static beams.
Fiber Adapters Available (see page 68)	NA	SC, ST, FC, SMA		NA	NA
Version					
Part Number	**7Z02405**	**7Z02440**		**7Z02406**	**7Z02422A** [a]

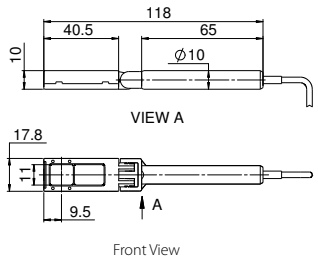
Notes:

(a) Swivel stand for BC20 sensor P/N 1Z09004

(b) The PD300-CIE and BC20 sensors are not fully supported by Ophir PC Interfaces (Juno, USBI, Pulsar and Quasar) or by StarLite Meter.

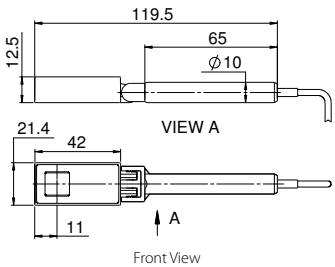
* For graphs see page 26-27

PD300-CIE / PD300-BB / PD300-BB-50mW with filter off



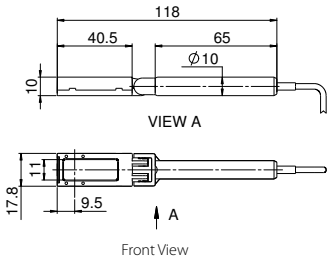
Front View

PD300-BB-50mW with filter installed



Front View

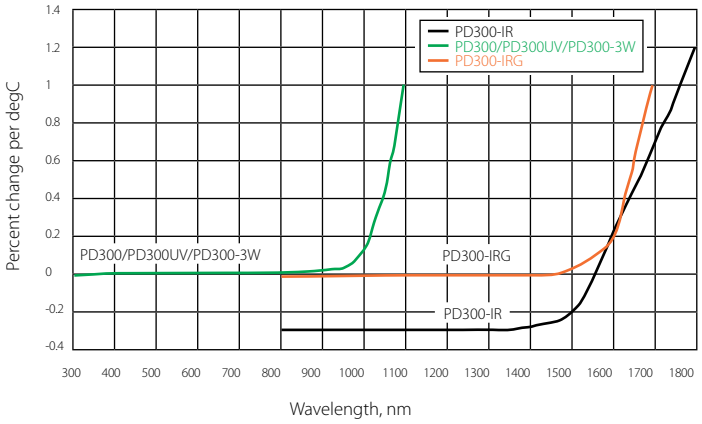
BC20



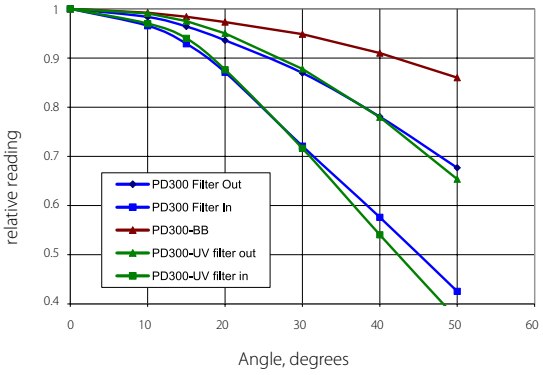
Front View

1.1.1.4 Graphs

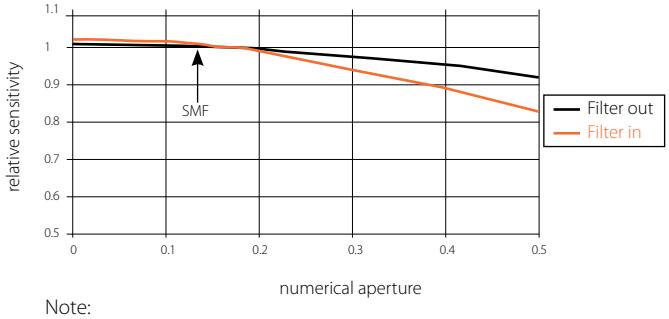
Temperature Coefficient of Sensitivity



PD300 Angle Dependence



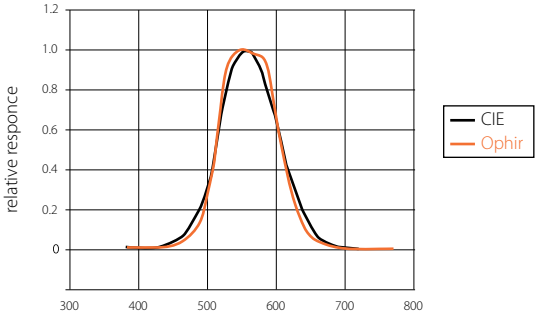
Dependence of Sensitivity on Numerical Aperture (PD300 - IRG)



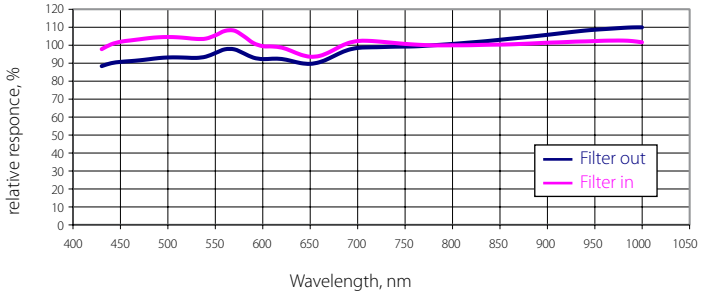
Note:

1. Graph assumes equal intensity into all angles up to maximum N.A.
2. Calibration is done with SMF, N.A. 0.13

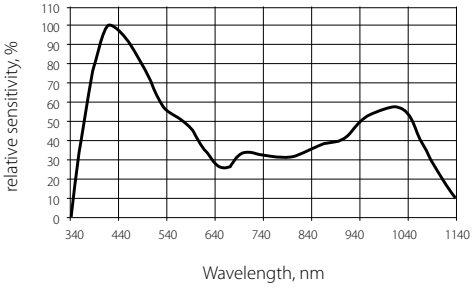
PD300-CIE Spectral Response vs. CIE Curve



Typical Sensitivity Curve of PD300-BB Sensors



Relative Spectral Response of BC20

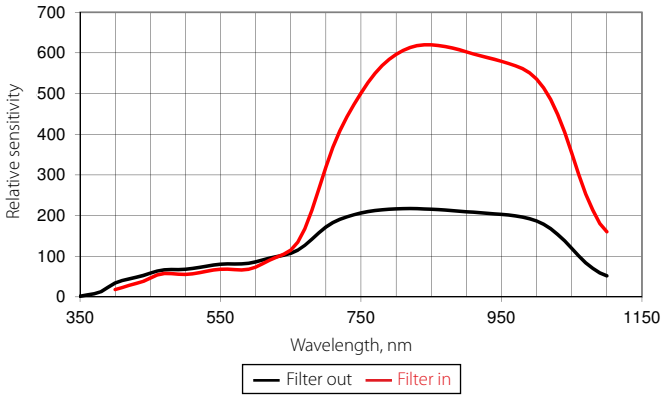


Graph of the approximate relative spectral response of the BC20 for purpose of interpolation, if the instrument is to be used at a wavelength other than the ones that are factory calibrated

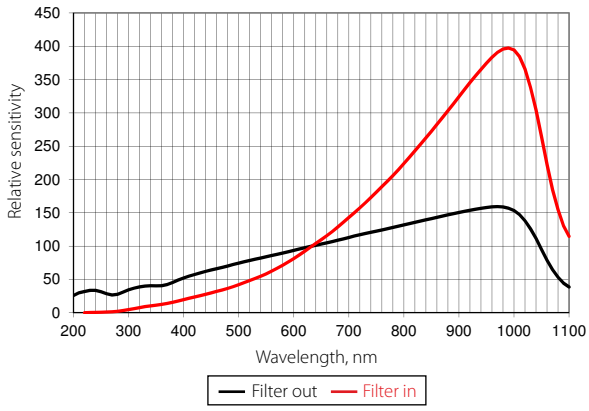
Approximate Spectral Response

Relative to 633nm or 1550nm

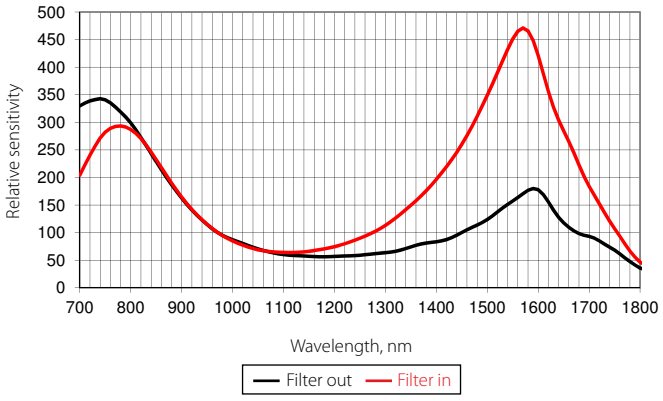
PD300 / PD300R



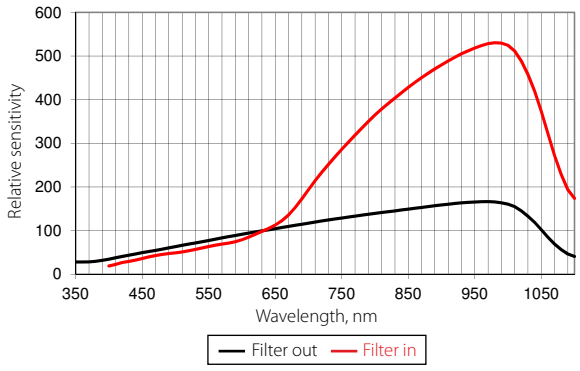
PD300-UV / PD300R-UV



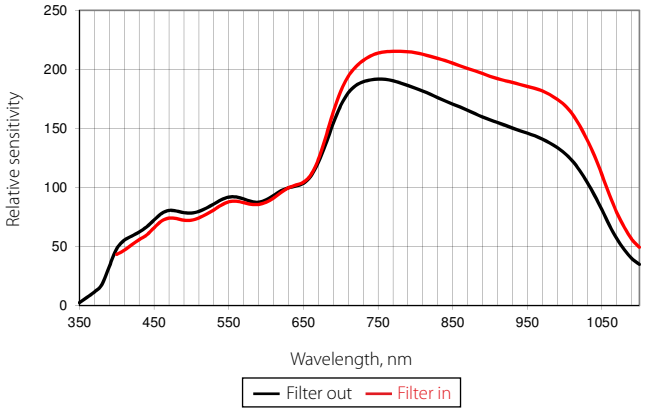
PD300-IR / PD300R-IR



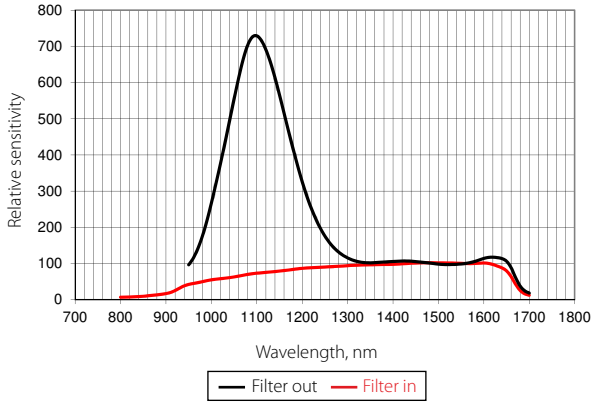
PD300-TP



PD300-3W / PD300R-3W



PD300-IRG



1.1.1.5 Integrating Spheres

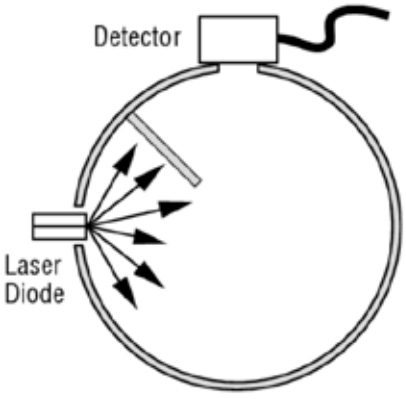
Introduction

Ophir Integrating Spheres are meant to measure divergent light sources such as LEDs. The light is introduced to the sphere through the input port, it is reflected many times by the highly reflecting diffuse coating on the inner wall of the sphere until it uniformly illuminates the inner surface of the sphere. A detector samples given small fraction of this light and thus can be used to measure the total power input into the sphere.

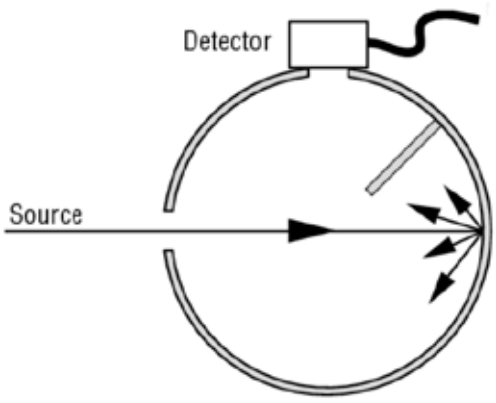
Ophir integrating spheres have a highly reflecting diffuse white coating for high efficiency and readings that are independent of beam size, position and divergence.

Divergent vs. Collimating Beam Input Considerations

Ophir Integrating Spheres can be used either with divergent input or collimated input as shown below. In order for an integrating sphere sensor to operate properly, the beam should never directly hit the detector and the detector should only see rays reflected from the wall. The diagram below shows how the sphere can be used with either a collimated or diverging beam. The sphere opening that is not being used is closed with a reflective plug.



This integrating sphere configuration is ideal for a divergent beam such as a laser diode



This integrating sphere configuration is ideal for a collimated beam source such as a collimated laser beam

Ophir has 1.5" spheres for 350 – 1100nm and for 800 – 1700nm and 4 different 5.3" spheres covering UV, visible, NIR and photometric CIE measurements at up to 30 Watts. There is a North pole port suitable for a small amount of light to be picked off via SMA fiber for wavelength measurement or any further analysis without affecting the overall system calibration. To maintain accuracy and guarantee performance, annual integrating sphere detector calibration is recommended.
Note that the system calibration is no longer valid if any component is changed from the original calibrated configuration. For a very high power level, elevated temperature of the integrating sphere system can affect the measurement accuracy, so the sphere must be properly cooled.

1.1.1.5 Integrating Spheres

1.1.1.5.1 Small Dimensions 1.5”

Features

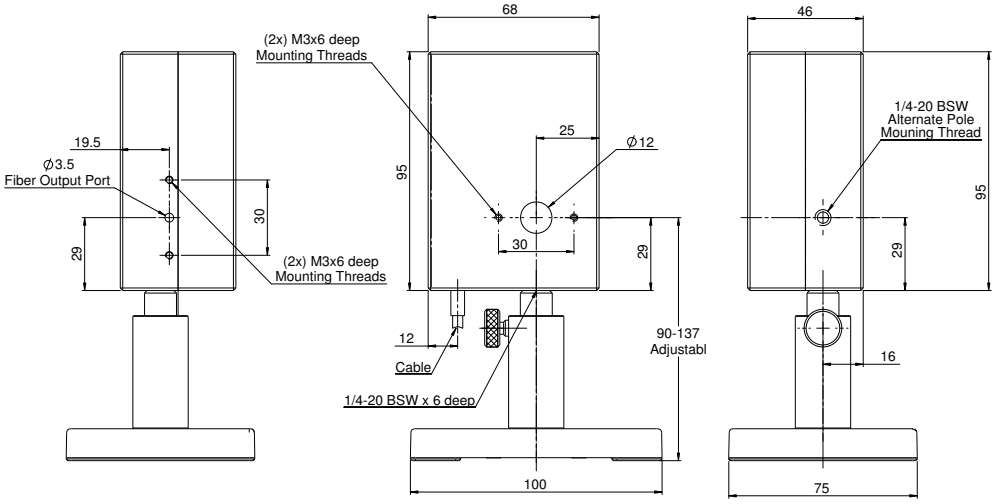
- Integrating sphere for divergent beams
- Ø12mm aperture
- Fiber or free space input

3A-IS

3A-IS-IRG

Model	3A-IS	3A-IS-IRG
Use	**Divergent beams to 3W for visible and NIR**	**Divergent beams to 3W for IR**
Detector Type	Si	InGaAs
Input Port Aperture mm	Ø12mm	Ø12mm
Spectral Range µm	0.35 - 1.1	0.8 – 1.7
Power Range	1µW – 3W	1µW – 3W
Power Scales	3W to 3µW and dBm	3W to 3µW and dBm
% Error vs Wavelength nm	±5 350 -1000, ±10 1000-1100	±5
Linearity with Power +/-%	1	1
Damage Threshold kW/cm^2	0.2 on integrating sphere surface	0.2 on integrating sphere surface
Maximum Pulse Energy mJ	5	5
Power Noise Level nW	20	20
Response Time with Meter s	0.2	0.2
Maximum Beam Divergence	±40 degrees	±40 degrees
Sensitivity to Beam Size and Angle	±2%	±2%
Cooling	convection	convection
Fiber Adapters Available (see page 69)	SC, ST, FC, SMA [a]	SC, ST, FC, SMA [a]
Weight Kg	0.6	0.6
Version	V1	
Part Number	**7Z02404**	**7Z02403**
Notes:	(a) One fiber output port available with output = 2E-4 of input power/mm^2 of fiber area.	

3A-IS/ 3A-IS-IRG



1.1.1.5 Integrating Spheres

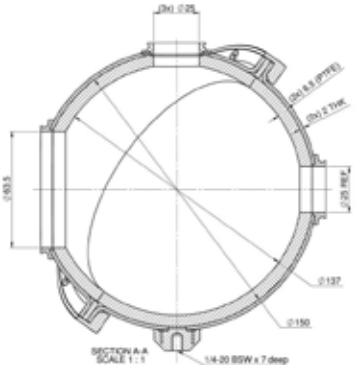
1.1.1.5.2 Large Dimensions 5.3"

Features

- 4 port Integrating spheres for collimated and divergent beams
- Ø63.5mm (2.5") aperture
- Fiber or free space input

Model	IS6	
Spectral Range µm	0.2 – 2.2	
Source Geometry [a] (see introduction)	Divergent ≥15°	Collimated <15°
Input Port Aperture mm	Ø63.5 (2.5")	Ø25.4 (1")
Maximum Beam Divergence	±40deg	NA
Sensitivity to Beam Size and Angle	±2%	±2%
Damage Threshold kW/cm^2	0.2 on integrating sphere surface	
Cooling	Convection	
Weight kg	1.3	
Version		
Part number		
IS6-C For collimated beams (2.5" plug 1" cover)	7Z02474	
IS6-D For divergent beams (1" plug 1" cover)	7Z02475	

Notes (a) In each configuration, the opposing port is closed with a port plug.



