Laser Power & Energy Measurement Laser Beam Analysis

2018

Table of contents

Ophir Power and Energy Meters – Versatility for Every Application

Ophir sensor, power meter and computer interface system means that virtually any sensor can work "plug and play" with any power meter or computer interface. Ophir has the widest range of sensors on the market with the highest performance so almost any measurement need can be accommodated. The measurement results can also be used in many ways - on the power meter screen, stored on board, sent to PC with results presented in many ways and on several platforms.

Pyroelectric Sensors
Energies pJ to Joules
Rep rates to 25kHz
(page 85)

Thermal Sensors
Powers mW to kW and
single shot energy
(page 38)

Photodiode Sensors
Powers pW to Watts
(page 24)

Computer Interfaces
with USB/Bluetooth/Ethernet

EA-1
Ethernet

Pulsar
1 ,2 ,4 channels

Power Meters
with USB/RS232

StarBright
added features

Vega
color

Nova II
general

Quasar
wireless

Juno
compact

StarLite
basic

Nova
rugged

Laser Star
2 channel

Software Solutions
StarLab, LabVIEW, StarCom &
COM Object

Calibration Capability at Ophir

Calibration is perhaps the most important of our products. In order to ensure the best possible calibration of your instruments, Ophir takes a number of extra steps not taken by other vendors.

Laser absorption varies with wavelength, so it is not enough to calibrate at one wavelength. If the variation is small, then the sensors are calibrated at several laser wavelengths and each laser covers a range of wavelengths. If the absorption variation with wavelength is considerable, the sensor is provided with an absorption correction curve activated by the wavelength of use. Going one step further, Ophir checks the curve at a number of NIST and PTB traceable wavelengths and corrects it if necessary. To do this, we have a complete line of calibration lasers so that we can always calibrate at or near the customer's wavelength. These lasers include powers up to 1000W and both CW and pulsed lasers. We also have a number of sensors calibrated at NIST and PTB used as calibration standards. Below is a list of the calibration wavelengths used at Ophir in calibrating our standard catalog sensors.

In addition to calibration variation with wavelength, there are other possible sources of calibration error such as nonlinearity, variation with position on the surface and for pyroelectric sensors, pulse frequency. All of these factors are taken into consideration in the calibration and accounted for. For a complete analysis of Ophir calibration accuracy and error budget, please see our website at:
www.ophiropt.com/calibration-procedure/tutorial

Special Calibration

In addition to standard calibration wavelengths shown below, customers can have their Ophir sensor calibrated at additional wavelengths for more accuracy. Please consult your Ophir agent for special requests.

Wavelengths of Calibration per Sensor Type

Wavelength	193	248	254	266	355	365	410	436	488	532	577	633	675	750	755	808	905	980	1014	1046	1064	1070	1310	1550	2100	2940	10600	Spectral Curve
Pulsed/Continuous	P	P	C	P	P	C	C	C	C	P,C	C	C	C	C	P	C	P	C	C	C	P,C	C	C	P,C	P	P	C	
Photodiode sensors																												
PD300						●		●	●		●	●							●	●								●
PD300-UV			●			●		●	●		●	●							●	●								●
PD300-IR																●		●						●				●
PD300-3W						●		●	●		●	●								●								●
PD300-IRG																●		●		●			●	●				●
IS-1, IS-1-2W						●		●			●									●								●
IS-6			●			●		●			●									●								●
3A-IS								●				●	●							●								●
Thermal sensors																												
Standard Broadband<1000W										●											●						●	
Standard Broadband 1-15kW																●						●					●	
Helios																						●						
30K-W																						●						
120K-W																						●						
LP1 type										●						●		●								●		●
LP2 type																						●						
Comet 10K																						●					●	
Comet 1K										●												●					●	
P type										●											●							
PF type		●								●											●						●	
PF with diffuser				●	●					●											●				●			
HE type										●											●				●	●		
HE with diffuser		●			●					●											●							
EX type		●								●																		
SV type	●																				●						●	
Pyroelectric sensors																												
PD10-C, PD10-pJ-C	●	●					●										●											●
PD10-IR-pJ-C, PD10-IR-C											●						●							●				
PE9-C	●				●																●			●				
PE9-ES-C					●																●			●				
PE10-C					●																●							
BB type																					●							
BF type	●	●			●					●											●					●		●
BF with diffuser		●			●					●											●				●	●		●
Metallic (standard)		●			●																●					●		●
PE50BB-DIF-C										●											●				●			
PE50-DIF-ER-C										●											●				●	●		
PE50-DIF-C	●	●								●											●				●	●		
PE100BF-DIF-C										●											●			●				

Sensors

1.0 Sensors Table of Contents

Power sensors

Photodiode Power Sensors

Standard photodiode sensors – 10pW – 3W

Round photodiode sensors – 20pW – 3W

Special photodiode sensors – 50pW – 50mW and 20mLux – 200kLux

Integrating Spheres

Accessories for IS6

LED measurement – UV, VIS, NIR

LED Power Sensors 20pW - 3W

LED Irradiance and Dosage Sensors 15nW/cm²-8w/cm²

Accessories for Photodiode Sensors

Accessories for PD300 series

Accessory	Description	Page
PD300-CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300	37
PD300-CDRH-3.5mm	Ø3.5mm aperture adapter for CDRH measurements for PD300	37
Fiberoptics Adapters		
PD300 F.O. adapters	Adapters for mounting fibers to PD300 sensors (ST, FC, SMA, SC)	37

Accessories for PD300R series, PD300-IRG, 3A-IS, IS-1 series and FPS-1

Accessory	Description	Page
PD300R CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300R	37
Fiberoptics Adapters		
Accessory	**Description**	**Page**
F.O. adapters	Adapters for mounting fibers to PD300R, PD300-IRG, 3A-IS, IS-1 series and FPS-1 spectrum analyzer (ST, FC, SMA, SC)	37
Female SM1 to SM1 Adapter	Adapter to convert from female SM1 to male SM1	37

Thermal Power Sensors

Low Noise Lock In Power Sensors 300fW – 100mW

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
RM9 sensor	Radiometer for extremely low powers w/o chopper	Ø8mm	0.15-12µm	100nW-100mW	N.A.	39
RM9-THz	Radiometer for extremely low powers w/o chopper for THz	Ø8mm	0.1-30THz	100nW-100mW	N.A.	39
RM9-PD	Photodiode for extremely low powers w/o chopper	Ø8mm	0.2-1.1µm	300fW-300nW	N.A.	39
RM9 sensor and RMC1 Chopper	Complete set, RM9 with chopper	Ø8mm	0.15-12µm	100nW-100mW	N.A.	39
RM9-THz sensor and RMC1 Chopper	Complete set RM9-THz with chopper	Ø8mm	0.1-30THz	100nW-100mW	N.A.	39
RM9-PD sensor and RMC1 Chopper	Complete set RM9-PD with chopper measure to 300fW	Ø8mm	0.2-1.1µm	300fW-300nW	N.A.	39

High sensitivity thermal sensors – 8µW – 12W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
2A-BB-9	Compact, for very low powers	Ø9.5mm	0.19-20µm	20µW-2W	20µJ-2J	41
3A	Very low powers	Ø9.5mm	0.19-20µm	10µW-3W	20µJ-2J	41
3A-QUAD	Power & position, very low powers up to 3W	Ø9.5mm	0.19-20µm	100µW-3W	20µJ-2J	46
3A-P	Low powers and energies	Ø12mm	0.15-8µm	15µW-3W	20µJ-2J	41
3A-P-QUAD	As above for short pulse lasers	Ø12mm	0.15-8µm	160µW-3W	30µJ-2J	46
3A-PF-12	As above with higher UV pulsed damage threshold	Ø12mm	0.15-20µm	15µW-3W	20µJ-2J	41
3A-P-THz	3A-P sensor calibrated for Terahertz wavelengths	Ø12mm	0.1-30THz	15µW-3W	20µJ-2J	42
3A-FS	Lowest powers, Fused Silica window	Ø9.5mm	0.19-20µm	8µW-3W	15µJ-2J	42
3A-P-FS-12	For divergent beams, window blocks infrared	Ø12mm	0.22 - 2.1µm	15µW - 3W	20µJ-2J	42
12A	Wide dynamic range to 12W	Ø16mm	0.19-20µm	2mW-12W	1mJ-30J	43
12A-P	Short pulse lasers to 12W	Ø16mm	0.15-8µm	2mW-12W	1mJ-30J	43

Low power thermal sensors – 10mW – 50W (Continuous) / 150W (Intermittent)

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
10A	General purpose to 10W	Ø16mm	0.19-20µm	10mW-10W	6mJ-2J	44
10A-PPS	Power, position & size to 10W	Ø16mm	0.19-20µm	20mW-10W	6mJ-2J	46
30A-BB-18	General purpose to 30W	Ø17.5mm	0.19-20µm	10mW-30W	6mJ-30J	44
L30A-10MM	Thin Profile to 30W	Ø26mm	0.15-20µm	80mW-30W	20mJ-60J	44
50(150)A-BB-26	General purpose to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	44
50(150)A-BB-26-QUAD	As above, power and position only	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	50
50(150)A-BB-26-PPS	Power, position & size to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	50
10A-P	Pulsed lasers up to 10W	Ø16mm	0.15-8µm	40mW-10W	10mJ-10J	45
30A-P-17	Short pulse lasers to 30W	Ø17mm	0.15-8µm	60mW-30W	40mJ-30J	45
50A-PF-DIF-18	High energy density pulsed beams	Ø17.5mm	0.24 - 2.2µm	140mW-50W	60mJ-200J	45
15(50)A-PF-DIF-18	As above, compact for intermittent use	Ø17.5mm	0.24 - 2.2µm	140mW-50W	60mJ-200J	45
30A-N-18	High power density pulsed YAG	Ø17.5mm	0.532, 1.064µm	60mW-30W	30mJ-200J	45
BT50A-15	Beam Trap for up to 50W, very low backscatter	Ø15mm	0.19-20µm	N.A.	N.A.	47

Low-medium power thermal sensors – apertures 12mm to 35mm, 10mW – 150W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
30(150)A-BB-18	CW to 30W, intermittent to 150W	Ø17.5mm	0.19-20µm	30mW-150W	20mJ-100J	48
30(150)A-LP1-18	As above, high damage threshold for long pulses and CW	Ø17.5mm	0.25-2.2µm	30mW-150W	20mJ-300J	48
L50(150)A-BB-35	CW to 50W, intermittent to 150W	Ø35mm	0.19-20µm	100mW-150W	40mJ-300J	48
L50(150)A-LP1-35	CW to 50W, intermittent to 150W high damage threshold for long pulses	Ø35mm	0.25-2.2µm	100mW-150W	40mJ-300J	48
L50(150)A-PF-35	CW to 50W, intermittent to 150W for short pulse lasers	Ø35mm	0.15-20µm	100mW-150W	50mJ-300J	48
30(150)A-SV-17	Very high damage threshold, 30W continuous 150W intermittent	Ø17mm	0.19-12µm	100mW-150W	50mJ-300J	49
30(150)A-HE-17	High energy and average power YAGs and harmonics 30W continuous 150W intermittent	Ø17mm	0.19-0.625µm, 1.064µm, 2.1µm, 2.94µm	50mW-150W	60mJ-200J	49
30(150)A-HE-DIF-17	For highly concentrated Q switched pulses to 30W, intermittent to 150W	Ø17mm	0.19-3µm except for 0.625-0.9µm	50mW-150W	60mJ-200J	49

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
20C-SH	Compact smart sensor	Ø12mm	0.19-20µm	10mW-20W	6mJ-10J	51
L30C-SH	Larger aperture, smart sensor	Ø26mm	0.19-20µm	80mW-50W	30mJ-30J	51
L30C-LP2-26-SH	As above with LP2 absorber for high pulse energies	Ø26mm	0.25-2.2µm	300mW-100W	30mJ-2000J	51
100C-SH	Low profile, smart sensor	Ø18mm	0.19-20µm	60mW-100W	N.A	51
150C-SH	High power, smart sensor	Ø18mm	0.19-20µm	60mW-60W	20mJ-100J	51
150W-SH	High power, water cooled smart sensor	Ø18mm	0.19-20µm	100mW-150W	50mJ-100J	51

Medium power thermal sensors – apertures 50 to 65mm, 100mW – 300W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
L40(150)A	CW to 35W, intermittent to 150W, large aperture	Ø50mm	0.19-20µm	100mW-150W	100mJ-4000J	52
L40(150)A-LP2-50	As above, high damage threshold for long pulses	Ø50mm	0.25-2.2µm, 2.94µm	300mW-150W	100mJ-10000J	52
L40(150)A-EX	As above for excimer lasers	Ø50mm	0.15-0.7µm, 10.6µm	100mW-150W	100mJ-200J	52
L50(150)A	CW to 50W, intermittent to 150W	Ø50mm	0.19-20µm	100mW-150W	100mJ-4000J	52
L50(300)A	CW to 50W, intermittent to 300W, very large aperture	Ø65mm	0.19-20µm	400mW-300W	200mJ-300J	53
L50(300)A-LP2-65	As above, high damage threshold for CW and long pulses	Ø65mm	0.25-2.2µm	400mW-300W	200mJ-1KJ	53
L50(300)A-PF-65	CW to 50W, intermittent to 300W, large beam short pulses	Ø65mm	0.15-20µm	400mW-300W	200mJ-300J	53
L50(300)A-IPL	For gel coupled IPL sources	Ø65mm	0.5-1.3µm	400mW-300W	120mJ-1000J	54
L40(150)A-IPL	Energy meter for gel coupled IPL radiation	22x22mm	0.5-1.3µm	N.A.	100mJ-2000J	54

Medium-high power fan cooled thermal sensors – 10mW – 1100W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
F50A-BB-18	General purpose to 50W, very stable reading	Ø17.5mm	0.19-20µm	10mW-50W	6mJ-50J	55
F100A-PF-DIF-33	High average power, short pulse lasers	Ø33mm	0.24-2.2µm	50mW-100W	60mJ-200J	55
F150A-BB-26	Fan cooled to 150W	Ø26mm	0.19-20µm	50mW-150W	20mJ-100J	55
F150A-BB-26-PPS	Power, position & size to 150W	Ø26mm	0.19-20µm	50mW-150W	20mJ-100J	50
FL250A-BB-35	Fan cooled to 250W	Ø35mm	0.19-20µm	150mW-250W	50mJ-300J	56
FL250A-LP2-35	As above, high damage threshold for long pulses and CW	Ø35mm	0.25-2.2µm	100mW-250W	50mJ-300J	56
FL250A-LP1-DIF-33	Fan cooled to 250W with diffuser for high power and energy density	Ø33mm	0.4-3µm	400mW-250W	400mJ-600J	56
FL250A-BB-50	Fan cooled to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	57
FL250A-BB-50-PPS	Power, position & size to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	59
FL400A-BB-50	Fan cooled to 500W	Ø50mm	0.19-20µm	300mW-500W	75mJ-600J	57
FL400A-LP2-50	Fan cooled to 400W, high power densities and long pulses	Ø50mm	0.35-2.2µm, 10.6µm	100mW-500W	250mJ-600J	57
FL600A-BB-65	Fan cooled to 600W	Ø65mm	0.19-11µm	5W-600W	600mJ-600J	58
FL600A-LP2-65	Fan cooled to 600W for long pulsed lasers	Ø65mm	0.35-2.2µm	5W-600W	600mJ-600J	58
FL1100A-BB-65	Fan cooled to 1100W	Ø65mm	0.19-11µm	5W-1100W	600mJ-600J	58
FL1100A-LP2-65	As above for high power densities and long pulses	Ø65mm	0.35-2.2µm	5W-1100W	600mJ-1000J	58

High power thermal sensors – 0.5W – 6000W

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
L250W	Thin profile, 20mm thick, water cooled to 250W	Ø50mm	0.19-20µm	1W-250W	120mJ-200J	61
L300W-LP2-50	Thin profile, 20mm thick, water cooled to 300W	Ø50mm	0.35-2.2µm, 10.6µm	0.5W-300W	200mJ-300J	61
1000W-BB-34	Water cooled to 1000W	Ø34mm	0.19-20µm	5W-1000W	400mJ-300J	62
1000W-BB-34-QUAD	Power & position, high powers up to 1000W	Ø34mm	0.19-20µm	5W-1000W	500mJ-300J	59
1000WP-BB-34	Water cooled to 1000W with non contaminating water circuit	Ø34mm	0.19-20µm	5W-1000W	400mJ-300J	62
1000W-LP2-34	Water cooled to 1000W, high power densities and long pulses	Ø34mm	0.35-2.2µm	5W-1000W	400mJ-300J	62
L1500W-BB-50	Water cooled to 1500W	Ø50mm	0.19-20µm	15W-1500W	500mJ-200J	63
L1500W-LP2-50	As above, high power densities and long pulses	Ø50mm	0.35-2.2µm	15W-1500W	500mJ-200J	63
L2000W-BB-120	Water cooled to 2000W. Very large aperture 120mm	Ø120mm	0.19-20µm	1W-2000W	6J-6000J	64
L100(500)A-PF-120	For short exposures, measure energies to 6000J	Ø120mm	0.15-20µm	1W-500W	6J-6000J	64
5000W-BB-50	Water cooled to 5000W	Ø50mm	0.19-20µm	20W-5000W	N.A.	65
5000W-LP2-50	As above, high power densities and long pulses	Ø50mm	0.35-2.2µm	20W-5000W	N.A.	65
6K-W-BB-200x200	Very large aperture 198x198mm to 6000W. Calorimetric measurement	198x198mm	0.19-20µm	200W-6000W	N.A.	66

Very high power water cooled thermal sensors 100W – 120kW

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
10K-W-BB-45	Water cooled to 11,000W, very high power densities	Ø45mm	0.8-2µm, 10.6µm	100W-11kW	N.A.	67
15K-W-BB-45	Water cooled to 15,000W, high power densities	Ø45mm	0.8-2µm, 10.6µm	100W-15kW	N.A.	67
30K-W-BB-74	Water cooled to 30,000W, high power densities	Ø74mm	0.8-2µm, 10.6µm	100W-30kW	N.A.	68
120K-W	Water cooled to 120,000W, Highest powers	Ø200mm	0.9-1.1µm	10kW-120kW	N.A.	68

Beam dumps up to 11kW

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
BDFL500A-BB-50	fan cooled beam dump up to 500W	Ø50mm	0.19-20µm	up to 500W	N.A.	69
BDFL1500A-BB-65	Water cooled beam dump up to 1500W	Ø65mm	0.19-20µm	up to 1500W	N.A.	69
BD5000W-BB-50	Water cooled beam dump up to 5000W	Ø50mm	0.19-20µm	up to 5000W	N.A.	69
BD10K-W	Water cooled beam dump up to 11,000W	Ø45mm	0.8-20µm	up to 11kW	N.A.	69

Short Exposure High Power Sensors

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
Helios	No water cooling meter for short exposures up to 12kW	Ø50mm	860-1100nm	200W-12kW	N.A.	70
L40(150)A-LP2-50	As above for high power densities and long pulses	Ø50mm	0.25-2.2µm	300mW-150W	100J-10,000J	71
L30C-LP2-26-SH	As above for high power densities and long pulses	Ø26mm	0.25-2.2µm	10W-100W	100J-2000J	71
Comet 1K	Portable low-cost power probe with low powers	Ø50mm	0.2-20µm	20W-1000W	N.A.	72
Comet 10K	Portable low-cost power probe with high powers	Ø100mm	0.98-1.07µm and 10.6µm	200W-10,000W	N.A.	72
Comet 10K-HD	Portable low-cost power probe with high damage threshold	Ø55mm	0.98-1.07µm and 10.6µm	200W-10,000W	N.A.	72

Accessories for High Power Water Cooled Sensors

Accessory	Description	Page
1000W / L1500W Protective Housing	Housing with shutter to protect 1000W and L1500W sensors from contamination with debris	73
5000W/10K-W/15K-W Protective Housing with Shutter	Housing with shutter to protect 5000W, 10K-W and 15K-W sensors from contamination with debris	74
10K-W and 15K-W Scatter Shield	Shield to mount on front flange of 10K-W and 15K-W sensors. Reduces backscatter of radiation by 2/3	75
30K-W Scatter Shield	Shield to mount on front flange of 30K-W sensor. Reduces backscatter of radiation by 2/3	75
Heavy Duty Stand for 10K-W/15K-W	Heavy Duty Stand for 10K-W and 15K-W	75
Metric Water Fittings for water cooled sensors	Water connectors for metric size tubing instead of standard inch size	76
1000W/1500W/5000W/10K-W/15K-W Protective Cover	Housing with shutter to protect sensors from contamination with debris	76
10K-W / 15K-W Scatter Shield Cover	10K-W and 15K-W with Scatter Shield	76
30K-W Protective Cover	Protective cover with target pattern for 30K-W (one supplied with device)	76
30K-W Scatter Shield Cover	30K-W with Scatter Shield	76

BeamTrack - Power / Position / Size Sensors

Sensor	Features	Aperture	Spectral Range	Power Range	Energy Range	Page
3A-QUAD	Power & position, very low powers up to 3W	Ø9.5mm	0.19-20µm	100µW-3W	20µJ-2J	80
3A-P-QUAD	As above for short pulse lasers	Ø12mm	0.15-8µm	160µW-3W	30µJ-2J	80
10A-PPS	Power, position & size to 10W	Ø16mm	0.19-20µm	20mW-10W	6mJ-2J	80
50(150)A-BB-26-QUAD	As above, power and position only	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	81
50(150)A-BB-26-PPS	Power, position & size to 50W, 150W intermittent	Ø26mm	0.19-20µm	40mW-150W	20mJ-100J	81
F150A-BB-26-PPS	Power, position & size to 150W	Ø26mm	0.19-20µm	50mW-150W	20mJ-100J	81
FL250A-BB-50-PPS	Power, position & size to 250W, large aperture	Ø50mm	0.19-20µm	150mW-250W	80mJ-300J	82
1000W-BB-34-QUAD	Power & position, high powers up to 1000W	Ø34mm	0.19-20µm	5W-1000W	500mJ-300J	82

Accessories for thermal sensors

Fiberoptic adapters

Accessory	Description	Page
Thermal F.O. adapters	Adapters for mounting fibers to thermal sensors (ST, FC, SMA, SC)	83

Accessories for High Power Sensors

Accessories

Accessory	Description	Page
Protective Housing for 1000W, L1500W, 5000W, 10k-W and 15k-W sensors	Protective housing with shutter providing protection from debris of material working process	84
Scatter Shield for 10K-W, 15K-W and 30K-W sensors	Shield to mount on front flange of 10K-W/30K-W sensors. Reduces backscatter of radiation by 2/3	84
Protective covers for Scatter Shields for 10K-W, 15K-W and 30K-W	Protective Cover to mount on Scatter Shields protecting the Shield from debris of material working process	84
Protective Covers with Target	Protective cover with target pattern for 1000W/1500W/5000W/10K-W/15K-W and 30K-W (one supplied with device)	84
Metric Water Connectors for water cooled sensors	Water connectors for metric size tubing instead of standard inch size	84
Heavy Duty Stand for 10K-W/15K-W	Heavy Duty Stand for 10K-W and 15K-W	84

General Accessories

Accessories

Accessory	Description	Page
SH to BNC Adapter	Allows connection of sensor to voltage measuring device for measurement of raw voltage output	84

Replacement Parts

Accessories

Accessory	Description	Page
N Polarity Power Supply/Charger 12V 2A N-2.1x5.5	Negative Polarity Power Supply/Charger for Vega, Nova II, Laserstar, Nova, Pulsar, Quasar, EA-1, 120K-W, 6K-W and Fan Cooled Sensors	84
P Polarity Power Supply/Charger 12V 2A P-1.35x3.5	Positive Polarity Power Supply/Charger for StarLite, StarBright and RM9 Chopper	84

Energy sensors

Photodiode and Pyroelectric Energy Sensors

Photodiode energy sensors – 10pJ – 15µJ

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PD10-C	Very low energies down to nJ, Silicon photodiode	Ø10mm	0.19-1.1µm	1nJ-20µJ	20,000Hz	89
PD10-IR-C	Very low energies down to nJ, Germanium photodiode	Ø5mm	0.7-1.8µm	1nJ-600nJ	10,000Hz	89
PD10-pJ-C	Lowest energies down to pJ, Silicon photodiode	Ø10mm	0.2-1.1µm	10pJ-200nJ	20,000Hz	89
PD10-IR-pJ-C	Lowest energies down to pJ, Germanium photodiode	Ø5mm	0.7-1.8µm	30pJ-20nJ	10,000Hz	89

Pyroelectric energy sensors – 0.1µJ – 10J

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PE9-C	Pyroelectric for very low energies	Ø8mm	0.15-12µm	0.2µJ-1mJ	25,000Hz	90
PE9-ES-C	Pyroelectric for lowest energies	Ø8mm	0.15-12µm	0.1-200µJ	20,000Hz	90
PE10-C	Pyroelectric for low energies	Ø12mm	0.15-12µm	1µJ-10mJ	25,000Hz	91
PE10BF-C	As above, high damage threshold	Ø12mm	0.15-3µm, 10.6µm	7µJ-10mJ	250Hz	91
PE25-C	Medium aperture pyroelectric	Ø24mm	0.15-3µm	8µJ-10J	10,000Hz	92
PE25BF-C	As above, high damage threshold	Ø24mm	0.15-3µm, 10.6µm	60µJ-10J	250Hz	92
PE50-C	Large aperture pyroelectric	Ø46mm	0.15-3µm	10µJ-10J	10,000Hz	93
PE50BF-C	As above, high damage threshold	Ø46mm	0.15-3µm, 10.6µm	120µJ-10J	250Hz	93

High energy pyroelectric sensors – 10µJ – 40J

Sensor	Features	Aperture	Spectral Range	Energy Range	Maximum Frequency	Page
PE50-DIF-C	Pyroelectric with diffuser, high repetition rate. Complete calibration curve	Ø35mm	0.19-2.2µm, 2.94µm	20µJ-10J	10,000Hz	94
PE25BF-DIF-C	Pyroelectric with diffuser for high damage threshold. Complete calibration curve	Ø20mm	0.24-2.2µm	100µJ-10J	250Hz	94
PE50BF-DIF-C	Pyroelectric with diffuser for highest damage threshold. Complete calibration curve	Ø35mm	0.19-2.2µm, 2.94µm	200µJ-10J	250Hz	95
PE50BF-DIFH-C	Similar to PE50BF-DIF-C but with higher damage threshold	Ø35mm	0.19-2.2µm, 2.94µm	200µJ-10J	250Hz	95
PE50BB-DIF-C	Pyroelectric with removable diffuser. Wide spectral range w/o diffuser	Ø46mm Ø33mm with diffuser	0.19-20µm, 0.4-2.5µm with diffuser	100µJ-40J	40Hz	95
PE50-DIF-ER-C	Pyroelectric with removable diffuser. Especially for Erbium laser	Ø46mm Ø33mm with diffuser	0.19-3µm, 0.4-3µm with diffuser	10µJ-30J	10,000Hz	97
PE100BF-DIF-C	Largest aperture pyroelectric with removable diffuser	Ø96mm Ø85mm with diffuser	0.15-3µm, 0.4-2.5µm with diffuser	400µJ-40J	200Hz	97
FPE80BF-DIF-C	Fan cooled pyroelectric for high ave powers to 200W	Ø53mm	0.19-2.2µm, 2.94µm	1mJ-40J	250Hz	98
PE80BF-DIF-C	Ppyroelectric with diffuser for high power densities	Ø67mm	0.19-2.2µm, 2.94µm	4mJ-40J	250Hz	98

Energy Sensors Accessories

Accessories for pyroelectric sensors

Fiberoptic adapters

Accessory	Description	Page
Pyroelectric F.O. Adapters	Adapters for mounting fibers to pyroelectric sensors (ST, FC, SMA, SC)	99

Accessories

Accessory	Description	Page
Removable Heat Sink	Heat sink that is fastened to rear of PE-C sensors. Allows average power ~50-70% higher than without heat sink	99
Scope Adapter	Plugs in between the PE sensor and power meter. Provides BNC output to scope to see every pulse up to the maximum frequency of the sensor	99
Beam Splitter Assembly	Beam Splitter Assembly to measure pulsed laser sources too energetic for direct measurement. Use with the Beam Splitter can be calibrated by setting the laser to a lower energy that will not damage the sensor and swiveling between position A and B and then taking the ratio of A and B	99
Nova PE-C Adapter	The adapter plugs between the Nova D15 socket and the smart plug of the PE-C sensor to allow the Nova to operate with PE-C series sensors. See PE-C spec sheet for details	100
Damage Threshold Test Plates	Test plates with same absorber coating as the sensor. For testing that laser beam is not above damage threshold (1 such plate is included with sensor package). There are test plates of the following types: Metallic, BF and THz	100
PE-C to PE Size Adapter	The newer PE-C series sensors have a Ø62mm diameter. The older PE series sensors have a Ø85mm diameter. This adapter allows using the PE-C type sensors in jigs and setups that were originally designed for PE sensors	100
N Polarity Power Supply/Charger AC/DC 12V 2A N-2.1x5.5	Negative Polarity Power Supply/Charger for FPE80BF-DIF-C sensor	100