Accessories for IS6

Accessory	Description	Part number
Port plugs	Port plugs close ports with matte white reflective integrating sphere material. They eliminate the port from the sphere geometry	
IS-1" Port plug	White reflectance coated Ø25.4mm plug	7Z08280A
IS-2.5" Port plug	White reflectance coated Ø63.5mm plug	7Z08283A
Port covers	Port Covers close ports with a black matt surface. They prevent extraneous light from entering the sphere without changing the sphere configuration. These covers can also be used as blanks for making specialized port adapters.	
IS-1" Port cover	Matt black coated Ø25.4mm plug	7Z08282A
IS-2.5" Port cover	Matt black coated Ø63.5mm plug	7Z08281A
Adapters and reducers	The adapters are black coated and the reducers white coated	
1" SMA fiber adapter	Attaches to the 1" port for SMA fiber input/output	7Z08285
1" FC fiber adapter	Attaches to the 1" port for FC fiber input/output	7Z08286
2.5" to 1" reducer	Attaches to the 2.5" port and turns it into a 1" port	7Z08287
1" to SM1 adapter	Attaches to the 1" port and has a female SM1 thread	7Z08289
1" to C-mount adapter	Attaches to the 1" port and has a female C-mount thread	7Z08290
1" to C-mount reducer	Attaches to the 1" port. Has a male C-mount thread and 11mm aperture	7Z08288

1.1.1.6 LED measurement – UV, VIS, NIR

Introduction

UV, VIS and IR LEDs are replacing traditional light sources and thus enabling new applications. Ophir offers a number of choices for LED measurement. There are a number of sources for measuring the power of divergent LED beams as presented in section 1.1.1.5.1. There are also radiometer sensors for measuring the irradiance of large area illumination in units of Watts/cm^2 as presented in section 1.1.1.5.2

1.1.1.6.1 LED Power Sensors

20pW to 3W

Features

- 20pW to 3W
- 200nm to 1100nm
- Photodiode detectors – spectrally calibrated for LEDs and lasers
- Thermal sensors – power measurement is insensitive to wavelength
- Fiber or free space input
- Compatible with all Ophir meters, acquisition devices and StarLab PC software

3A-IS

PD300-UV with Filter off

PD300R-UV with Filter off

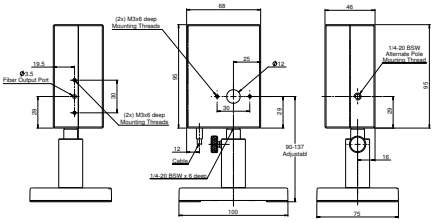
3A

Model	**3A-IS**	**PD300-UV**		**PD300R-UV**		**3A**
Use	**Compact integrating sphere**	**Standard photodiode sensor for UV-NIR**		**Round photodiode sensor for UV-NIR**		**Thermal sensor. Flat spectrum response. For fiber coupled source**
Detector Type	Silicon	Silicon		Silicon		Thermal
Input Port Aperture mm	Ø12	10x10		Ø10		Ø9.5
Filter Mode		Filter out	Filter in	Filter out	Filter in	
Spectral Range µm	0.35 – 1.1	0.2-1.1	0.22-1.1	0.2-1.1	0.22-1.1	0.19-20
Power Range	1µW – 3W	3mW-20pW	300mW-2µW	3mW-20pW	300mW-2µW	10µW-3W
Power Scales	3W to 3µW and dBm	3mW to 3nW and dBm	300mW to 300µW and dBm	3mW to 3nW and dBm	300mW to 300µW and dBm	3W-300µW
Resolution nW	1	0.001	100	0.001	100	100
Maximum Power	3W	3mW	300mW	3mW	300mW	3W
Accuracy (including error due to temp variations)						
% Error vs Wavelength nm	±5 350 – 1000 ±10 1000 – 1100	±6 200-270 ±3 270-950 ±5 950-1100	±10 220-400 ±5 400-950 ±7 950-1100	±6 200-270 ±3 270-950 ±5 950-1100	±10 220-400 ±5 400-950 ±7 950-1100	±3%
Damage Threshold W/cm^2	200	10	50	10	50	1000
Max Pulse Energy	5mJ	0.4 µJ	15 µJ	0.4 µJ	15 µJ	2J
Noise Level for Filter Out	20nW	1pW		1pW		2µW
Response Time with Meter s	0.2	0.2		0.2		1.8
Beam Position Dependence	N.A.	±2%		±2%		±2%
Linearity with Power +/-%	1	0.5		0.5		1.5
Fiber Adapters Available (see page 68-69)	SMA [(a)], FC, ST, SC	SMA, FC, ST, SC		SMA, FC, ST, SC		SMA, FC, ST, SC
Weight kg	0.6	0.07		0.11		0.2
Version	V1					
Part Number	**7Z02404**	**7Z02413**		**7Z02438**		**7Z02621**

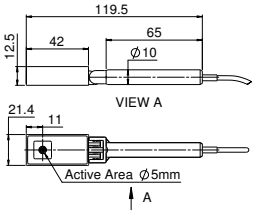
Notes: (a) One fiber output port available with output = 2E-4 of input power/mm^2 of fiber area.

* For sensors drawings please see page 32

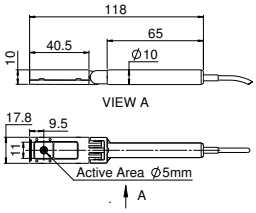
3A-IS



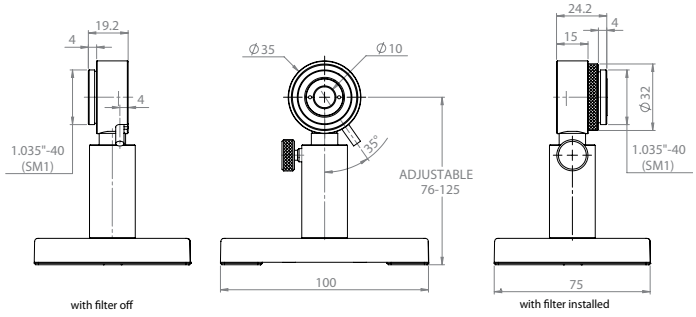
PD300-UV/PD300-IR Filter installed
(Ø5mm for PD300-IR only)



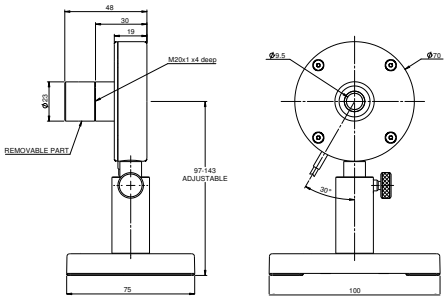
PD300-UV/PD300-IR Filter off
(Ø5mm for PD300-IR only)



PD300R-UV



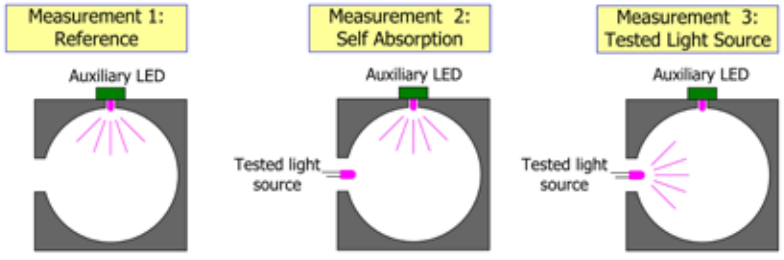
3A



Self-Absorption Calibration Accessory for the 3A-IS Integrating Sphere (AUX-LED)

The detector inside the 3A-IS is calibrated for operation with the aperture unobstructed. Diffused light that reaches the aperture from inside the sphere freely exits. This will also hold true when the light source is mounted on an absorbing surface and placed in front of the sphere. The effect of self-absorption is noticed when part of the aperture is blocked by a reflective material or if the light source protrudes into the sphere. In these examples, the geometry and reflectance of the sphere are changed, leading to errors of up to ±20%.
This effect can be corrected for by using the AUX-LED self-absorption auxiliary light source as shown in the following illustration. A reading is taken of the 390nm Auxiliary LED output with the light source to be measured installed and then again with it not installed. From these measurements we can get a measurement corrected for the effect of the light source as shown in the formula below.
The AUX-LED emits at 390nm, and thus is optimized for measuring UV LEDs in the range of 365nm-400nm. For other LED wavelengths, please contact Ophir. The accessory is attached to the 3A-IS using two screws.

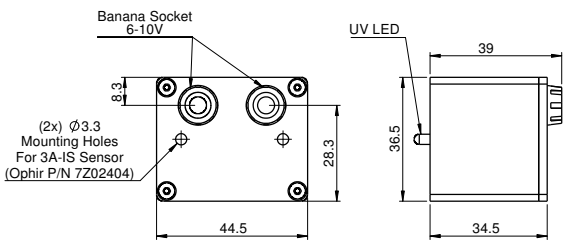
Self-Absorption correction procedure



$$\text{Corrected Measurement} = \frac{\text{Measurement 1 X Measurement 3}}{\text{Measurement 2}}$$

3A-IS with AUX-LED and VEGA meter

AUX-LED



AUX-LED Specifications

Standard wavelength	390nm
Operation voltage	6V-10V, the LED is current regulated
Dimensions	36.5x44.5x34.5mm
Part number	**7Z08292**

1.1.1.6.2 LED Irradiance and Dosage Sensors

15nW/cm² to 8W/cm²

Features

- Measure irradiance in W/cm²
- Cosine corrected
- 200nm to 850nm
- Ø8mm aperture
- For narrowband LED source

PD300RM-UV / PD300RM-8W

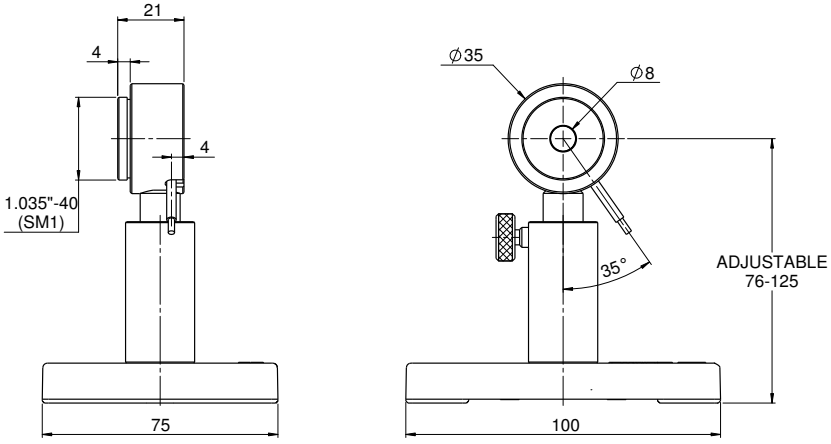
Model	PD300RM-UV	PD300RM-8W
Detector Type	Silicon	Silicon
Input Port Aperture mm	Ø8	Ø8
Spectral Range nm	200-850	350-850
Functions	Irradiance [W/cm²] Dosage [J/cm²]	Irradiance [W/cm²] Dosage [J/cm²]
Irradiance Range	15nW/cm² – 300mW/cm²	0.2µW/cm² – 8W/cm²
Irradiance Scales	300mW/cm² to 300nW/cm² (7 scales), Auto ranging	30W/cm² to 30µW/cm² (7 scales), Auto ranging
Resolution nW/cm²	0.1	0.01
Maximum Irradiance	200nm-450nm, 300mW/cm² 450nm-700nm, 150mW/cm² 700nm-850nm, 100mW/cm²	350nm-450nm, 8W/cm² 450nm-850nm, 3W/cm²
Dosage Sample Rate	500 samples per second	500 samples per second
Accuracy		
% error vs Wavelength nm [a] [b]	±8%, 200-250nm	±5%, 350-400nm
	±5%, 250-400nm	±4%, 400-850nm
	±3%, 400-850nm	
Thermal Coefficient %/°C	-0.03	-0.03
Damage Threshold W/cm²	10	50
Max Pulse Energy (for laser ns pulse) µJ	0.4	20
Noise Level nW/cm²	1	5
Response Time with Meter s	0.2	0.2
Linearity %	±0.5	±0.5
f'2 Cosine Correction Factor Accuracy	4%	4%
Size	Ø35 x 21mm see drawing	Ø35 x 21mm see drawing
Weight	110g	110g
Operation Temperature	-20°C ~+60°C	-20°C ~+60°C [c]
Storage Temperature	-20°C ~ +80°C	-20°C ~ +80°C
Compatible Meter	Ophir StarBright and StarLite	Ophir StarBright and StarLite
Version		
Part number	**7Z02479**	**7Z02480**

Notes: (a) Accuracy given for lasers. Accuracy for LEDs depends on peak wavelength, wavelength tolerance bandwidth. Contact Ophir for more details.

Notes: (b) Accuracy includes uncertainty of NIST calibrated reference.

Notes: (c) Do not exceed 2 minutes of continuous exposure at > 5W/cm².

PD300RM-UV / PD300RM-8W



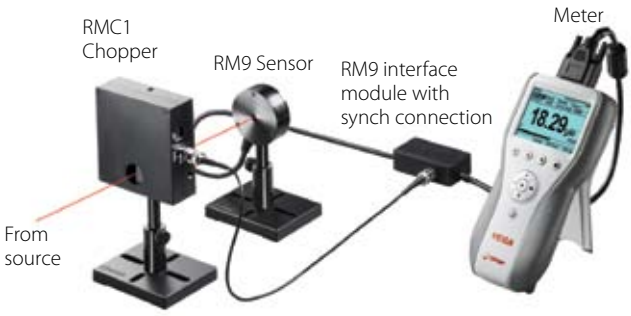
1.1.2 Thermal Power Sensors

1.1.2.1 Low Noise Lock In Power Sensors

300fW to 100mW

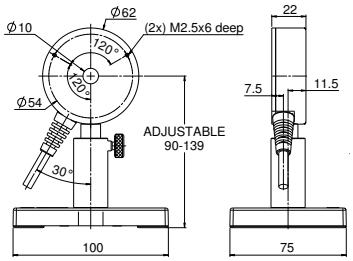
Features

- Chopper and lock in amplifier for lowest noise and drift
- Wavelength range from UV to deep IR
- RM9 pyro is not sensitive to background radiation

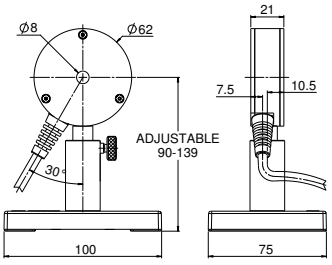


The RM9 series Radiometers use a pyroelectric or photodiode sensor in conjunction with chopped CW or quasi CW radiation, using a digitally synthesized lock-in amplifier to reduce external noise to a minimum. The signal is passed through the 18Hz chopper and the chopped signal is detected by the sensor. All signals not at this 18Hz frequency are suppressed. The output of the sensor is displayed on a standard Ophir meter or PC interface. The chopper may be placed at any convenient location but preferably close to the signal source so as to eliminate interference from all unchopped radiation.

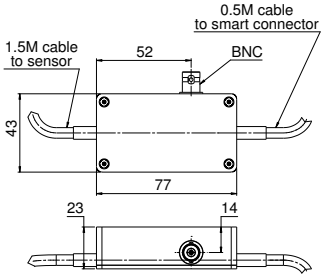
RM9-PD Sensor



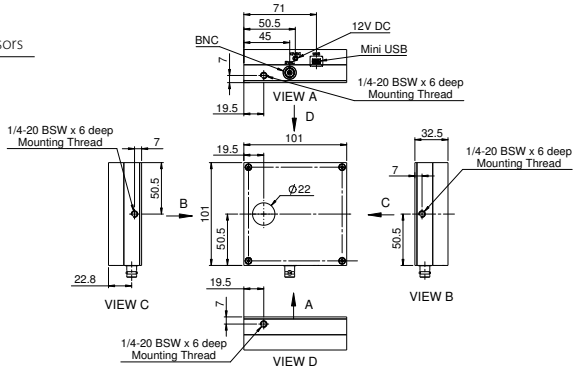
RM9 Sensor



Interface Module



Radiometer-Chopper



Specifications

Model	RM9 Sensor	
Use	**Very low level signals**	
Model	**RM9**	**RM9-PD**
Absorber Type	Pyroelectric	Si Photodiode
Spectral Range µm	0.15 - 12 (a)	0.2 - 1.1 (b)
Aperture mm	Ø8mm	Ø8mm
Surface Reflectivity % approx.	50	50
Power Range (c)	100nW – 100mW	300fW – 300nW
Power Scales	100mW to 3µW	300nW to 3pW
Power Noise Level (d)	~30nW	30fW
Minimum Frequency for Pulsed Sources	200Hz	200Hz
Thermal Drift (20min) (e)	~30nW	N.A.
Power Accuracy (a) (b)	±5%	±5%
Damage Threshold W/cm²	5	5
Response Time with Display (0-95%) s	3.5	3.6
Linearity with Power	±2%	±2.5%
Connections:		
1. 1.5 meter cable hard wired to interface module.		
2. BNC connector on module for connection to chopper (2 meter BNC to BNC cable included). Perform zeroing with BNC cable removed.		
3. 0.5 meter cable from module terminated in DB15 connector.		
Cooling	convection	convection
Weight kg	0.37	0.37
Version		
Part Number for RM9/RM9-PD with RMC1 Chopper (f)	**7Y70669**	**7Y70672**
Part Number for RM9/RM9-PD Sensor	**7Z02952**	**7Z02953**

Notes: (a) At calibrated wavelengths 500 – 1100nm. At other wavelengths, there is an additional error as follows: <500nm add ±8%, 1100 – 3000nm add ±5%, 10.6µm add ±15%

Notes: (b) At calibrated wavelengths 200 – 1100nm. For <700nm add ±2% additional error

Notes: (c) For LaserStar, Pulsar, USBI, Quasar and Nova/Orion, upper limit is 1mW for RM9 and 90nW for RM9-PD. For these models, accuracy may also be less than values given above

Notes: (d) Averaged over 10s

Notes: (e) In a typical laboratory environment

Notes: (f) The RMC1 or another chopper unit that can be set to 18Hz is required for operation of the RM9 sensors

Model	RMC1 Chopper
Use	**Chopper for RM9/RM9-PD**
Aperture	Ø22mm
Chopping frequency (a)	18Hz
Power consumption	85mA
Connections:	
1. BNC to interface module	
2. 12V wall cube power supply (included)	
3. Mini USB connector (factory use only)	

Notes: (a) not adjustable by user.

1.1.2.2 High Sensitivity Thermal Sensors

10µW to 3W

Features

- Very low noise and drift to measure very low powers and energies
- PF absorber has high damage threshold for CW and pulses
- Up to 3W

3A / 3A-P / 3A-PF-12

Model	3A	3A-P	3A-PF-12
Use	**General purpose**	**Short pulses**	**Short Pulses UV**
Absorber Type	Broadband	P type	PF type
Spectral Range µm	0.19 - 20	0.15 - 8	0.15 - 20
Aperture mm	Ø9.5mm	Ø12mm	Ø12mm
Maximum Beam Divergence	NA	NA	NA
Power Mode			
Power Range [a]	10µW - 3W	15µW - 3W	15µW - 3W
Power Scales	3W to 300µW	3W to 300µW	3W to 300µW
Power Noise Level	2µW	4µW	4µW
Thermal Drift (30min) [a]	5 - 20µW	5 - 30µW	5 - 30µW
Maximum Average Power Density kW/cm²	1	0.05	3
Response Time with Meter (0-95%) typ. s	1.8	2.5	2.5
Power Accuracy +/-% [d]	3	3	3 [c]
Linearity with Power +/-%	1.5	1.5	1.5
Energy Mode			
Energy Range	20µJ - 2J	20µJ - 2J	20µJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J to 200µJ
Minimum Energy	20µJ	20µJ	20µJ
Maximum Energy Density J/cm² [b]			
<100ns	0.3	1	1.5
0.5ms	1	1	7
2ms	2	1	15
10ms	4	1	40
Cooling	convection	convection	convection
Weight kg	0.2	0.2	0.2
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Version		V1	
Part number: Standard Sensor	**7Z02621**	**7Z02622**	**7Z02720**
BeamTrack Sensor: Beam Position & Size (p. 65)	**7Z07934**	**7Z07935**	

Note: (a) Depending on room airflow and temperature variations. Lowest measurable powers are achieved by thermally quiet room conditions, using removable snout, averaging and offset subtraction.

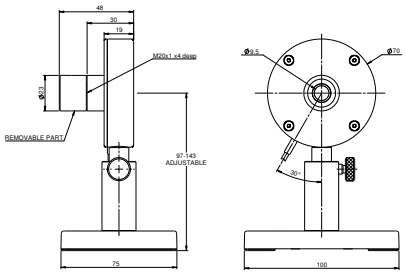
Note: (b) For P and PF types and shorter wavelengths derate maximum energy density as follows:

Wavelength	P type Derate to value	PF type Derate to value
1064nm	Not derated	Not derated
532nm	Not derated	Not derated
355nm	40% of stated value	70% of stated value
266nm	5% of stated value	15% of stated value
193nm	10% of stated value	5% of stated value

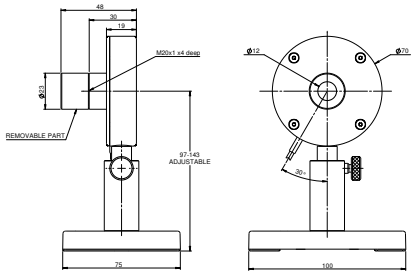
Note: (c) Calibrated from 193nm to 2.2µm and at 10.6µm. There is an additional error of +/-1% from 450nm to 650nm.

Note: (d) The 3A has a relatively large spectral variation in absorption and has a calibrated spectral curve at all wavelengths in its spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, the accuracy will be ±3% as above for 532nm, 905nm, 1064nm and 10.6µm but there will be an additional error of up to 3% at other wavelengths in the spectral range 190 – 3000nm.

3A



3A-P / 3A-PF-12



1.1.2.2 High Sensitivity Thermal Sensors

8µW to 3W

Features

- Very low noise and drift to measure very low powers and energies
- Broadband and P absorbers for CW and short pulses
- Up to 3W
- Version for Terahertz

3A-P-THz

3A-FS

3A-P-FS-12

Model	3A-P-THz	3A-FS	3A-P-FS-12
Use	**Calibrated for Terahertz radiation**	**With removable window**	**For divergent beams, window blocks infrared**
Absorber Type	P type	Broadband + F.S. window	P type + F.S. window
Spectral Range µm	0.3THz - 10THz	0.19 - 20 [b]	0.22 - 2.1
Aperture mm	Ø12mm	Ø9.5mm	Ø12mm
Maximum Beam Divergence	NA	NA	±40 degrees
Power Mode			
Power Range [f]	15µW - 3W	8µW - 3W	15µW - 3W
Power Scales	3W to 300µW	3W to 300µW	3W to 300µW
Power Noise Level	4µW [d]	2µW	6µW
Thermal Drift (30min) [a]	5 - 30µW	2 - 10µW	20 - 40µW
Maximum Average Power Density kW/cm²	0.05	1	0.05
Response Time with Meter (0-95%) typ. s	2.5	1.8	2.5
Power Accuracy +/-%	8 [c]	3	3
Linearity with Power +/-%	1.5	1.5	1.5
Energy Mode			
Energy Range	20µJ - 2J	15µJ - 2J	20µJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J to 200µJ
Minimum Energy	20µJ	15µJ	20µJ
Maximum Energy Density J/cm² [e]			
<100ns	1	0.3	1
0.5ms	1	1	1
2ms	1	2	1
10ms	1	4	1
Cooling	convection	convection	convection
Weight kg	0.2	0.2	0.15
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA
Version			
Part number	**7Z02742**	**7Z02628**	**7Z02687**

Note: (a) Depending on room airflow and temperature variations

Note: (b) Remove window for measurement beyond 2.2µm

Note: (c) 2 sigma standard lab traceable for >0.6THz. For 0.5THz and below add 4% to error

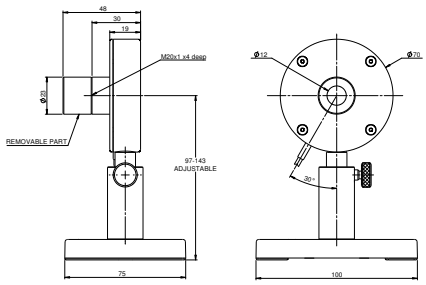
Note: (d) Back reflections from meter can sometimes cause interference effects with source. Unit should be tilted ~10° in this case

Note: (e) For P type and shorter wavelengths derate maximum energy density as follows:

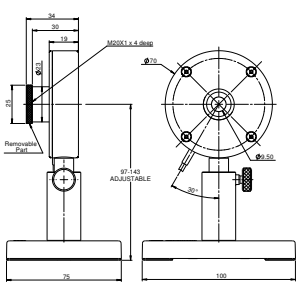
Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	5% of stated value
193nm	10% of stated value

Note: (f) Lowest measurable powers are achieved by thermally quiet room conditions, using removable snout, averaging and offset subtraction

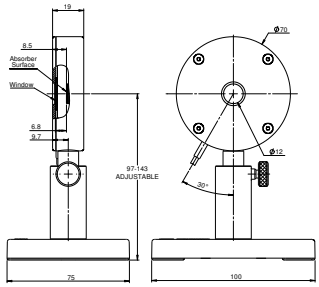
3A-P-THz



3A-FS



3A-P-FS-12



1.1.2.2 High Sensitivity Thermal Sensors

2mW to 12W

Features

- Very low noise and drift to measure very low powers and energies
- Broadband and P absorbers for CW and short pulses
- Up to 12W
- Spectrally flat

12A/ 12A-P

Model	**12A**	**12A-P**	
Use	**General purpose**	**Short pulses**	
Absorber Type	Broadband	P type	
Spectral Range µm	0.19 - 20	0.15 - 8	
Aperture mm	Ø16mm	Ø16mm	
Power Mode			
Power Range	2mW - 12W	2mW - 12W	
Power Scales	12W to 20mW	12W to 20mW	
Power Noise Level	50µW	50µW	
Thermal Drift (30min) [a]	40 - 150µW	40 - 150µW	
Maximum Average Power Density kW/cm²	25	0.05	
Response Time with Meter (0-95%) typ. s	2.5	3.5	
Power Accuracy +/-%	3	3	
Linearity with Power +/-%	1.5	1.5	
Energy Mode			
Energy Range	1mJ - 30J	1mJ - 30J	
Energy Scales [b]	30J to 30mJ	30J to 30mJ	
Minimum Energy mJ	1	1	
Maximum Energy Density J/cm² [c]			
Pulse rate:		Single	10 - 30Hz
<100ns	0.3	10	1
0.5ms	5	10	1
2ms	10	10	1
10ms	30	10	1
Cooling	convection	convection	
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	
Weight kg	0.35	0.35	
Version	V1		
Part number	**7Z02638**	**7Z02624**	

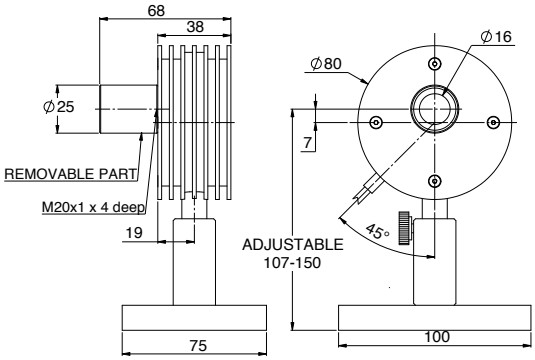
Notes: (a) Depending on room airflow and temperature variations

Notes: (b) For the 30mJ energy scale measurements it is recommended to use the screw on barrel supplied with the sensor to protect from direct air flow

Notes: (c) For P type and shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

12A/ 12A-P



1.1.2.3 Low Power Thermal Sensors

20mW to 50W

Features

- Convection air cooled
- Broadband absorber
- Ø16mm to Ø26mm apertures
- Fast response time

10A

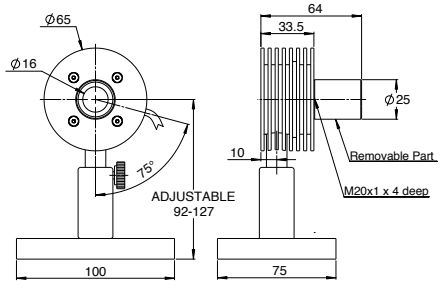
30A-BB-18

L30A-10MM

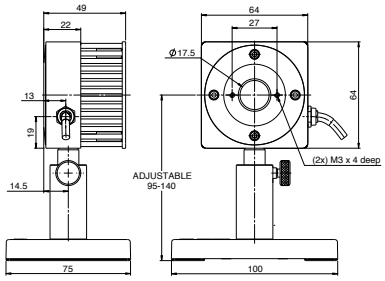
50(150)A-BB-26

Model	10A	30A-BB-18	L30A-10MM	50(150)A-BB-26
Use	**Low power**	**General purpose**	**Thin profile**	**General purpose**
Absorber Type	Broadband	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.15 - 20	0.19 - 20
Aperture mm	Ø16mm	Ø17.5mm	Ø26mm	Ø26mm
Power Mode				
Power Range	20mW - 10W	20mW - 30W	80mW - 30W	40mW - 150W
Maximum Power Intermittent	N.A.	N.A.	8W free standing, 30W heat sinked	150W for 1.5min, 100W for 2.2min, 50W continuous
Power Scales	10W / 5W / 0.5W	30W / 5W	30W / 3W	150W / 50W / 5W
Power Noise Level	1mW	1mW	4mW	2mW
Maximum Average Power Density kW/cm²	28	20 at 30W 28 at 10W	20 at 30W 28 at 10W	12 at 150W 17 at 50W
Response Time with Meter (0-95%) typ. s	0.8	0.8	1.5	1.5
Power Accuracy +/-%	3	3	3	3
Linearity with Power +/-%	1	1	1	1.5
Energy Mode				
Energy Range	6mJ - 2J	6mJ - 30J	20mJ - 60J	20mJ - 100J
Energy Scales	2J / 200mJ	30J / 3J / 300mJ	60J / 20J /2J / 200mJ	100J / 30J / 3J / 300mJ
Minimum Energy mJ	6	6	20	20
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.3	0.3
0.5ms	2	2	5	5
2ms	2	2	10	10
10ms	2	2	30	30
Cooling	convection	convection	convection / conduction	convection
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.2	0.3	0.1	0.3
Version	V1.1			
Part number: Standard Sensor	**7Z02637**	**7Z02692**	**7Z02273**	**7Z02696**
BeamTrack Sensor: Beam Position & Size (p. 65/66)	**7Z07904**			**7Z07900**

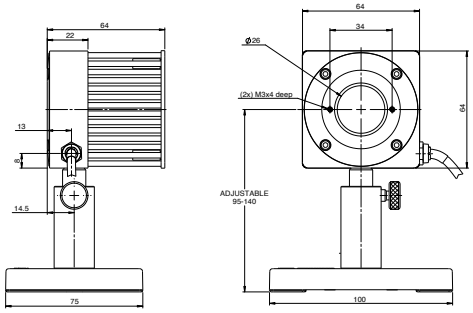
10A



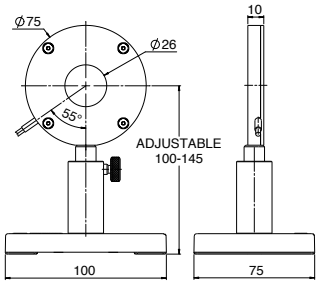
30A-BB-18



50(150)A-BB-26



L30A-10MM



1.1.2.3 Low Power Thermal Sensors

40mW to 50W

Features

- Convection air cooled
- P, PF and N type absorbers for short pulses
- Ø16mm to 17.5mm apertures

10A-P

30A-P-17

15(50)A-PF-DIF-18

50A-PF-DIF-18

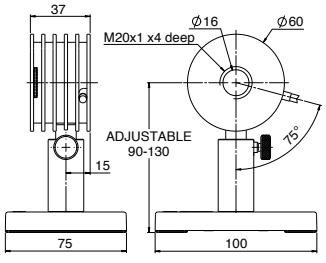
30A-N-18

Model	10A-P	30A-P-17	15(50)A-PF-DIF-18/ 50A-PF-DIF-18	30A-N-18
Use	**Short pulse to 10W**	**Short pulse to 30W**	**High energy density pulsed beams**	**High power density pulsed YAG**
Absorber Type	P type	P type	PF type + diffuser	N type
Spectral Range µm	0.15 - 8	0.15 - 8	0.24 - 2.2	0.532, 1.064
Aperture mm	Ø16mm	Ø17mm	Ø17.5mm	Ø17.5mm
Power Mode				
Power Range	40mW - 10W	60mW - 30W	140mW - 50W	60mW - 30W
Maximum Intermittent Power W	N.A.	N.A.	(for 15(50)A-PF-DIF-18 only) 50W for 5min, 15W continuous	N.A.
Power Scales	10W / 2W / 200mW and dBm	30W / 3W	50W / 5W	30W / 3W
Power Noise Level	2mW	3mW	7mW	3mW
Maximum Average Power Density kW/cm²	0.05	0.05	0.5	5
Response Time with Meter (0-95%) typ. s	3.5	2.5	2	2
Power Accuracy +/-%	3	3	5	3
Linearity with Power +/-%	1.5	1.5	1.5	1
Energy Mode				
Energy Range	10mJ - 10J	40mJ - 30J	60mJ - 200J	30mJ - 200J
Energy Scales	10J / 2J / 200mJ	30J / 3J	200J / 30J / 3J	200J / 30J / 3J
Minimum Energy mJ	10	40	60	30
Maximum Energy Density J/cm² (a)				
Pulse rate:	Single 10 - 30Hz	Single 10 - 30Hz	10 - 50Hz	10 - 50Hz
<1µs	10 1	10 1	4	1
0.5ms	10 1	10 1	15	20
5ms	10 1	10 1	50	>100
Cooling	convection	convection	convection	convection
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.2	0.3	0.35	0.3
Version	V3			
Part number	**7Z02649**	**7Z02693**	**7Z02740/ 7Z02738**	**7Z02695**

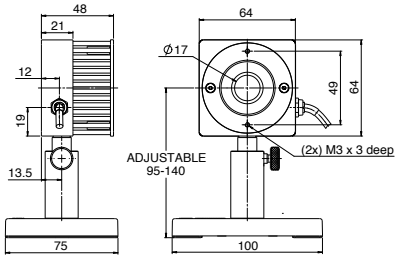
Note: (a) For shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value	Wavelength	Derate to value
1064nm	Not derated	1064nm	Not derated
532nm	Not derated	532nm	80% of stated value
355nm	40% of stated value	355nm	60% of stated value
266nm	10% of stated value	266nm	40% of stated value
193nm	10% of stated value	193nm	N.A.

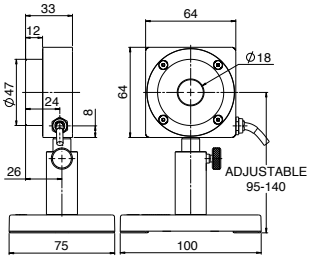
10A-P



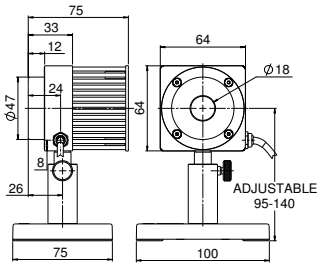
30A-P-17



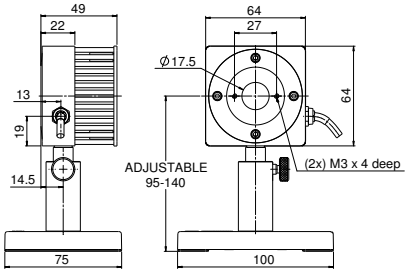
15(50)A-PF-DIF-18



50A-PF-DIF-18



30A-N-18



1.1.2.4 Low - Medium Power Thermal Sensors - Apertures to 35mm

30mW to 150W

Features

- Convection air cooled
- CW to 30W or 50W, intermittent to 150W
- Ø17.5mm and Ø35mm apertures

30(150)A-BB-18
30(150)A-LP1-18

L50(150)A-BB-35
L50(150)A-LP1-35
L50(150)A-PF-35

Model	**30(150)A-BB-18**	**30(150)A-LP1-18**	**L50(150)A-BB-35**	**L50(150)A-LP1-35**	**L50(150)A-PF-35**
Use	**General purpose**	**High power density and long pulse lasers**	**General purpose**	**High power density and long pulse lasers**	**Short pulse lasers**
Absorber Type	Broadband	LP1	Broadband	LP1	PF
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.19 - 20	0.25 - 2.2	0.15-20
Aperture mm	Ø17.5mm	Ø17.5mm	Ø35mm	Ø35mm	Ø35mm
Power Mode					
Power Range	30mW - 150W	30mW - 150W	100mW - 150W	100mW - 150W	100mW - 150W
Maximum Intermittent Power W	150W for 1.5min, 100W for 2.2min, 30W continuous		150W for 1.5min, 100W for 2.5min, 50W continuous		
Power Scales	150W / 30W / 3W	150W / 30W / 3W	150W / 50W / 5W	150W / 50W / 5W	150W / 50W /5W
Power Noise Level	2mW	2mW	4mW	4mW	4mW
Maximum Average Power Density kW/cm²	12 at 150W 20 at 30W	38 at 150W 97 at 30W	12 at 150W 17 at 50W	38 at 150W 75 at 50W	3
Response Time with Meter (0-95%) typ. s	1.2	1.2	2	2	2
Power Accuracy +/-%	3	3 [(a)]	3	3 [(a)]	4 [(b)]
Linearity with Power +/-%	1	1	1	1	1
Energy Mode					
Energy Range	20mJ - 100J	20mJ - 300J	40mJ - 300J	40mJ - 300J	50mJ - 300J
Energy Scales	100J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J	300J / 30J / 3J
Minimum Energy mJ	20	20	40	40	50
Maximum Energy Density J/cm²					Single [(c)] 10-50Hz [(c)]
<100ns	0.3	0.05	0.3	0.05	3 [(d)] 1.5
0.5ms	5	20	5	20	7 7
2ms	10	50	10	50	15 15
10ms	30	250	30	250	40 40
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight kg	0.3	0.3	0.35	0.35	0.35
Version					
Part number	**7Z02699**	**7Z02721S**	**7Z02730**	**7Z02726S**	**7Z02737**

Note:

(a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

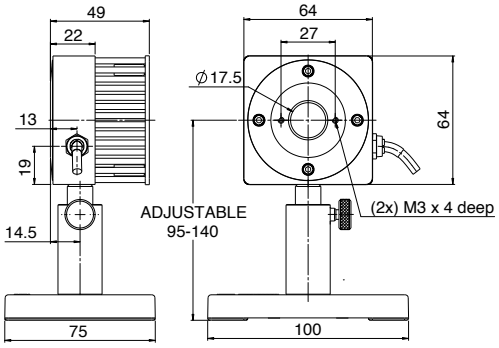
(b) Calibrated for 0.25 – 2µm, 10.6µm

(c) For 10-50Hz, derate as follows:

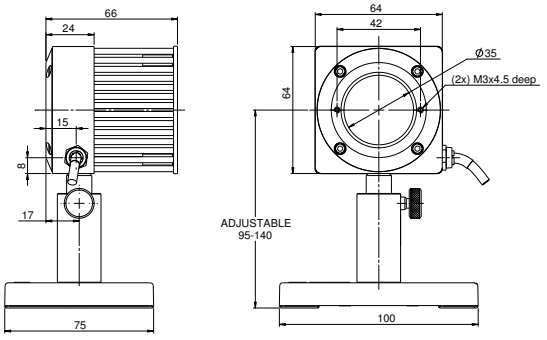
Wavelength	Derate to value
1064nm	Not derated
532n	Not derated
355n	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(d) Damage threshold 1.5J/cm² for wavelengths <500nm