Fast photodetector model FPS-1

Accessory	Description	Page
FPS-1 Fast Photodetector	Connect to oscilloscope to measure temporal beam profile. 1.5ns response time	101

Customized Solutions (OEM) Power and Energy Sensors

Standard Customized Solutions (OEM) thermal sensors – 100pW – 600W

Sensor	Features	Aperture	Spectral Range	Power Range [a]	Size	Page
3A-UA	Low power, built in amplifier (RS232/analog)	Ø9.5mm	0.19-20µm	100µW-3W	50x50x38mm	105
PD300-UAS	compact, photodiode, built in amplifier (RS232/analog)	10x10mm	0.2-1.1µm	100pW-50mW	38x38x32mm	105
20C-SH	Compact smart sensor	Ø12mm	0.19-20µm	10mW-20W	38x38x14mm	106
20C-UAS	compact, built in amplifier (RS232/analog)	Ø12mm	0.19-20µm	10mW-20W	38x38x34mm	106
20C-UAU	Compact, external amplifier (USB/analog)	Ø12mm	0.19-20µm	10mW-20W	38x38x14mm	106
L30C-SH	Medium aperture, smart sensor	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	107
L30C-LP2-26-SH	As above with LP2 absorber for high pulse energies	Ø26mm	0.25-2.2µm	300mW-100W	60X60X38mm	107
L30C-UA	Medium aperture, built-in amplifier (RS232/analog)	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	107
L30C-UAU	Medium aperture, built-in amplifier (USB)	Ø26mm	0.19-20µm	80mW-50W	60x60x38mm	107
100C-SH	Low profile, smart sensor	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	108
100C-UA	Low profile, separate amplifier (RS232/analog)	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	108
100C-UAU	Low profile, separate amplifier (USB)	Ø18mm	0.19-20µm	60mW-100W	48x48x14.5mm	108
100W-AXL-UAF	High power, very fast response (50ms) built in amplifier, water cooled (RS232/analog)	Ø26mm	0.19-20µm	400mW-100W	60X60X45mm	108
150C-SH	High power, smart sensor	Ø18mm	0.19-20µm	60mW-150W	50.8x50.8x33mm	109
150C-UA	High power, built-in amplifier (RS232/analog)	Ø18mm	0.19-20µm	60mW-150W	50x50x38mm	109
150C-UAU	High power, built-in amplifier (USB)	Ø18mm	0.19-20µm	60mW-150W	50x50x38mm	109
150W-UA	High power, built-in amplifier, water cooled (RS232/analog)	Ø18mm	0.19-20µm	100mW-150W	50x50x38mm	109
150W-UAU	High power, built-in amplifier, water cooled (USB)	Ø18mm	0.19-20µm	100mW-150W	50x50x38mm	109
L150C-UA	Large aperture, built-in amplifier (RS232/analog)	Ø50mm	0.19-20µm	0.2W-150W	80x80x45mm	110
L150C-UAU	Large aperture, built-in amplifier (USB)	Ø50mm	0.19-20µm	0.2W-150W	80x80x45mm	110
L250W-UA	Large aperture, built-in amplifier, water cooled (RS232/analog)	Ø50mm	0.19-20µm	0.3W-250W	80x80x58mm	110
L250W-UAU	Large aperture, built-in amplifier, water cooled (USB)	Ø50mm	0.19-20µm	0.3W-250W	80x80x58mm	110
L300W-UA	Large aperture, built-in amplefier, water cooled (RS232/analog)	Ø50mm	0.19-20µm	0.5W-300W	80x80x58mm	110
L300W-UAU	Large aperture, built-in amplifier, water cooled (USB connection)	Ø50mm	0.19-20µm	0.5W-300W	80x80x58mm	110
600W-UA	High power, built in amplifier, (RS232/analog)	Ø26mm	0.35-2.2µm	5W-600W	65x65x49mm	110
600W-UAU	High power, built in amplifier, (USB)	Ø26mm	0.35-2.2µm	5W-600W	65x65x49mm	110
Other Sensors	Ophir offers many other Customized Solutions (OEM) sensors. For your Customized Solutions (OEM) solution please fill the questionnaire on our website: www.ophiropt.com/photonics or contact us: USA: sales@ophir-spiricon.com Other: ophir.sales@ophiropt.com customer.support@ophiropt.com					

Note: (a) Effective Dynamic Range for a given sensor is ~ 30:1

EA-1 Ethernet Adapter for Customized Solutions (OEM) smart sensors

Accessory	Description	Page
EA-1 Ethernet Adapter	Compact ethernet PC adapter for smart sensor	111

Standard Customized Solutions (OEM) pyroelectric energy sensors – 0.1µJ – 40J

Sensor	Features	Aperture	Spectral Range	Energy Range	Max. Freq.	Size	Page
PE10-C-RE	Non amplified compact sensor	Ø12mm	0.19-10.6µm	Depends on configuration	Depends on configuration	Ø22 x 7.5mm	114
PE-C-RS232	PE smart sensors with built in output	choose from standard PE-C	choose from standard PE-C	same as equiv. PE-C	same as equiv. PE-C	same as std PE-C	114
PE-C-RE	Custom smart PE sensors	usually 10mm	0.19-10.6µm	same as equiv. PE-C	same as equiv. PE-C	Can be very small	114
Other Sensors	Ophir offers many other Customized Solutions (OEM) sensors. For your Customized Solutions (OEM) solution please fill the questionnaire on our website: www.ophiropt.com/photonics or contact us: USA: sales@ophir-spiricon.com Other: ophir.sales@ophiropt.com customer.support@ophiropt.com						

Sensor Finder Program

Finding the proper sensor(s) to meet your measurement needs has never been easier. With our sensor finder program just enter your laser parameters and the proper measuring sensors for your application will be displayed on the screen. The program calculates the power and energy density capabilities of each absorber, based on the laser wavelength, pulse length, repetition rate and other relevant parameters. It also compares all the other requirements such as maximum and minimum power, energy, beam size, etc.

In addition to finding the right sensor for your application, the Sensor Finder Program offers the following features:

- Report printing
- How close the recommended sensors are to the specified damage threshold
- Calculation of input power and energy density and average power
- Tips on further action if no solution is found

Order of Selection

The sensors are selected in terms of cost effectiveness and ease of use, i.e. photodiode sensors and thermopiles are selected first and then pyroelectric sensors. If you want to measure only power, pyro sensors will not be selected even if they could operate within all other given laser parameters.

Aperture

Since it is not practical to allow the beam to fill the entire aperture, the sensors are selected so that the sensor aperture is always at least 2mm or 10% larger than the beam. If the beam is rectangular its corners can touch the aperture.

Using the Sensor Finder Program

The Sensor Finder Program is available for use online at:
www.ophiropt.com/sensor-finder
It can also be downloaded for use on your own PC at:
www.ophiropt.com/sensor-finder-download

Sensor Finder Input Screen

1. When the program is started, the above screen appears: In Step 1, Select the laser type [CW or pulsed], the beam type [flat top or Gaussian and if flat top, circular or rectangular] and whether you wish to measure both power and energy or just laser power.

2. In Step 2, Enter the required laser parameters: beam diameter, wavelength, max/min power or max/min energy, rep rate and pulse width. If minimum power is not entered, then the program assumes the minimum is ½ the maximum.
   If desired, enter these optional criteria: exposure time – the maximum time the sensor measures at a time. If you only plan to measure the laser power for short periods at a time, Ophir offers more compact sensors for intermittent use.
   Sensor size – only sensors smaller than the specified dimensions will be selected.

3. In Step 3 click “Find Sensor”.

4. The sensors that meet specified criteria will be listed in the output screen shown below. The sensor type and how close to the damage threshold are listed for each result. The input parameters are listed on top.

5. In order to find compatible displays, click “Meter Finder”. In order to find compatible PC interfaces click “PC Interfaces”.

6. To save the results, click “Save”. To print the results, click “Print”.

Sensor Finder Output Screen

Damage Threshold

Some sensors are closer to the laser damage threshold than others. Since the damage threshold can vary somewhat from case to case and also is cumulative, the Sensor Finder Program mentions how close a particular sensor is to the damage threshold. The displayed percent of damage threshold is the highest of either the power or the energy threshold. It is recommended to select a sensor that is less than 50% of the damage threshold.

Power/Energy Meters

In order to find power/energy meters or PC interfaces that are compatible with various sensors, click "Meter Finder" or "PC Interfaces". Note that some of the newer sensors, such as the Pyro-C line sensors are only compatible with the newer meters and PC interfaces.

General Introduction

Types of Power/Energy Sensors

Power and Single Shot Energy Sensors

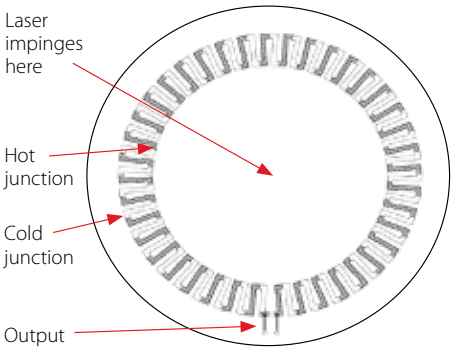
Ophir provides two types of power sensors: Photodiode sensors and Thermal sensors. Photodiode sensors are used for low powers from picowatts up to hundreds of milliwatts and as high as 3W. Thermal sensors are for use from fractions of a milliwatt up to thousands of watts. Thermal sensors can also measure single shot energy at pulse rates not exceeding one pulse every ~5s.

Repetitive Pulse Energy Sensors

For higher pulse rates, Ophir has pyroelectric energy sensors able to measure pulse rates up to tens of kHz. These are described in the energy sensor section, section 1.2.

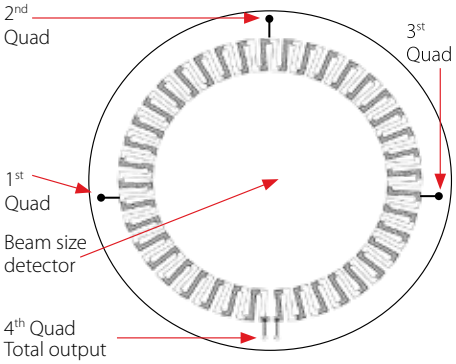
Thermal Sensors

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.



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



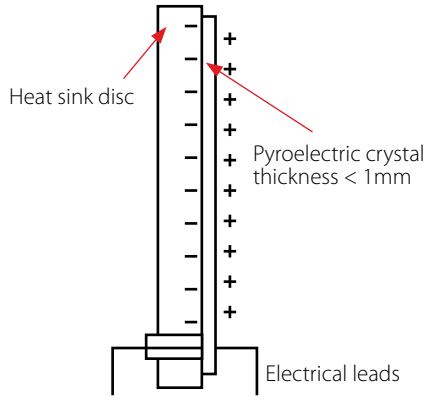
Using Power Sensors to Measure Single Shot Energy

Although Ophir thermal power sensors are used primarily to measure power, they can measure single shot energy as well where they integrate the power over time flowing through the disc 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.

Single shot energy can also be used to measure high power laser power. The sensor is exposed to a pulse of the laser power on the order of 0.3– 2s and the energy measured is converted to a power reading. In this way, a relatively small non water cooled sensor can measure powers up to over 10,000W. See “Short Exposure High Power Sensors” section on page 70-72

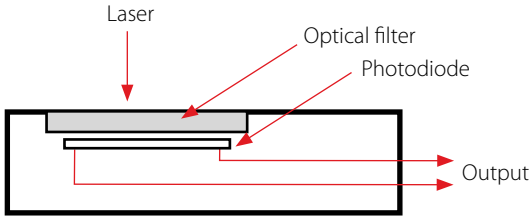
Pyroelectric Sensors

Pyroelectric type sensors are useful for measuring the energy of repetitively pulsed lasers at up to 25,000Hz and are sensitive to low energies.
They are less durable than thermal types and therefore should not be used whenever it is not necessary to measure the energy of each pulse and average power measurement is sufficient.
Pyroelectric sensors use a pyroelectric crystal that generates an electric charge proportional to the heat absorbed. Since the two surfaces of the crystal are metalized, the total charge generated is collected and therefore the response is not dependent on beam size or position. This charge then charges a capacitor in parallel with the crystal and the voltage difference thus generated is proportional to the pulse energy. After the energy is read by the electronic circuit, the charge on the crystal is discharged to be ready for the next pulse.



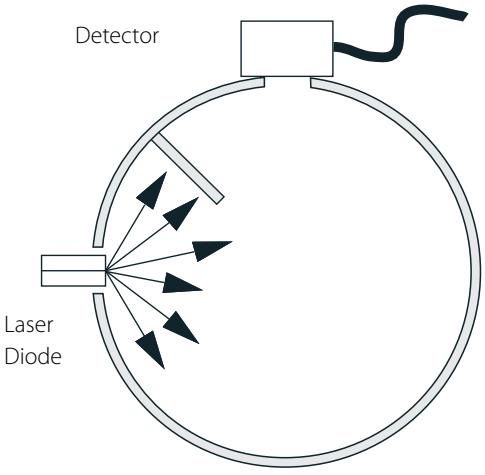
Photodiode Sensors for Lower Powers

In addition to the thermal sensors described above, Photodiode sensors are used for low powers from picowatts up to hundreds of milliwatts and as high as 3W.
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 2mW. 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 3W without saturation.



Integrating Spheres

Integrating Spheres are meant to measure divergent light sources such as LEDs. The light is introduced to the sphere through the input port, and reflected many times by the highly reflecting diffuse surface of the inner wall of the sphere until it uniformly illuminates the inner surface of the sphere. A detector samples a 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. This integrating sphere configuration is ideal for a divergent beam such as from a laser diode. Ophir also offers integrating spheres configured for measuring collimated laser beams. Ophir has spheres of various sizes for covering UV, visible, NIR lasers up to 30 Watts. There is a North Pole auxiliary port suitable for picking off a small amount of light via an 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.

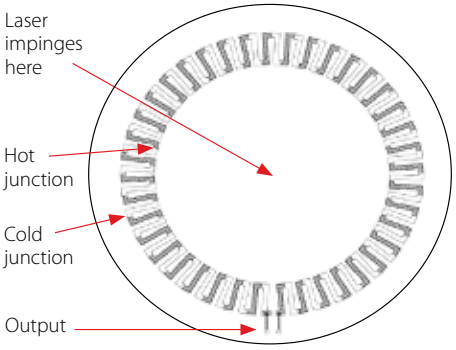


Power sensors

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.

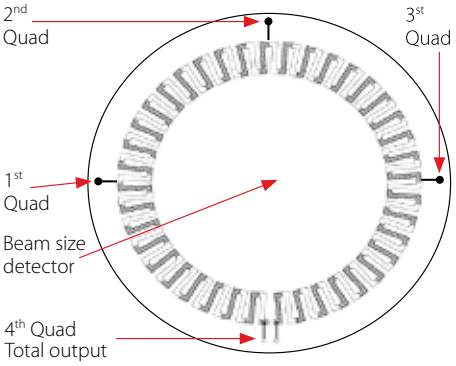


Using Power Sensors to Measure Single Shot Energy

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

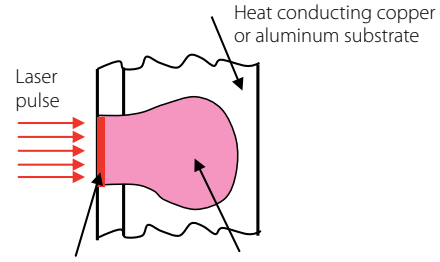
The traditional surface absorbers have a much lower damage threshold at > 1000W, where they can damage at 2-3 kW/cm^2. Ophir has developed coatings that improve the damage threshold for high power lasers. These coatings are denser and have higher heat conductivity than previous coatings. This LP2 coating also has a much higher damage threshold for long pulses reaching power damage thresholds of up to 10kW/cm^2 and 300J/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 a 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.

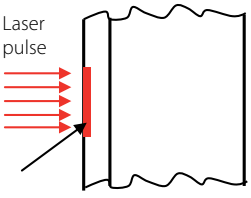
Long laser pulse (>100µs) or continuous

(A) Surface absorber



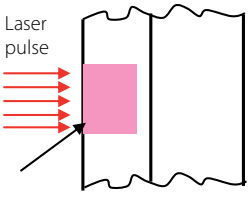
Short laser pulse <10µs

(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 120 kilowatts. Ophir meters also have the highest damage threshold available – up to 10kW/cm^2 at 10kW. 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 by 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, 15K-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, 15K-W and 30K-W sensors work on the thermopile principle, where the radial heat flow in the absorber disc 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 over the entire range of 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

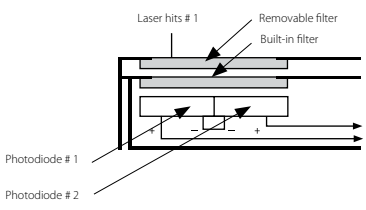
Photodiode Sensors

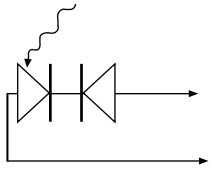
A photodiode sensor is a semiconductor device that produces a current proportional to light intensity and has a high degree of linearity over a large range of light power levels - from fractions of a nW to about 2mW. Above that light level, corresponding to a current of about 1mA, the electron density 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 3W 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 PD300-1W 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 on. 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

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

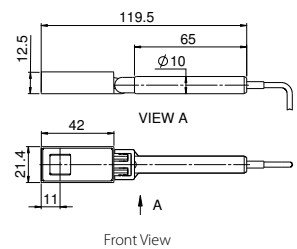
Model	PD300			PD300-1W			PD300-3W			PD300-TP		
Use	**General**			**Powers to 1W**			**Powers to 3W**			**Thin profile for tight fit**		
Detector Type	silicon			silicon			silicon			silicon		
Aperture	10x10mm			10x10mm			10x10mm			10x10mm		
Filter mode	Filter out		Filter in	Filter out		Filter in	Filter 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		30	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 37)	ST, FC, SMA, SC			ST, FC, SMA, SC			ST, FC, SMA, 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

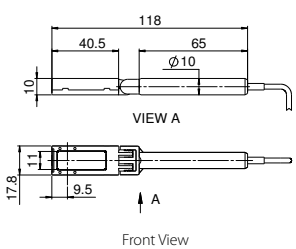
* For graphs see page 28-29

* For PD300-3W drawing see PD300-UV/PD300-IR drawing on page 25

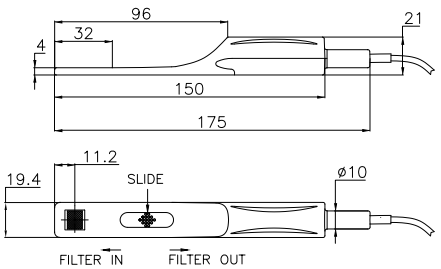
PD300 / PD300-1W filter installed



PD300 / PD300-1W filter off



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

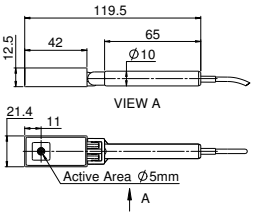
PD300-UV / PD300-IR with filter installed

PD300-IRG with fiber input

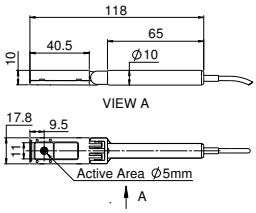
Model	**PD300-UV/ PD300-UV-193**				**PD300-IR**				**PD300-IRG**			
Use	**Lowest powers from 200-1100nm**				**Low powers from 700-1800nm**				**Telecom wavelength fiber and free space measurements**			
Detector Type	silicon				germanium				InGaAs			
Aperture	10x10mm				Ø5mm				Ø5mm for free space beams			
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		150µW to 200mW	
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	200	
	400	3	300		1000-1300	30	300		1100	0.8	200	
	600	3	300		1400	30	250		1200	0.8	200	
	800 - 950	2.5	150		1500	25	80		1300	0.8	200	
	1064	3	300		1600	30	100		1550	0.8	200	
					1800	30	300		>1600	0.8	200	
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 37)	ST, FC, SMA, SC				ST, FC, SMA, SC				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 28-29

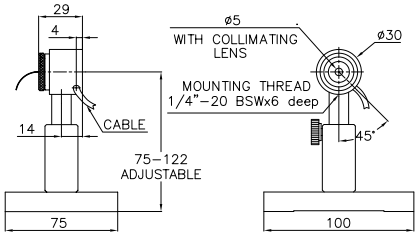
PD300-UV / PD300-IR filter installed
(Ø5mm for PD300-IR only)



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

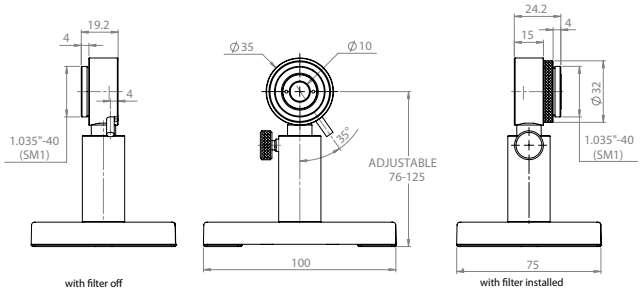
PD300R Filter Off

PD300R Filter installed

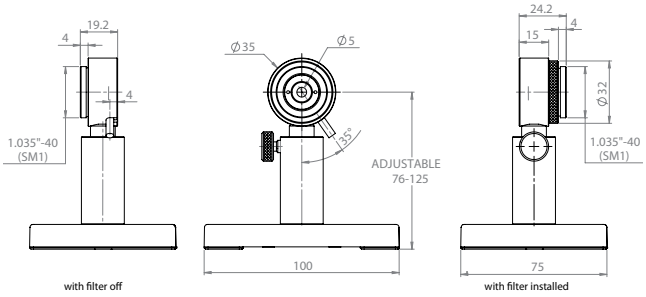
Model	PD300R		PD300R-3W		PD300R-UV		PD300R-IR	
Use	General		Powers to 3W		Lowest powers from 200-1100nm		IR wavelengths 700-1800nm	
Detector Type	silicon		silicon		silicon		germanium	
Aperture	Ø10mm		Ø10mm		Ø10mm		Ø5mm	
Filter mode	Filter out	Filter in	Filter out	Filter in	Filter out	Filter in	Filter 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	30	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 37)	ST, FC, SMA, SC		ST, FC, SMA, SC		ST, FC, SMA, SC		ST, FC, SMA, SC	
Version								
Part Number	**7Z02436**		**7Z02437**		**7Z02438**		**7Z02439**	

* For graphs see page 28-29

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 human visual perception 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 with continuous wavelength curve**
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)	400 - 1100 (see graph) [C]
Filter Mode		Filter out	Filter in		
Power Range	50pW to 4mW	50pW to 4mW	1nW to 50mW	20mLux to 200kLux	0.1mW 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	1mLux	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 37)	NA	ST, FC, SMA, SC		NA	NA
Version					V1
Part Number	**7Z02405**	**7Z02440**		**7Z02406**	**7Z02481** [a]

Notes:

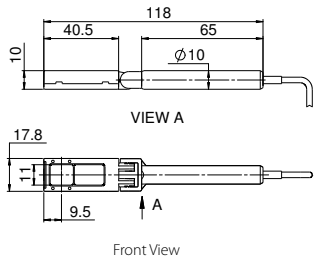
(a) Swivel stand for BC20 sensor P/N 1Z09004

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

(c) The user can select up to 5 wavelengths from the spectral range. When used with the Nova or LaserStar meters, the sensor will only have the discrete wavelengths 405nm, 633nm, 650nm, 675nm and 780nm

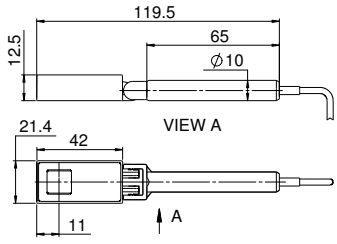
* For graphs see page 28-29

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



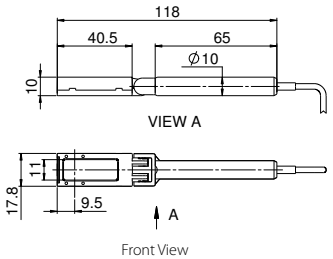
Front View

PD300-BB-50mW with filter installed



Front View

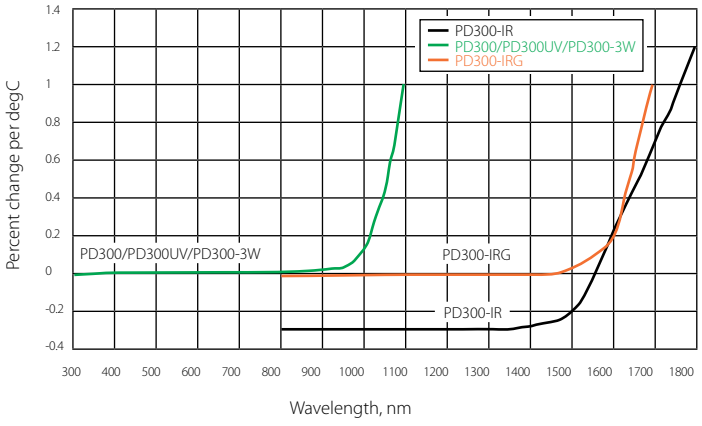
BC20



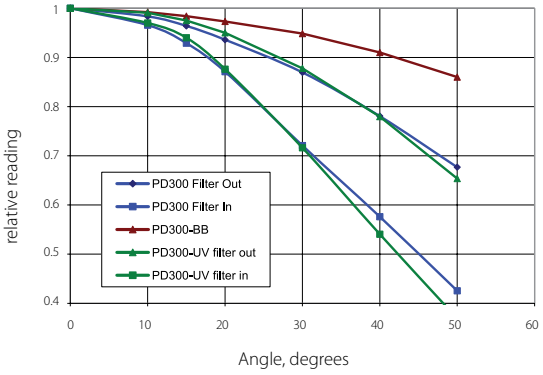
Front View

1.1.1.4 Graphs

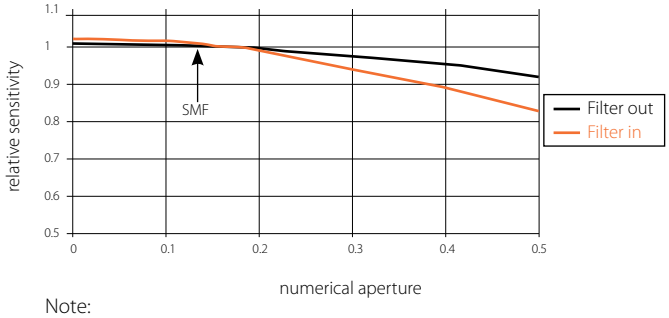
Temperature Coefficient of Sensitivity



PD300 Angle Dependence



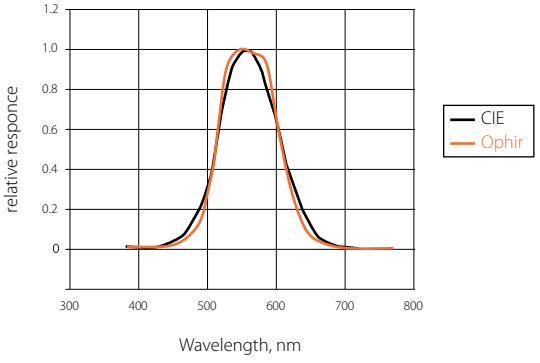
Dependence of Sensitivity on Numerical Aperture (PD300 - IRG)



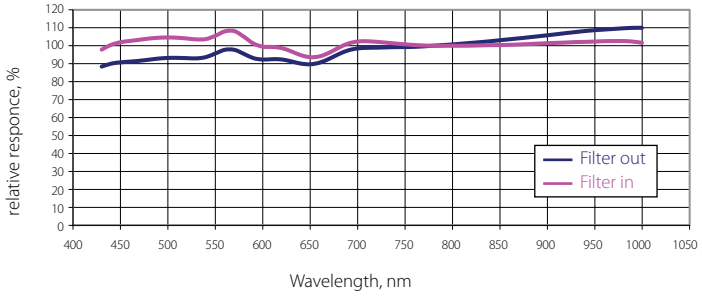
Note:

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

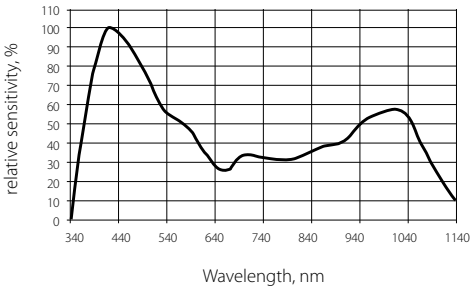
PD300-CIE Spectral Response vs. CIE Curve