30(150)A-BB-18 / 30(150)A-LP1-18



L50(150)A-BB-35 / L50(150)A-LP1-35 / L50(150)A-PF-35



1.1.2.4 Low - Medium Power Thermal Sensors - Apertures to 17mm

50mW to 150W

Features

- Special purpose SV and HE absorbers
- For concentrated beams and pulses
- Convection air cooled
- CW to 30W, intermittent to 150W
- Ø17mm aperture

30(150)A-SV-17 / 30(150)A-HE-17

30(150)A-HE-DIF-17

Diffuser installed

Diffuser off

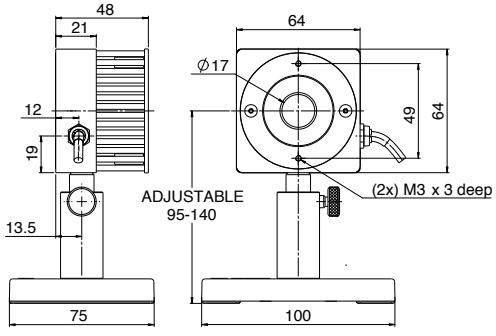
Model	**30(150)A-SV-17**			**30(150)A-HE-17**			**30(150)A-HE-DIF-17**		
Use	**High power and energy density**			**High energy and average power pulsed lasers**			**Concentrated beam pulsed lasers - has removable diffuser**		
Absorber Type	SV			HE			HE		
Spectral Range µm	0.19 - 12			0.19 - 0.625, 1.064, 2.1, 2.94			0.19 - 3 except for 0.625 - 0.9 (b)		
Aperture mm	Ø17mm			Ø17mm			Ø17mm		
Power Mode									
Power Range	100mW - 150W			50mW - 150W			50mW - 150W		
Maximum Intermittent Power W	150W for 1.5min, 100W for 2.2min, 30W continuous								
Power Scales	150W / 30W / 3W			150W / 30W / 3W			150W / 30W / 3W		
Power Noise Level	5mW			3mW			3mW		
Maximum Average Power Density kW/cm²	60 at 150W			0.5			0.5		
Response Time with Meter (0-95%) typ. s	1.7			3.8			3.8		
Power Accuracy +/-%	3			3			5 (b)		
Linearity with Power +/-%	1			1.5			1.5		
Energy Mode									
Energy Range	50mJ - 300J			60mJ - 200J			60mJ - 200J		
Energy Scales	300J / 30J / 3J			200J / 30J / 3J			200J / 30J / 3J		
Minimum Energy mJ	50			60			60		
Maximum Energy Density J/cm²	Pulse width (a)	Single	10-50Hz	Pulse width (a)	Single	10-50Hz	Pulse width <100ns, 10 - 50Hz		
							Wavelength	DIF IN	DIF OUT
	<100ns	1	1	<100ns	5	2	1064nm	5	2
	0.5ms	20	20	0.5ms	100	25	532nm	4	2
	2ms	50	50	2ms	150	40	355nm	1.5	1
Cooling	convection / ballistic			convection / ballistic			convection / ballistic		
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC			ST, FC, SMA, SC			NA		
Weight kg	0.3			0.3			0.4		
Version									
Part number	**7Z02724**			**7Z02722**			**7Z02729**		

Notes:

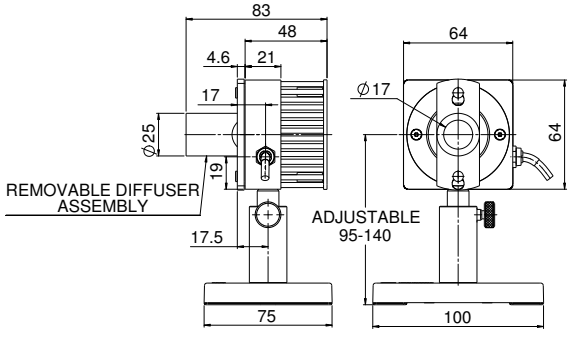
(a) At 1064nm. For shorter wavelengths derate maximum energy density to:
355nm 50% of above values
266nm 50% of above values
193nm 10% of above values

(b) With diffuser in, sensor is only calibrated for 1064, 532 and 355nm wavelengths.

30(150)A-SV-17 / 30(150)A-HE-17



30(150)A-HE-DIF-17



1.1.2.4 Low - Medium Power Thermal Sensors – Apertures to 26mm

Standard OEM Smart Sensors

10mW to 150W

Features

- Sensors come with threaded holes for mounting to host system
- Compact
- Up to 150W
- Ø12 to Ø26mm

20C-SH

L30-C-SH / L30C-LP1-26-SH

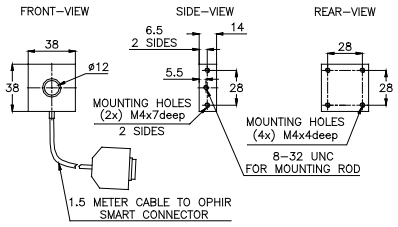
100C-SH

150C-SH

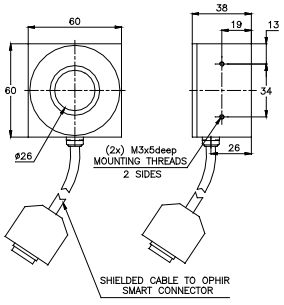
Model	20C-SH	L30C-SH	L30C-LP1-26-SH	100C-SH	150C-SH / 150W-SH
Use	**Compact**	**Larger aperture**	**High pulse energy and intermittent power**	**Slim profile**	**Compact higher power**
Absorber Type	Broadband	Broadband	LP1	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.25 – 2.2	0.19 - 20	0.19 - 20
Aperture mm	Ø12	Ø26	Ø26	Ø18	Ø18
Power Mode					
Minimum power	10mW	80mW	80mW	60mW	60mW / 100mW
Maximum power free standing	4W continuous,	10W continuous,	10W continuous,	4W	5W continuous,
	20W for 1.8min	50W for 4min	100W for 2min		150W for 1min
heat sinked	20W	50W	100W	100W	60W cond. / 150W water
Power Scales	20W / 3W	50W / 5W	100W / 10W	100W / 30W / 3W	150W / 30W
Power Noise Level	0.2mW	4mW	4mW	3mW	3mW / 5mW
Maximum Average Power Density kW/cm²	23 at 20W 35 , at 4W	17 at 50W, 28 at 10W	40 at 100W	30 at 4W, 14 at 100W	30 at 5W, 20 at 60W / 12 at 150W
Response Time with Meter (0-95%), typ. s	0.8	1.5	1.5	1.2	1.2
Power Accuracy +/-%	3	3	3	3	3
Linearity with Power +/-%	1	1	2	1	1
Energy Mode					
Energy Range	6mJ-10J	30mJ-30J	30mJ-2000J	NA	20mJ-100J / 50mJ-100J
Energy Scales	10J / 1J	30J / 3J / 300mJ	2kJ / 300J / 30J / 3J / 300mJ	NA	100J / 30J / 3J
Minimum Energy mJ	6	30	30	NA	20
Maximum Energy Density J/cm²					
<100ns	0.3	0.3	0.05	0.3	0.3
0.5ms	2	5	20	5	5
2ms	2	10	50	10	10
10ms	2	30	250	30	30
Cooling	Conduction	Conduction	Conduction	Conduction	Conduction / Water
Weight kg	0.2	0.3	0.3	0.2	0.3
Version					
Part number	**7Z02602**	**773434**	**7Z02766S**	**7Z02680**	**7N77023 [a] / 771001**

Notes: (a) P/N 7N77023 replaces P/N 77023

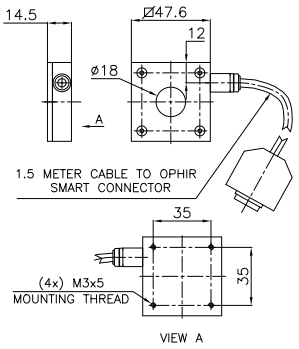
20C-SH



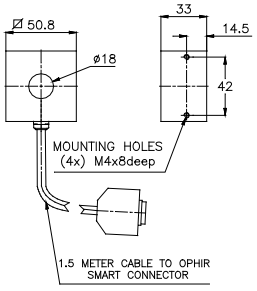
L30-C-SH / L30C-LP1-26-SH



100C-SH



150C-SH



1.1.2.5 Medium Power Large Aperture Thermal Sensors - Apertures 50mm

100mW to 150W

Features

- Thin profile
- CW to 35W or 50W, intermittent to 150W
- Pulse energies up to 4000 Joules
- For continuous, long pulse and Excimer lasers. For measuring high power lasers by exposure to <1s pulses

L40(150)A / L40(150)A -LP1

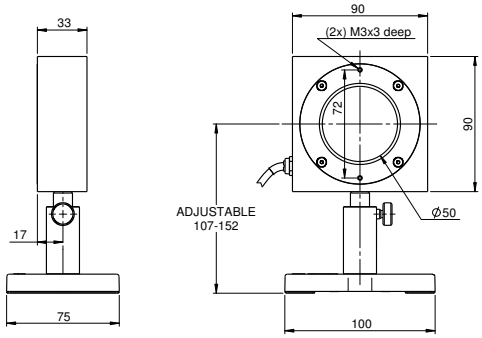
L40(150)A -EX

L50(150)A

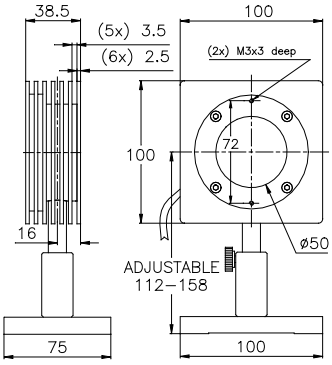
Model	L40(150)A	L40(150)A-LP1	L40(150)A-EX	L50(150)A
Use	**General purpose**	**Long pulse lasers**	**Excimer lasers**	**General purpose**
Absorber Type	Broadband	LP1	EX	Broadband
Spectral Range µm	0.19 - 20	0.25 - 2.2, 2.94	0.15 - 0.7, 10.6	0.19 - 20
Aperture mm	Ø50mm	Ø50mm	Ø50 mm	Ø50mm
Power Mode				
Power Range	100mW - 150W	100mW - 150W	100mW - 150W	100mW - 150W
Maximum Intermittent Power	150W for 3min, 80W for 5.5min, 35W continuous			150W for 4min, 100W for 6min, 50W continuous
Power Scales	150W / 20W	150W / 20W	150W / 20W	150W / 20W
Power Noise Level	5mW	10mW	5mW	5mW
Maximum Average Power Density kW/cm²	12 at 150W 20 at 35W	38 at 150W 90 at 35W	2	12 at 150W 17 at 50W
Response Time with Meter (0-95%) typ. s	2.5	2.5	2.5	2.5
Power Accuracy +/-%	3	3 [(a)]	3	3
Linearity with Power +/-%	1	1	1	1
Energy Mode				
Energy Range	100mJ - 4000J	100mJ - 4000J	100mJ - 200J	100mJ - 4000J
Energy Scales	4kJ / 400J / 40J / 4J	4kJ / 400J / 40J / 4J	200J / 30J / 3J	4kJ / 400J / 40J / 4J
Minimum Energy mJ	100	100	100	100
Maximum Energy Density J/cm²				
<100ns	0.3	0.05	0.5	0.3
1µs	0.4	0.3	0.6	0.4
0.5ms	5	20	6	5
2ms	10	50	12	10
10ms	30	250	25	30
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.6	0.6	0.6	0.6
Version	V2	V2	V1	
Part number	**7Z02626**	**7Z02685S**	**7Z02614**	**7Z02633**

Notes: (a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2940nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

L40(150)A / L40(150)A -LP1 / L40(150)A -EX



L50(150)A



1.1.2.5 Medium Power Large Aperture Thermal Sensors - Apertures 65mm

400mW to 300W

Features

- Thin profile, very large aperture
- CW to 50W, intermittent to 300W
- Ø65mm aperture
- IPL version for IPL medical light sources

L50(300)A / L50(300)A-LP1 / L50(300)A-PF-65

L50(300)A-IPL

Model	**L50(300)A**	**L50(300)A-LP1**	**L50(300)A-PF-65**	**L50(300)A-IPL**
Use	**General purpose**	**Long pulse lasers**	**Large beam short pulsed lasers**	**Intense pulsed light sources**
Absorber Type	Broadband	LP1	PF type	LP1 + coated window [b]
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.15 - 20	0.5 - 1.1
Aperture mm	Ø65mm	Ø65mm	Ø65mm	Ø65mm
Power Mode				
Power Range	400mW - 300W	400mW - 300W	400mW - 300W	400mW - 300W
Maximum Intermittent Power		300W for 2min, 150W for 4.5min, 50W continuous		
Power Scales	300W / 30W	300W / 30W	300W / 30W	300W / 30W
Power Noise Level	20mW	20mW	20mW	20mW
Maximum Average Power Density kW/cm²	9.5 at 300W 17 at 50W	23 at 300W 75 at 50W	3	20
Response Time with Meter (0-95%) typ. s	3	3	3	3
Power Accuracy +/-%	3	3 [a]	4 [c]	6 for most gel or air coupled IPL sources
Linearity with Power +/-%	1	1	1	1
Energy Mode				
Energy Range	200mJ - 300J	200mJ - 300J	200mJ - 300J	120mJ - 300J
Energy Scales	300J / 60J / 6J	300J / 60J / 6J	300J / 60J / 6J	300J / 60J / 6J
Minimum Energy mJ	200	200	200	120
Maximum Energy Density J/cm²			Single [d] 10-50Hz [d]	
<100ns	0.3	0.05	3 [e] 1.5	0.05
1µs	0.4	0.3	3 [e] 1.5	0.3
0.5ms	5	20	7 7	20
2ms	10	40	15 15	40
10ms	30	100	40 40	100
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Weight kg	0.9	0.9	0.9	1.0
Version		V1		
Part number	**7Z02658**	**7Z02641S**	**7Z02743**	**7Z02651**

Notes:

(a) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

(c) Calibrated for 0.25 – 2µm, 10.6µm

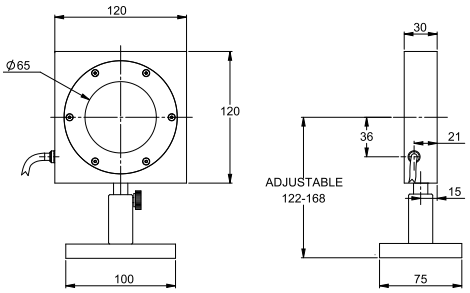
(d) For 10-50Hz, derate as follows:

Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(e) Damage threshold 1.5J/cm2 for wavelengths <500nm

(b) Sensor has a window for gel coupled IPL sources where IPL source is coupled to window with gel or water for measurement. Can also measure air coupled IPLs

L50(300)A / L50(300)A-LP1 / L50(300)A-PF-65 / L50(300)A-IPL



1.1.2.6 Medium-High Power Fan Cooled Thermal Sensors

50mW to 250W

Features

- General purpose and high damage threshold
- Fan cooled
- Up to 250W
- Ø26mm to Ø35mm apertures

F100A-PF-DIF-33

F150A-BB-26

FL250A-BB-35 / FL250A-LP1-35

FL250A-LP1-DIF-33

Model	F100A-PF-DIF-33	F150A-BB-26	FL250A-BB-35	FL250A-LP1-35	FL250A-LP1-DIF-33
Use	**Short pulse lasers**	**General purpose**	**General purpose**	**High power density and long pulse lasers**	**Diffuser for highest energy densities**
Absorber Type	PF type + diffuser	Broadband	Broadband	LP1	LP1 + diffuser
Spectral Range µm	0.24-2.2	0.19 - 20	0.19 - 20	0.25 - 2.2	0.4 - 3
Aperture mm	Ø33mm	Ø26mm	Ø35mm	Ø35mm	Ø33mm
Power Mode					
Power Range (d)	50mW - 100W	50mW - 150W	150mW - 250W	150mW - 250W	400mW - 250W
Power Scales	100W / 30W / 3W	150W / 30W / 3W	250W / 30W	250W / 30W	250W / 30W
Power Noise Level (d)	6mW	3mW	15mW	15mW	20mW (e)
Maximum Average Power Density kW/cm²	0.5	12 at 150W 17 at 50W	10 at 250W 12 at 150W	27 at 250W 39 at 150W	2
Response Time with Meter (0-95%) typ. s	2.5	1.5	2	2	2.5
Power Accuracy +/-%	5	3	3	3 (c)	3 (b)
Linearity with Power +/-%	1.5	1	1	1	1.5
Energy Mode					
Energy Range	60mJ - 200J	20mJ - 100J	50mJ - 300J	50mJ - 300J	400mJ - 600J
Energy Scales	200J / 30J / 3J	100J / 30J / 3J / 300mJ	300J / 30J / 3J	300J / 30J / 3J	600J / 60J
Minimum Energy mJ (d)	60	20	50	50	400
Maximum Energy Density J/cm²					
<100ns	4 (a)	0.3	0.3	0.05	0.5
0.5ms	15 (a)	5	5	20	200
2ms	35 (a)	10	10	50	400
10ms	50 (a)	30	30	250	1000
Cooling	fan	fan	fan	fan	fan
Fiber Adapters Available (see page 69)	NA	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	NA
Weight kg	0.8	0.35	0.4	0.4	0.45
Version					
Part number: Standard Sensor	**7Z02744**	**7Z02727**	**7Z02728**	**7Z02731S**	**7Z02733**
BeamTrack Sensor: Beam Position & Size (p. 66)		**7Z07901**			

Notes: (a) For shorter wavelengths derate maximum energy density as follows:

Wavelength	Derate to value
1064nm	not derated
532nm	80% of stated value
355nm	60% of stated value
266nm	40% of stated value
193nm	NA

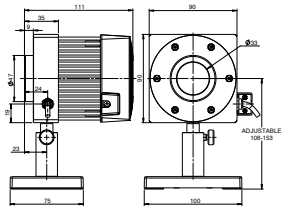
Notes: (b) at calibrated wavelengths 532nm, 755nm, 1064nm and 2940nm only

Notes: (e) When sensor is hot, there can be large zero offset up to 300mW

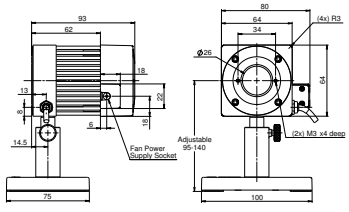
Notes: (c) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

Notes: (d) For lower powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

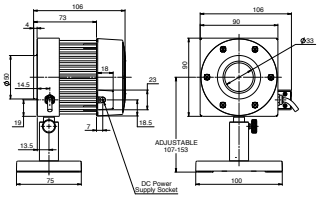
F100A-PF-DIF-33



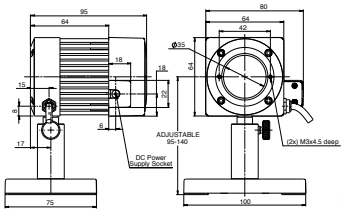
F150A-BB-26



FL250A-LP1-DIF-33



FL250A-BB-35 / FL250A-LP1-35



1.1.2.6 Medium-High Power Fan Cooled Thermal Sensors

150mW to 500W

Features

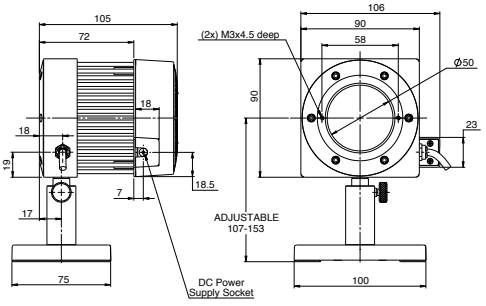
- High powers and energies, large apertures
- Fan cooled
- Up to 500W
- Ø50mm aperture

FL250A-BB-50 / FL400A-BB-50 / FL400A-LP1-50

Model	FL250A-BB-50	FL400A-BB-50	FL400A-LP1-50
Use	**General purpose**	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	Broadband	LP1
Spectral Range µm	0.19 - 20	0.19 - 20	0.35 - 2.2, 10.6
Aperture mm	Ø50mm	Ø50mm	Ø50mm
Power Mode			
Power Range [a]	150mW - 250W	300mW - 500W	300mW - 500W
Maximum Intermittent Power	NA	500W for 1 min, 400W continuous	500W for 1 min, 400W continuous
Power Scales	250W / 30W	500W / 50W	500W / 50W
Power Noise Level [a]	10mW	40mW	40mW
Maximum Average Power Density kW/cm²	10 at 250W 12 at 150W	8.5 at 400W 12 at 150W	19 at 400W 38 at 150W
Response Time with Meter (0-95%) typ. s	2.5	2.8	2.8
Power Accuracy +/-%	3	3	3 [b]
Linearity with Power +/-%	1	1.5	1.5
Energy Mode			
Energy Range	80mJ - 300J	75mJ - 600J	75mJ - 600J
Energy Scales	300J / 30J / 3J	600J / 60J / 6J	600J / 60J / 6J
Minimum Energy mJ [a]	80	75	75
Maximum Energy Density J/cm²			
<100ns	0.3	0.3	0.05
1µs	0.4	0.4	0.3
0.5ms	5	5	20
2ms	10	10	50
10ms	30	30	200
Cooling	fan	fan	fan
Fiber Adapters Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight kg	0.8	0.9	0.9
Version			
Part number: Standard Sensor	**7Z02739**	**7Z02734**	**7Z02749S**
BeamTrack Sensor: Beam Position & Size (p. 67)	**7Z07902**		

Notes: (a) For lower powers up to 50W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.
Notes: (b) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. This LP1 sensor is calibrated for 1.06µm and 10.6µm. Nova, Orion and LaserStar meters do not support the spectral curve feature and when used with those meters, accuracy will be ±3% for 1.06µm and 10.6µm, and ±6% for other wavelengths in the spectral range 600 – 1100nm.