Typical Sensitivity Curve of PD300-BB Sensors



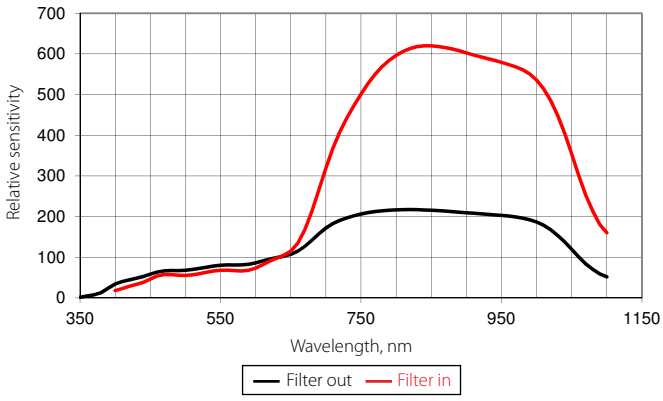
Relative Spectral Response of BC20



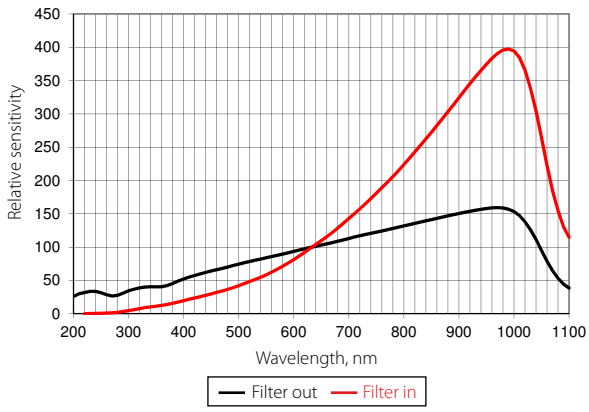
Approximate Spectral Response

Relative to 633nm or 1550nm

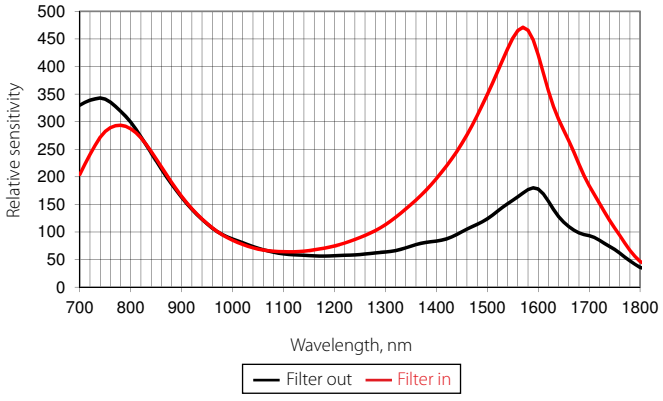
PD300 / PD300R



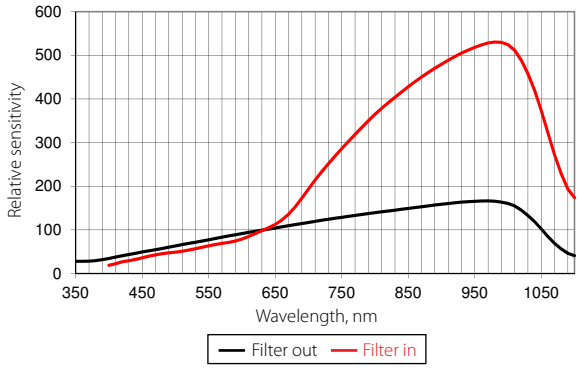
PD300-UV / PD300R-UV



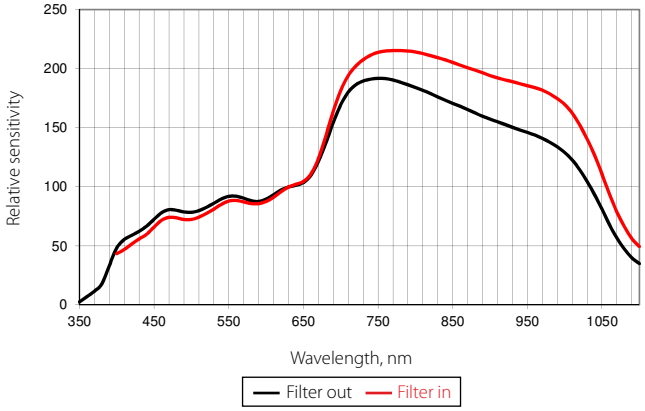
PD300-IR / PD300R-IR



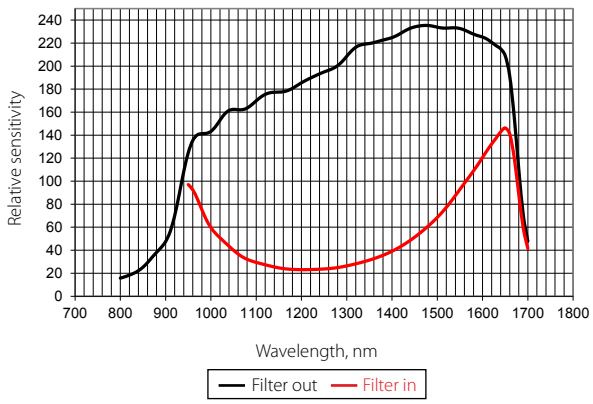
PD300-TP



PD300-3W / PD300R-3W



PD300-IRG



1.1.1.5 Integrating Spheres

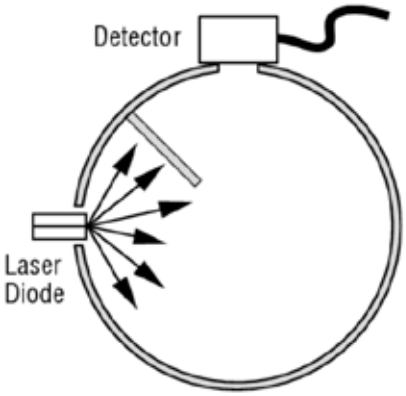
Introduction

Ophir Integrating Spheres are used for measuring divergent light sources such as laser diodes and 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 a small fraction of this light and thus can be used to measure the total power input into the sphere.

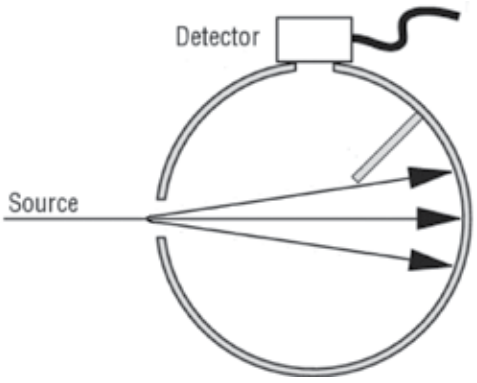
Ophir integrating spheres have a highly reflecting diffuse white coating for high efficiency and readings that are independent of beam size, position and divergence.

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 beams. The unused port that is not being used is closed with a reflective plug.



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



This integrating sphere configuration is ideal for a collimated beam source such as a collimated laser beam or slightly divergent beam <±15deg

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 sampled via an 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”

20nW to 3W

Features

- Integrating sphere for divergent beams
- Up to ∅12mm aperture
- Fiber or free space input

IS-1 / IS-1-2W

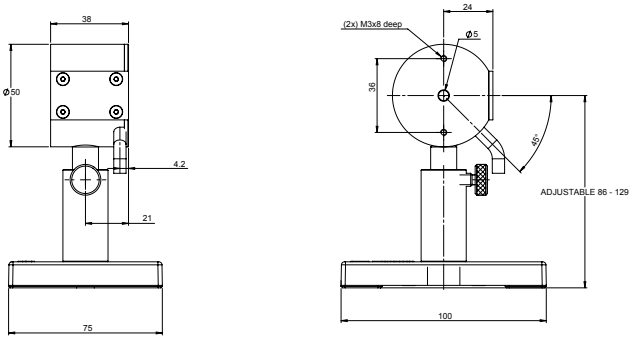
3A-IS

3A-IS-IRG

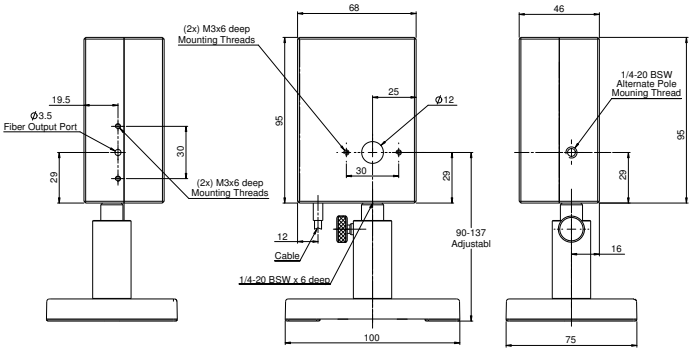
Model	IS-1	IS-1-2W	3A-IS	3A-IS-IRG
Use	**Divergent beams to 20mW for UV to NIR**	**Divergent beams to 2W for visible and NIR**	**Divergent beams to 3W for visible and NIR**	**Divergent beams to 3W for IR**
Detector Type	Si	Si	Si	InGaAs
Input Port Aperture mm	∅5mm	∅5mm	∅12mm	∅12mm
Spectral Range µm	0.20 - 1.1	0.35 - 1.1	0.35 - 1.1	0.8 – 1.7
Power Range	20nW – 20mW	1µW – 2W	1µW – 3W	1µW – 3W
Power Scales	20mW to 200nW and dBm	2W to 20µW and dBm	3W to 3µW and dBm	3W to 3µW and dBm
% Error vs Wavelength nm	±7 200-250 ±5 250-450 ±4 450-950 ±8 950-1100	±5 250-450 ±4 450-950 ±8 950-1100	±5 350 -1000 ±10 1000-1100	±5
Linearity with Power +/-%	1	1	1	1
Damage Threshold kW/cm^2	1 on integrating sphere surface	1 on integrating sphere surface	0.2 on integrating sphere surface	0.2 on integrating sphere surface
Maximum Pulse Energy µJ	2	300	500	500
Power Noise Level nW	1	20	20	20
Response Time with Meter s	0.2	0.2	0.2	0.2
Maximum Beam Divergence	±40 degrees	±45 degrees	±40 degrees	±40 degrees
Sensitivity to Beam Size and Angle	±2%	±1% to 40 deg ±3% to 45 deg	±2%	±2%
Cooling	convection	convection	convection	convection
Fiber Adapters Available (see page 37)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA [a], SC	ST, FC, SMA [a], SC
Weight kg	0.25	0.25	0.6	0.6
Version			V1	
Part Number	**7Z02465**	**7Z02484**	**7Z02404**	**7Z02403**

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

IS-1 / IS-1-2W



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
- Can be ordered with or without detectors

Model	**IS6**	
Use	**For use with customer detector or as light source**	
Detector	None – see below for detector versions	
Spectral Range µm	0.2 – 2.2	
Source Geometry [a] (see introduction)	**Divergent** (input from 2.5" side)	**Collimated** (input from 1" side)
Input Port Aperture mm	Ø25.4 (1") [b]	Ø25.4 (1")
Maximum Beam Divergence	±40deg	NA
Sensitivity to Beam Size	±3% [c]	±1%
Power Range	Depends on detector – see below	
Damage Threshold kW/cm^2	1 on integrating sphere surface	
Cooling	Convection	
Weight kg	1.4	
Type	**P/N**	
IS6-D For divergent beams (input from 2.5" side)	7Z02475	
IS6-C For collimated beams (input from 1" side)	7Z02474	
Supplied Aperture Covers (see page 33)	**IS6-D:** 2.5" to 1" reducer + 1" port plug + 3 ea.1" port covers **IS6-C:** 2.5" port plug + 3 ea. 1" port covers	

Notes: (a) In each configuration, the opposing port is closed with a port plug. See diagram in introduction page 30. The divergent type should be used for beams with >±15deg divergence and the collimated type for beams with <±15deg divergence.
(b) The sphere is supplied with the 2" to 1" reducer. If desired, the sphere can be used without the reducer at full aperture of 63.5mm (2").
(c) For beams up to 30deg divergence, variation with beam size is ±1%.

IS6 without detector

IS6 with Detectors - calibrated - VIS and UV types

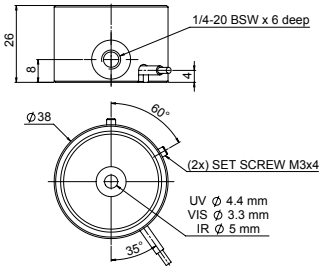
In the detector versions, the IS6 with detector comes with a calibrated wavelength curve.

	IS6-D with Detector				**IS6-C with Detector**			
Model	**IS6-D-VIS**		**IS6-D-UV**		**IS6-C-VIS**		**IS6-C-UV**	
Detector type	**VIS**		**UV**		**VIS**		**UV**	
Use	**High powers for divergent beams**		**Low powers for divergent beams**		**High powers for collimated beams**		**Low powers for collimated beams**	
Type	Si with filter		Si		Si with filter		Si	
Spectral Range µm	0.4 – 1.1		0.2 – 1.1		0.4 – 1.1		0.2 – 1.1	
Power Range (approx.)	20µW to 30W		300nW to 1W		20µW to 30W		300nW to 1W	
Power Scales	30W to 300µW		1W to 3µW		30W to 300µW		1W to 3µW	
Linearity with Power ±%	1		1		1		1	
Configuration	Divergent		Divergent		Collimated		Collimated	
Power Noise Level	1µW		15nW		1µW		15nW	
Maximum Pulse Energy mJ	2		0.05		2		0.05	
Maximum Beam Divergence	±40deg		±40deg		NA		NA	
Sensitivity to Beam Size	±3% [c]		±3% [c]		±1%		±1%	
Maximum Power vs. Wavelength	nm	W	nm	W	nm	W	nm	W
	<670	30	<600	1	<670	30	<600	0.7
	790	30	800-1000	0.5	790	20	800-1000	0.3
	904	20	1064	1	904	15	1064	0.5
	1064	30			1064	25		
% error per Wavelength nm	10 360 - 410		10 200 - 270		10 360 - 410		10 200 - 270	
	5 410 - 950		5 270 - 950		5 410 - 950		5 270 - 950	
	7 950 - 1100		7 950 - 1100		7 950 - 1100		7 950 - 1100	
Part Number	**7Z02471**		**7Z02473**		**7Z02470**		**7Z02472**	
Supplied Aperture Covers (see page 33)	**IS6-D (with detector):** 2.5" to 1" reducer + 1" port plug + 2 ea. 1" port covers **IS6-C (with detector):** 2.5" port plug + 1" port plug + 1" port covers							

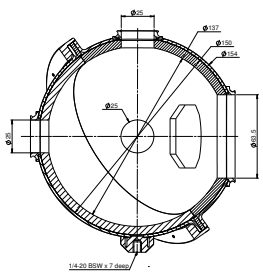
IS6-D with detector for divergent beams

IS6-C with detector for collimated beams

IS6-D-VIS / IS6-D-UV / IS6-D-IR
IS6-C-VIS / IS6-C-UV / IS6-C-IR



IS6



IS6 with Detectors - calibrated - IR types

In the detector versions, the IS6 with detector comes with a calibrated wavelength curve.

	IS6-D with Detector		IS6-C with Detector	
Model	**IS6-D-IR**		**IS6-C-IR**	
Detector type	**IR**		**IR**	
Use	**Low powers for divergent beams**		**Low powers for collimated beams**	
Type	Germanium		Germanium	
Spectral Range µm	0.7 – 1.8		0.7 – 1.8	
Power Range (approx.)	20µW to 30W		20µW to 30W	
Power Scales	30W to 300µW		30W to 300µW	
Linearity with Power ±%	1		1	
Configuration	Divergent		Collimated	
Power Noise Level	1µW		1µW	
Maximum Pulse Energy mJ	0.08		0.08	
Maximum Beam Divergence	±40deg		NA	
Sensitivity to Beam Size	±3% (a)		±1%	
Maximum Power vs. Wavelength	nm	W	nm	W
	<1400	20	<1400	30
	1400-1650	8	1400-1650	15
	>1650	15	>1650	30
% error per Wavelength nm	7 700 - 900		7 700 - 900	
	5 900 - 1400		5 900 - 1400	
	10 1400 - 1800		10 1400 - 1800	
Part Number	**7Z02477**		**7Z02476**	
Supplied Aperture Covers (see table below)	**IS6-D** (with detector): 2.5" to 1" reducer + 1" port plug + 2 ea. 1" port covers **IS6-C** (with detector): 2.5" port plug + 1" port plug + 1" port covers			

Notes: (a) For beams up to 30deg divergence, variation with beam size is ±1%

See drawings and pictures on page 32

1.1.1.5.3 Accessories for IS6

Accessory	Description	Part number
Port plugs	Port plugs close ports with white sphere material, eliminating the port from the sphere geometry.	
IS-1" Port plug	White reflectance material Ø25.4mm plug	7Z08280A
IS-2.5" Port plug	White reflectance material Ø63.5mm plug	7Z08283A
Port covers	Port Covers close ports with a black matte 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	Matte black coated Ø25.4mm plug	7Z08282A
IS-2.5" Port cover	Matte 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

IS-2.5" Port Plug

IS-1" Port Plug

IS-2.5" Port Cover

IS-1" Port Cover

2.5" to 1" Reducer

1" FC Fiber Adapter

1" to SM1 Adapter

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. There are also radiometer sensors for measuring the irradiance of large area illumination in units of Watts/cm^2 as presented in section 1.1.1.6.2

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

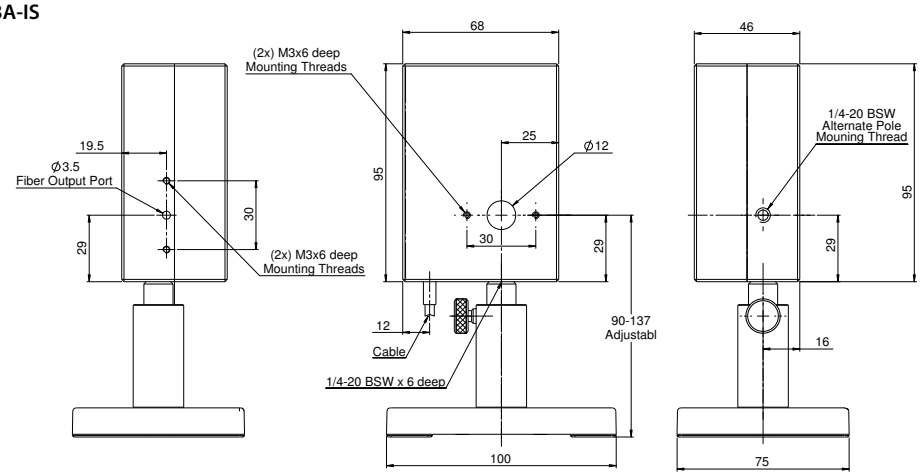
3A

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	20pW-3mW	2µW-300mW	20pW-3mW	2µW-300mW	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 37 & 83)	ST, FC, SMA [(a)], SC	ST, FC, SMA, SC		ST, FC, SMA, SC		ST, FC, SMA, SC
Weight kg	0.6	0.07		0.11		0.2
Version	V1					
Part Number	**7Z02404**	**7Z02413**		**7Z02438**		**7Z02621**

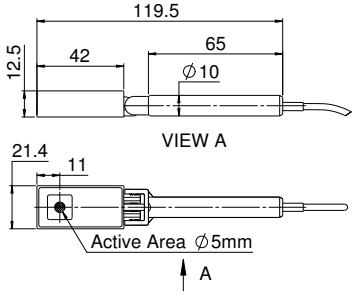
Notes: (a) One fiber output port available with output = 2E-4 of input power/mm^2 of fiber area.

* For sensors drawings please see page 35

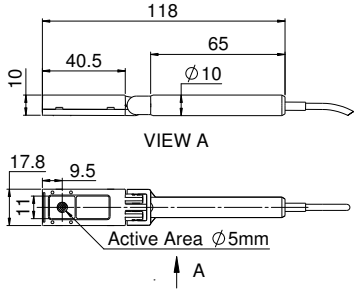
3A-IS



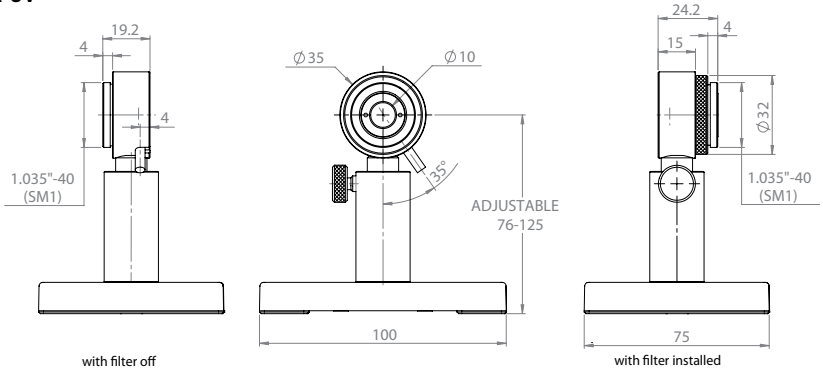
PD300-UV / PD300-IR Filter installed
(Ø5mm for PD300-IR only)



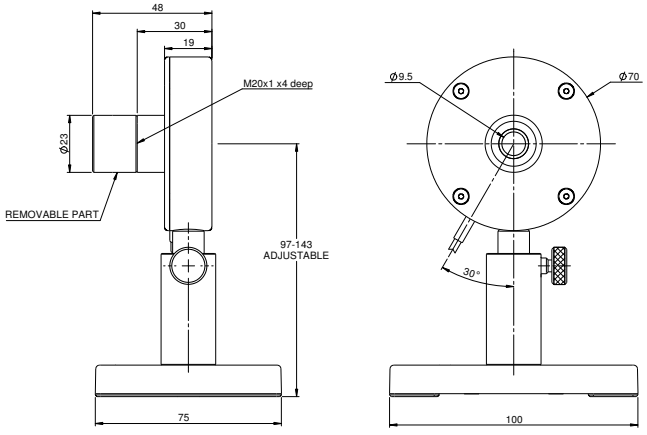
PD300-UV / PD300-IR Filter off
(Ø5mm for PD300-IR only)



PD300R-UV



3A



1.1.1.6.2 LED Irradiance and Dosage Sensors

15nW/cm² to 8W/cm²

PD300RM-UV / PD300RM-8W

Features

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

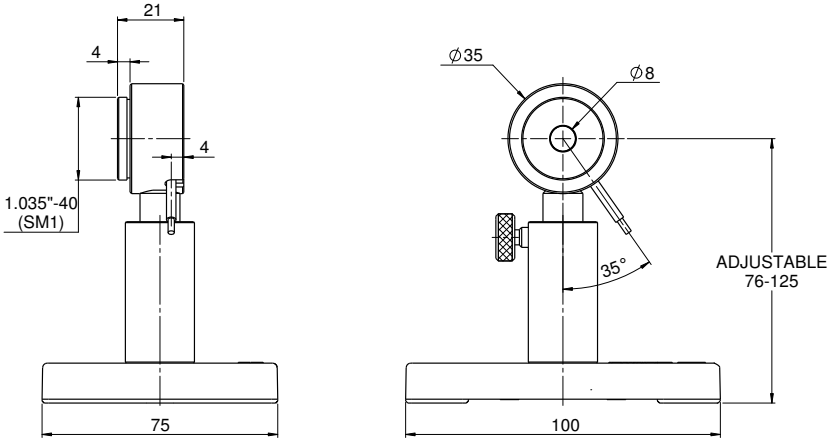
Model	PD300RM-UV	PD300RM-8W
Detector Type	Silicon	Silicon
Input Port Aperture mm	Ø8	Ø8
Spectral Range nm	200-850	350-850
Functions	Irradiance [W/cm²] Dosage [J/cm²]	Irradiance [W/cm²] Dosage [J/cm²]
Irradiance Range	15nW/cm² – 300mW/cm²	0.2µW/cm² – 8W/cm² (c)
Irradiance Scales	300mW/cm² to 300nW/cm² (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 (c)
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	10%	10%
Size	Ø35 x 21mm see drawing	Ø35 x 21mm see drawing
Weight	110g	110g
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 30 seconds of continuous exposure at > 5W/cm².

PD300RM-UV / PD300RM-8W



1.1.1.7 Accessories for Photodiode Sensors

Fiberoptic Adapters and Other Accessories

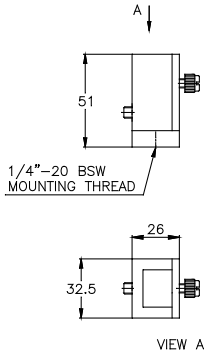
PD300 with F.O. Adapter Mounted

Accessories and Fiberoptic Adapters for PD300 series

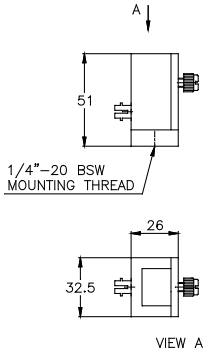
Accessory	Description	Part number			
PD300-CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300	7Z02418			
PD300-CDRH-3.5mm	Ø3.5mm aperture adapter for CDRH measurements for PD300	7Z08336			

Fiber Adapters for Sensor Series	Adapters for mounting fibers to PD300 sensors as shown below	SC type	ST type	FC, FC / APC type	SMA type
PD300 Series		7Z08221	7Z02210	7Z02213	7Z02212

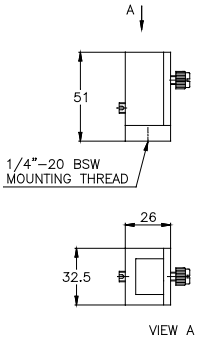
PD300-FO-SMA



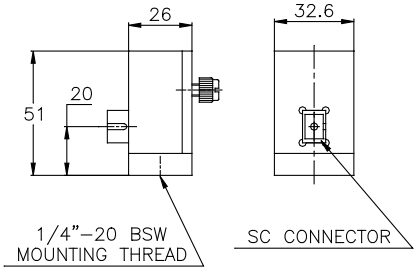
PD300-FO-ST



PD300-FO-FC



PD300-FO-SC



Accessories and Fiberoptic Adapters for PD300R series, PD300-IRG, 3A-IS, IS-1 series and FPS-1

SC fiber adapter

ST fiber adapter

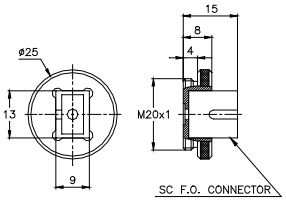
FC fiber adapter

SMA fiber adapter

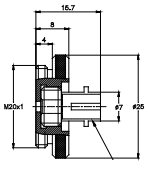
Accessory	Description	Part number			
PD300R-CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300R	7Z08347			

Fiber Adapters for Sensor Series	Fiber adapter mounting bracket (1 bracket fits all fiber adapters)	SC type	ST type	FC, FC / APC type	SMA type
PD300R Series and FPS-1	1G02259	7Z08227	7Z08226	7Z08229	1G01236
3A-IS / 3A-IS-IRG	7Z08213	7Z08227	7Z08226	7Z08229	1G01236
IS-1 / IS-1-2W	7Z08331	7Z08227	7Z08226	7Z08229	1G01236
PD300-IRG	not needed			7Z08216	7Z08222
Female SM1 to SM1 Adapter	For mounting PD300R series and FPS-1 to SM1 optical components and systems				1G02260

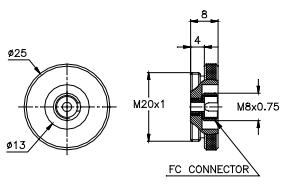
SC fiber adapter



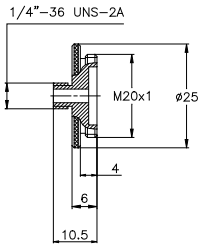
ST fiber adapter



FC fiber adapter



SMA fiber adapter

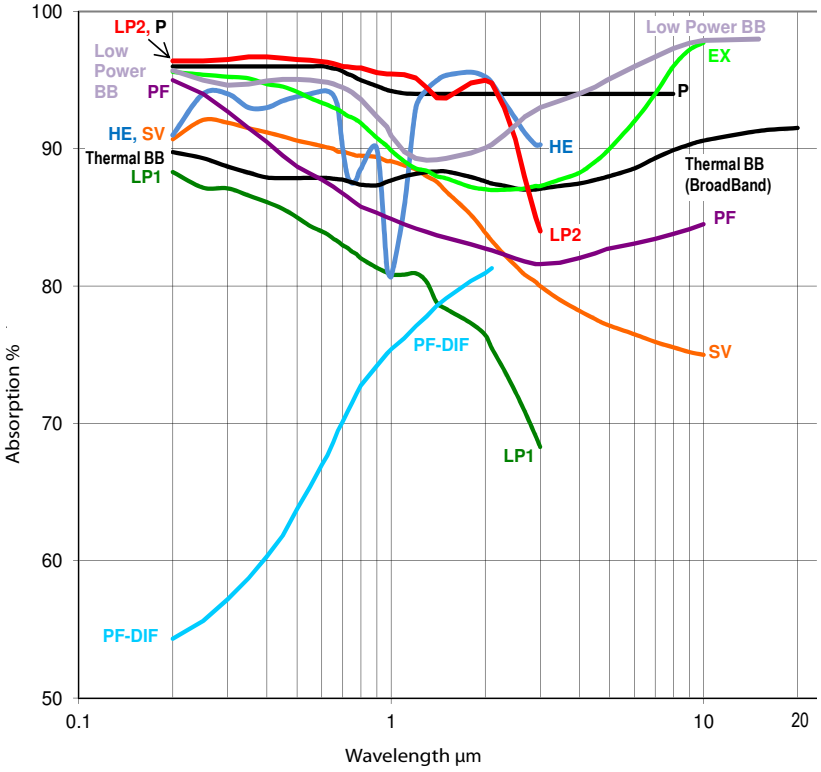


Female SM1 to SM1 Adapter

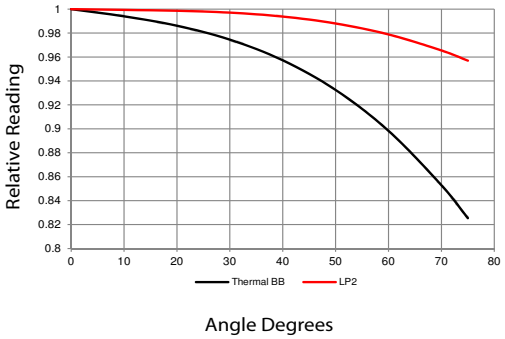
1.1.2 Thermal Power Sensors

Absorption, Angle Dependence and Damage Graphs for Thermal Sensors

Absorption vs. Wavelength

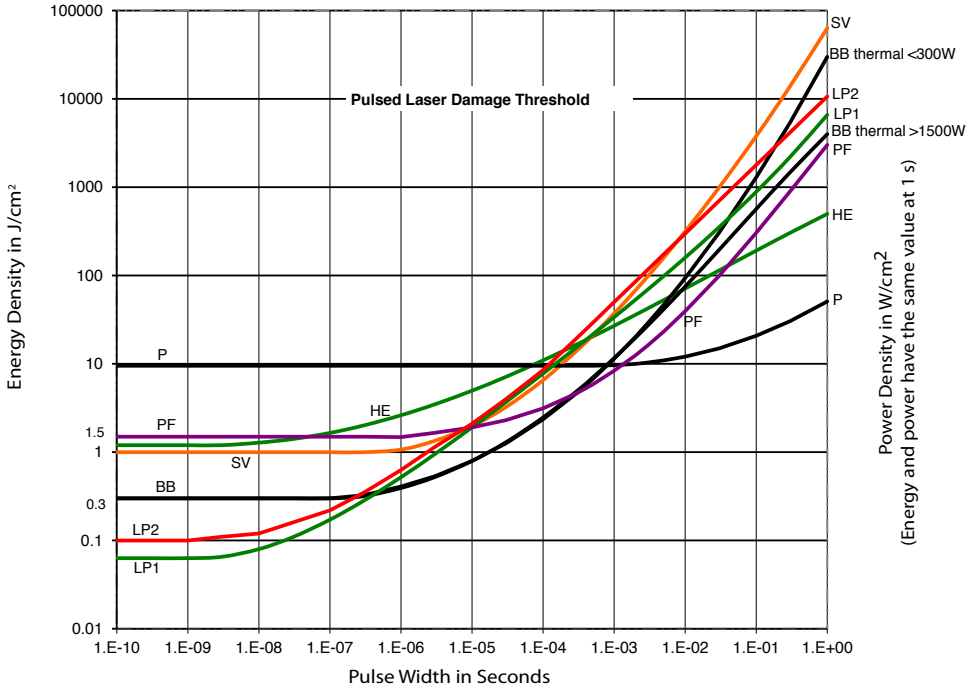


Response vs. Incidence Angle



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

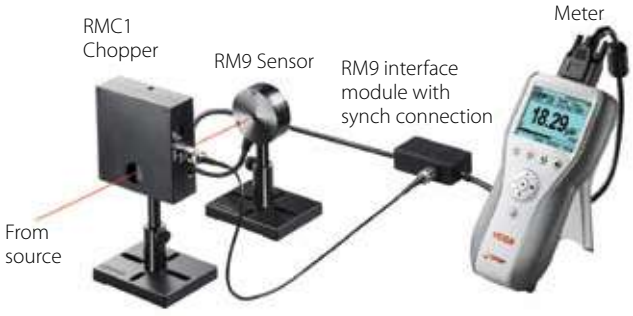


1.1.2.1 Low Noise Lock In Power Sensors

300fW to 100mW

Features

- Chopper and lock in amplifier for lowest noise and drift
- Wavelength range from UV to deep IR including Terahertz
- 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.

Specifications

Model	**RM9**	**RM9-THz**	**RM9-PD**
Use	**Low level signals**	**Low level Terahertz**	**Very low level signals**
Detector Type	Pyroelectric	Pyro with THz absorber	Si Photodiode
Spectral Range	0.15 - 12µm (a)	0.1 – 30THz (g)	0.2 - 1.1µm (b)
Aperture mm	Ø8mm	Ø8mm	Ø8mm
Surface Reflectivity % approx.	50	40 - 70	50
Power Range (c)	100nW – 100mW	100nW – 100mW	300fW – 300nW
Power Scales	100mW to 3µW	100mW to 3µW	300nW to 3pW
Power Noise Level (d)	~30nW	~20nW	30fW
Minimum Frequency for Pulsed Sources	200Hz	200Hz	200Hz
Thermal Drift (20min) (e)	~30nW	~15nW	N.A.
Power Accuracy	±5% (a)	±10% (g)	±5% (b)
Damage Threshold W/cm²	5	5	5
Response Time with Meter (0-95%) s	3.5s	3.5s	3.6s
Linearity with Power	±2%	±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	convection
Weight kg	0.37	0.37	0.37
Version			
Part Number for RM9 Series with RMC1 Chopper (f)	**7Y70669**	**7Y70678**	**7Y70672**
Part Number for RM9 Series Sensors	**7Z02952**	**7Z02956**	**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/RM9-THz 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 series sensors

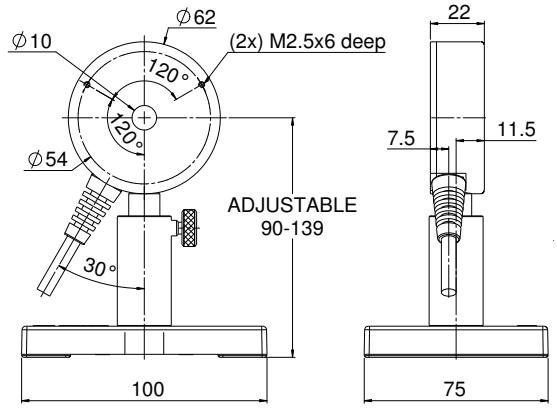
Notes: (g) The sensor is calibrated for 0.7, 1.5, 2.5, 4 and 10THz. Response at other frequencies can be interpolated from the graph on page 40. Stated accuracy is for frequencies or interpolated frequencies in the range 0.7 – 5THz. For 5 – 10THz, the calibration uncertainty is 15% and for frequencies outside that range, approximate readings can be calculated from the graph but no specified accuracy is given.

* For drawings please see page 40

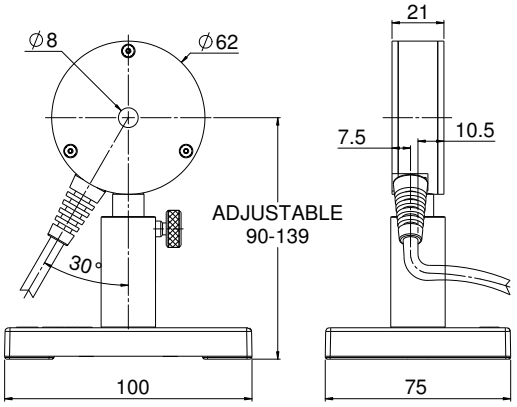
Model	**RMC1 Chopper**
Use	**Chopper for RM9 Series**
Aperture	Ø22mm
Chopping Frequency (a)	18Hz
Power Consumption	85mA
Connections:	
1. BNC to interface module	
2. 12V wall cube power supply (included)	
3. Mini USB connector (factory use only)	

Notes: (a) not adjustable by user.

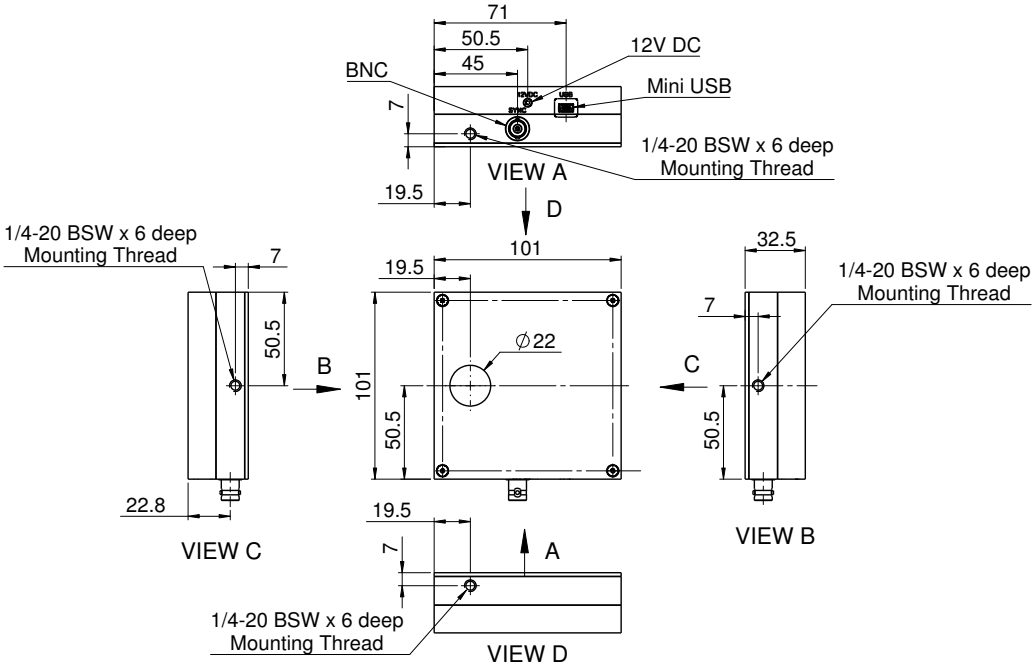
RM9-PD Sensor



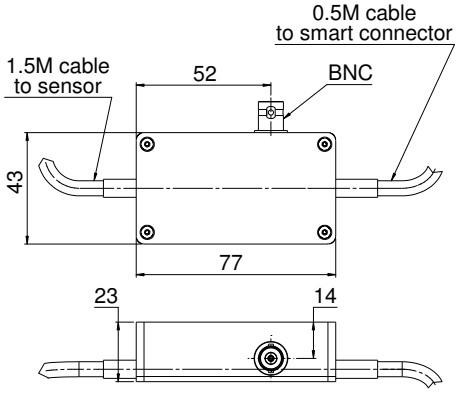
RM9 / RM9-THz Sensors



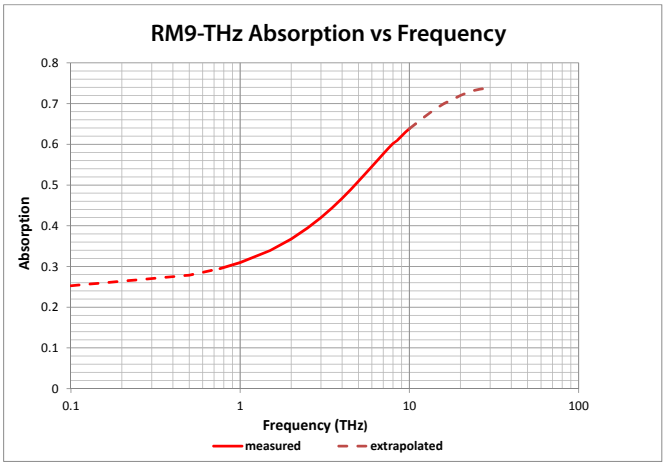
Radiometer-Chopper



Interface Module



RM9-THz Absorption vs Frequency



1.1.2.2 High Sensitivity Thermal Sensors

10µW to 3W

Features

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

2A-BB-9

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

Model	2A-BB-9	3A	3A-P	3A-PF-12
Use	**General purpose**	**General purpose**	**Short pulses**	**Short Pulses UV**
Absorber Type	Low power broadband	Low power broadband	P type	PF type
Spectral Range µm	0.19 - 20	0.19 - 20	0.15 - 8	0.15 - 20
Aperture mm	Ø9.5mm	Ø9.5mm	Ø12mm	Ø12mm
Maximum Beam Divergence	NA	NA	NA	NA
Power Mode				
Power Range [a]	20µW - 2W	10µW - 3W	15µW - 3W	15µW - 3W
Power Scales	2W to 200µW	3W to 300µW	3W to 300µW	3W to 300µW
Power Noise Level	1µW	1µW	3µW	3µW
Thermal Drift (30min) [a]	5 - 20µW	5 - 20µW	5 - 30µW	5 - 30µW
Maximum Average Power Density kW/cm²	1	1	0.05	3
Response Time with Meter (0-95%) typ. s	1.8	1.8	2.5	2.5
Power Accuracy +/-% [d]	3	3	3	3 [c]
Linearity with Power +/-%	1	1	1	1
Energy Mode				
Energy Range	20µJ - 2J	20µJ - 2J	20µJ - 2J	20µJ - 2J
Energy Scales	2J to 200µJ	2J to 200µJ	2J to 200µJ	2J to 200µJ
Minimum Energy	20µJ	20µJ	20µJ	20µJ
Maximum Energy Density J/cm² [b]				
<100ns	0.3	0.3	1	1.5
0.5ms	1	1	1	7
2ms	2	2	1	15
10ms	4	4	1	40
Cooling	convection	convection	convection	convection
Weight kg	0.2	0.2	0.2	0.2
Fiber Adapters Available (see page 83)	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC	ST, FC, SMA, SC
Version			V1	
Part number: Standard Sensor	**7Z02767**	**7Z02621**	**7Z02622**	**7Z02720**
BeamTrack Sensor: Beam Position & Size (p. 46)		**7Z07934**	**7Z07935**	

Note: (a) Depending on room airflow and temperature variations. Lowest measurable powers are achieved by thermally quiet room conditions, using removable snout (for 3A, 3A-P, 3A-PF-12 sensors), averaging and offset subtraction.

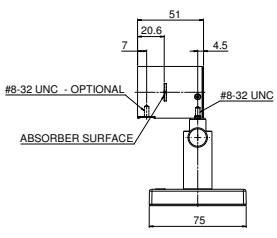
Note: (b) **For P and PF types** and shorter wavelengths derate maximum energy density as follows:

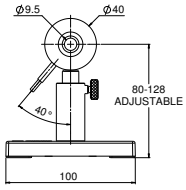
Wavelength	P type Derate to value	PF type Derate to value
1064nm	Not derated	Not derated
532nm	Not derated	Not derated
355nm	40% of stated value	70% of stated value
266nm	5% of stated value	15% of stated value
193nm	10% of stated value	5% of stated value

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

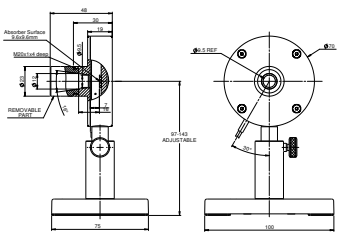
Note: (d) The 3A and 2A-BB-9 sensors have a relatively large spectral variation in absorption and has a calibrated spectral curve at all wavelengths in its spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, the 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.

2A-BB-9

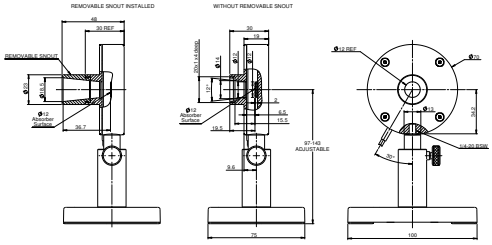




3A



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	0.1THz - 30THz (c)	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	1	1
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 83)	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 calibration for 0.6THz – 10THz. For 0.3 - 0.5THz add 4% to error.
Outside this region the sensor will measure but is not calibrated.

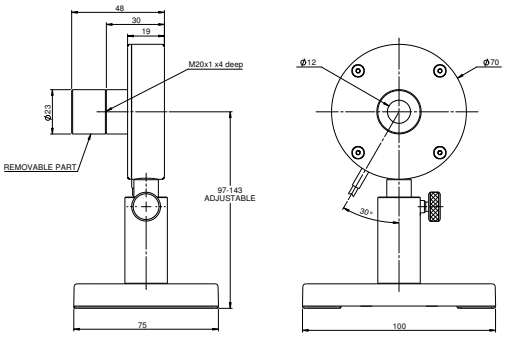
Note: (d) Back reflections from meter can sometimes cause interference effects with source. Unit should be tilted ~10° in this case

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

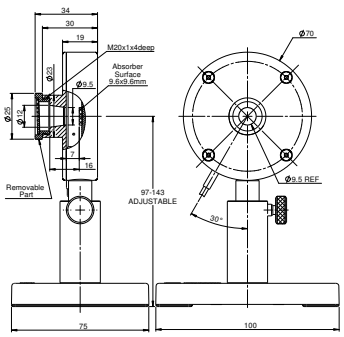
Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	5% of stated value
193nm	10% of stated value

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

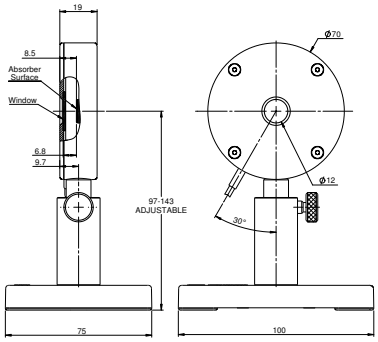
3A-P-THz



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	Low power 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 83)	ST, FC, SMA, SC	ST, FC, SMA, SC	
Weight kg	0.35	0.35	
Version	V1		
Part number	**7Z02638**	**7Z02624**	

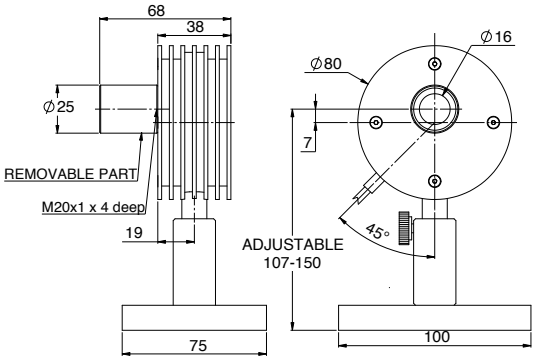
Notes: (a) Depending on room airflow and temperature variations

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

10mW to 50W

Features

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

10A

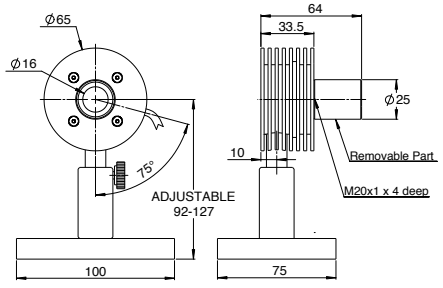
30A-BB-18

L30A-10MM

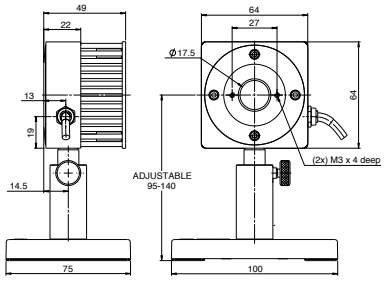
50(150)A-BB-26

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	10mW - 10W	10mW - 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 / 0.5W	30W / 3W	150W / 50W / 5W
Power Noise Level	0.2mW	0.5mW	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 83)	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. 46/50)	**7Z07904**			**7Z07900**

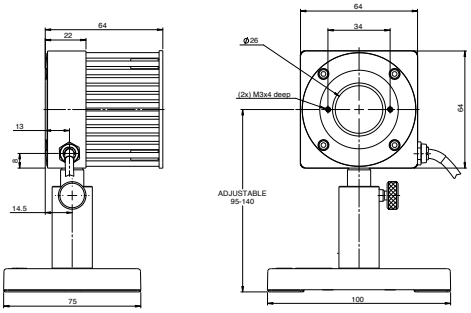
10A



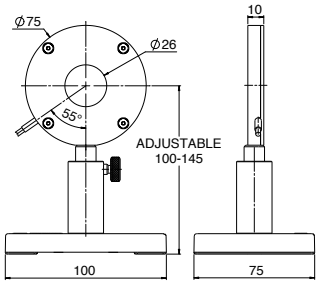
30A-BB-18



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

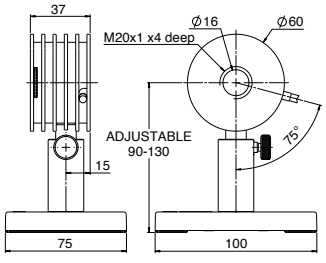
30A-N-18

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 83)	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**

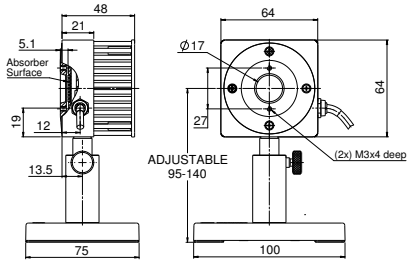
Note: (a) For shorter wavelengths derate maximum energy density as follows:

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.

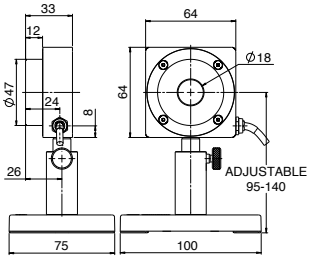
10A-P



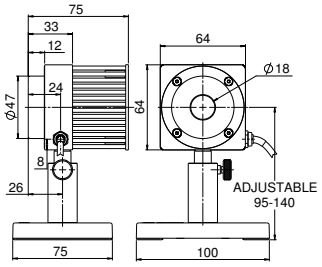
30A-P-17



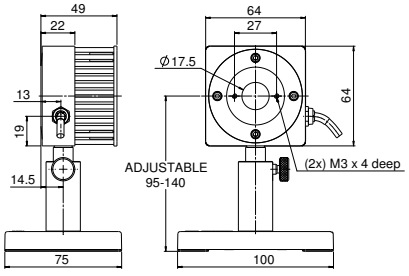
15(50)A-PF-DIF-18



50A-PF-DIF-18



30A-N-18



1.1.2.3 Low Power Thermal Sensors

1.1.2.3.1 Low Power BeamTrack-Power / Position / Size Sensors

100µW to 10W

3A-QUAD / 3A-P-QUAD

10A-PPS

Features (see introduction in pages 77-79)

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

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 83)	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 and EA-1 interfaces and StarLab application.

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

Notes: (c) For position within inner 30% of aperture. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

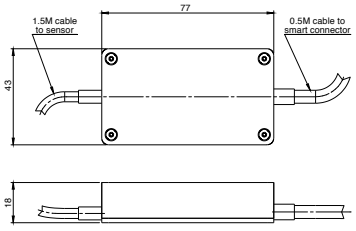
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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

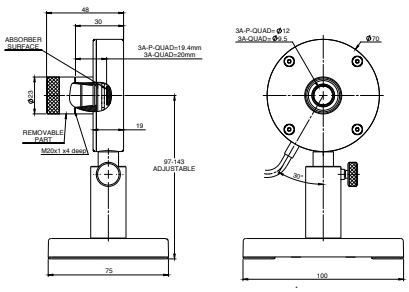
Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

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.

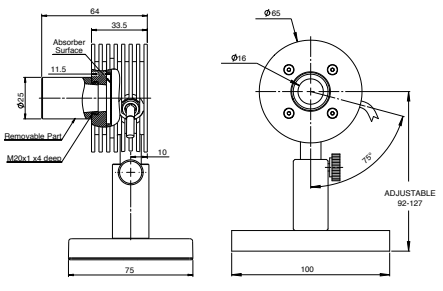
Interface Module on cable



3A-QUAD / 3A-P-QUAD



10A-PPS



1.1.2.3 Low Power Thermal Sensors

1.1.2.3.2 Beam Trap

Up to 50W

BT50A-15

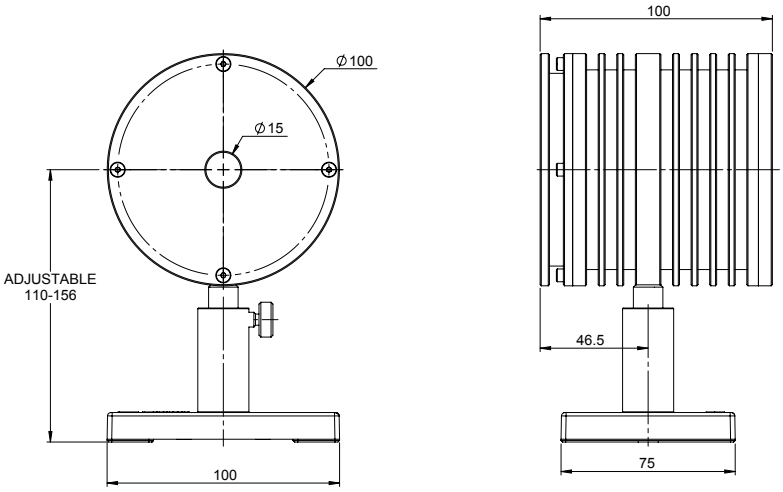
Features

- Does not measure power, traps beam only
- Power capacity up to 50W
- Backscattered power 0.05%
- Pulsed damage threshold 4J/cm²
- Average power density up to 16kW/cm²
- Ø15mm aperture

The BT50A-15 absorbs a laser beam that is inserted into the entrance aperture parallel to the unit's optic axis. The beam trap is designed that only a very small fraction of the light is backscattered. The BT50A-15 does not measure power. It is a beam trap only.
When operated at full power, the BT50A-15 can heat up to over 100degC. Note that the absorbing element of the beam trap is graphite which may not be suitable for some environments.

Model	**BT50A-15**	
Use	**Beam trap for CW and pulsed lasers up to 50W average power**	
Absorber Type	Broadband graphite absorber	
Spectral Range µm	0.19 - 20	
Backscatter	0.05% or less, typical	
Aperture mm	Ø15mm	
Maximum Acceptance Angle	±10 degrees	
Maximum Incident Power	50W	
Maximum Average Power Density	16kW/cm²	
Maximum Energy Density	<100ns pulses 2ms pulses	4J/cm² 100J/cm²
Cooling	convection	
Dimensions	See drawing below	
Weight kg	0.9	
Version		
Part number	**7Z17204**	

BT50A-15



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 83)	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.

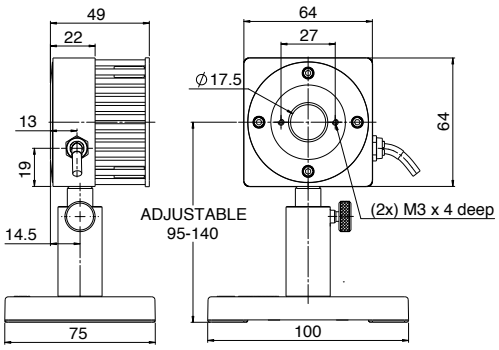
(b) Calibrated for 0.25 – 2µm, 10.6µm

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

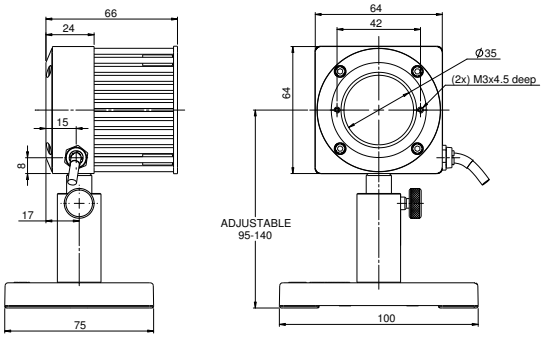
Wavelength	Derate to value
1064nm	Not derated
532n	Not derated
355n	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(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 or 50W, 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

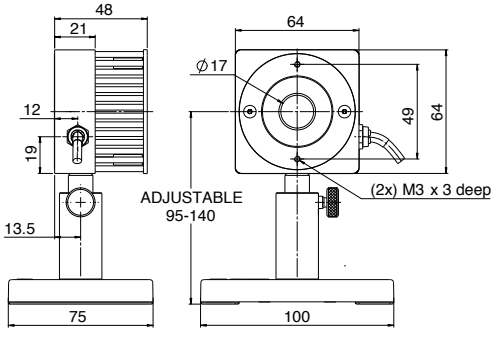
Model	**30(150)A-SV-17**			**30(150)A-HE-17**			**30(150)A-HE-DIF-17**		
Use	**High power and energy density**			**High energy and average power pulsed lasers**			**Concentrated beam pulsed lasers - has removable diffuser**		
Absorber Type	SV			HE			HE		
Spectral Range µm	0.19 - 12			0.19 - 0.625, 1.064, 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 83)	ST, FC, SMA, SC			ST, FC, SMA, SC			NA		
Weight kg	0.3			0.3			0.4		
Version									
Part number	**7Z02724**			**7Z02722**			**7Z02729**		

Notes:

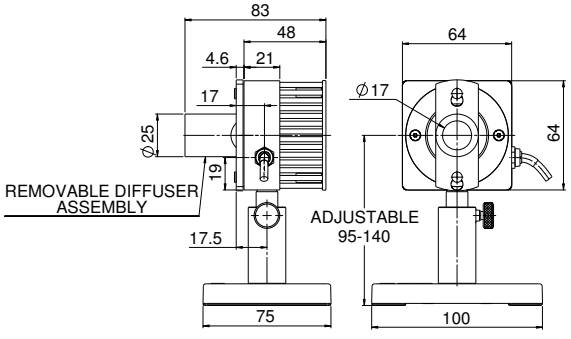
(a) At 1064nm. For shorter wavelengths derate maximum energy density to:
355nm 50% of above values
266nm 50% of above values
193nm 10% of above values

(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

1.1.2.4.1 Medium Power BeamTrack-Power / Position / Size Sensors

40mW to 150W

Features (see introduction in pages 77-79)

- 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 83)	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 and EA-1 interfaces and StarLab application.