FL250A-BB-50 / FL400A-BB-50 / FL400A-LP1-50



1.1.2.6 Medium-High Power Fan Cooled Thermal Sensors

600mW to 1100W

Features

- High powers and energies, large apertures
- Fan cooled
- Up to 1100W
- Ø65mm aperture

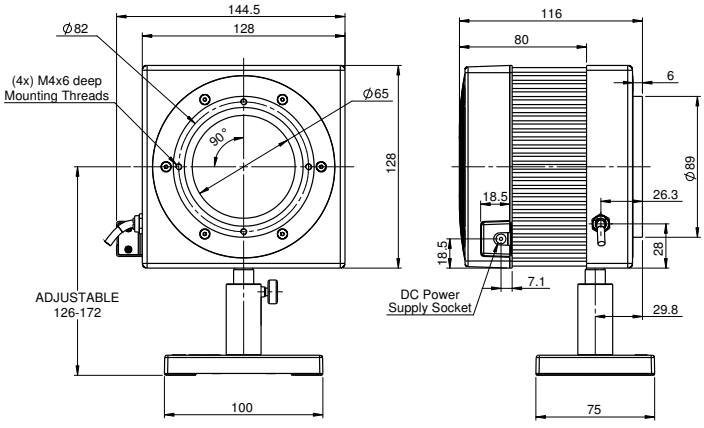
FL600A-BB-65/ FL600A-LP1-65/ FL1100A-BB-65

Model	FL600A-BB-65	FL600A-LP1-65	FL1100A-BB-65
Use	**General purpose**	**Long pulses**	**Highest power fan cooled**
Absorber Type	Broadband	LP1	Broadband
Spectral Range µm	0.19 - 20	0.35 – 2.2	0.19 - 20
Aperture mm	Ø65mm	Ø65mm	Ø65mm
Power Mode			
Power Range [a]	600mW - 600W	1W - 600W	600mW - 1100W
Power Scales	600W / 60W	600W / 60W	1100W / 500W / 50W
Power Noise Level [a]	50mW	60mW	100mW
Maximum Average Power Density kW/cm²	12 at 150W 7 at 600W	39 at 150W 11 at 600W	8 at 500W 5.5 at 1100W
Response Time with Display (0-95%) typ. s	3.2	3.2	3.2
Power Accuracy +/-%	3	3 [b]	3
Linearity with Power +/-%	1.5	1.5	1.5
Energy Mode			
Energy Range	250mJ - 600J	300mJ - 600J	250mJ - 600J
Energy Scales	600J / 60J / 6J	600J / 60J / 6J	600J / 60J / 6J
Minimum Energy mJ [a]	250	300	250
Maximum Energy Density J/cm²			
<100ns	0.3	0.05	0.3
1µs	0.4	0.3	0.4
0.5ms	5	15	5
2ms	10	40	10
10ms	30	200	30
Cooling	fan	fan	fan
Fiber Adapters	Consult Ophir representative	Consult Ophir representative	Consult Ophir representative
Weight kg	2.4	2.4	2.4
Version			
Part Number	**7Z02762**	**7Z02763S**	**7Z02761**

Notes: (a) For lower powers up to 50W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

Notes: (b) LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when this LP1 sensor is used with those meters, accuracy will be ±3% for 532nm, 808nm, 1064nm and 2100nm and ±6% for other wavelengths in the spectral range 400 – 1100nm.

FL600A-BB-65/ FL600A-LP1-65/ FL1100A-BB-65



1.1.2.7 High Power Thermal Sensors

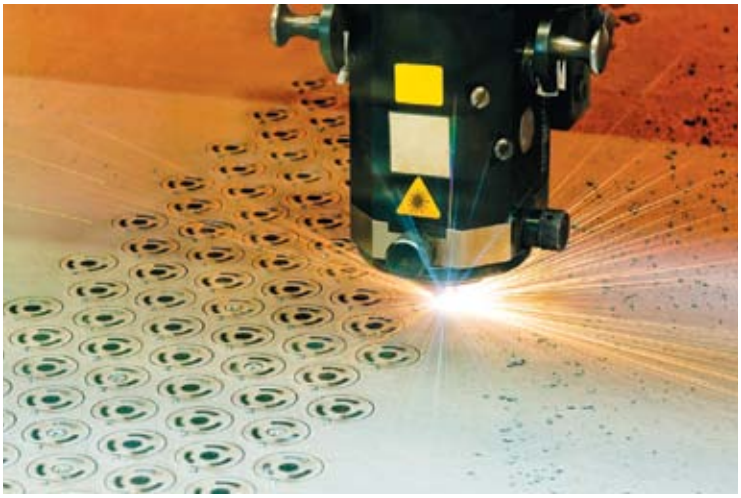
1.1.2.7.1 Introduction

1W to 120kW

Introduction to High Power Water Cooled Sensors

Ophir has many years experience in supplying measurement systems for high power industrial lasers and has the highest power measuring equipment available on the market – up to 100 kilowatts. Ophir meters also have the highest damage threshold available – up to 10kW/cm^2 at full power. Ophir supplies water cooled sensors from 300W up to 120kW and air cooled sensors up to 500W.
All sensors supplied by Ophir have been tested at up to full power and their linearity verified over the entire power range. This is done deflecting a fraction of the power with a beam splitter into a lower power sensor whose linearity has previously been verified by NIST or PTB. In some cases, it is done by measuring the reading over the power range against a higher power sensor that has been previously measured.
The accuracy, linearity and damage specifications have been carefully verified over many years of development and use by the largest existing user base.
In addition to power meters for high powers, Ophir also has beam profilers, beam dumps and protective enclosures for industrial lasers.

Calibration Method and Estimated Accuracy for Ophir High Power Sensors



Ophir models 5000W, 10K-W, Comet 10K and 30K-W are calibrated using relatively low power lasers not exceeding 1000W. Using laser powers that are in many cases much lower than the power rating of the sensors being calibrated raises the question of calibration accuracy. The following explanation clearly demonstrates that these highest power sensors are indeed accurate to ±5% over their measurement range as specified. The 5000W, 10K-W and 30K-W sensors work on the thermopile principle, where the radial heat flow in the absorber disk causes a temperature difference between the hot and cold junctions of the thermopile which in turn causes a voltage difference across the thermopile. Since the instrument is a thermopile voltage generating device, it must be linear at low values of output. Therefore, if it has been shown to be linear up to full power – as it has - it will necessarily be linear at very low powers and if the calibration is correct at low powers, it will remain correct at high powers as well. On the other hand, although the output may be linear at low powers, there may be a zero offset that, due to the relatively low output at low powers, will cause an error in calibration.
For example, if calibration is performed at 200W and the output of the sensor is 10µV/W (a typical value) and there is a zero offset of only 1µV, this will cause a calibration error of 10%.

Ophir's calibration method always measures the difference between the reading with power applied and without power applied, thus eliminating error due to zero offset. This measurement is taken several times to insure accuracy. The above measurement method assures that the calibration inaccuracy due to measurement errors is less than 1%, comparable to the expected errors in our lower powered sensors. In order to verify this, all of our high power sensors have been measured by comparison to various calibration standards. These measurements have shown Ophir sensors to be well within the claimed limits of linearity.

The Comet 10K series measures the heat rise of the absorbing puck when irradiated by the laser for 10s. In order to calibrate the Comet 10K, we simply irradiate with a lower power laser for longer e.g. 150W for 60s. Thus the heating effect is similar to that of a higher power laser. Tests of the Comet calibrated by this method vs. NIST traceable high power sensors has shown that it is accurate and reproducible.
For more information on calibration please consult our website at
www.ophiropt.com/calibration-procedure/tutorial

1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water Cooled Thermal Sensors

1W to 300W

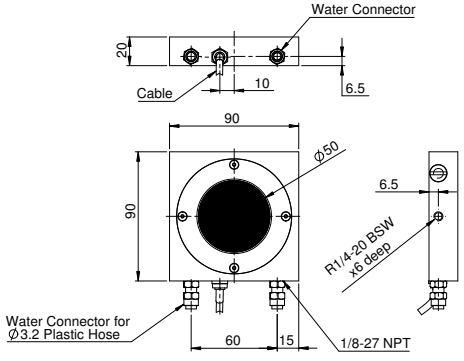
Features

- High powers
- Water cooled
- Up to 300W
- Ø50mm aperture

L250W / L300W-LP1-50

Model	L250W	L300W-LP1-50
Use	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP1
Spectral Range µm	0.19 - 20	0.35-2.2, 10.6
Aperture mm	Ø50mm	Ø50mm
Power Mode		
Power Range	1W - 250W	1W - 300W
Power Scales	250W / 30W	300W / 30W
Power Noise Level	50mW	50mW
Maximum Average Power Density kW/cm²	10 at 250W 14 at 100W	23 at 300W 38 at 150W
Response Time with Meter (0-95%) typ. s	2.5	2.5
Power Accuracy +/-%	3	3 (a)
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	120mJ - 200J	200mJ - 300J
Energy Scales	200J / 30J / 3J	300J / 30J / 3J
Minimum Energy mJ	120	200
Maximum Energy Density J/cm²		
<100ns	0.3	0.05
1µs	0.4	0.3
0.5ms	5	20
2ms	10	50
10ms	30	200
Cooling	water	water
Minimum Water Flow Rate at Full Power	1 liter/min (b)	1 liter/min (b)
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Weight kg	0.6	0.6
Version		
Part number	**7Z02688**	**7Z02748S**
Notes: (a)	Calibrated for 1.064µm and 10.6µm. LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be ±3% for 1.06µm and 10.6µm, and ±6% for other wavelengths in the spectral range 600-1100nm.	
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	

L250W / L300W-LP1-50



1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water Cooled Thermal Sensors

5W to 1000W

Features

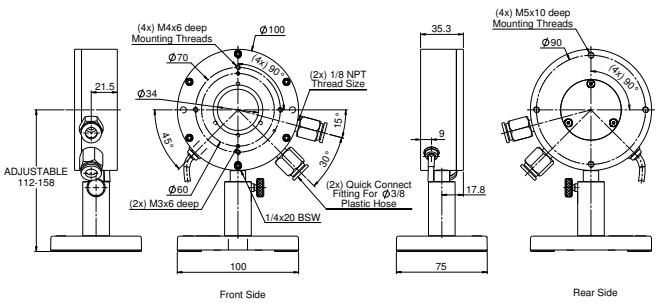
- High powers
- Water cooled
- Up to 1000W
- Ø34mm aperture
- 1000WP for noncontaminating water flow

1000W-BB-34 / 1000W-LP1-34

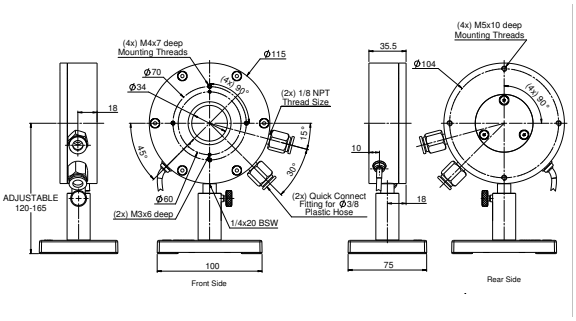
1000WP-BB-34

Model	1000W-BB-34 / 1000WP-BB-34	1000W-LP1-34
Use	**General purpose / Controlled materials in contact with water flow [d]**	**High power densities and long pulses**
Absorber Type	Broadband	LP1
Spectral Range µm	0.19 - 20	0.35-2.2, 10.6
Aperture mm	Ø34mm	Ø34mm
Power Mode		
Power Range	5W - 1000W	5W - 1000W
Power Scales	1000W / 200W	1000W / 200W
Power Noise Level	200mW	200mW
Maximum Average Power Density kW/cm²	8 at 500W 6 at 1000W	14 at 500W 6 at 1000W
Response Time with Meter (0-95%) typ. s	2.5	2.5
Power Accuracy +/-%	3 [a]	3 [a, c]
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	400mJ - 300J	400mJ - 300J
Energy Scales	300J / 30J	300J / 30J
Minimum Energy mJ	400mJ	400mJ
Maximum Energy Density J/cm²		
<100ns	0.3	0.05
1µs	0.4	0.3
0.5ms	5	20
2ms	10	50
10ms	30	200
Cooling	water	water
Minimum Water Flow Rate at Full Power	1.8 liter/min [b]	1.8 liter/min [b]
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Weight kg	0.8 / 0.9	0.8
Version	V3 / NA	
Part number: Standard Sensor	**7Z02750 / 7Z02753**	**7Z02758S**
BeamTrack Sensor: Beam Position & Size (p. 59)	**7Z07936**	
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	Calibrated for ~0.8µm, 1.064µm and 10.6µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	
Notes: (c)	LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be the stated accuracy for 1.06µm, 10.6µm, 0.8µm and an additional ±3% for other wavelengths in the spectral range 600 – 1100nm.	
Notes: (d)	The 1000WP-BB-34 has a nylon rear housing and nothing but nylon and copper in contact with the water flow. This prevents contamination of the water flow with aluminum and prevents the possibility of corrosion.	

1000W-BB-34 / 1000W-LP1-34



1000WP-BB-34



1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water Cooled Thermal Sensors

15W to 1500W

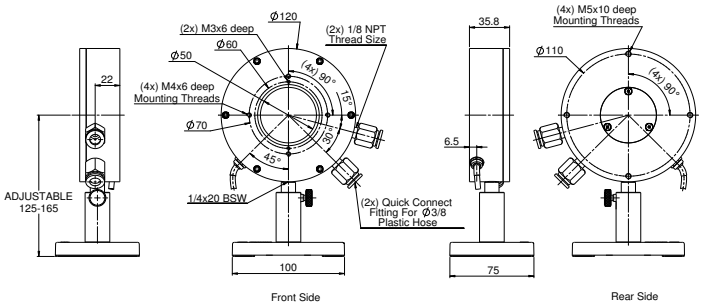
Features

- High powers
- Water cooled
- Up to 1500W
- Ø50mm aperture

L1500W-BB-50 / L1500W-LP1-50

Model	**L1500W-BB-50**	**L1500W-LP1-50**
Use	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP1
Spectral Range µm	0.19 - 20	0.35-2.2, 10.6
Aperture mm	Ø50mm	Ø50mm
Power Mode		
Power Range	15W - 1500W	15W - 1500W
Power Scales	1500W / 300W	1500W / 300W
Power Noise Level	700mW	700mW
Maximum Average Power Density kW/cm²	8 at 500W 4 at 1500W	14 at 500W 3.5 at 1500W
Response Time with Meter (0-95%) typ. s	2.7	2.7
Power Accuracy +/-%	4 (a)	4 (a, c)
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	500mJ - 200J	500mJ - 200J
Energy Scales	200J / 20J	200J / 20J
Minimum Energy mJ	500mJ	500mJ
Maximum Energy Density J/cm²		
<100ns	0.3	0.05
1µs	0.4	0.3
0.5ms	5	20
2ms	10	50
10ms	30	200
Cooling	water	water
Minimum Water Flow Rate at Full Power	2.5 liter/min (b)	2.5 liter/min (b)
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Weight kg	1.2	1.2
Version	V2	
Part number	**7Z02752**	**7Z02759S**
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	Calibrated for ~0.8µm, 1.064µm and 10.6µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	
Notes: (c)	LP1 sensors have relatively large spectral variation in absorption and have a calibrated spectral curve at all wavelengths in their spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, accuracy will be the stated accuracy for 1.06µm, 10.6µm, 0.8µm and an additional ±3% for other wavelengths in the spectral range 600 – 1100nm.	
Notes: (d)	The 1000WP-BB-34 has a nylon rear housing and nothing but nylon and copper in contact with the water flow. This prevents contamination of the water flow with aluminum and prevents the possibility of corrosion.	

L1500W-BB-50 / L1500W-LP1-50



1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water / Air / Conduction Cooled Thermal Sensors

1W to 2000W

Features

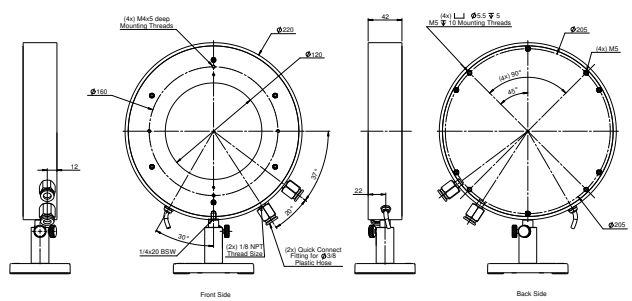
- Very large aperture
- Broadband or Pulsed absorber
- Up to 2000W
- Ø120mm aperture

L2000W-BB-120

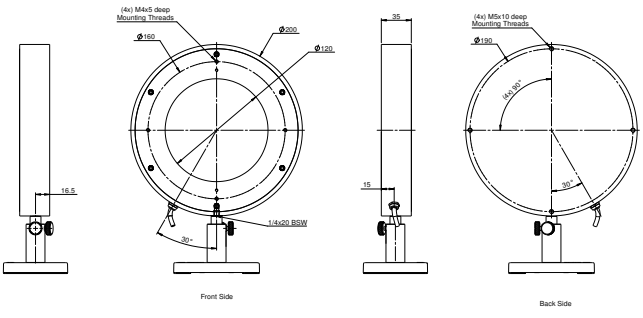
L100(500)A-PF-120

Model	**L2000W-BB-120**	**L100(500)A-PF-120**
Use	**Very large beams**	**High peak power, high energy measurements**
Absorber Type	Broadband	PF volume absorber
Spectral Range µm	0.19 – 20	0.15 – 20
Aperture mm	Ø120mm	Ø120mm
Power Mode		
Power Range	1W – 2000W	1W – 500W
Maximum Intermittent Power	NA	500W for 2min, 100W continuous, 500W continuous if heat sinked on rear
Power Scales	2000W / 200W	500W / 50W
Power Noise Level	50mW	50mW
Maximum Average Power Density W/cm²	1200 at 1000W 60 at 2000W	2000
Response Time with Meter (0-95%) typ. s	6	6
Power Accuracy +/-%	3 (a)	4 (a)
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	2J – 6000J	2J – 6000J
Energy Scales	6KJ / 600J / 60J	6KJ / 600J / 60J
Minimum Energy mJ	2J	2J
Maximum Energy Density J/cm²		Single 10-50Hz (c)
<100ns	0.3	3 (d) 1.5
1µs	0.4	3 (d) 1.5
0.5ms	5	7 7
2ms	10	15 15
10ms	30	40 40
1s	4000	3000 NA
Cooling	water	convection or conduction
Minimum Water Flow Rate at Full Power	2 liter/min (b)	NA
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Weight kg	4.5	4.4
Version		
Part number	**7Z02751**	**7Z02765**
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	Calibrated for 0.25 – 2µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	
Notes: (c)		For 10-50Hz derate as follows: 1064nm not derated 532nm not derated 355nm 70% of stated value 266nm 15% of stated value 193nm 10% of stated value
Notes: (d)		Damage threshold 1.5J/cm² for wavelengths <500nm

L2000W-BB-120



L100(500)A-PF-120



1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water Cooled Thermal Sensors

20W to 5000W

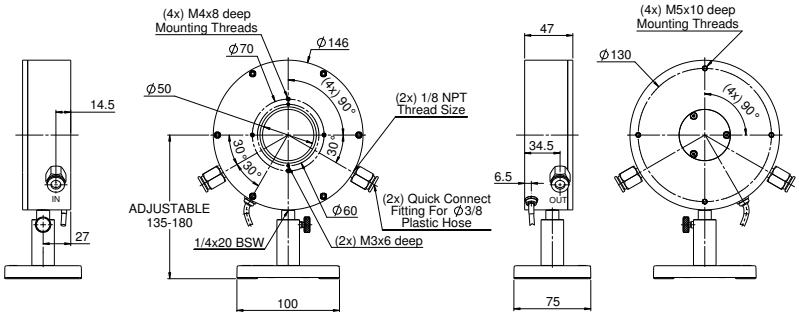
Features

- Powers up to 5000W
- Water cooled
- Ø50mm aperture

5000W-BB-50 / 5000W-LP1-50

Model	**5000W-BB-50**	**5000W-LP1-50**
Use	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP1
Spectral Range µm	0.19 - 20	0.35 – 2.2
Aperture mm	Ø50mm	Ø50mm
Power Mode		
Power Range	20W - 5000W	20W - 5000W
Power Scales	5000W / 500W	5000W / 500W
Power Noise Level	1W	1W
Maximum Average Power Density kW/cm²	6 at 1000W 2 at 5000W	6 at 1000W 2 at 5000W
Response Time with Meter (0-95%) typ. s	3	3
Power Accuracy +/-%	5 (a)	5 (a)
Linearity with Power +/-%	2	2
Energy Mode		
Energy Range	NA	NA
Energy Scales	NA	NA
Minimum Energy mJ	NA	NA
Maximum Energy Density J/cm²		
<100ns	0.3	0.05
1µs	0.4	0.3
0.5ms	5	20
2ms	10	50
10ms	30	200
Cooling	water	water
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Percent of Light Backscattered		
Minimum Water Flow Rate at Full Power	4.5 liter/min (b)	4.5 liter/min (b)
Cable Length	1.5 meters	1.5 meters
Weight kg	2.8	2.8
Version	V1	
Part number	**7Z02754**	**7Z02760S**
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	Calibrated for ~0.8µm and 1.064µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min.	

5000W-BB-50 / 5000W-LP1-50



Front Side **Rear Side**

1.1.2.7 High Power Thermal Sensors

1.1.2.7.3 Calorimetric Power Meter

200W to 6000W

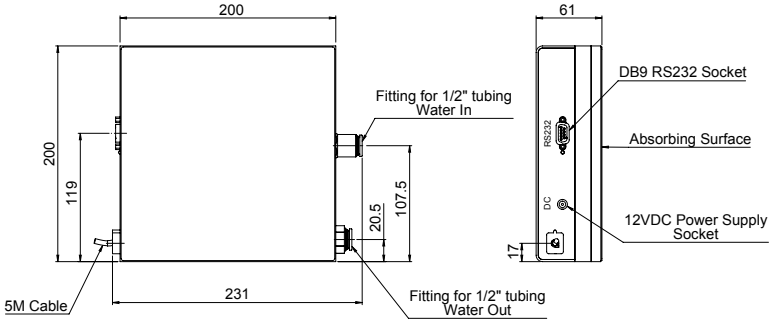
Features

- Very large aperture 200mm x 200mm
- Water cooled
- Up to 6000W
- Smart sensor or RS232 interface

6K-W-BB-200 x 200

Model	**6K-W-BB-200x200**
Use	**Largest size beams to 6kW**
Measurement Method	Calorimetric, measure water temperature rise and flow rate
Absorber Type	Broadband
Spectral Range µm [a]	0.19 - 20
Aperture mm	198 x198mm
Power Mode	
Power Range	200W – 6000W
Power Scales	6kW / 1kW
Power Noise Level	5W
Maximum Average Power Density kW/cm²	1.5 at 1000W 0.4 at 6000W
Response Time with Meter (0-95%) typ. s	50
Power Accuracy +/-%	4 [a] [b]
Linearity with Power +/-%	2 [b]
Maximum Energy Density J/cm²	
<100ns	0.3
1µs	0.4
0.5ms	5
2ms	10
10ms	30
1s	4000
Cooling	water
Recommended Flow Rates	6 liter/min [b]
Outputs	1. 5 meter cable terminated in DB15 Smart Connector measuring power only. 2. RS232 with supplied PC program measuring power, water temp. and water flow rate. In RS232 mode, the sensor is powered by the supplied 12V wall cube.
Fiber Adapters	N.A.
Dimensions	See drawing
Weight kg	3.6
Version	
Part number	**7Z02764**
Notes: (a)	Calibrated for ~0.8µm and 1.08µm at flow rate of 6 liters/min. Calibration for 10.6µm available
Notes: (b)	Min flow rate at maximum power 6 liter/min. Flow rate may be proportionately less at lower power. Flow rate dependence of reading is ±2% for flow rates between 5 and 9 liters/min. Water temperature range 15-25°C. Water temperature rate of change <1°C/min, at max power, proportionately less at lower power

6K-W-BB-200 x 200



1.1.2.7 High Power Thermal Sensors

1.1.2.7.4 Very High Power Water Cooled Thermal Sensors

100W to 30kW

Features

- Very high powers
- Water cooled
- Up to 30kW
- Up to ∅74mm aperture

10K-W-BB-45

30K-W-BB-74

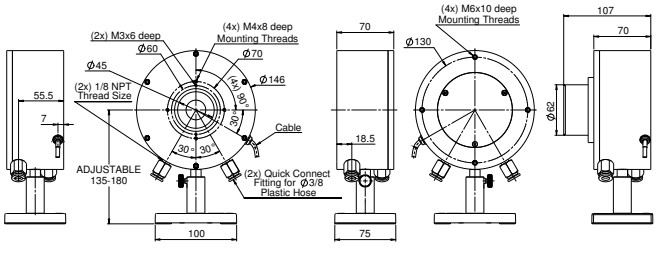
30K-W-BB-74 with optional scatter shield

Model	**10K-W-BB-45**	**30K-W-BB-74**
Use	**High power up to 11kW**	**High power up to 30kW**
Absorber Type	Beam deflector + broadband absorber	Beam deflector + broadband absorber
Spectral Range µm [a]	0.8 - 2, 10.6	0.8 - 2, 10.6
Aperture mm	Ø45mm	Ø74mm
Power Range	100W – 11kW	100W – 30kW
Power Scales	11kW / 6kW / 600W	30kW / 6kW / 600W
Power Noise Level	1W	1W
Backscattered Power [b, e]	~3.5% without Scatter Shield, ~1% with Scatter Shield	~4.3% without Scatter Shield, ~1.3% with Scatter Shield
Maximum Average Power Density kW/cm²	See note [c] and table [1] below	10kW/cm² anywhere in the beam [c]
Response Time with Meter (0-95%) typ. s	2.7	7
Power Accuracy +/-%	5 [a]	5 [a]
Linearity with Power +/-%	2	2
Cooling	water [d]	water [d]
Minimum Water Flow Rate	10 liter/min at full power, proportionally less at lower power. Min flow rate 2 liter/min [d]	25 liter/min at full power, proportionally less at lower power. Min flow rate 6 liter/min [d]
Water Pressure Requirements at Max Flow Rate	Pressure drop across sensor ~0.2MPa.	Pressure drop across sensor ~0.2MPa. Pressure drop across 8 meters of ½" tubing with 9.5mm ID is ~0.3MPa.
Water Connectors [e]	Quick connector for 3/8" OD nylon tubing	Quick connector for ½" OD nylon tubing
Cable Length	5 meters	10 meters
Weight kg	4.5	19
Version	V3	V2
Part number	**7Z02756**	**7Z02757**
Notes: (a)	Calibrated at 1.064µm and 10.6µm. For other wavelengths in the range 0.8 – 2µm add up to ±2% to the calibration error	Calibrated at 1.07µm. For other wavelengths in the range 0.8 – 2µm add up to ± 2% to the calibration error
Notes: (b)	When scatter shield is installed, use the NIRS setting to compensate for slightly higher reading. When not installed, use the NIR setting	When scatter shield is installed, use the 107S laser setting to compensate for the slightly higher reading. When not installed, use the 107 setting
Notes: (c)	For circular beam centered within ¼ of beam diameter. IMPROPERLY CENTERED BEAM CAN CAUSE DAMAGE TO SENSOR. Maximum tilt angle ±5 degrees. For rectangular beam please consult Ophir representative	
Notes: (d)	Water temperature range 15-30°C. Water temperature rate of change <1°C/min	
Notes: (e)	For further information and options see **Accessories for High Power Sensors** on pages 59, 60 & 61	

Table: (1)

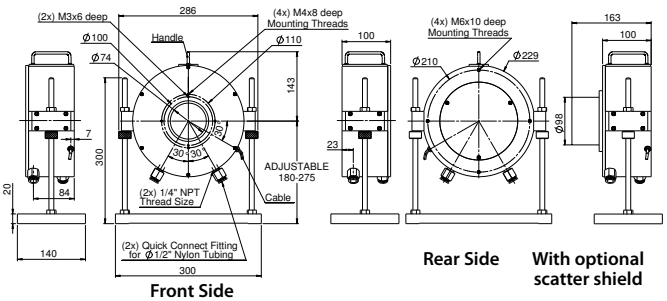
Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

10K-W-BB-45



Front Side | Rear Side | With optional scatter shield

30K-W-BB-74



Front Side | Rear Side | With optional scatter shield

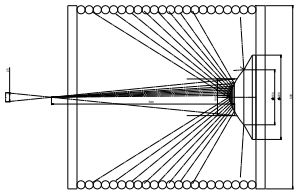
1.1.2.7 High Power Thermal Sensors

1.1.2.7.4 Very High Power Water Cooled Thermal Sensors

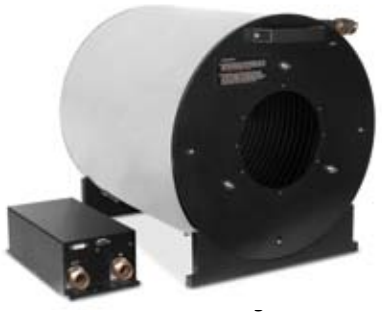
10kW to 120kW

Features

- Highest powers
- Water cooled
- Up to 120kW
- Ø200mm aperture

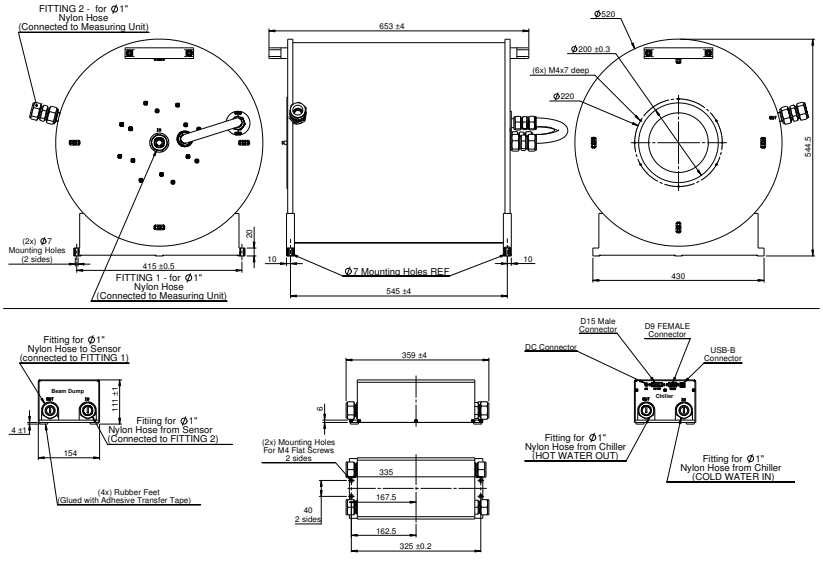


Laser Beam Path



Model	**120K-W** [c]
Use	**Measuring Highest powers to 120kW**
Measurement Type	Water cooled beam absorber chamber with deflecting cone. Separate power measuring unit monitoring input and output cooling water flow and temperature
Spectral Range µm	0.8 –1.1µm [a]
Aperture mm	Ø200
Power Range for Calibrated Reading	10kW – 120kW
Power Noise Level	±20W with stable water temperature
Backscattered Power	Less than 1%
Limitations on Beam	Designed for near Gaussian beam. Beam to be focused with 500 - 1000mm FL lens and meter placed so that the $1/e^2$ beam diameter on reflecting cone is Ø100mm in diameter (see sketch above)
Beam Centering Requirements	Beam to be centered on deflecting cone ±5mm and parallel ±2degrees
Response Time	40s at flow rate 60 liter/min and 60s at flow rate 20 liter/min
Power Accuracy +/-%	5 [a]
Cooling Requirements	Water flow rate, 60 liters/min at max power. Inlet temperature 15-20degC. Inlet water temperature rate of change <0.3degC/min at full power, proportionately less at lower power [b]
Fiber Adapters	Consult Ophir representative
Water Pressure Drop across Beam Absorber	4 bar at 60 liter/min flow rate
Water Connections	Up to 4 meters in each direction of 1" OD 13/16" ID flexible nylon tubing
Outputs	1. Cable terminated in DB9 plug with RS232 ASCII output reading power, flow rate and temperature on PC. Cable lengths 10 meters (recommended for access to full data). 2. Cable terminated in DB15 Ophir smart plug reading power.
Dimensions	See drawing below
Weight kg	Beam Absorber 50kg. Power measuring unit 10kg
Version	
Part number	**7Z02691**
Notes: (a)	Calibrated for 1.07 µm
Notes: (b)	Minimum flow rate should not be below 20 liter/min. It is recommended that the user install a safety interlock flow switch on the return water line (after beam dump) to immediately shut down the laser if flow rate drops
Notes: (c)	100K-W sensor is available as well as a Customized Solutions (OEM) sensor upon request. The accessories and graphs referring to 120K-W sensor are also relevant to the 100K-W sensor

120K-W



1.1.2.7 High Power Thermal Sensors

1.1.2.7.5 Power Pucks

20W to 10kW

Features

- Comet power pucks measure heat rise from 10s exposure to laser
- Accurate, built in temperature compensation algorithm
- Up to 10kW
- Up to 100mm apertures

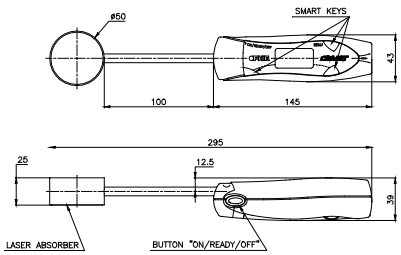
Comet 1K

Comet 10K

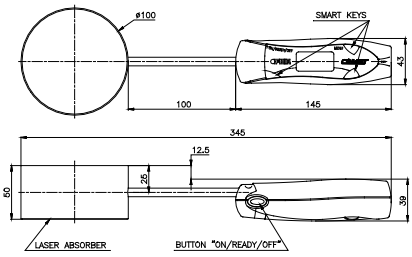
Comet 10K-HD

Model	Comet 1K		Comet 10K		Comet 10K-HD		
Use	**For powers to 1kW**		**For powers to 10kW**		**For high power density beams**		
Absorber Type	Broadband		Broadband		Broadband with reflective cone beam spreader		
Spectral Range µm	0.2 - 20		1.06 and 10.6		1.06 and 10.6		
Aperture mm	Ø50mm		Ø100mm		Ø55mm		
Power Mode							
Power Range	20W to 1kW		200W to 10kW		200W to 10kW		
Repeatability			±1% for same initial temperature				
Maximum Average Power Density kW/cm²	Power	Damage Threshold	Power	Damage Threshold	Power	Damage Threshold	
						Beam dia <40	Beam dia >40
	100W	10	1kW	3.5	1kW	10	7
	200W	8	2kW	2.8	2kW	10	6
	300W	6	3kW	2.5	3kW	8	5
	500W	5	5kW	1.5	5kW	6	3
	1kW	4	10kW	1	10kW	4	2
Power Accuracy +/-%	5		5		5		
Linearity with Power +/-%	±2% ±1W from 20W to 1kW		±2% from 1kW to 10kW		±2% from 1kW to 10kW		
Number of readings before probe must be cooled (for 25°C starting temp.)	100W	4	1kW	4	1kW	4	
	300W	3	3kW	3	3kW	3	
	400W	2	4kW	2	4kW	2	
	1kW	1	10kW	1	10kW	1	
Maximum Energy Density J/cm²							
<100ns	0.3		0.3		1		
10µs	0.8		0.8		3		
1ms	10		10		30		
10ms	50		50		150		
Time to Reading	Initial reading 10s after exposure, final reading 20s after exposure		Initial reading 20s after exposure, final reading 40s after exposure		Initial reading 30s after exposure, final reading 70s after exposure		
Temperature Compensation	Temperature compensated to give accurate readings independent of starting probe temperature						
Maximum Permitted Probe Temperature	70°C before measurement, 140°C after measurement						
Display	2x8 character LCD. Character height 5mm. CE Approved.						
Operation Mode	AUTO: Automatic measurement with laser set to 10s timed exposure. Unit senses temperature rise and measures automatically. MANUAL: User places probe in front of beam for 10s. Unit beeps to indicate start and stop measurement points. History: Stores last three readings. Calibration: Can be recalibrated by user.						
Battery	2 x AA. Lifetime in normal use approximately 1 year.						
Weight kg	0.3		1.2		1.2		
Version			V1		V2		
Part number	**7Z02702**		**7Z02705**		**7Z02706**		