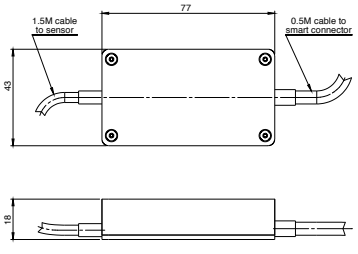
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

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. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

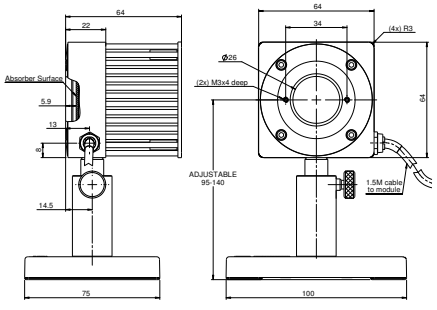
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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%.

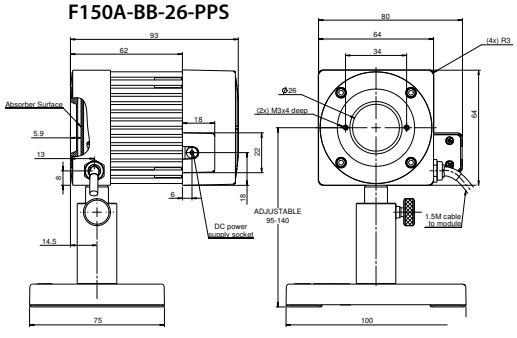
Interface Module on cable



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



F150A-BB-26-PPS



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

1.1.2.4.2 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

Model	20C-SH	L30C-SH	L30C-LP2-26-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	LP2	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.25 – 2.2	0.19 - 20	0.19 - 20
Absorption	~88%	~88%	>94% from 0.25 to 1.1µm	~88%	~88%
Aperture mm	Ø12	Ø26	Ø26	Ø18	Ø18
Power Mode					
Minimum power	10mW	80mW	300mW	60mW	60mW / 100mW
Maximum power free standing	4W continuous, 20W for 1.8min	10W continuous, 50W for 4min	10W continuous, 100W for 2min	4W	5W continuous, 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	15mW	3mW	3mW / 5mW
Maximum Average Power Density kW/cm²	23 at 20W, 35 at 4W	17 at 50W, 28 at 10W	42 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 (b)	3	3
Linearity with Power +/-%	1	1	1.5	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	0.1	0.3	0.3
0.5ms	2	5	50	5	5
2ms	2	10	130	10	10
10ms	2	30	400	30	30
>300ms	NA	NA	See below (c, d)	NA	NA
Cooling	Conduction	Conduction	Conduction	Conduction	Conduction / Water
Weight kg	0.2	0.3	0.3	0.2	0.3
Version					
Part number	**7Z02602**	**773434**	**7Z02775**	**7Z02680**	**7N77023 (a) / 771001**

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

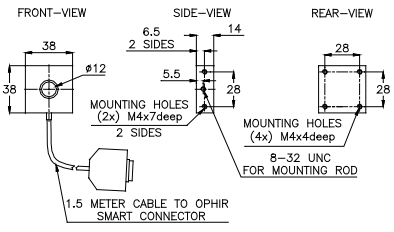
Note: (b) Above 1.1µm there is an additional calibration uncertainty of up to 2%

Note: (c) This mode is used to measure power of high power lasers by measuring the energy of a short exposure. The StarBright meter has a Pulsed Power mode where the user may specify the pulse width and get a reading directly in units of power for a short exposure energy measurement. See also page 71

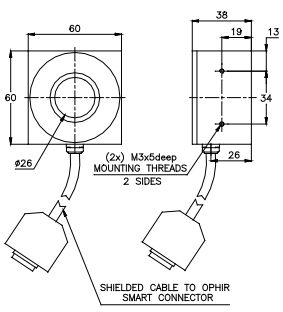
Note: (d) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses.
Total energy for a series of measurements should not exceed 2kJ. Recommended time between shots 12s.

Laser Power W	Recommended Exposure s	Number of shots before cooling down	Min 1/e² beam dia. mm
100	4	20	9
500	1	20	9
1000	1	10	13
2000	1	5	17
4000	0.5	5	22

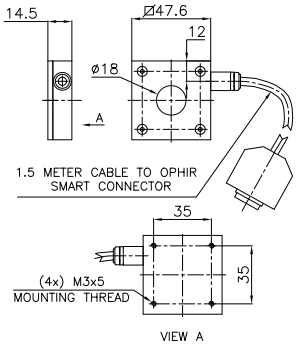
20C-SH



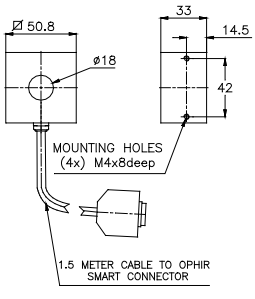
L30C-SH / L30C-LP2-26-SH



100C-SH



150C-SH



1.1.2.5 Medium Power Large Aperture Thermal Sensors - Apertures 50mm

100mW to 150W and up to 10kJ

Features

- Thin profile
- CW to 35W or 50W, intermittent to 150W
- Pulse energies up to 10,000 Joules
- For continuous, long pulse and Excimer lasers
- Measure high power lasers by 0.3-2s exposures

L40(150)A

L40(150)A-LP2-50

L40(150)A -EX

L50(150)A

Model	**L40(150)A**	**L40(150)A-LP2-50**	**L40(150)A-EX**	**L50(150)A**
Use	**General purpose**	**CW and Long Pulse Lasers**	**Excimer lasers**	**General purpose**
Absorber Type	Broadband	LP2	EX	Broadband
Spectral Range µm	0.19 - 20	0.25 - 2.2, 2.94	0.15 - 0.7, 10.6	0.19 - 20
Absorption	~88%	>94% from 0.25 to 1.1µm	~95%	~88%
Aperture mm	Ø50mm	Ø50mm	Ø50 mm	Ø50mm
Power Mode				
Power Range [b]	100mW - 150W	300mW - 150W	100mW - 150W	100mW - 150W
Maximum Intermittent Power [b]	150W for 3min, 80W for 5.5min, 35W continuous	150W for 4min, 80W for 8min, 40W continuous	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	15mW	5mW	5mW
Maximum Average Power Density kW/cm²	12 at 150W 20 at 35W	33 at 150W 50 at 40W	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 - 10,000J	100mJ - 200J	100mJ - 4000J
Energy Scales	4kJ / 400J / 40J / 4J	10kJ / 1kJ / 100J / 10J	200J / 30J / 3J	4kJ / 400J / 40J / 4J
Minimum Energy mJ	100	100	100	100
Maximum Energy Density J/cm²				
<100ns	0.3	0.1	0.5	0.3
1µs	0.4	0.9	0.6	0.4
0.5ms	5	50	6	5
2ms	10	130	12	10
10ms	30	400	25	30
>300ms	See below [b, c]	See below [b, c]	NA	See below [b, c]
Cooling	convection / ballistic	convection / ballistic	convection / ballistic	convection / ballistic
Fiber Adapters Available (see page 83)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.6	0.8	0.6	0.6
Version	V2		V1	
Part number	**7Z02626**	**7Z02783**	**7Z02614**	**7Z02633**

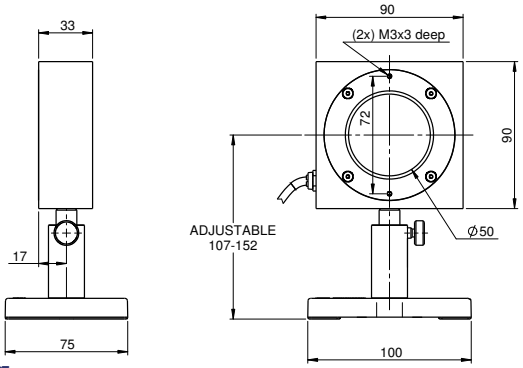
Notes: (a) Above 1.1µm there is an additional calibration uncertainty of up to 2% except at the additional calibration point of 2.94µm where the additional uncertainty is 1%.

Notes: (b) This mode is used to measure power of high power lasers by measuring the energy of a short exposure. The StarBright meter has a Pulsed Power mode where the user may specify the pulse width and get a reading directly in units of power for a short exposure energy measurement. See also page 71

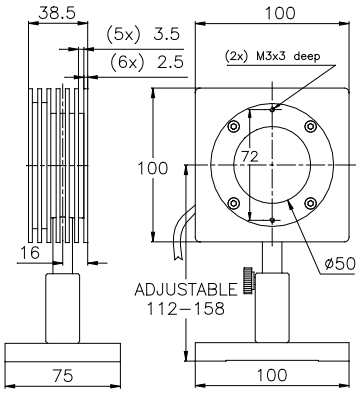
Notes: (c) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses. Total energy for a series of measurements should not exceed 20kJ. Recommended time between shots 12s.

Laser power W	Recommended Exposure s	Number of shots before cooling down	Min 1/e² beam dia. mm	
			L40(150)A / L50(150)A	L40(150)A-LP2-50
500	2	20	15	9
1000	1	20	20	9
2000	1	10	30	12
4000	1	5	40	15
5000	1	4	NA	18
10000	0.3	2	NA	22

L40(150)A / L40(150)A-LP2-50 / 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

L50(300)A-LP2-65

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

Model	**L50(300)A**	**L50(300)A-LP2-65**	**L50(300)A-PF-65**
Use	**General purpose**	**Long pulse lasers**	**Large beam short pulsed lasers**
Absorber Type	Broadband	LP2	PF type
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.15 - 20
Absorption	~88%	>94% from 0.25 to 1.1µm	~85%
Aperture mm	Ø65mm	Ø65mm	Ø65mm
Power Mode			
Power Range	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
Power Noise Level	20mW	20mW	20mW
Maximum Average Power Density kW/cm²	9.5 at 300W 17 at 50W	17 at 300W 50 at 50W	3
Response Time with Meter (0-95%) typ. s	3	3	3
Power Accuracy +/-%	3	3 (a)	4 (b)
Linearity with Power +/-%	1	1	1
Energy Mode			
Energy Range	200mJ - 300J	200mJ - 1000J	200mJ - 300J
Energy Scales	300J / 60J / 6J	1000J / 600J / 60J / 6J	300J / 60J / 6J
Minimum Energy mJ	200	200	200
Maximum Energy Density J/cm²			Single (c) 10-50Hz (c)
<100ns	0.3	0.1	3 (d) 1.5
1µs	0.4	0.9	3 (d) 1.5
0.5ms	5	50	7 7
2ms	10	130	15 15
10ms	30	400	40 40
Cooling	convection / ballistic	convection / ballistic	convection / ballistic
Weight kg	0.9	0.9	0.9
Version			
Part number	**7Z02658**	**7Z02782**	**7Z02743**

Notes:

(a) Above 1.1µm there is an additional calibration uncertainty of up to 2%.

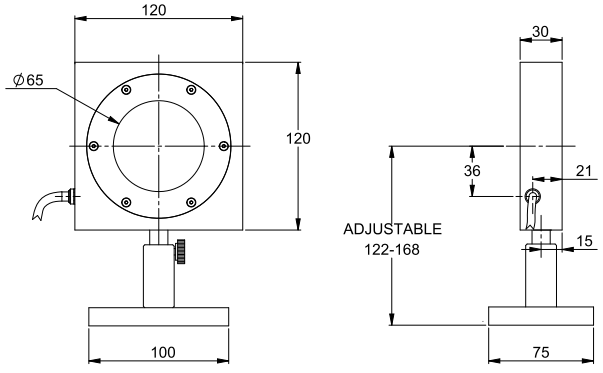
(b) Calibrated for 0.25 – 2µm, 10.6µm

(c) 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

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

L50(300)A / L50(300)A-LP2-65 / L50(300)A-PF-65



1.1.2.5 Medium Power Large Aperture Thermal Sensors - Apertures 65mm

1.1.2.5.1 Sensors for Intense Pulsed Light IPL

100mJ to 2000J

Features

- L50(300)A-IPL: Large aperture with glass for gel coupling
- L40(150)A-IPL: Designed for gel coupled sources
- L50(300)A-LP2-65: Large aperture and low angle dependence

L50(300)A-IPL

L40(150)A-IPL

L50(300)A-LP2-65

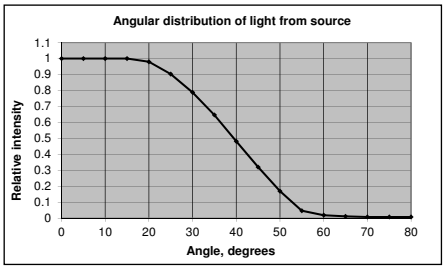
Model	L50(300)A-IPL	L40(150)A-IPL	L50(300)A-LP2-65
Use	**Gel and Air coupled IPL and laser sources**	**Gel coupled IPL sources and laser sources**	**Air coupled IPL and laser sources**
Absorber Type	LP2 + coated window [a]	LP2 + pyramid coupling to capture large output light angles	LP2
Spectral Range µm	0.5 - 1.3	0.5 - 1.3	0.25 – 2.2
Absorption	86%	92%	>94% from 0.25 to 1.1µm
Aperture mm	Ø65mm	22x22mm [b]	Ø65mm
Power Mode			
Power Range	400mW - 300W	NA	400mW - 300W
Maximum Intermittent Power	300W for 2 min, 150W for 4.5min, 50W continuous	NA	300W for 2min, 150W for 4.5min, 50W continuous
Power Scales	300W / 30W	NA	300W / 30W
Power Noise Level	20mW	NA	20mW
Maximum Average Power Density kW/cm²	17 at 300W 50 at 50W	NA	17 at 300W 50 at 50W
Response Time with Meter (0-95%) typ. s	3	NA	3
Power Accuracy +/-%	6 for most gel or air coupled IPL sources	NA	3 [e]
Linearity with Power +/-%	1	NA	1
Energy Mode			
Energy Range	120mJ - 1000J	100mJ - 2000J	200mJ – 1000J
Energy Scales	1000J / 600J / 60J / 6J	2000J / 600J / 60J / 6J	1000J / 600J / 60J / 6J
Minimum Energy mJ	120	100	200
Damage Threshold	Maximum Energy Density J/cm²	Maximum Energy J	Maximum Energy Density J/cm²
<100ns	0.1	1	0.1
1µs	0.9	9	0.9
0.5ms	50	500	50
2ms	130	1300	130
10ms	400	2000	400
Energy Accuracy +/-%	8 for gel coupled source 5 for air coupled source [c]	8 for gel coupled source [c]	5 for air coupled source [d]
Cooling	convection / ballistic	convection / ballistic	convection / ballistic
Weight kg	1.0	1.0	0.9
Version	V1		
Part number	**7Z02780**	**7Z02771**	**7Z02782**

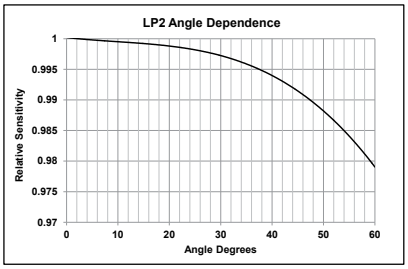
Notes: (a) Sensor has a window for gel coupled IPL sources where IPL source is coupled to window with gel or water for measurement. Can also measure air coupled IPLs

Notes: (b) If the source is longer than the aperture, it can overfill and the output can be calculated proportionately

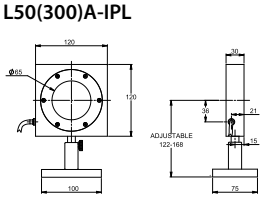
Notes: (d) Accurate measurement of air coupled sources due to low angular dependence of LP2 coating. See graph below.
Notes: (e) Above 1.1µm there is an additional calibration uncertainty of up to 2%.

Note: (c) The assumed angular distribution of the IPL light is given below. The angle dependence of the LP2 coating is shown below.

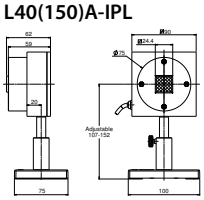




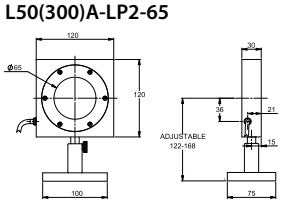
L50(300)A-IPL



L40(150)A-IPL



L50(300)A-LP2-65



1.1.2.6 Medium - High Power Fan Cooled Thermal sensors

10mW to 150W

Features

- General purpose and high damage threshold
- Fan cooled
- Powers to 150W
- Ø17.5mm to Ø35mm apertures
- F50A-BB-18 very stable reading and wide dynamic range

F50A-BB-18

F100A-PF-DIF-33

F150A-BB-26

Model	F50A-BB-18	F100A-PF-DIF-33	F150A-BB-26
Use	**Monitoring stability of power**	**Short pulse lasers**	**General purpose**
Absorber Type	Broadband	PF type + diffuser	Broadband
Spectral Range µm	0.19 - 20	0.24 – 2.2	0.19 - 20
Aperture mm	Ø17.5mm	Ø33mm	Ø26mm
Power Mode			
Power Range [d]	10mW – 50W [a]	50mW - 100W	50mW - 150W
Power Scales	50W / 5W / 500mW	100W / 30W /3W	150W / 30W / 3W
Power Noise Level [d]	0.5mW	6mW	3mW
Maximum Average Power Density kW/cm²	17 at 50W 28 at 10W	0.5	12 at 150W 17 at 50W
Response Time with Meter (0-95%) typ. s	0.8	2.5	1.5
Power Accuracy +/-%	3	5 [c]	3
Linearity with Power +/-%	1	1.5	1
Energy Mode			
Energy Range	6mJ - 50J [a]	60mJ - 200J	20mJ - 100J
Energy Scales	50J / 5J / 500mJ	200J / 30J / 3J	100J / 30J / 3J / 300mJ
Minimum Energy mJ [d]	6	60	20
Maximum Energy Density J/cm²			
<100ns	0.3	4 [b]	0.3
0.5ms	2	15 [b]	5
2ms	2	35 [b]	10
10ms	2	50 [b]	30
Cooling	fan	fan	fan
Fiber Adapters Available (see page 83)	ST, FC, SMA, SC	NA	ST, FC, SMA, SC
Weight kg	0.35	0.8	0.35
Version			
Part number: Standard Sensor	**7Z02718**	**7Z02744**	**7Z02727**
BeamTrack Sensor: Beam Position & Size (p. 50)			**7Z07901**

Notes: (a) Fan should be on for power above 3W. Fan should be off for measuring very low power and for energy measurement.

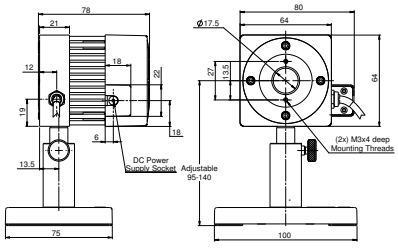
Notes: (b) For shorter wavelengths derate maximum energy density as follows: Wavelength Derate to value:

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

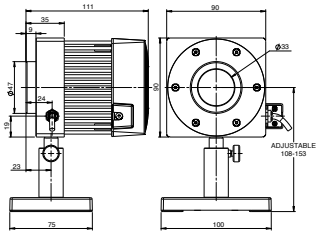
Notes: (c) Calibrated at specified wavelengths only: 266nm, 355nm, 532nm, 1064nm and 2100nm only

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

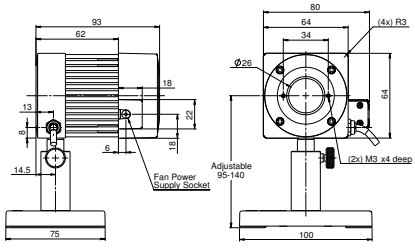
F50A-BB-18



F100A-PF-DIF-33



F150A-BB-26



1.1.2.6 Medium - High Power Fan Cooled Thermal Sensors

100mW to 250W

Features

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

FL250A-BB-35

FL250A-LP2-35

FL250A-LP1-DIF-33

Model	FL250A-BB-35	FL250A-LP2-35	FL250A-LP1-DIF-33
Use	**General purpose**	**High power density and long pulse lasers**	**Diffuser for highest energy densities**
Absorber Type	Broadband	LP2	LP1 + diffuser
Spectral Range µm	0.19 - 20	0.25 - 2.2	0.4 - 3
Absorption	~88%	>94% from 0.25 to 1.1µm	20%
Aperture mm	Ø35mm	Ø35mm	Ø33mm
Power Mode			
Power Range [c]	150mW - 250W	100mW - 250W	400mW - 250W
Power Scales	250W / 30W	250W / 30W	250W / 30W
Power Noise Level [c]	15mW	10mW	20mW [d]
Maximum Average Power Density kW/cm²	10 at 250W 12 at 150W	20 at 250W 33 at 150W	2
Response Time with Meter (0-95%) typ. s	2	2	2.5
Power Accuracy +/-%	3	3 [b]	3 [a]
Linearity with Power +/-%	1	1	1.5
Energy Mode			
Energy Range	50mJ - 300J	50mJ - 300J	400mJ - 600J
Energy Scales	300J / 30J / 3J	300J / 30J / 3J	600J / 60J
Minimum Energy mJ [c]	50	50	400
Maximum Energy Density J/cm²			
<100ns	0.3	0.1	0.5
0.5ms	5	50	200
2ms	10	130	400
10ms	30	400	1000
Cooling	fan	fan	fan
Fiber Adapters Available (see page 83)	ST, FC, SMA, SC	ST, FC, SMA, SC	NA
Weight kg	0.4	0.4	0.45
Version			
Part number	**7Z02728**	**7Z02777**	**7Z02733**

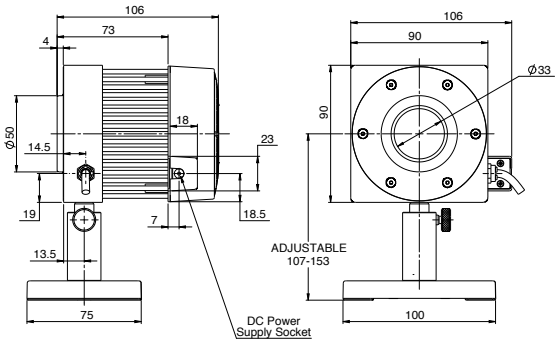
Notes: (a) Calibrated at specified wavelengths only: 532nm, 755nm, 1064nm and 2940nm

Notes: (b) Above 1.1µm there is an additional calibration uncertainty of up to 2%

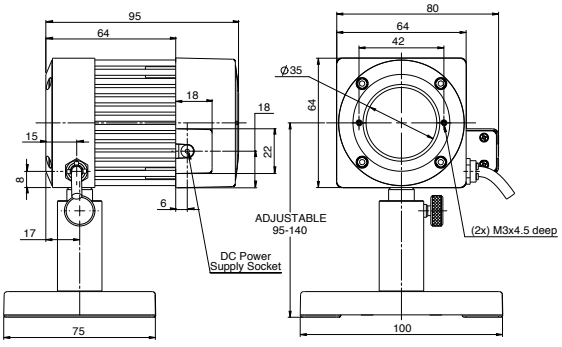
Notes: (c) For lower powers up to 30W it is recommended to work with the fan off and then the noise level is ~5 times lower. It is also recommended to measure energy with the fan off

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

FL250A-LP1-DIF-33



FL250A-BB-35 / FL250A-LP2-35



1.1.2.6 Medium - High Power Fan Cooled Thermal Sensors

100mW to 500W

Features

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

FL250A-BB-50 / FL400A-BB-50

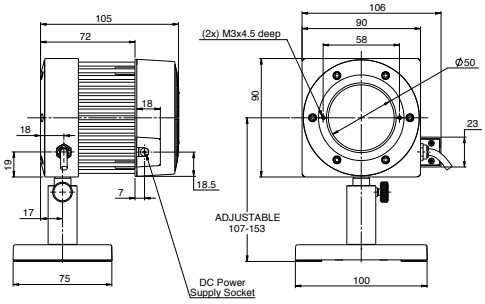
FL400A-LP2-50

Model	FL250A-BB-50	FL400A-BB-50	FL400A-LP2-50
Use	**General purpose**	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	Broadband	LP2
Spectral Range µm	0.19 - 20	0.19 - 20	0.35 - 2.2, 10.6 [b]
Absorption	~88%	~88%	>96% from 0.35 to 1.1µm, 75% for 10.6µm
Aperture mm	Ø50mm	Ø50mm	Ø50mm
Power Mode			
Power Range [a]	150mW - 250W	300mW - 500W	100mW - 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	15mW
Maximum Average Power Density kW/cm²	10 at 250W 12 at 150W	8.5 at 400W 12 at 150W	10 at 400W 20 at 150W
Response Time with Meter (0-95%) typ. s	2.5	4	4
Power Accuracy +/-%	3	3	3 [b]
Linearity with Power +/-%	1	1.5	1.5
Energy Mode			
Energy Range	80mJ - 300J	75mJ - 600J	250mJ - 600J
Energy Scales	300J / 30J / 3J	600J / 60J / 6J	600J / 60J / 6J
Minimum Energy mJ [a]	80	75	250
Maximum Energy Density J/cm²			
<100ns	0.3	0.3	0.07
1µs	0.4	0.4	0.6
0.5ms	5	5	35
2ms	10	10	90
10ms	30	30	270
Cooling	fan	fan	fan
Fiber Adapters Available (see page 83)	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**	**7Z02778**
BeamTrack Sensor: Beam Position & Size (p. 59)	**7Z07902**		

Notes: (a) For lower powers up to 50W it is recommended to work with the fan off and then the noise level is ~5 times lower. It is also recommended to measure energy with the fan off.

Notes: (b) This LP2 sensor is calibrated for 0.35-1.1µm and 10.6µm. For other wavelengths in the spectral range 1100 – 2200nm there is an additional calibration uncertainty of up to 1%.

FL250A-BB-50 / FL400A-BB-50 / FL400A-LP2-50



1.1.2.6 Medium - High Power Fan Cooled Thermal Sensors

5W to 1100W

Features

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

FL600A-BB-65 / FL1100A-BB-65

FL600A-LP2-65 / FL1100A-LP2-65

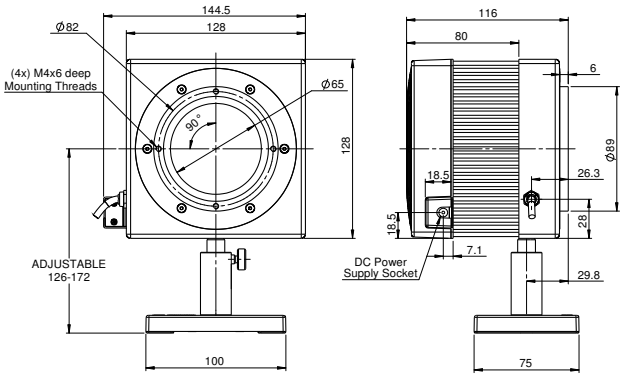
Model	FL600A-BB-65	FL600A-LP2-65	FL1100A-BB-65	FL1100A-LP2-65
Use	**General purpose**	**Long pulses**	**Highest power fan cooled**	**Long pulses**
Absorber Type	Broadband	LP2	Broadband	LP2
Spectral Range µm	0.19 - 11	0.35 – 2.2	0.19 - 11	0.35 – 2.2
Absorption	~88%	>94% from 0.35 to 1.1µm	~88%	>94% from 0.35 to 1.1µm
Aperture mm	Ø65mm	Ø65mm	Ø65mm	Ø65mm
Power Mode				
Power Range	5W - 600W	5W - 600W	5W - 1100W	5W - 1100W
Power Scales	600W / 60W	600W / 60W	1100W / 500W / 50W	1100W / 800W / 80W
Power Noise Level	200mW	200mW	200mW	200mW
Maximum Average Power Density kW/cm²	12 at 150W 7 at 600W	33 at 150W 11 at 600W	8 at 500W 5.5 at 1100W	33 at 150W 11 at 600W 9 at 1100W
Response Time with Meter (0-95%) typ. s [c]	4	4	4	4
Power Accuracy +/-%	3	3 [b]	3	3 [b]
Linearity with Power +/-%	1.5	1.5	1.5	1.5
Energy Mode [a]				
Energy Range	600mJ - 600J	600mJ - 600J	600mJ - 600J	600mJ - 1000J
Energy Scales	600J / 60J / 6J	600J / 60J / 6J	600J / 60J / 6J	1000J / 600J / 60J / 6J
Minimum Energy mJ	600	600	600	600
Maximum Energy Density J/cm²				
<100ns	0.3	0.1	0.3	0.1
1µs	0.4	0.9	0.4	0.9
0.5ms	4	50	4	50
2ms	10	130	10	130
10ms	30	400	30	400
Cooling	fan	fan	fan	fan
Fiber Adapters	Consult Ophir representative	Consult Ophir representative	Consult Ophir representative	Consult Ophir representative
Weight kg	2.4	2.4	2.4	2.6
Version				
Part Number	**7Z02762**	**7Z02779**	**7Z02761**	**7Z02784**

Notes: (a) It is recommended to measure energy with the fan off.