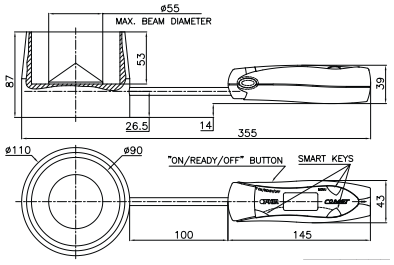
Comet 1K



Comet 10K



Comet 10K-HD



1.1.2.7 High Power Thermal Sensors

1.1.2.7.6 Beam Dumps

Up to 11kW

Features

- Up to 11kW CW
- Water or Fan cooled
- High Power Density
- Ø45-65mm aperture

BDFL500A-BB-50

BDFL1500A-BB-65

BD5000W-BB-50

BD10K-W

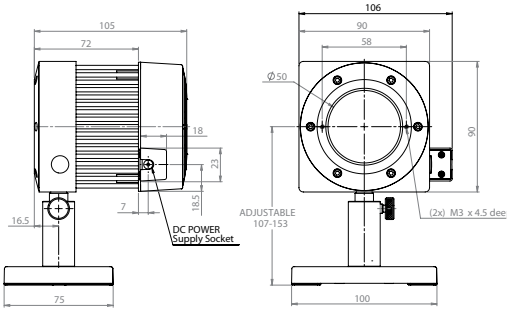
Model	BDFL500A-BB-50	BDFL1500A-BB-65	BD5000W-BB-50	BD10K-W	
Use		**General purpose High power beam dump**			
Absorber Type	Broadband	Broadband	Broadband	Beam Deflector + Broadband	
Spectral Range µm	0.19 - 20	0.19 - 20	0.19 - 20	0.8 - 20	
Typical Absorption		86% for 600 to 2500nm, 82% for 10.6µm			
Aperture mm	Ø50mm	Ø65mm	Ø50mm	Ø45mm	
Maximum Incident Power	500W	1500W	5000W	11,000W	
Maximum Average Power Density	7kW/cm²	6kW/cm² at 1000W 1.5kW/cm² at 1500W	6kW/cm² at 1000W 3kW/cm² at 5000W	See note (b) below	
Maximum Energy Density J/cm²				See note (b) below	
<100ns	0.3	0.3	0.3		
1µs	0.4	0.4	0.4		
0.5ms	5	5	5		
2ms	10	10	10		
10ms	30	30	30		
Cooling	fan	fan	water	water	
Minimum Water Flow Rate at Full Power	N/A	N/A	4.5 liter/min (a)	10 liter/min (a)	
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61	See pages 59, 60 & 61	See pages 59, 60 & 61	
Weight kg	0.9	2.4	2.8	4.5	
Version					
Part number	**7Z17200**	**7Z17203**	**7Z17201**	**7Z17202**	

Notes: (a): Water temperature range 18-30°C. Water temperature rate of change <1°C/min

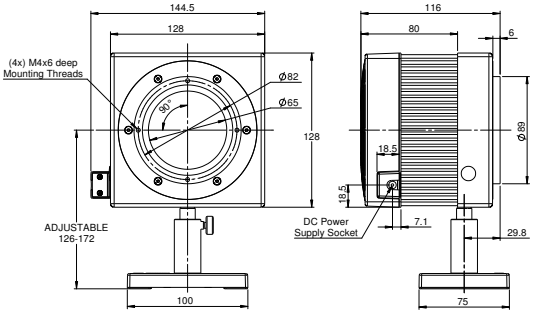
Notes: (b): Max power and energy density

Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

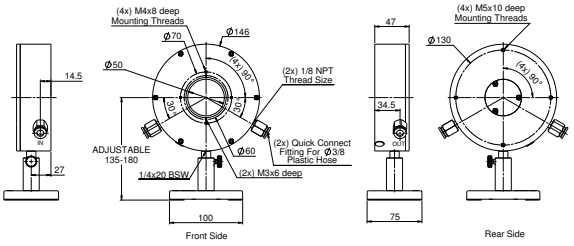
BDFL500A-BB-50



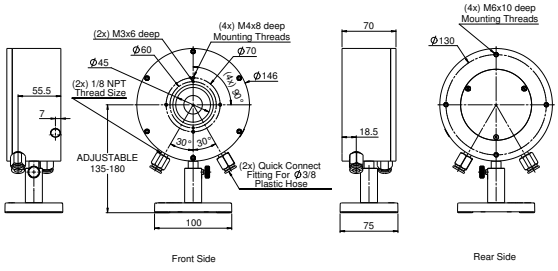
BDFL1500A-BB-65



BD5000W-BB-50



BD10K-W



OPHIR Photonics A Newport Company

1.1.2.7 High Power Thermal Sensors

1.1.2.7.7 Accessories for High Power Water Cooled Sensors

Protective Housing for 5000W and 10K-W sensors

Protective Housing and Shutter for Ophir Power sensors 5000W and 10K-W

A protective housing with shutter is available for Ophir models 5000W and 10K-W for use in industrial environments where sensors may be contaminated by debris from material working process.
The protective housing and shutter prevent contamination sensor, particularly the absorbing surface by this debris. The housing has a solenoid actuated shutter that can be opened when needed for measuring and be closed otherwise. The protective housing is fastened to the front flange of the sensor [a].

Protective Housing

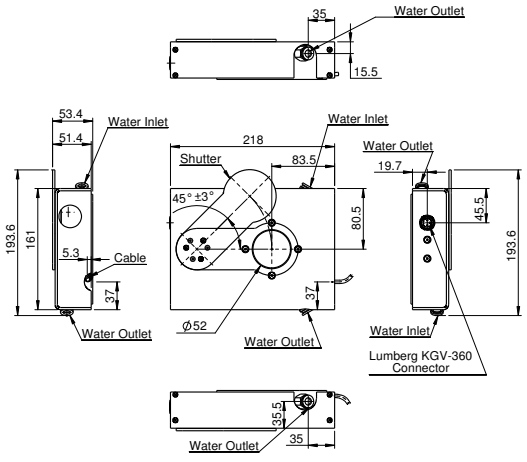
Protective Housing Mounted on Sensor (shutter open)

Protective Housing Mounted on Sensor (shutter closed)

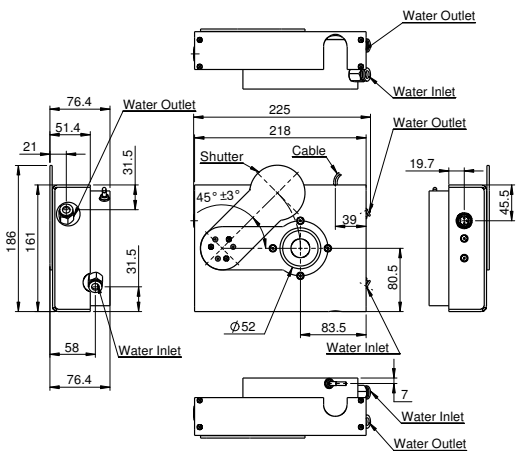
Model	**5000W / 10K-W protective housing with shutter**
Use	**Protection from debris of material working process**
Sensors Supported	For 5000W and 10K-W. Needs threaded front flange [a]
Aperture	Exposes full aperture of sensors
Solenoid Actuating Power	12-24VDC 0.5A , Shutter is normally Closed [b]
Electrical Connection	Lumberg SV30 male connector with 2m cable as supplied
Dimensions	See drawing below
Housing Material	Sheet aluminum
Part number	**7Z08277**
Notes: (a)	When fitting the housing to previous versions of the 5000W/5000W-LP sensors P/N 7Z02119/7Z02255 or 10K-W sensor P/N 7Z02645, that do not have the requisite threads, it will be necessary to exchange the front flange of the sensor with a new one having the requisite mounting threads. For details, consult Ophir representative.
Notes: (b)	In order to prevent possible damage to the shutter, it is recommended to safety interlock the shutter and laser so that if shutter is closed (no power to the solenoid), the laser will also be closed.

Protective Housing for 5000W and 10K-W

As mounted on 5000W



As mounted on 10K-W



Scatter Shield

Scatter Shield for mounting on front flange of 10K-W and 30K-W to reduce backscattered power.

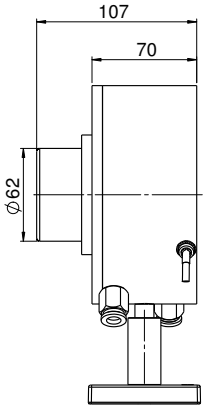
3 to 4% of the light impinging on the 10K-W and 30K-W is backscattered in a diffuse manner. This can cause heating of surrounding surfaces. Scatter Shields are available to greatly reduce this affect. When installed on the front flange of the sensors, they will reduce the backscatter by about 70%.
The shield works in two ways:
1. By absorbing much of the backscattered light.
2. By reflecting some of it back into the sensor where that light is reabsorbed.

Since some of the light is reabsorbed, the power reading is 1-1.5% higher than without the shield, so an additional laser setting is given for use when the shield is mounted to adjust for this difference.

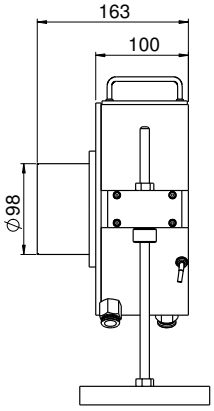
10K-W Scatter Shield

30K-W Scatter Shield

Model	10K-W Scatter Shield	30K-W Scatter Shield
Wavelength range of use	0.8 – 2µm	0.8 – 2µm
Laser setting with and without shield	with NIRS, without NIR	with 107S, without 107
Backscatter with and without shield	with 0.9%, without 3.2%	with 1.4%, without 4.3%
Part number	**7Z08295**	**7Z08293**



10K-W with Scatter Shield



30K-W with Scatter Shield

Metric Water Fittings for water cooled sensors

The standard water fittings supplied with Ophir standard water cooled sensors are quick connect fittings for 1/4", 3/8" and 1/2" plastic tubing. Metric water fittings are also available if desired as follows:

7I07038 1/4" - 12mm

7I07039 1/8" - 10mm

Connector	For use with	Part Number
1/4" NPT to 12mm O.D. tubing	30K-W	7I07038
1/8" NPT to 10mm O.D. tubing	All other water cooled sensors	7I07039

Protective Covers with Target Pattern for 1000W, L1500W, 5000W, 10K-W and 30K-W sensors

Models 10K-W and 30K-W as well as the scatter shields for these models come with a black anodized aluminum cover. The 10K-W aluminum cover also fits the 5000W models. These covers are available to be ordered separately if desired. The ordering information is given here.

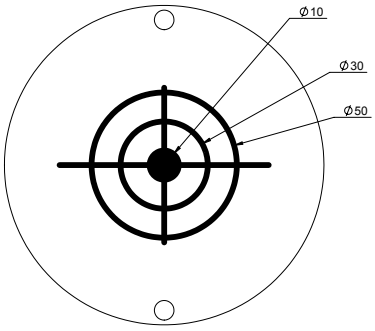
Protective Cover	For use with	Part Number
30K-W Protective Cover	30K-W	1G02406
10K-W Protective Cover	10K-W, 5000W, L1500W, 1000W	1G01332

Note that for the 1000W & L1500W sensors the covers need to be ordered separately and do not come with the sensor.

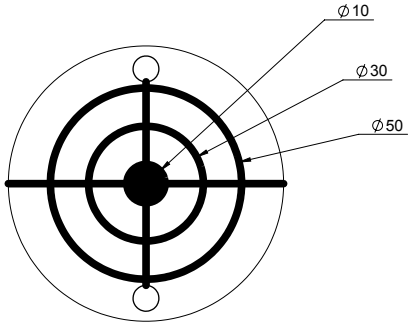
30K-W with Protective Cover

10K-W with Protective Cover

30K-W Protective Cover



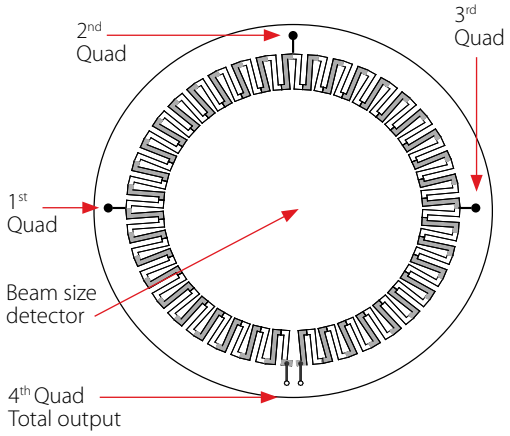
10K-W Protective Cover



1.1.3 BeamTrack Power / Position / Size Sensors

1.1.3.1 Introduction

Ophir now has the BeamTrack line of thermal sensors that can measure beam position and beam size while measuring power. This innovative device will provide an additional wealth of information on your laser beam – centering, beam position, beam wander, beam size as well as power and single shot energy. The BeamTrack sensor is illustrated schematically here and works as follows: the signal coming from the sensor is divided into 4 quadrants so by measuring and comparing the output from the 4 sections we can determine the position of the center of the beam to a high degree of accuracy. In addition to the 4 quadrants, there is now a special patented beam size detector. After processing outputs from these various detectors, the user is presented with the beam position as well as beam size. Note that the beam size is calibrated only for Gaussian beams but for other beams it will give relative size information and will indicate if the beam is changing size.



Operation of BeamTrack Sensors

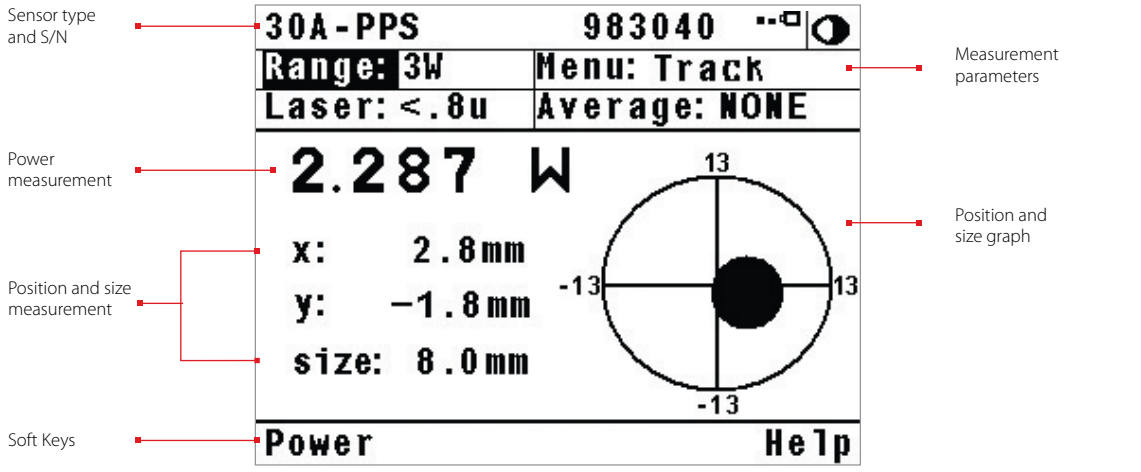
BeamTrack sensors look similar to Ophir thermal sensors of the same type except that there is a small electronics module on the cable from the sensor to the smart plug. When BeamTrack sensors are plugged into compatible displays or PC interfaces (StarBright, StarLite, Nova II, Vega and Juno), along with the power measurement, there is a visual display of the beam position and beam size. The beam position can be accurately tracked and logged for beam wander measurements.

The beam size is calibrated only for Gaussian beams but other beams may be measured and the sensor will give a repeatable measurement of the relative beam size for tracking changes in the size of the beam over time.

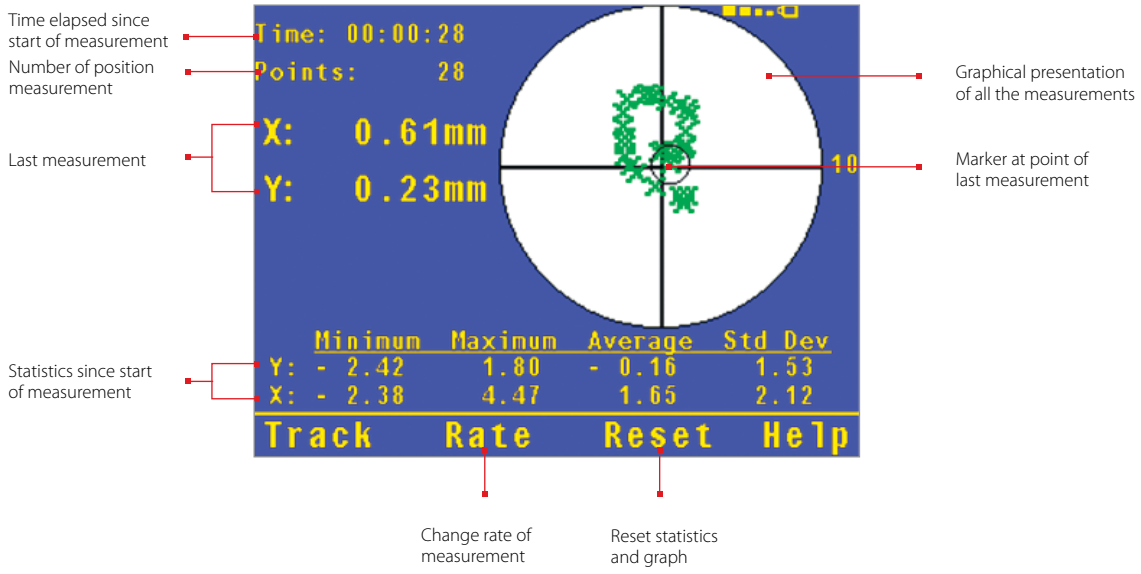
1.1.3.2 BeamTrack Device Software Support

- BeamTrack sensors are fully supported by the StarBright, StarLite, Vega, Nova-II and Juno devices
- Attach the sensor to the meter. On startup, it will be recognized as a BeamTrack sensor and tracking options will be enabled
- Use the Track screen to measure power, position and size simultaneously
- Use the Stability screen to measure pointing stability (also known as beam wander) over time

Track Screen on Nova II



Pointing Stability Screen of Vega

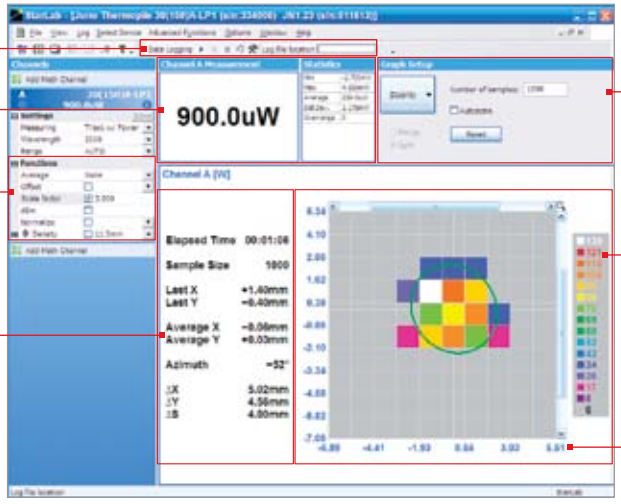


1.1.3.3 BeamTrack PC Software Support

- StarLab
- COM Object for System Integrators including demo applications in VB, VC+ and MatLab the Track screen to measure power, position and size simultaneously
- LabVIEW Demo Application

Examples of some StarLab Screens

Stability Screen



Log data for future review

Power measurement and statistics

Functions (apply to power only)

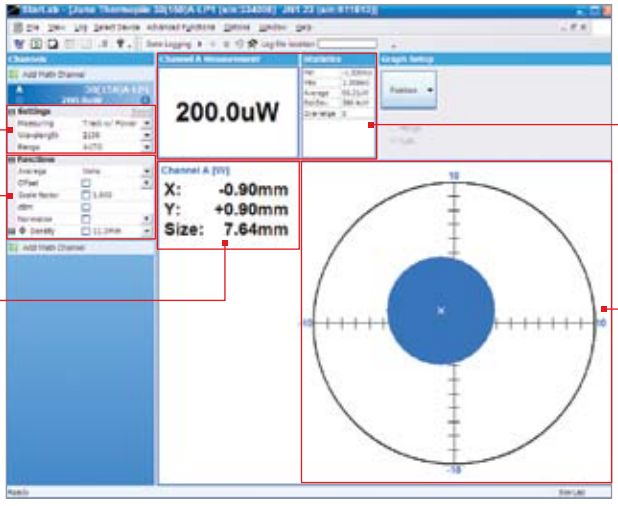
Statistics of the stability sample

Graph controls including; Sample size, Autoscale option, Reset button and Graph type selections

Stability Graph. The more hits in one location the brighter the color

Graph can be zoomed in and out manually or auto-scaled

Position & SizeScreen



Parameter configuration

Functions (applies to power only)

Position and size displayed numerically

Power measurement and statistics

Graph with spot drawn to scale and market on position

1.1.3.4 Low Power BeamTrack-Power / Position / Size Sensors

100µW to 10W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

3A-QUAD / 3A-P-QUAD

10A-PPS

Model	3A-QUAD [a]	3A-P-QUAD [a]	10A-PPS [a]
Use	**General purpose**	**Short pulses**	**Low power**
Functions	Power / Energy / Position	Power / Energy / Position	Power / Energy / Position / Size
Absorber Type	Broadband	P type	Broadband
Spectral Range µm	0.19 - 20	0.15 - 8	0.19 - 20
Aperture mm	Ø9.5mm	Ø12mm	Ø16mm
Power Mode			
Power Range	100µW - 3W	160µW - 3W	20mW - 10W
Power Scales	3W to 300µW	3W to 300µW	10W / 5W / 0.5W
Power Noise Level	5µW	10µW	1mW
Thermal Drift (30min)%	10 - 40µW [b]	10 - 40 µW [b]	NA
Maximum Average Power Density kW/cm²	1	0.05	28
Response Time with Meter (0-95%) typ. s	1.8	2.5	0.8
Power Accuracy +/-% [f]	3	3	3
Linearity with Power +/-%	1	1	1
Energy Mode			
Energy Range	20µJ - 2J	30µJ - 2J	6mJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J / 200mJ
Minimum Energy	20µJ	30µJ	6mJ
Maximum Energy Density J/cm²			
<100ns	0.3	1 [e]	0.3
0.5ms	1	1 [e]	2
2ms	2	1 [e]	2
10ms	4	1 [e]	2
Beam Tracking Mode			
Position			
Beam Position Accuracy mm [c]	0.15	0.15	0.15
Beam Position Resolution mm	0.02	0.02	0.02
Min Power for Position Measurement	300µW	400µW	50mW
Size [d]			
Size Accuracy mm	NA	NA	±(5%+50µm) for centered beam
Size Range mm (4σ beam diameter)	NA	NA	1.5 - 10
Min Power for Size Measurement	NA	NA	50mW
Cooling	convection	convection	convection
Weight kg	0.3	0.3	0.3
Fiber Adapter Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Part number	**7Z07934**	**7Z07935**	**7Z07904**

Notes: (a) The BeamTrack features are supported by StarBright, StarLite, Nova II and Vega meters, Juno interface and StarLab application.