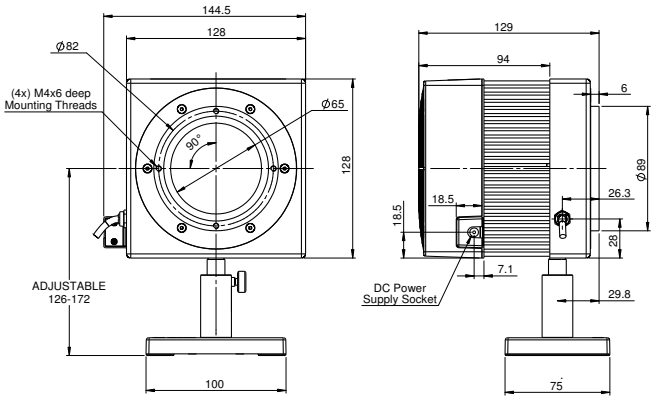
Notes: (b) Above 1.1µm there is an additional calibration uncertainty of up to 2%.

Notes: (c) Time to reach 98% of final reading is ~30s. 99% within ~2minutes. This time may be longer at low powers less than 20W.

FL600A-BB-65 / FL600A-LP2-65



FL1100A-BB-65 / FL1100A-LP2-65



1.1.2.6 Medium - High Power Thermal Sensors

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

150mW to 1000W

Features (see introduction in pages 77-79)

- 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/cm^2	10 at 250W, 12 at 150W	10 at 500W, 7 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/cm^2		
<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/cm^2	NA
Cooling	fan	water
Minimum Water Flow Rate at Full Power	NA	10 liter/min [g]
Fiber Adapter Available (see page 83)	ST, FC, SMA, SC	Consult Ophir representative
Accessories for High Power Sensors	NA	See pages 73-76
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 and EA-1 interfaces and StarLab application.

Notes: (b) For 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: (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. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

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

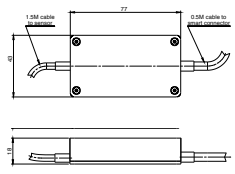
Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

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

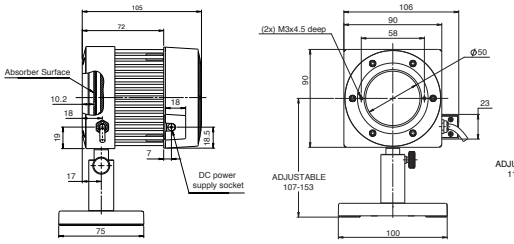
Notes: (g) Water temperature range 18-30°C, Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa.

Notes: (h) Position accuracy for the central 10 mm of the aperture as limited by beam position resolution. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

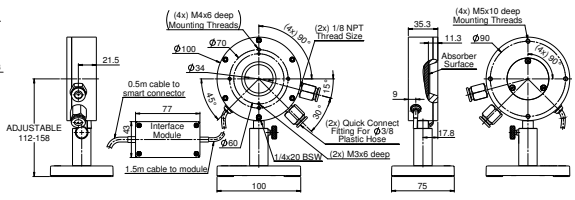
Interface Module on cable



FL250A-BB-50-PPS



1000W-BB-34-QUAD



1.1.2.7 High Power Thermal Sensors

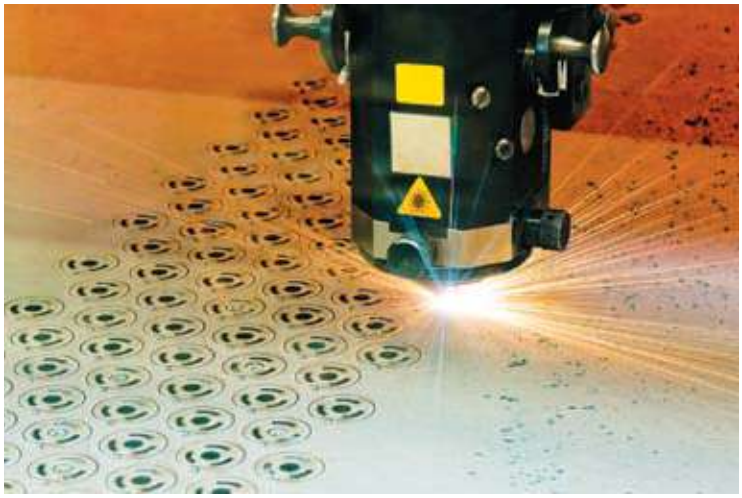
1.1.2.7.1 Introduction

1W to 120kW

Introduction to High Power Water Cooled Sensors

Ophir has many years experience supplying measurement systems for high power industrial lasers and has the highest power measuring equipment available on the market – up to 120 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 1100W.
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 Comet, 5000W, 10K-W, 15K-W 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, 15K-W and 30K-W sensors work on the thermopile principle, where the radial heat flow in the absorber disc 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 over the entire range of 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 procedure includes measuring 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**

Most Ophir high power sensors are water cooled. Customers often have questions about our water cooled sensors such as the correct flow rate and pressure under various conditions and the quality of the water required. For further information on water cooled sensors, please see our tutorial on the subject at **http://www.ophiropt.com/laser--measurement/knowledge-center/article/10000**

1.1.2.7 High Power Thermal Sensors

1.1.2.7.2 High Power Water Cooled Thermal Sensors

0.5W to 300W

Features

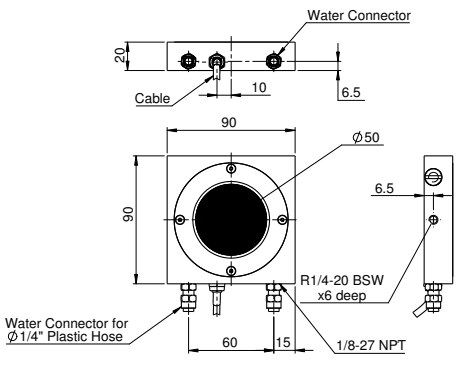
- High powers
- Water cooled
- Up to 300W
- Ø50mm aperture

L250W

L300W-LP2-50

Model	**L250W**	**L300W-LP2-50**
Use	**General purpose**	**High power densities and long pulses**
Absorber Type	Broadband	LP2
Spectral Range µm	0.19 - 20	0.35-2.2, 10.6 [a]
Absorption	~88%	>96% from 0.35 to 1.1µm, 75% for 10.6µm
Aperture mm	Ø50mm	Ø50mm
Power Mode		
Power Range	1W - 250W	0.5W - 300W
Power Scales	250W / 30W	300W / 30W
Power Noise Level	50mW	20mW
Maximum Average Power Density kW/cm²	10 at 250W 14 at 100W	12 at 300W 20 at 150W
Response Time with Meter (0-95%) typ. s	2.5	2.5
Power Accuracy +/-%	3	3 [a]
Linearity with Power +/-%	2	1.5
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	0.07
1µs	0.4	0.6
0.5ms	5	35
2ms	10	90
10ms	30	270
Cooling	water	water
Minimum and Recommended water flow at full power [b]	2 liter/min 4 liter/min	2 liter/min 4 liter/min
Accessories for High Power Sensors	See pages 73-76	See pages 73-76
Weight kg	0.6	0.6
Version		
Part number	**7Z02688**	**7Z02776**
Notes: (a)	This LP2 sensor is calibrated for 0.35 - 1.1µm and 10.6µm. For other wavelengths in the spectral range 1100 – 2200nm there is an additional calibration uncertainty of up to 1%.	
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa.	

L250W / L300W-LP2-50



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

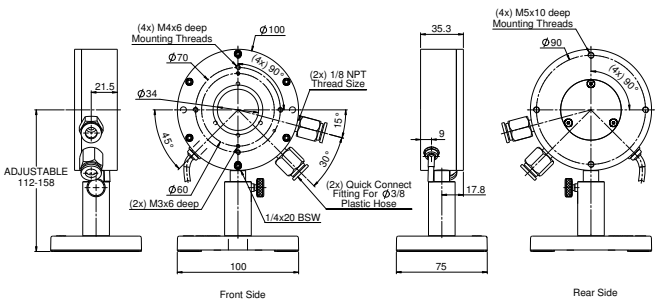
1000W-BB-34

1000WP-BB-34

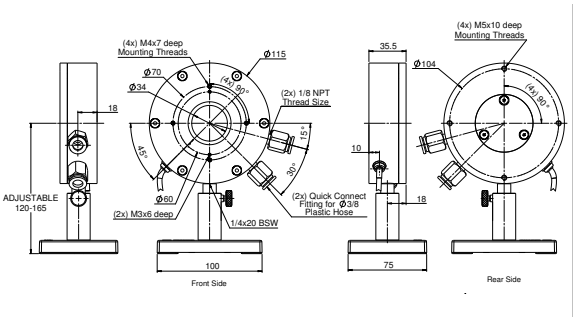
1000W-LP2-34

Model	**1000W-BB-34 / 1000WP-BB-34**	**1000W-LP2-34**
Use	**General purpose and CO_2 laser / Controlled materials in contact with water flow** [c]	**High power densities and long pulses**
Absorber Type	Broadband	LP2
Spectral Range µm	0.19 - 20	0.35 – 2.2
Absorption	~88%	>94% from 0.35 to 1.1µm
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	10 at 500W 7 at 1000W	12 at 500W 10 at 1000W
Response Time with Meter (0-95%) typ. s	2.5	2.5
Power Accuracy +/-%	3 [a]	3 [a]
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	0.1
1µs	0.4	0.9
0.5ms	5	50
2ms	10	130
10ms	30	400
Cooling	water	water
Minimum and Recommended water flow at full power [b]	3 liter/min 10 liter/min	3 liter/min 10 liter/min
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 73-76	See pages 73-76
Weight kg	0.8 / 0.9	0.8
Version	V3 / NA	
Part number: Standard Sensor	**7Z02750 / 7Z02753**	**7Z02774**
BeamTrack Sensor: Beam Position & Size (p. 59)	**7Z07936**	
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	For spectral range 0.35 to 1.1µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa. The recommended flow rate can be lowered proportionately at lower than full power but should not be below the minimum. When used at full power with substantially below the recommended flow rate, the damage threshold may be as much as 20% lower and the response time may not be optimum.	
Notes: (c)	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-LP2-34



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

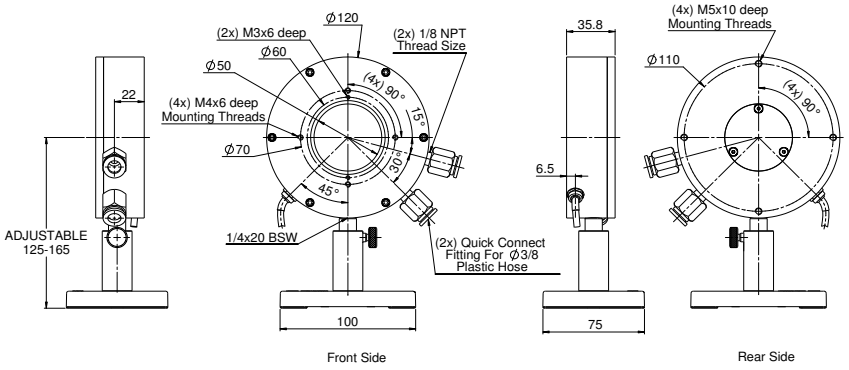
- High powers
- Water cooled
- Up to 1500W
- Ø50mm aperture

L1500W-BB-50

L1500W-LP2-50

Model	**L1500W-BB-50**	**L1500W-LP2-50**
Use	**General purpose and CO_2 laser**	**High power densities and long pulses**
Absorber Type	Broadband	LP2
Spectral Range µm	0.19 - 20	0.35 – 2.2
Absorption	~88%	>94% from 0.35 to 1.1µm
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	7 at 1000W 4 at 1500W	10 at 1000W 5.5 at 1500W
Response Time with Meter (0-95%) typ. s	2.7	2.7
Power Accuracy +/-%	4 (a)	4 (a)
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	0.1
1µs	0.4	0.9
0.5ms	5	50
2ms	10	130
10ms	30	400
Cooling	water	water
Minimum and Recommended water flow at full power (b)	3.5 liter/min 10 liter/min	3.5 liter/min 10 liter/min
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 73-76	See pages 73-76
Weight kg	1.2	1.2
Version	V2	
Part number	**7Z02752**	**7Z02772**
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	For spectral range 0.35 to 1.1µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa. The recommended flow rate can be lowered proportionately at lower than full power but should not be below the minimum. When used at full power with substantially below the recommended flow rate, the damage threshold may be as much as 20% lower and the response time may not be optimum.	

L1500W-BB-50 / L1500W-LP2-50



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

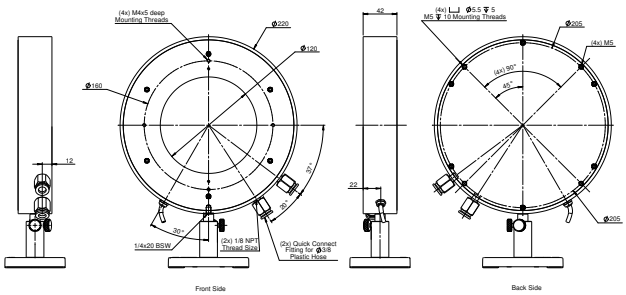
- Very large aperture
- Broadband or Pulsed absorber
- Up to 2000W
- Ø120mm aperture

L2000W-BB-120

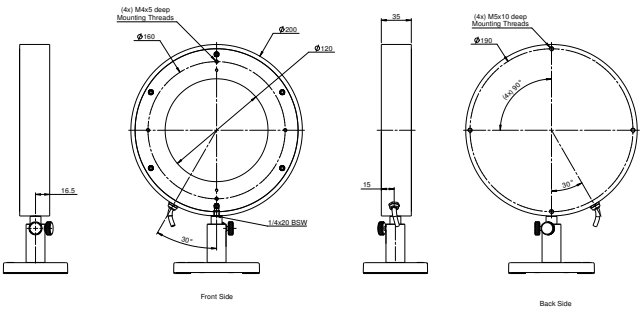
L100(500)A-PF-120

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	700 at 1000W 150 at 1500W 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	6J – 6000J	6J – 6000J
Energy Scales	6KJ / 600J / 60J	6KJ / 600J / 60J
Minimum Energy	6J	6J
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	10 liter/min (b)	NA
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 73-76	See pages 73-76
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. Pressure drop across sensor 0.06MPa.	
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

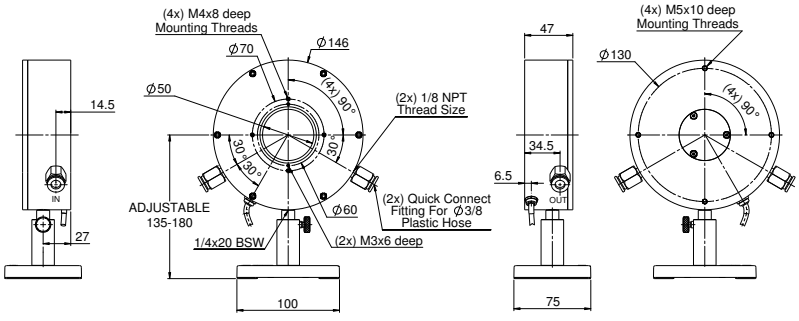
- Powers up to 5000W
- Water cooled
- Ø50mm aperture

5000W-BB-50

5000W-LP2-50

Model	**5000W-BB-50**	**5000W-LP2-50**
Use	**General purpose and CO_2 laser**	**High power densities and long pulses lasers**
Absorber Type	Broadband	LP2
Spectral Range µm	0.19 - 20	0.35 – 2.2
Absorption	~88%	>94% from 0.35 to 1.1µm
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	3 at 3kW 1.7 at 5kW	5 at 3kW 2.5 at 5kW
Response Time with Meter (0-95%) typ. s	3	3
Power Accuracy +/-%	4 (a)	4 (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	0.1
1µs	0.4	0.9
0.5ms	5	50
2ms	10	130
10ms	30	400
Cooling	water	water
Fiber Adapters	Consult Ophir representative	Consult Ophir representative
Accessories for High Power Sensors	See pages 73-76	See pages 73-76
Minimum and Recommended water flow at full power (b)	5 liter/min 10 liter/min	5 liter/min 10 liter/min
Cable Length	1.5 meters	1.5 meters
Weight kg	2.8	2.8
Version	V1	
Part number	**7Z02754**	**7Z02773**
Notes: (a)	Calibrated for ~0.8µm, 1.064µm and 10.6µm	For spectral range 0.35 to 1.1µm
Notes: (b)	Water temperature range 18-30°C. Water temperature rate of change <1°C/min. Pressure drop across sensor 0.06MPa. The recommended flow rate can be lowered proportionately at lower than full power but should not be below the minimum. When used at full power with substantially below the recommended flow rate, the damage threshold may be as much as 20% lower and the response time may not be optimum.	

5000W-BB-50 / 5000W-LP2-50



Front Side **Rear Side**

1.1.2.7 High Power Thermal Sensors

1.1.2.7.3 Calorimetric Power Meter

200W to 6000W

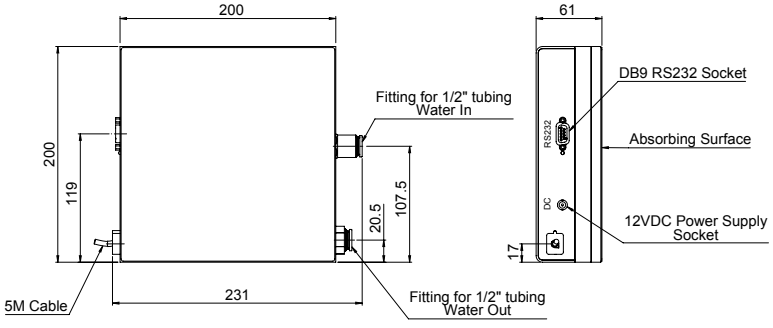
Features

- 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 WaterFlowMeter PC Application 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. Pressure drop across sensor 0.05MPa.

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 15kW

Features

- Very high powers
- Water cooled
- Up to 15kW
- Up to Ø45mm apertures

10K-W-BB-45

10K-W-BB-45
With optional scatter shield

15K-W-BB-45

Model	**10K-W-BB-45**	**15K-W-BB-45**
Use	**High power up to 11kW**	**High power up to 15kW**
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	Ø45mm
Power Range	100W – 11kW	100W – 15kW
Power Scales	11kW / 6kW / 600W	15kW / 4kW / 400W
Power Noise Level	1W	1W
Backscattered Power [b, e]	~3.5% without Scatter Shield, ~1% with Scatter Shield	~3.5% without Scatter Shield, ~1% with Scatter Shield
Maximum Average Power Density kW/cm²	See note [c] and table [1] below	See note [c] and table [1] below
Response Time with Meter (0-95%) typ. s	2.7	3.5
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]	15 liter/min at full power, proportionally less at lower power. Min flow rate 3 liter/min [d]
Water Pressure Requirements at Max Flow Rate	Pressure drop across sensor ~0.2MPa.	Pressure drop across sensor ~0.3MPa.
Water Connectors [e]	Quick connector for 3/8" OD nylon tubing	Quick connector for 3/8" OD nylon tubing
Cable Length	5 meters	5 meters
Weight kg	4.5	6
Version	V3	
Part number	**7Z02756**	**7Z02770**

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

Notes: (b) When scatter shield is installed, use the NIRS setting to compensate for slightly higher reading. When not installed, use the NIR 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.

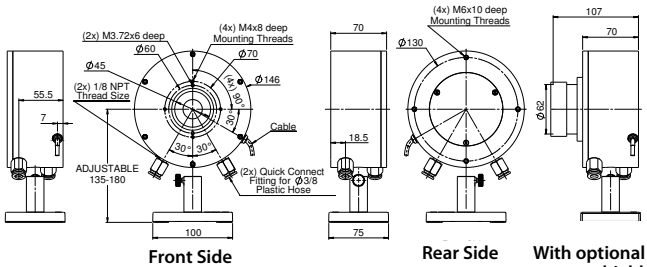
Notes: (d) Water temperature range 15-30°C. Water temperature rate of change <1°C/min

Notes: (e) Heavy duty stand is available as optional extra. For further information and other options see **Accessories for High Power Sensors** on pages 73-76.

Table: (1)

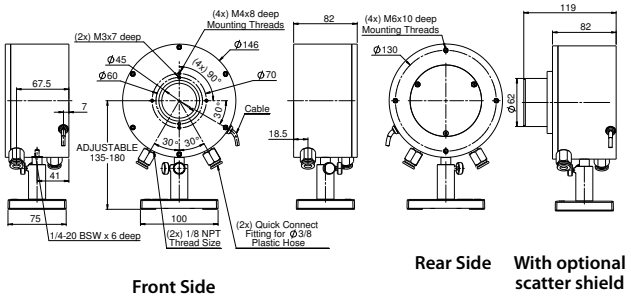
Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

10K-W-BB-45



Front Side | Rear Side | With optional scatter shield

15K-W-BB-45



Front Side | Rear Side | With optional scatter shield

1.1.2.7 High Power Thermal Sensors

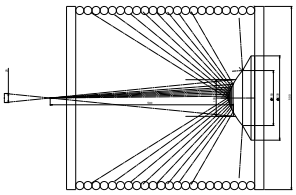
1.1.2.7.4 Very High Power Water Cooled Thermal Sensors

100W to 120kW

Features

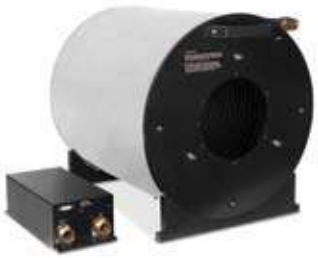
- Highest powers
- Water cooled
- Up to 120kW
- Ø200mm aperture

30K-W-BB-74



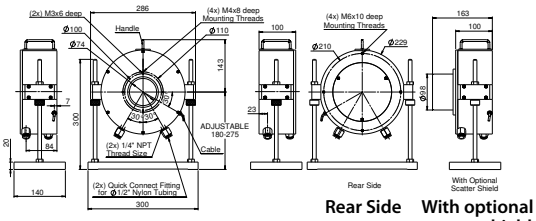
Laser Beam Path

120K-W



Model	**30K-W-BB-74**	**120K-W**
Use	**High power up to 30kW**	**Measuring Highest powers to 120kW**
Measurement Type	Beam deflector + broadband absorber	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 - 2, 10.6	0.9 –1.1 (a)
Aperture mm	Ø74mm	Ø200
Power Range for Calibrated Reading	100W – 30kW	10kW – 120kW
Power Noise Level	1W	±20W with stable water temperature
Backscattered Power	~4.3% without Scatter Shield, ~1.3% with Scatter Shield (b, c)	Less than 1%
Maximum Average Power Density kW/cm²	10kW/cm² anywhere in the beam (c)	Designed for near Gaussian beam. The 1/e² beam diameter should have a divergence of 2.5 to 6 degrees and should be Ø100mm in diameter at the reflecting cone (see sketch above)
Beam Centering Requirements IMPROPERLY CENTERED BEAM CAN CAUSE DAMAGE TO SENSOR	For circular beam centered within ¼ of beam diameter. Maximum tilt angle ±5 degrees. For rectangular beam please consult Ophir representative.	Beam to be centered on deflecting cone ±5mm and parallel ±2degrees
Response Time 0-95% typ	7s	40s at flow rate 60 liter/min and 60s at flow rate 20 liter/min
Power Accuracy +/-%	5 (a)	5 (a)
Linearity with Power +/-%	2	2
Cooling Requirements	25 liter/min at full power, proportionally less at lower power. Min flow rate 6 liter/min. Water temperature range 15-30ºC. Water temperature rate of change <1ºC/min	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	Consult Ophir representative
Water Pressure Drop across Beam Absorber	Pressure drop across sensor ~0.2MPa. Pressure drop across 8 meters of ½" tubing with 9.5mm ID is ~0.3MPa	0.4MPa at 60 liter/min flow rate
Water Connections	Quick connector for ½" OD nylon tubing (c)	Up to 4 meters in each direction of 1" OD 13/16" ID flexible nylon tubing
Outputs	10 meter cable terminated in DB15 smart connector	1. Cable terminated in DB9 plug with RS232 ASCII output reading power, flow rate and temperature on PC (using WaterFlowMeter PC App). Cable lengths 10 meters (recommended for access to full data). 2. Cable terminated in DB15 Ophir smart plug reading power.
Dimensions	See drawing below	See drawing below
Weight kg	19	Beam Absorber 50kg. Power measuring unit 10kg
Version	V2	
Part number	**7Z02757**	**7Z02691**
Notes: (a)	Calibrated at 1.07µm. For other wavelengths in the range 0.8 – 2µm add up to ± 2% to the calibration error	Calibrated for 1.07 µm
Notes: (b)	When scatter shield is installed, use the 107S laser setting to compensate for the slightly higher reading. When not installed, use the 107 setting	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)	For further information and options see **Accessories for High Power Sensors** on pages 73-76	

30K-W-BB-74

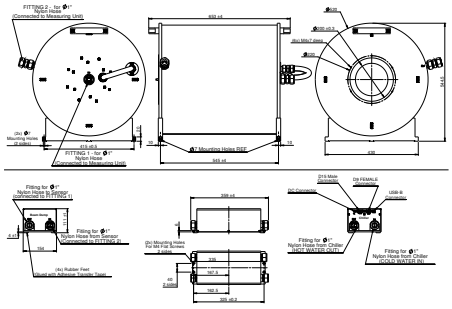


Front Side

Rear Side

With optional scatter shield

120K-W



1.1.2.7 High Power Thermal Sensors

1.1.2.7.5 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

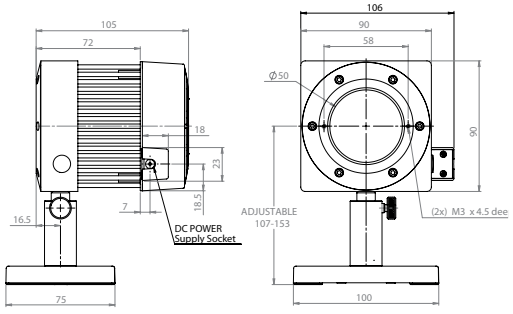
Model	BDFL500A-BB-50	BDFL1500A-BB-65	BD5000W-BB-50	BD10K-W
Use		**General purpose High power beam dump**		
Absorber Type	Broadband	Broadband	Broadband	Beam Deflector + Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.19 - 20	0.8 - 20
Typical Absorption		86% for 600 to 2500nm, 82% for 10.6µm		
Aperture 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	10 liter/min (a)	10 liter/min (a)
Accessories for High Power Sensors	See pages 73-76	See pages 73-76	See pages 73-76	See pages 73-76
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. Pressure drop across BD5000W-BB-50 beam dump 0.06MPa. Pressure drop across BD10K-W beam dump 0.2MPa.