Notes: (b) Depending on room airflow and temperature variations.

Notes: (c) For position within inner 30% of aperture.

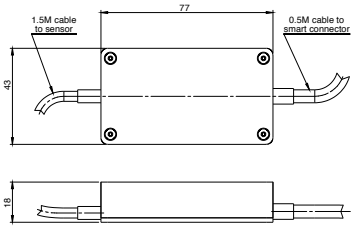
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

Notes: (e) For P type and shorter wavelengths derate maximum energy density as follows:

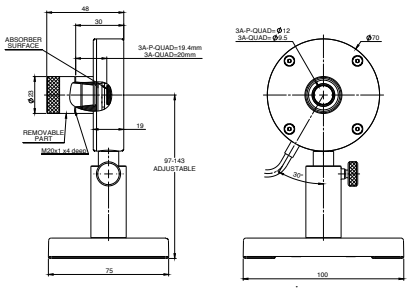
Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

Notes: (f) The 3A-QUAD has a relatively large spectral variation in absorption and has a calibrated spectral curve at all wavelengths in its spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, the accuracy will be ±3% as above for 532nm, 905nm, 1064nm and 10.6µm but there will be an additional error of up to 3% at other wavelengths in the spectral range 190 – 3000nm.

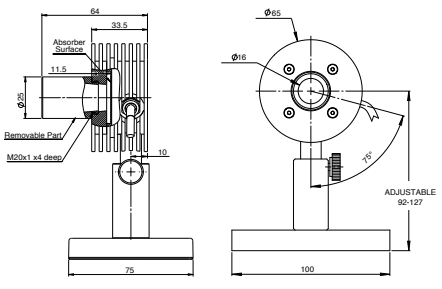
Interface Module on cable



3A-QUAD / 3A-P-QUAD



10A-PPS



1.1.3.5 Medium Power BeamTrack-Power / Position / Size Sensors

40mW to 150W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

50(150)A-BB-26-QUAD / 50(150)A-BB-26-PPS

F150A-BB-26-PPS

Model	50(150)A-BB-26-QUAD [a]	50(150)A-BB-26-PPS [a]	F150A-BB-26-PPS [a]
Use	**General purpose**	**General purpose**	**General purpose**
Functions	Power / Energy / Position	Power / Energy / Position / Size	Power / Energy / Position / Size
Absorber Type	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.19 - 20
Aperture mm	Ø26mm	Ø26mm	Ø26mm
Power Mode			
Power Range	40mW - 150W	40mW - 150W	50mW - 150W [b]
Maximum Intermittent Power	150W for 1.5min, 100W for 2.2min, 50W continuous	150W for 1.5min, 100W for 2.2min, 50W continuous	N.A.
Power Scales	150W / 50W / 5W	150W / 50W / 5W	150W / 30W / 3W
Power Noise Level	2mW	2mW	8mW [b]
Maximum Average Power Density kW/cm^2	12 at 150W, 17 at 50W	12 at 150W, 17 at 50W	12 at 150W, 17 at 50W
Response Time with Meter (0-95%) typ. s	1.5	1.5	1.5
Power Accuracy +/-%	3	3	3
Linearity with Power +/-%	1.5	1.5	1
Energy Mode			
Energy Range	20mJ - 100J	20mJ - 100J	20mJ - 100J
Energy Scales	100J / 30J / 3J / 300mJ	100J / 30J / 3J / 300mJ	100J / 30J / 3J / 300mJ
Minimum Energy mJ	20	20	20 [b]
Maximum Energy Density J/cm^2			
<100ns	0.3	0.3	0.3
0.5ms	5	5	5
2ms	10	10	10
10ms	30	30	30
Beam Tracking Mode			
Position			
Beam Position Accuracy mm [c]	0.1	0.1	0.1
Beam Position Resolution mm	2.5% of beam size	2.5% of beam size	2.5% of beam size
Min Power for Position Measurement	1W	1W	1W
Size [d]			
Size Accuracy mm [e]	N.A.	±5% for centered beam	±5% for centered beam
Size Range mm (4σ beam diameter)	N.A.	Ø3 - 20	Ø3 - 20
Min Power Density for Size Measurement	N.A.	1 W/cm^2	1 W/cm^2
Cooling	convection	convection	fan
Fiber Adapter Available (see page 69)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Weight Kg	0.4	0.4	0.45
Version			
Part number	**7Z07937**	**7Z07900**	**7Z07901**

Notes: (a) The BeamTrack features are supported by StarBright, StarLite, Nova II and Vega meters, Juno interface and StarLab application.

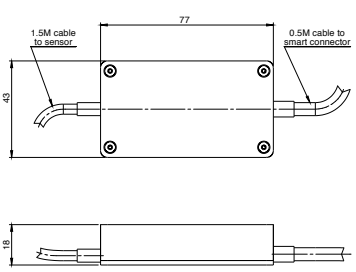
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

Notes: (c) Position accuracy for the central 10mm of the aperture as limited by beam position resolution. Position can be tracked with ±1mm accuracy over the entire aperture. Accuracy is reduced by a factor of 3 at minimum power.

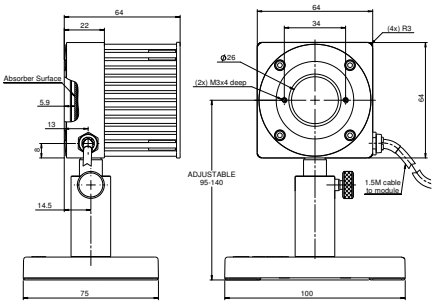
Notes: (d) Assumes laser beam with Gaussian (TEM$_{00}$) distribution. For other modes, size measurement is relative.

Notes: (e) Accuracy spec will be maintained for beams from 3.5 to 17mm not deviating from center more than 15% of beam diameter. For beams below 8mm in size and powers above 75W error in size can reach ±10%.

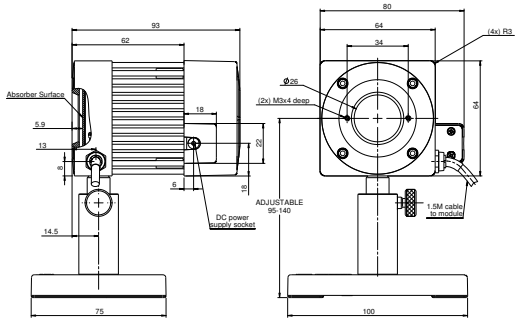
Interface Module on cable



50(150)A-BB-26-QUAD / 50(150)A-BB-26-PPS



F150A-BB-26-PPS



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1.1.3.6 Medium-High Power BeamTrack-Power / Position / Size Sensors

150mW to 1000W

Features

- All the features of standard power sensors plus...
- Accurate tracking of beam position to fractions of a mm
- Monitoring of the laser beam size

FL250A-BB-50-PPS

1000W-BB-34-QUAD

Model	FL250A-BB-50-PPS [a]	1000W-BB-34-QUAD [a]
Use	**General purpose**	**General purpose**
Functions	Power / Energy / Position / Size	Power / Energy / Position
Absorber Type	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20
Aperture mm	Ø50mm	Ø34mm
Power Mode		
Power Range	150mW - 250W [b]	5W - 1000W
Power Scales	250W / 30W	1000W / 200W
Power Noise Level	15mW	200mW
Maximum Average Power Density kW/cm²	10 at 250W, 12 at 150W	7.5 at 500W, 6 at 1000W
Response Time with Meter (0-95%) typ. s	2.8	2.5
Power Accuracy +/-%	3	3 [f]
Linearity with Power +/-%	1.5	2
Energy Mode		
Energy Range	80mJ - 300J	500mJ – 300J
Energy Scales	300J / 30J / 3J	300J / 30J
Minimum Energy mJ	80	500mJ
Maximum Energy Density J/cm²		
<100ns	0.3	0.3
1µs	0.4	0.4
0.5ms	5	5
2ms	10	10
10ms	30	30
Beam Tracking Mode		
Position		
Beam Position Accuracy mm	0.2 [c]	0.5 [h]
Beam Position Resolution mm	0.1	0.1
Min Power for Position Measurement	2W	10W
Size [d]		
Size Accuracy mm [e]	±5% for centered beam	NA
Size Range mm (4σ beam diameter)	Ø5-35	NA
Min Power Density for Size Measurement	3 W/cm²	NA
Cooling	fan	water
Minimum Water Flow Rate at Full Power	NA	1.8 liter/min [g]
Fiber Adapter Available (see page 69)	ST, FC, SMA, SC	Consult Ophir representative
Accessories for High Power Sensors	See pages 59, 60 & 61	See pages 59, 60 & 61
Weight Kg	0.9	0.9
Version		
Part number	**7Z07902**	**7Z07936**

Notes: (a) The BeamTrack features are supported by StarBright, StarLite, Nova II and Vega meters, Juno interface and StarLab application.

Notes: (b) For powers up to 50W it is recommewnded to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

Notes: (c) Position accuracy for the central 20mm of the aperture as limited by beam position resolution. Position can be tracked with ±1mm accuracy over central 32mm of the aperture. Accuracy is reduced by a factor of 3 at minimum power.

Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

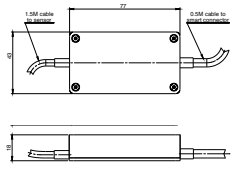
Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

Notes: (f) Calibrated for ~0.8µm, 1.064µm and 10.6µm

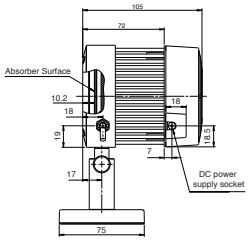
Notes: (g) Water temperature range 18-30°C, Water temperature rate of change <1°C/min

Notes: (h) Position accuracy for the central 10 mm of the aperture as limited by beam position resolution.

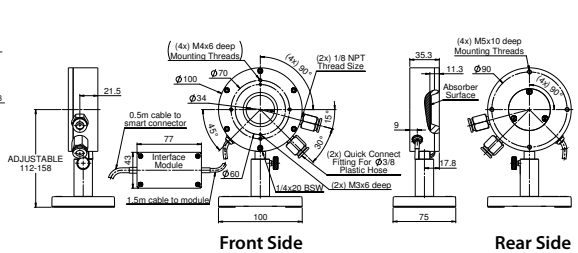
Interface Module on cable



FL250A-BB-50-PPS



1000W-BB-34-QUAD



1.1.4 Power Sensors Accessories

1.1.4.1 Accessories for PD300 Sensors

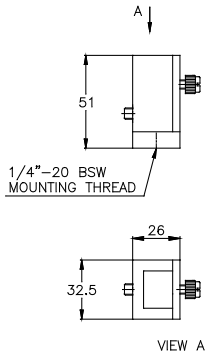
(For PD300R, PD300-IRG and 3A-IS series, see page 69)

Fiberoptic Adapters and Other Accessories

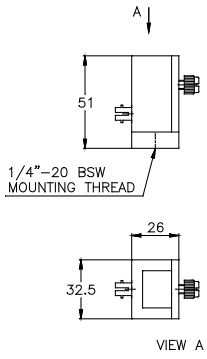
PD300 with F.O. Adapter Mounted

Accessory	Description	Part number			
PD300-CDRH	Ø7mm aperture adapter for CDRH measurements	7Z02418			
Fiber Adapters	Adapters for mounting fibers to PD300 sensors as shown below	SC type	ST type	FC, FC/APC type	SMA type
PD300 F.O. Adapter		7Z08221	7Z02210	7Z02213	7Z02212

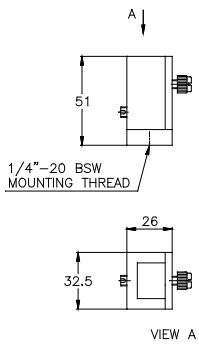
PD300-FO-SMA



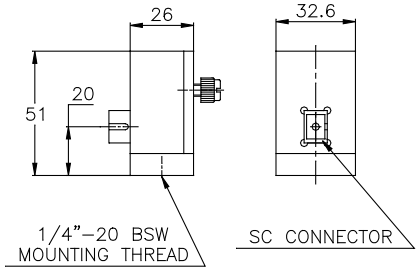
PD300-FO-ST



PD300-FO-FC



PD300-FO-SC



1.1.4.2 Accessories for Thermal Sensors, PD300R, PD300-IRG, 3A-IS and FPS-1

Fiberoptic Adapters and Other Accessories

SC fiber adapter

ST fiber adapter

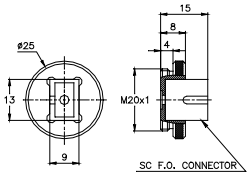
FC fiber adapter

SMA fiber adapter

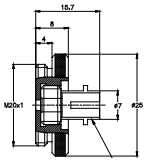
Sensor Series	Fiber adapter mounting bracket (1 bracket fits all fiber adapters)	SC fiber adapter	ST fiber adapter	FC, FC/APC fiber adapter	SMA fiber adapter
Thermal Sensors					
3A / 3A-QUAD / 3A-P / 3A-P-QUAD / 3A-PF-12 / 3A-FS / 3A-P-THz	not needed				
10A / 10A-PPS / 10A-P	not needed				
12A / 12A-P	not needed				
30A-BB-18 / 30A-N-18 / 30(150)A-BB-18 / 30(150)A-LP1-18	7Z08211				
50(150)A-BB-26 / 50(150)A-BB-26-PPS / 50(150)A-BB-26-QUAD / F150A-BB-26 / F150A-BB-26-PPS	7Z08210	7Z08227	7Z08226	7Z08229	1G01236
L50(150)A-BB-35 / L50(150)A-LP1-35 / L50(150)A-PF-35 / FL250A-BB-35 / FL250A-LP1-35	7Z08265				
30A-P-17 / 30(150)A-SV-17 / 30(150)A-HE-17	7Z08230				
L40(150)A / L40(150)A-LP1 / L50(150)A	7Z08238 (a)				
FL250A-BB-50 / FL250A-BB-50-PPS / FL400A-BB-50 / FL400A-LP1-50	7Z08212				
L100(500)A-PF-120 / FL600A-BB-65 / FL600A-LP1-65 / 1000WP-BB-34 / 1000W-BB-34 / 1000W-BB-34-QUAD / 1000W-LP1-34 / L1000W-BB-120 / FL1100A-BB-65 / L1500W-BB-50 / L1500W-LP1-50 / L2000W-BB-120 / 5000W-BB-50 / 5000W-LP1-50 / 10K-W-BB-45 / 30K-W-BB-74 / 120K-W	Threaded holes exist	Consult Ophir representative			
Photodiode Sensors					
PD300R series and FPS-1	1G02259	7Z08227	7Z08226	7Z08229	1G01236
3A-IS / 3A-IS-IRG	7Z08213	7Z08227	7Z08226	7Z08229	1G01236
PD300-IRG	not needed			7Z08216	7Z08222
Accessories for High Power Sensors					
Protective Housing for 5000W and 10K-W sensors	Protective Housing with shutter to protect from debris			7Z08277	See page 59
Scatter Shield for 10K-W and 30K-W sensors	Scatter Shield to reduce backscattered power			7Z08295 (for 10K-W) 7Z08293 (for 30K-W)	See page 60
Metric Water Connectors for water cooled sensors	Metric Water Connectors are quick connect fittings for 1/4", 3/8" and 1/2" plastic tubing			7107039 7107038 (for 30K-W)	See page 61
Protective Covers with Target Pattern for 1000W, L1500W, 5000W, 10K-W and 30K-W sensors	Black anodized aluminum cover with a target pattern for directing the beam using a pointer			1G01332 1G02406 (for 30K-W)	See page 61
General Accessories					
SH to BNC Adapter	Allows connection of sensor to voltage measuring device for measurement of raw voltage output				7Z11010
Female SM1 to SM1 Adapter	For mounting PD300R series and FPS-1 to SM1 optical components and systems				1G02260

Note: (a) The fiber mounting bracket for these sensors is a triple adapter for mounting up to three different fibers looking at same spot

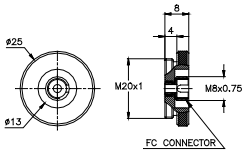
SC fiber adapter



ST fiber adapter

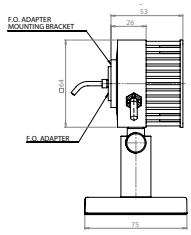


FC fiber adapter

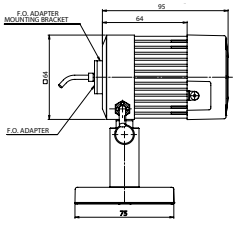


SM1 to M20 Adapter Mounting Bracket for PD300R Series and FPS-1, P/N 1G02259
Allows PD300R models to be used with above fiber adapters

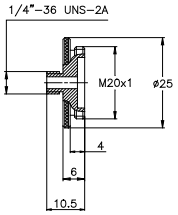
30A with F.O. input



FL250A with F.O. input



SMA fiber adapter



SH to BNC adapter
Allows raw voltage output from thermal sensors