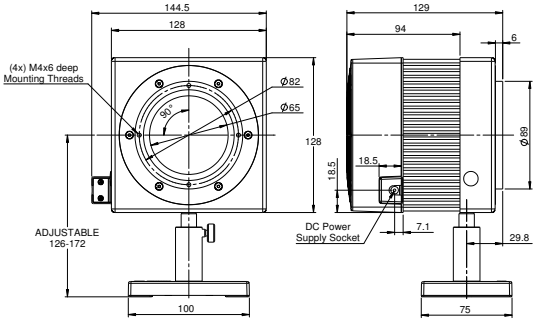
Notes: (b): Max power and energy density

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

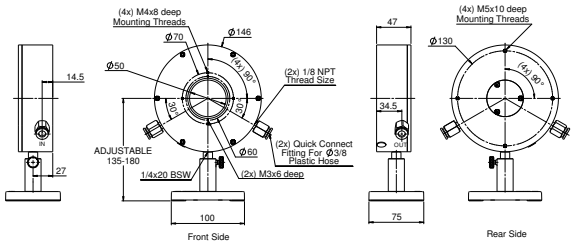
BDFL500A-BB-50



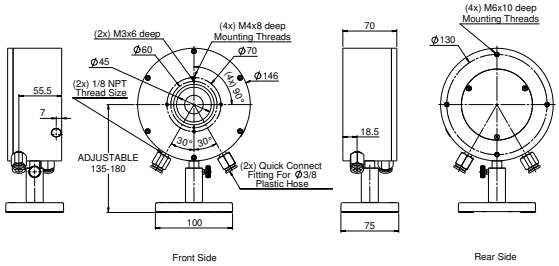
BDFL1500A-BB-65



BD5000W-BB-50



BD10K-W



1.1.2.8 Short Exposure High Power Sensors

1.1.2.8.1 Helios

200W to 12,000W

Features

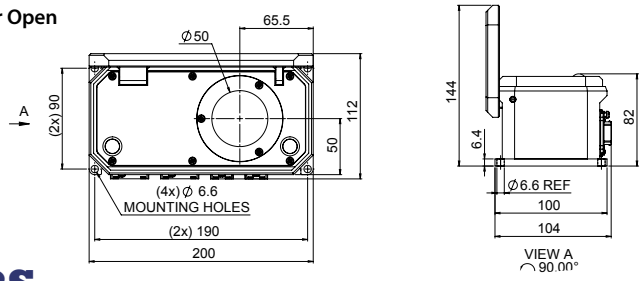
- No water cooling, up to 12000W
- Profinet and RS232 interface
- Remote actuated protective cover

The Helios measures high power industrial lasers of up to 12kW by measuring the energy of a short time exposure to this power. The laser is set to a pulse of from 0.3 to several seconds. The Helios measures the energy and exposure time of this sample of the power, and from this calculates the power. By keeping the pulse energy under 5 kJ, there is no need for water cooling and the sensor can be kept to a compact size. The Helios was designed with factory automation in mind. The cover can be opened and closed remotely to protect the sensor when not in use. The Helios laser power meter can communicate via Profinet or RS232 and comes with a simple PC application for easier integration into the customer's system. The Helios boasts a wide dynamic range, as well as high accuracy and repeatability, with a fast response time.
The sensor is housed in a dust-resistant industrial body to keep the Helios in clean working order even under harsh factory conditions. Its protective window is antireflection coated to reduce back reflection of the high power beam. The Helios is equipped with two power and Profinet ports for easy integration into existing line or ring topologies. In addition, RS232 communication is also included if preferred.

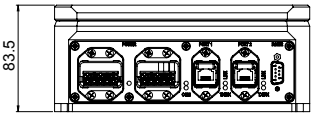
Model	**Helios**					
Use	**High power industrial laser measurement**					
Absorber Type	LP2, absorption ~94%					
Power Range	200W - 12kW					
Energy Range	200J - 5kJ					
Exposure Time (see table below)	0.3- 4s [a]					
Wavelength	860 - 1100nm [b]					
Aperture	50mm					
Max Beam Diameter	35mm					
Maximum Energy Density	4kJ/cm^2					
Accuracy	±3% [c]					
Linearity with Energy	±1.5% [d]					
Reproducibility	±1%					
Response Time	3s					
Waiting Time for Next Measurement	12s					
Maximum Exposure Before Cooling Down is Necessary	Maximum operating temperature of 60degC will be reached after exposure to 30kJ (e.g. 6 shots at 5000W, 1s). Cooling down time before another 5kJ shot, 3min.					
Power Supply	24 VDC ±5%, max 5 A (for daisy-chaining)					
Power Consumption	24 VDC ±5%, max 2 A					
Communication	Profinet, RS232					
Dimensions	(L x W x H) 200 x 100 x 84 mm (closed); 200 x 123 x 144 (open)					
Position of Mounting Holes	6.6 mm holes spaced at 90x190 mm					
Weight	2.5kg					
Operating Temperature	10-60ºC					
Humidity	10-80%					
Recommended exposure times and 1/e^2 Gaussian beam diameters	Laser power W	Recommended exposure s	min 1/e^2 beam dia. mm	Laser power W	Recommended exposure s	min 1/e^2 beam dia. mm
	500	2	9	5000	1	18
	1000	1	9	10000	0.3	22
	2000	1	12	12000	0.3	25
Connections	2 – RJ45 Industrial Ethernet connectors, 2 – Han PushPull Power Metal 24V power connection [e], 1 – DB9 RS232 connection, 7 – indicator LEDs					
Cover	Motor driven cover opens sideways					
Replacement Window	Replacement window for Helios (P/N 7Z08332)					
Version						
Part number	**7Z02768**					

Notes: (a) Repetitive pulses can also be measured as long as the total exposure time is within this range.
(b) Lasers down to 780nm can be measured with an additional 2% error.
(c) The power is calculated by measuring the energy and exposure time. The laser pulse is assumed to be rectangular for this calculation.
(d) For pulse widths in the range 0.3 – 4s.
(e) External power supply should be connected to the right-hand power jack. The left power connector can be used to connect power to another device (in a ring or line topology). If left unconnected, a plug is provided to keep the connector clean.

Helios with Cover Open



Helios with Cover Closed



1.1.2.8 Short Exposure High Power Sensors

1.1.2.8.2 Pulsed Power Mode

300mW to 10,000W

Features

- No water cooling
- Measure up to 10kW
- Cost Effective

L40(150)A-LP2-50

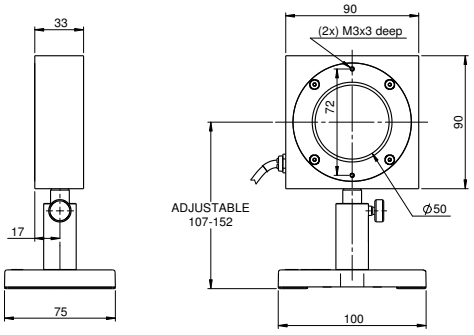
L30C-LP2-26-SH

If the full features of the Helios including protective cover, Profinet interface and pulse width measurement are not needed, similar performance can be obtained with the L40(150)A-LP2-50. The L40(150)A-LP2-50 has the same sensor as the Helios. It can measure powers from short exposure from 500W up to 10,000W. The user measures the energy of the pulse and knowing the pulse width calculates the power (e.g. 5000J in a 0.5s pulse = 10,000W). If using the StarBright meter or Juno PC interface[e] this can be calculated directly by inputting the laser pulse width into the Pulsed Power screen of the StarBright or the equivalent StarLab screen and exposing the sensor to the power for the requisite pulse width. The L40(150)A-LP2-50 will then directly give the power reading from the pulse energy measured. For lower powers, the L30C-LP2-26-SH will give similar performance for energies up to 2000J. For further information see pages 52 & 107

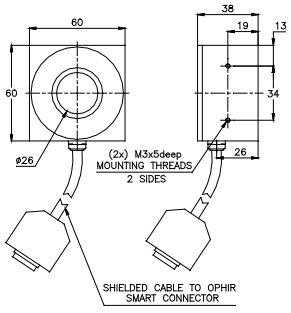
Model	**L40(150)A-LP2-50**			**L30C-LP2-26-SH**		
Absorber Type	LP2			LP2		
Spectral Range	0.25 – 2.2µm			0.25 – 2.2µm		
Absorption	>94% from 0.25 to 1.1µm			>94% from 0.25 to 1.1µm		
Power Range for CW use	300mW - 150W			10W free standing, 100W heat sinked		
Maximum Intermittent CW power	150W for 4min, 80W for 8min, 40W continuous			N.A.		
Pulsed Power Mode						
Exposure Time For Pulsed Power Mode (see table below)	0.3s - 2s [b]			0.5s - 4s [b]		
Energy Range	100mJ – 10,000J			30mJ – 2000J		
Aperture	Ø50mm			Ø26mm		
Max Beam Diameter	Ø35mm			Ø20mm		
Accuracy	±3% 700 – 1100nm [a], [c]			±3% 700 – 1100nm [a], [c]		
Linearity with Energy	±1.5% [d]			±1.5% [d]		
Reproducibility	±1%			±1%		
Response Time	2.5s			1.5s		
Waiting Time for Next Measurement	12s			12s		
Maximum Exposure Before Cooling Down is Necessary	20kJ (e.g. 4 shots of 5000Wx1s). Cooling down time before another 20kJ series, <10min.			10kJ (e.g. 5 shots of 2000Wx1s). Cooling down time before another 10kJ series, <10min.		
Compatible Meter/PC Interface	StarBright, Juno with StarLab [e]			StarBright, Juno with StarLab [e]		
Weight kg	0.6			0.3		
Operating Temperature	15-60ºC			15-60ºC		
Recommended Exposure Times and Beam Diameters	Laser power W	Recommened Exposure s	Min $1/e^2$ beam dia. mm	Laser Power W	Recommended Exposure s	Min $1/e^2$ beam dia. mm
	100	NA	NA	100	4	9
	500	2	9	500	1	9
	1000	1	9	1000	1	13
	2000	1	12	2000	1	17
	4000	1	15	4000	0.5	22
	5000	1	18			
	10000	0.3	22			
Connections	DB15 Smart Plug			DB15 Smart Plug		
Part Number	**7Z02783** (see page 52)			**7Z02775** (see page 107)		

Notes: (a) Above 1100nm there is an additional 1% uncertainty
(b) Repetitive pulses can also be measured as long as the total exposure time is within this range
(c) The power is calculated by measuring the energy and exposure time. The laser pulse is assumed to be rectangular for this calculation
(d) For pulse widths in the range 0.3 – 4s
(e) Pulsed Power function will be available on Juno late 2018

L40(150)A-LP2-50



L30C-LP2-26-SH



1.1.2.8 Short Exposure High Power Sensors

1.1.2.8.3 Comet 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

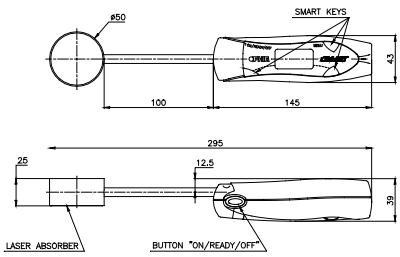
Comet 1K

Comet 10K

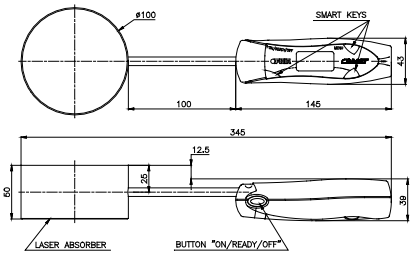
Comet 10K-HD

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		0.98-1.07 and 10.6		0.98-1.07 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**		

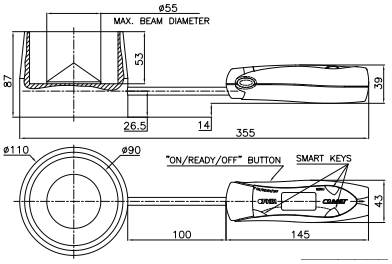
Comet 1K



Comet 10K



Comet 10K-HD



1.1.2.9 Accessories for High Power Water Cooled Sensors

1.1.2.9.1 Protective Housing for 1000W and L1500W Series Sensors

For use with 1000W and L1500W sensors in industrial environments where sensors may be contaminated by debris from material working process. The protective housing and shutter prevent contamination of the 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 for 1000W / L1500W
Mounted on Sensor (shutter open)
Rear view (cables)

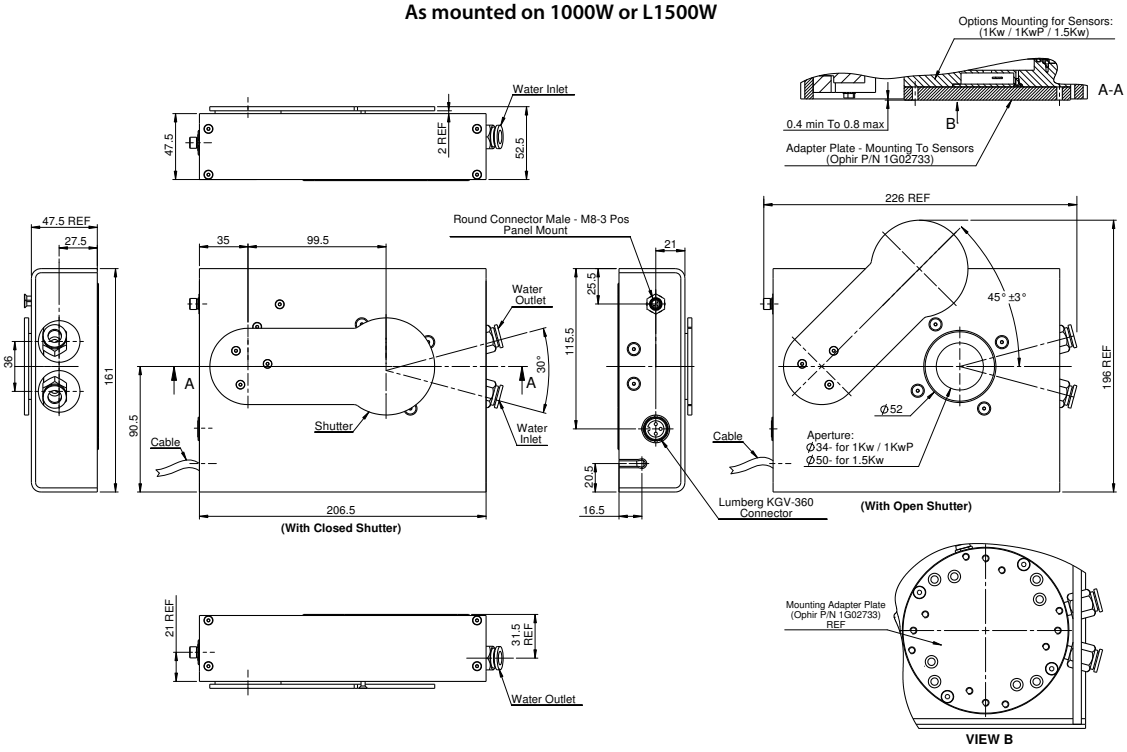
Protective Housing for 1000W / L1500W
Mounted on Sensor (shutter closed)
Front view (water connectors)

Model	**1000W / L1500W Protective Housing** [b]
Use	**Protection from debris of material working process**
Sensors Supported	For 1000W and L1500W. Needs threaded front flange [a]
Aperture	Exposes full aperture of sensors
Solenoid Actuating Power	24VDC 1A, Shutter is normally Closed
Electrical Connection	Lumberg SV30 male connector with 2m cable (P/N 7Z10377) as supplied. Black wire is ground
Interlock	Interlock switch is open if shutter is closed. This can be used to protect the shutter from accidental exposure to the laser
Electrical Connection for Interlock	3 Pin DIN connector with 1.5m cable (P/N 7E01513A)
Dimensions	See drawings below
Housing Material	Sheet aluminum
Part number	**7Z08334**

Note: (a) When fitting the housing to previous versions of the above sensors not having the requisite threads on their front flange, 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.

Note: (b) The 1000W / L1500W protective housing is provided with an adapter plate (P/N 1G02733) so the sensor bottom surface will protrude below the side walls of the housing thus enabling easy mounting to the work surface (see view B in drawing below).

Protective Housing for 1000W and L1500W
As mounted on 1000W or L1500W



1.1.2.9 Accessories for High Power Water Cooled Sensors

1.1.2.9.2 Protective Housing for 5000W, 10K-W and 15K-W Series Sensors

A protective housing with shutter is available for Ophir models 5000W, 10K-W and 15K-W for use in industrial environments where sensors may be contaminated by debris from material working process.
The protective housing and shutter prevent contamination of the 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 for 5000W / 10K-W / 15K-W

Protective Housing for 5000W / 10K-W / 15K-W Mounted on Sensor (shutter open)

Protective Housing for 5000W / 10K-W / 15K-W Mounted on Sensor (shutter closed)

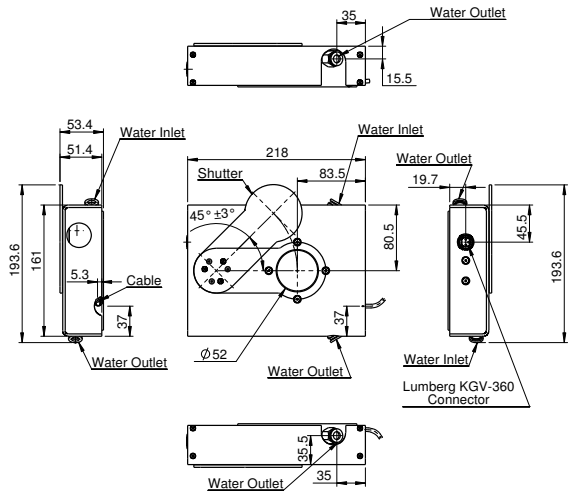
Model	**5000W / 10K-W / 15K-W Protective Housing**
Use	**Protection from debris of material working process**
Sensors Supported	For 5000W, 10K-W and 15K-W. Needs threaded front flange [a]
Aperture	Exposes full aperture of sensors
Solenoid Actuating Power	24VDC 1A, Shutter is normally Closed [b]
Electrical Connection	Lumberg SV30 male connector with 2m cable (P/N 7Z10377) as supplied. Black wire is ground
Dimensions	See drawing below
Housing Material	Sheet aluminum
Part number	**7Z08277**

Notes: (a) When fitting the housing to previous versions of the above sensors not having the requisite threads on their front flange, 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.

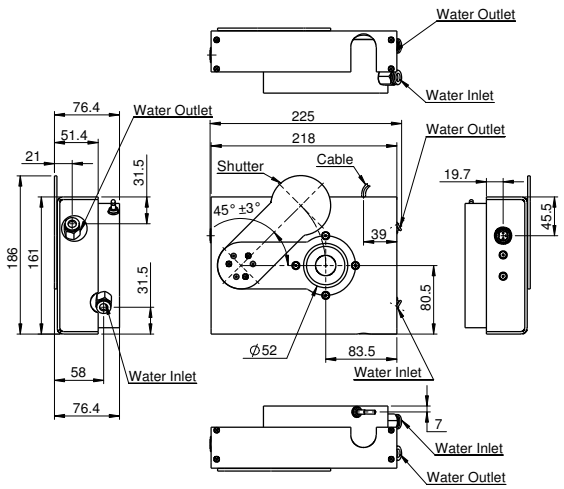
Notes: (b) In order to prevent possible damage to the shutter, it is recommended to safety interlock the shutter and laser so that if the shutter is closed (no power to the solenoid), the laser will not be directed at the sensor.

Protective Housing for 5000W, 10K-W and 15K-W

As mounted on 5000W



As mounted on 10K-W



1.1.2.9 Accessories for High Power Water Cooled Sensors

1.1.2.9.3 Scatter Shield

Scatter Shield for mounting on front flange of 10K-W / 15K-W and 30K-W to reduce backscattered power.

3 to 4% of the light impinging on the 10K-W / 15K-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.

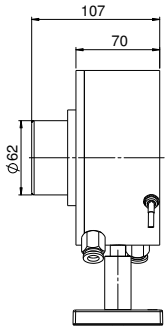
Since some of the light is reabsorbed, the power reading is 1-1.5% higher than without the shield, so an additional laser setting is given for use when the shield is mounted to adjust for this difference.

The scatter shield comes with a protective cover with target pattern for alignment that also can be purchased separately, (see page 76).

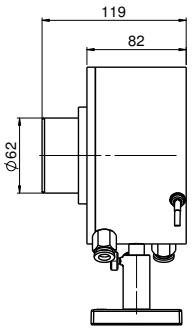
Scatter Shield with protective cover

Scatter Shield without protective cover

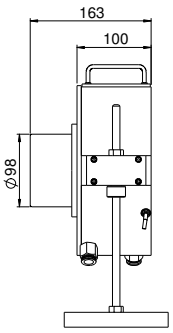
10K-W with Scatter Shield



15K-W with Scatter Shield



30K-W with Scatter Shield



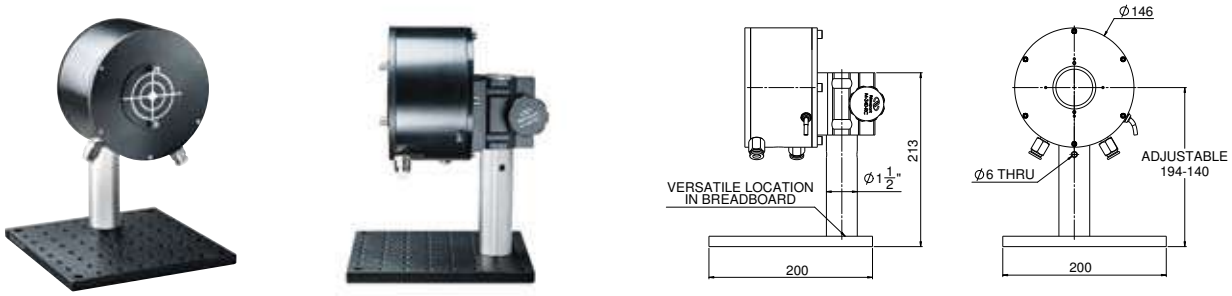
Model	10K-W / 15K-W Scatter Shield	30K-W Scatter Shield
Wavelength range of use	0.8 – 2µm	0.8 – 2µm
Laser setting with and without shield	with NIRS, without NIR	with 107S, without 107
Backscatter with and without shield	with 0.9%, without 3.2%	with 1.4%, without 4.3%
Part number	**7Z08295**	**7Z08293**

1.1.2.9.4 Heavy Duty Stand for 10K-W and 15K-W

For sustained use in an upright position, it may be advisable to purchase the heavy duty stand for the 10K-W and 15K-W due to their large size and weight. The heavy duty stand bolts onto existing threads on the rear of the 10K-W and 15K-W.

Model	Heavy Duty Stand for 10K-W and 15K-W
Part number	7Z08330

Heavy Duty Stand for 10K-W and 15K-W (Shown with a 15K-W sensor)



1.1.2.9 Accessories for High Power Water Cooled Sensors

1.1.2.9.5 Metric Water Connectors for Water Cooled Sensors

The standard water connection supplied with Ophir water cooled sensors are quick connect fittings for 3/8" and 1/2" plastic tubing. Metric water connectors are also available 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

1.1.2.9.6 Protective Covers with Target Pattern for High Power Sensors and for Scatter Shields

All the protective covers are made of black anodized aluminum, and have a cross pattern for alignment.

Sensors: The 5000W, 10K-W, 15K-W sensors are supplied with the 10K-W Protective Cover. This protective cover also fits the 1000W and L1500W sensors, but is not supplied with these sensors. The protective cover can be ordered separately for these sensors. The 30K-W sensor is supplied with the 30K-W Protective Cover.

Scatter Shields: 10K-W / 15K-W Scatter Shield (P/N 7Z08295) and 30K-W Scatter Shield (P/N 7Z08293) are supplied with their respective protective covers (P/N 7Z08345 for 10K-W / 15K-W and P/N 7Z08346 for 30K-W). For more information on scatter shields see page 75.

All protective covers can also be ordered separately (see table below).

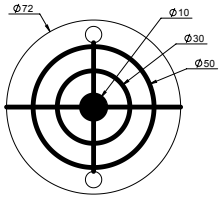
Protective Cover	For use with	Part Number
10K-W Protective Cover	15K-W, 10K-W, 5000W, L1500W, 1000W without scatter shield	1G01332
10K-W / 15K-W Scatter Shield Cover	10K-W and 15K-W with Scatter Shield	7Z08345
30K-W Protective Cover	30K-W without Scatter Shield	1G02406
30K-W Scatter Shield Cover	30K-W with Scatter Shield	7Z08346

Sensor with 10K-W Protective Cover

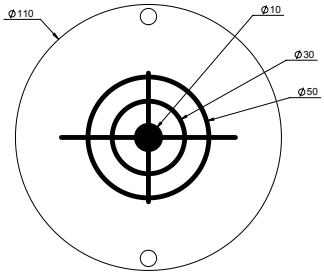
Sensor with 30K-W Protective Cover

Protective Cover on Scatter Shield

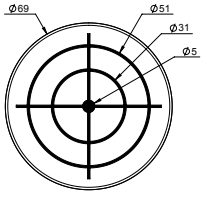
10K-W Protective Cover



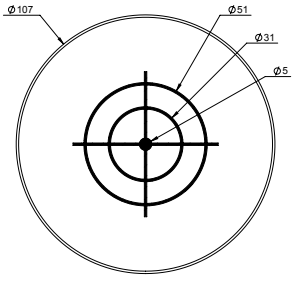
30K-W Protective Cover



10K-W / 15K-W Scatter Shield Cover



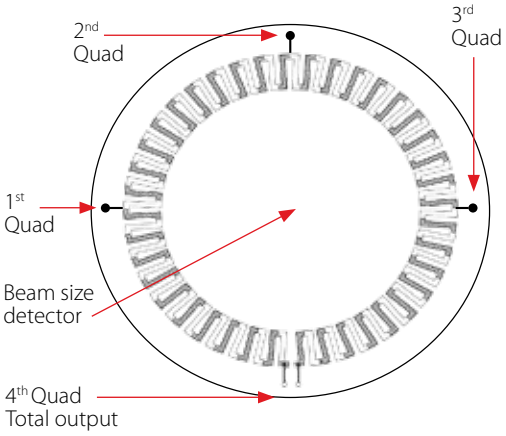
30K-W Scatter Shield Cover



1.1.3 BeamTrack Power / Position / Size Sensors

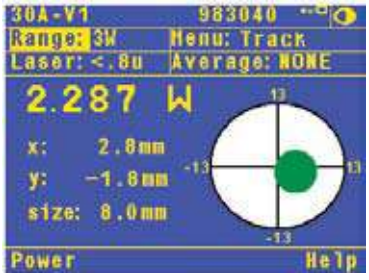
1.1.3.1 Introduction

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, Juno and EA-1), 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.

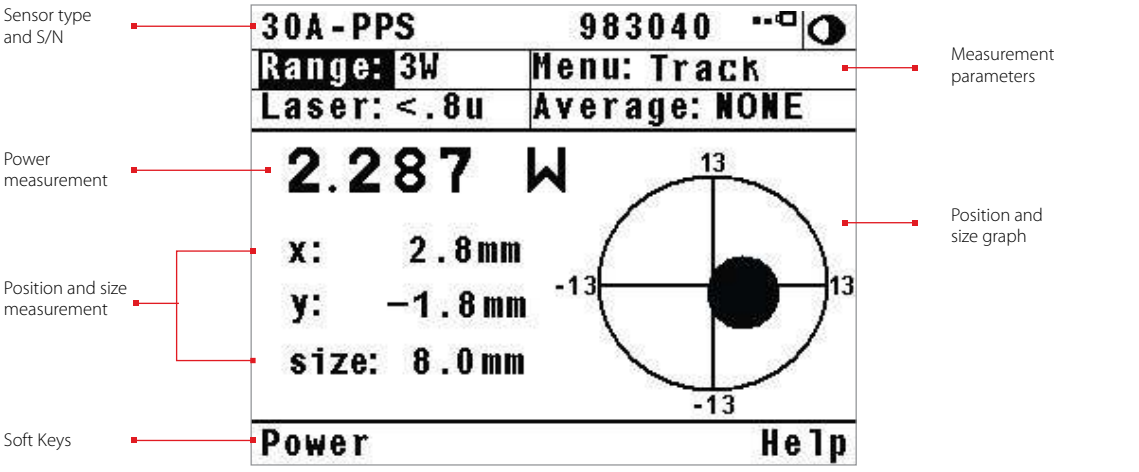
Model	Sensor Type	Max Power [W]	Position	Size
3A-QUAD	TH	3	√	
3A-P-QUAD	TH	3	√	
10A-PPS	TH	10	√	√
50(150)A-BB-26-QUAD	TH	50 (150 intermittent)	√	
50(150)A-BB-26-PPS	TH	50 (150 intermittent)	√	√
F150A-BB-26-PPS	TH	150	√	√
FL250A-BB-50-PPS	TH	250	√	√
1000W-BB-34-QUAD	TH	1000	√	

PD = Photodiode, TH = Thermal

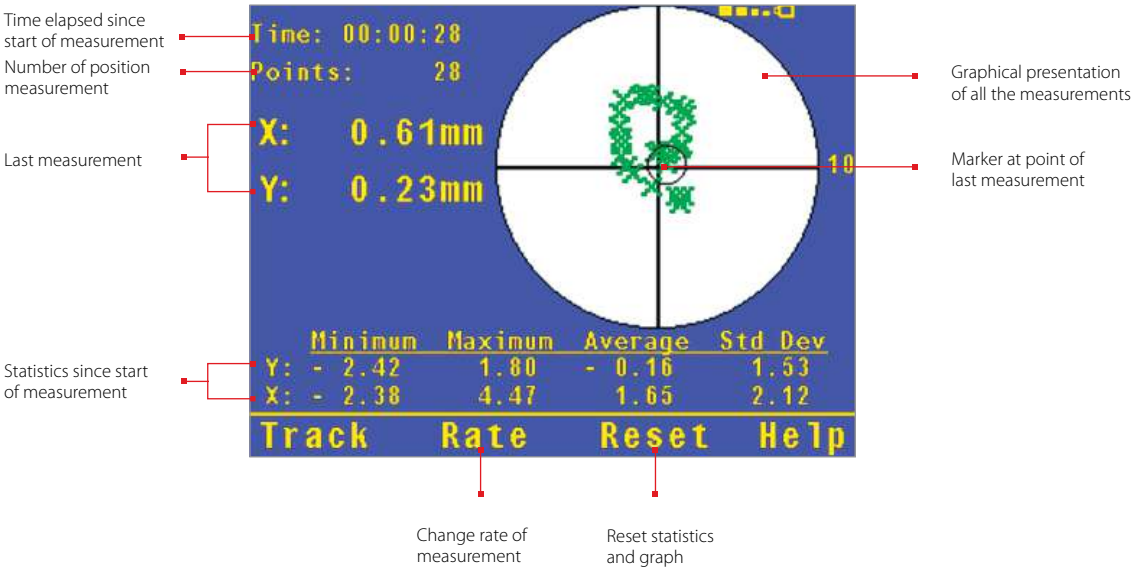
1.1.3.2 BeamTrack Device Software Support

- BeamTrack sensors are fully supported by the StarBright, StarLite, Vega, Nova-II, Juno and EA-1 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

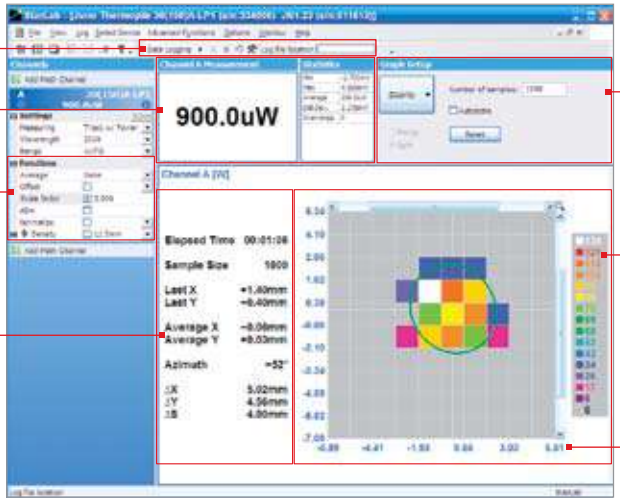


1.1.3.3 BeamTrack PC Software Support

- 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)

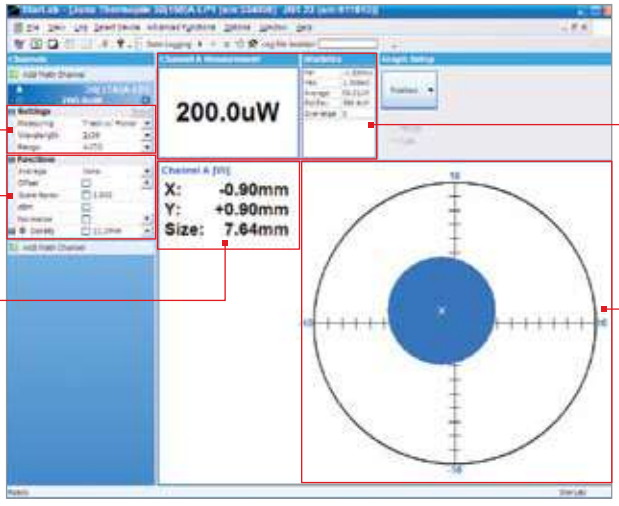
Statistics of the stability sample

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 83)	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 and EA-1 interfaces and StarLab application.

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

Notes: (c) For position within inner 30% of aperture. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

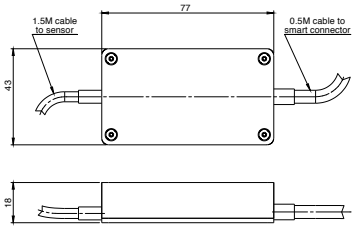
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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

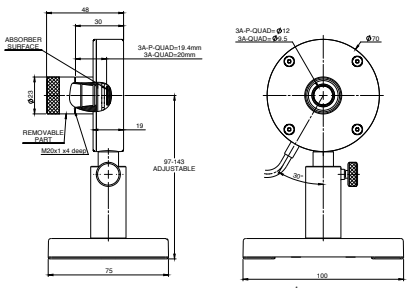
Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

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.

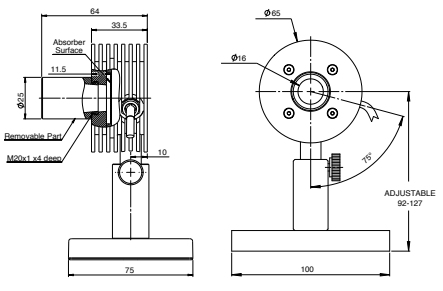
Interface Module on cable



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/cm²	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/cm²			
<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/cm²	1 W/cm²
Cooling	convection	convection	fan
Fiber Adapter Available (see page 83)	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 and EA-1 interfaces and StarLab application.

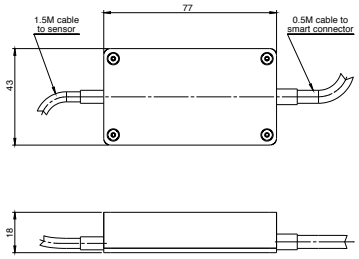
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

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. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

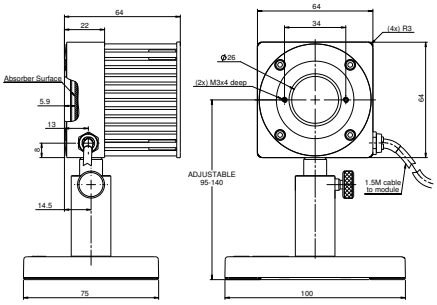
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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%.

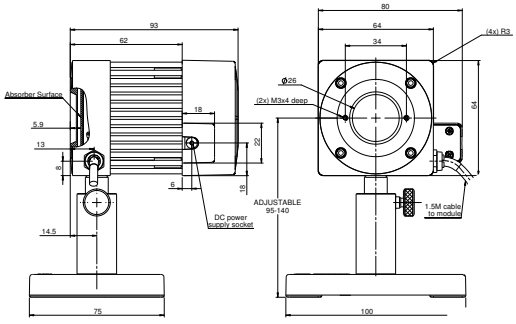
Interface Module on cable



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



F150A-BB-26-PPS



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	10 at 500W, 7 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	10 liter/min [g]
Fiber Adapter Available (see page 83)	ST, FC, SMA, SC	Consult Ophir representative
Accessories for High Power Sensors	NA	See pages 73-76
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 and EA-1 interfaces and StarLab application.

Notes: (b) For 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: (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. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

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

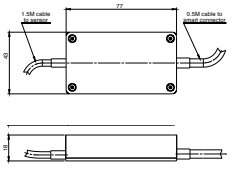
Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

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

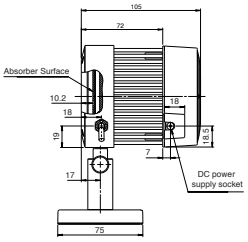
Notes: (g) Water temperature range 18-30°C, Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa.

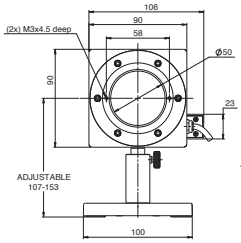
Notes: (h) Position accuracy for the central 10 mm of the aperture as limited by beam position resolution. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

Interface Module on cable

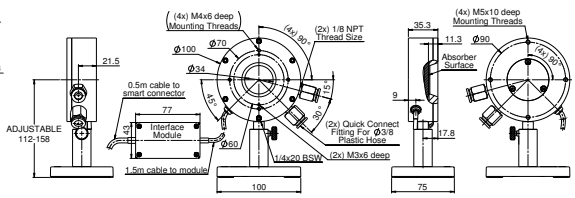


FL250A-BB-50-PPS





1000W-BB-34-QUAD



Front Side **Rear Side**

1.1.4 Accessories for Thermal Sensors

1.1.4.1 Fiberoptic Adapters

SC fiber adapter

ST fiber adapter

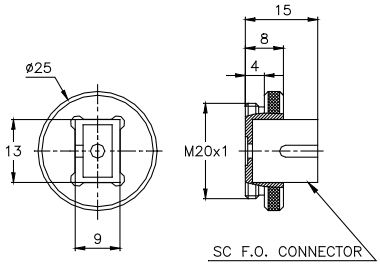
FC fiber adapter

SMA fiber adapter

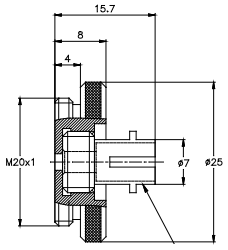
Sensor Series	Fiber adapter mounting bracket (1 bracket fits all fiber adapters)	SC fiber adapter	ST fiber adapter	FC, FC/APC fiber adapter	SMA fiber adapter
Thermal Sensors					
2A-BB-9 / 3A / 3A-QUAD / 3A-P / 3A-P-QUAD / 3A-PF-12 / 3A-FS / 3A-P-THz	not needed				
10A / 10A-PPS / 10A-P	not needed				
12A / 12A-P	not needed				
30A-BB-18 / 30A-N-18 / 30(150)A-BB-18 / 30(150)A-LP1-18 / F50A-BB-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-LP2-35	7Z08265				
30A-P-17 / 30(150)A-SV-17 / 30(150)A-HE-17	7Z08230				
L40(150)A / L40(150)A-LP2-50 / L50(150)A	7Z08238 (a)				
FL250A-BB-50 / FL250A-BB-50-PPS / FL400A-BB-50 / FL400A-LP2-50	7Z08212				
L100(500)A-PF-120 / FL600A-BB-65 / FL600A-LP2-65 / 1000WP-BB-34 / 1000W-BB-34 / 1000W-BB-34-QUAD / 1000W-LP2-34 / FL1100A-BB-65 / FL1100A-LP2-65 / L1500W-BB-50 / L1500W-LP2-50 / L2000W-BB-120 / 5000W-BB-50 / 5000W-LP2-50 / 10K-W-BB-45 / 30K-W-BB-74 / 120K-W	Threaded holes exist	Consult Ophir representative			

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

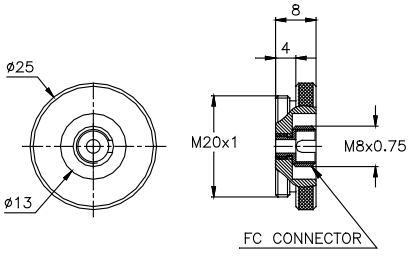
SC fiber adapter



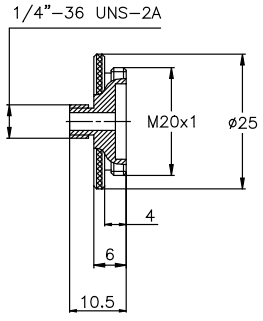
ST fiber adapter



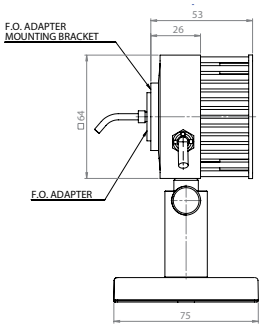
FC fiber adapter



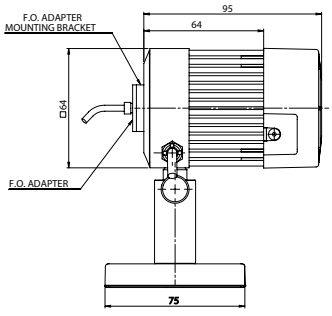
SMA fiber adapter



30A with F.O. input



FL250A with F.O. input



1.1.4.2 Other Accessories

Accessories for High Power Sensors	Description	P/N	Ref
Protective Housing for 1000W, L1500W, 5000W, 10K-W and 15K-W Sensors	Protective Housing with shutter to protect from debris	7Z08334 (for 1000W / L1500W) 7Z08277 (for 5000W / 10K-W / 15K-W)	See page 73 & 74
Scatter Shield for 10K-W, 15K-W and 30K-W Sensors	Scatter Shield to reduce backscattered power (including protective cover)	7Z08295 (for 10K-W / 15K-W) 7Z08293 (for 30K-W)	See page 75
Protective Covers for Scatter Shields with Target Pattern for 10K-W, 15K-W and 30K-W sensors	Protective covers for Ophir scatter shields. The cover has a target pattern for directing the beam using a pointer	7Z08345 (for 10K-W / 15K-W) 7Z08346 (for 30K-W)	See page 76
Protective Covers with Target Pattern for 1000W, L1500W, 5000W, 10K-W, 15K-W and 30K-W Sensors	Black anodized aluminum cover with a target pattern for directing the beam using a pointer	1G01332 (all except 30K-W) 1G02406 (for 30K-W)	See page 76
Metric Water Connectors for water cooled sensors	Metric Water Connectors are quick connect fittings for 3/8" and 1/2" plastic tubing	7107039 (all except 30K-W) 7107038 (for 30K-W)	See page 76
Heavy Duty Stand for 10K-W and 15K-W	For continuous use in vertical position, heavy duty stand is recommended	7Z08330	See page 75
General Accessories			
SH to BNC Adapter	Allows connection of sensor to current measuring device for measurement of raw current output	7Z11010	
Replacement Parts	**Application**	**P/N**	
N Polarity Power Supply/Charger 12V 2A N-2.1x5.5	For: Vega, Nova II, Nova, EA-1, Pulsar, Quasar, Laserstar, 120K-W, 6K-W, Fan Cooled Sensors	7E05029	
P Polarity Power Supply/Charger 12V 2A P-1.35x3.5	For: StarLite, StarBright, RM9 Chopper	7E05047	

Protective Housing

30K-W Scatter Shield

Protective Cover on Scatter Shield

7I07038 1/4" - 12mm

7I07039 1/8" - 10mm

30K-W with 74mm Aperture Protective Cover

10K-W with 34-50mm Aperture Protective Cover

Heavy Duty Stand for 10K-W and 15K-W (Shown with a 15K-W Sensor)

SH to BNC Adapter

N Polarity Power Supply/Charger
P Polarity Power Supply/Charger

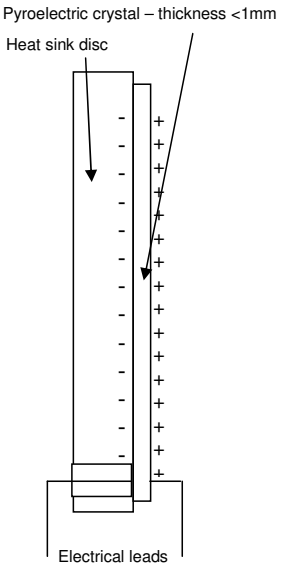
Energy sensors

1.2 Energy Sensors

Introduction

Pyroelectric sensors are for measuring repetitive pulse energies and average powers at pulse rates up to 25000 pulses per second and pulse widths up to 20ms. Note that single shot energy with pulse rates less than one pulse every 5s or so can be measured with thermal sensors described in the power sensor section.

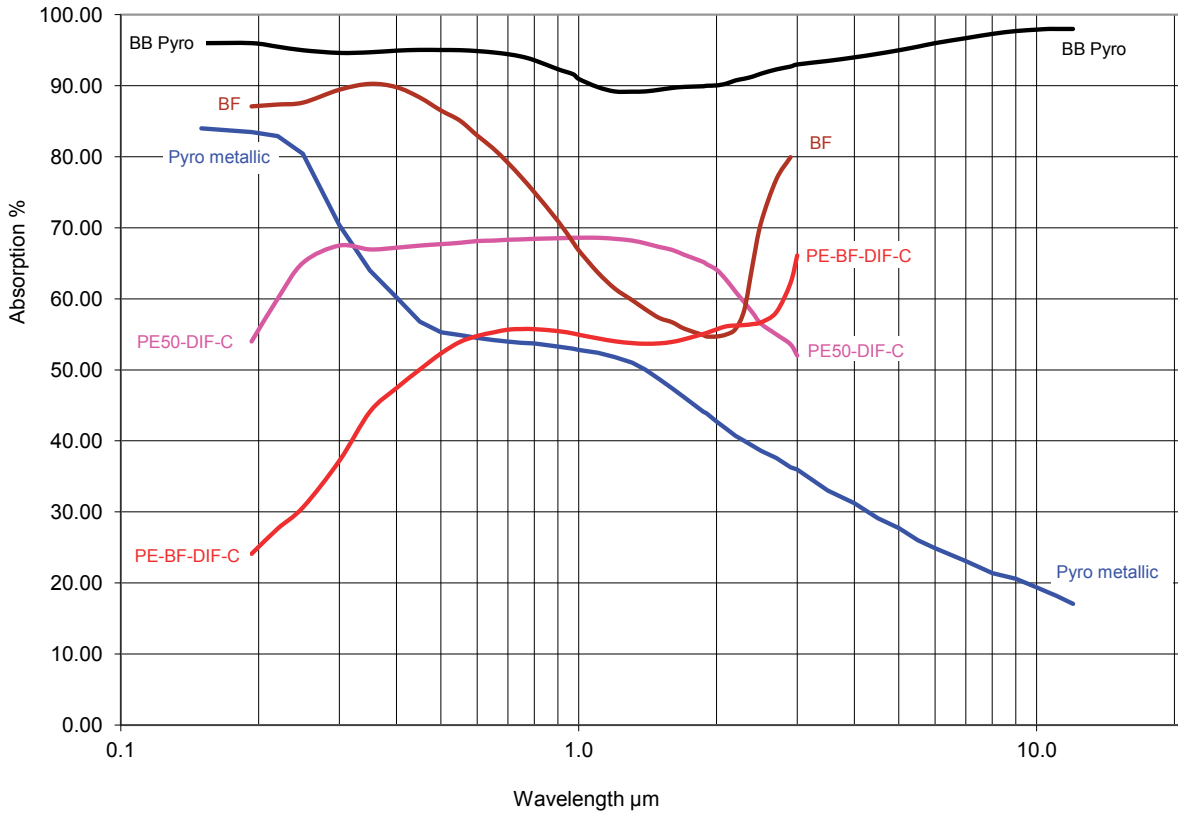
Pyroelectric Sensors



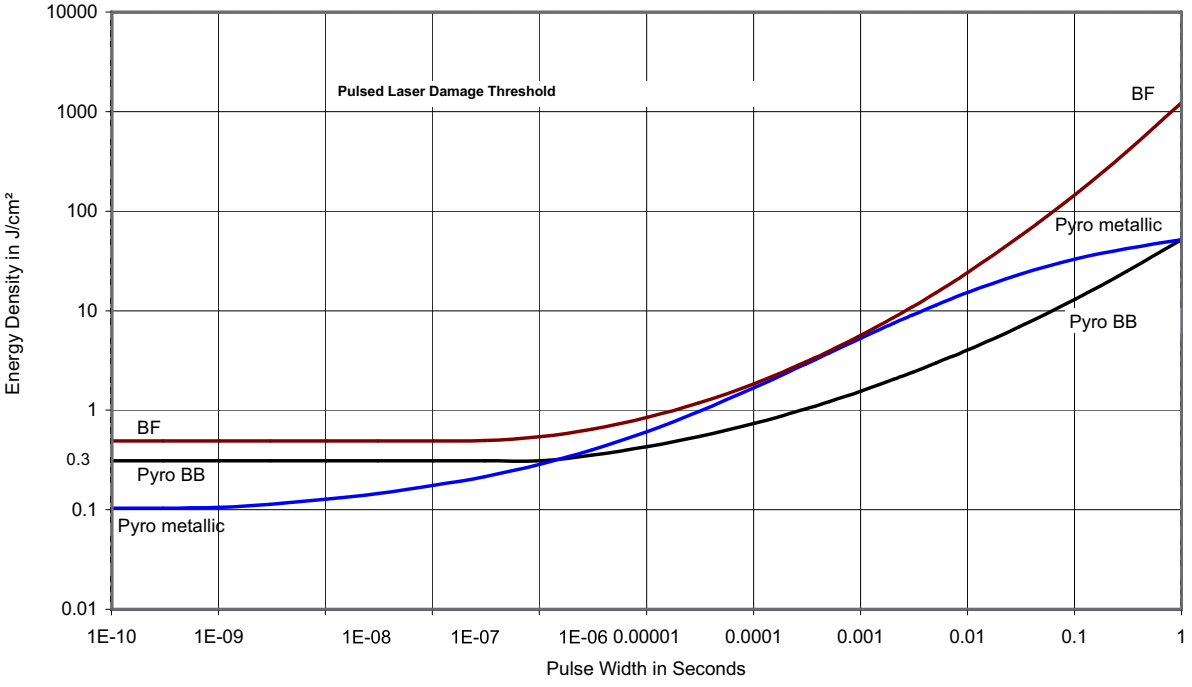
Pyroelectric type sensors are useful for measuring the energy of repetitively pulsed lasers at up to 25,000Hz and are sensitive to low energies.
They are less durable than thermal types and therefore should not be used whenever it is not necessary to measure the energy of each pulse and average power measurement is sufficient.
Pyroelectric sensors use a pyroelectric crystal that generates an electric charge proportional to the heat absorbed. Since the two surfaces of the crystal are metalized, the total charge generated is collected and therefore the response is not dependent on beam size or position. This charge then charges a capacitor in parallel with the crystal and the voltage difference thus generated is proportional to the pulse energy. After the energy is read by the electronic circuit, the charge on the crystal is discharged to be ready for the next pulse. The response time of the pyroelectric sensor depends on the time it takes for the heat to enter the crystal and heat it up. For metallic type pyro detectors, this time is tens of µs and thus the metallic type can run at a high repetition rate. For the BF and BB type, the response time is hundreds of µs with a correspondingly lower repetition rate.
Ophir pyroelectric detectors have unique and proprietary circuitry that allow them to measure long pulses as well as short pulses and work at a high duty cycle, i.e. where the pulse width is as much as 30% of the total cycle time.
Ophir came out with the compact C line of pyroelectric sensors that replaced previous models. The electronics and mechanics has been completely upgraded and the current sensors are superior in every way: more compact, wider dynamic range, have higher repetition rates and measure longer pulses. Through constant development, Ophir again brings you the best performance in the market.
Note: Older line of Pyroelectric sensors is not supported by the StarBrigt and StarLite meters.

Absorption and Damage Graphs for Pyroelectric Sensors

Absorption vs. Wavelength

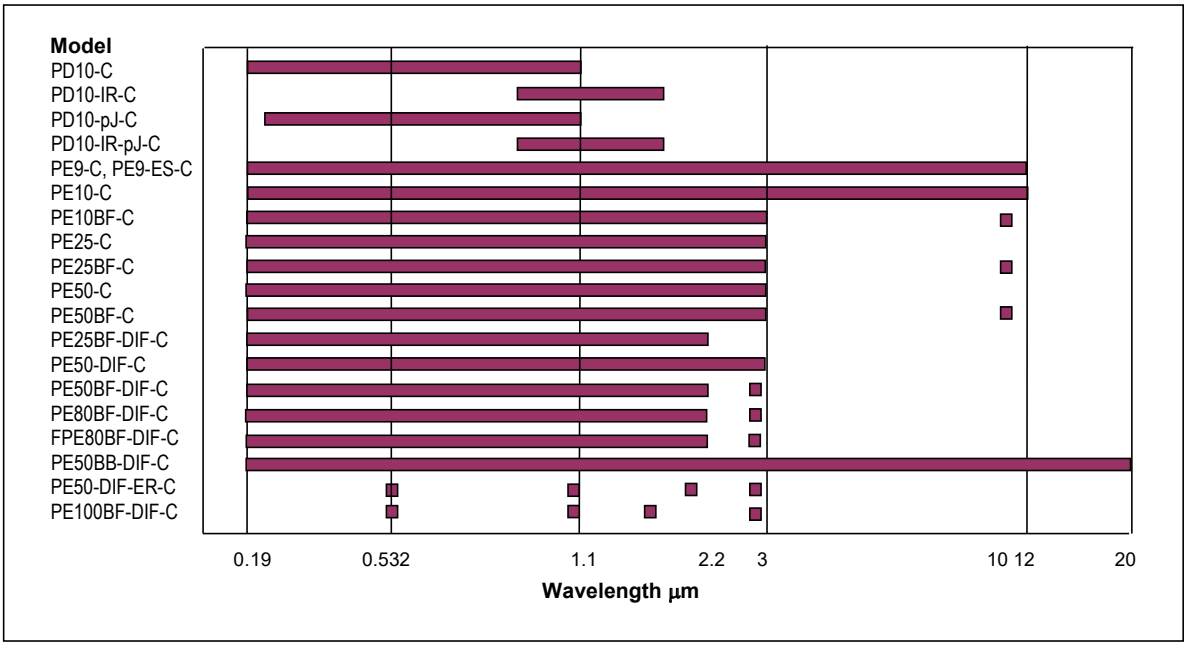


Damage Threshold vs. Pulse Width

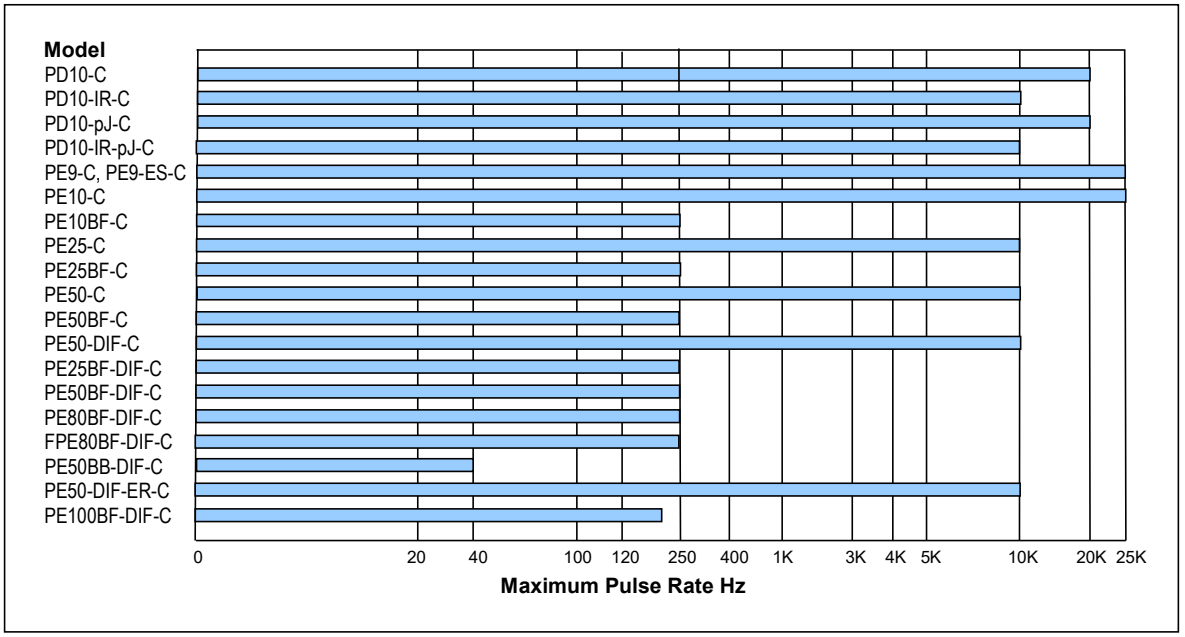


Wavelength Range and Repetition Rate for Energy Sensors

Wavelength Range



Repetition Rate Range



1.2.1 Photodiode Energy Sensors

10pJ to 15µJ

Features

- Silicon and Germanium detectors
- Very sensitive - down to 10pJ
- Repetition rates to 20kHz
- Wide spectral range

PD10-C / PD10-IR-C / PD10-pJ-C / PD10-IR-pJ-C

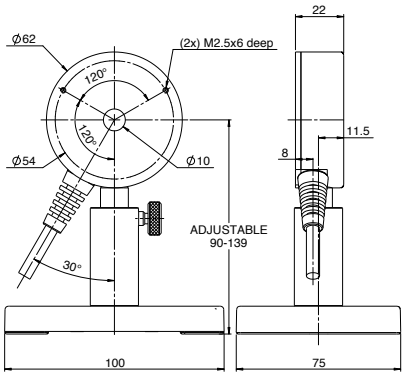
Model	PD10-C		PD10-IR-C		PD10-pJ-C		PD10-IR-pJ-C	
Use	**Low energies**		**Infrared**		**Lowest energies**		**Infrared, lowest energies**	
Aperture mm	Ø10		Ø5		Ø10		Ø5	
Absorber Type	Si photodiode		Ge photodiode		Si photodiode		Ge photodiode	
Spectral Range µm [a]	0.19 - 1.1		0.7 – 1.8		0.2 - 1.1		0.7 - 1.8	
Surface Reflectivity % approx.	50		30		30		30	
Calibration Accuracy +/-% [a]	5		5		5		5	
Energy Scales	20µJ to 20nJ		600nJ to 6nJ		200nJ to 200pJ		20nJ to 200pJ	
Lowest Measurable Energy nJ [b]	1 at 900nm		1 at 1550nm		0.01 at 900nm		0.03 at 1550nm	
Max Pulse Width ms	0.005		0.005		0.005		0.005	
Maximum Pulse Rate pps	20kHz		10kHz		20kHz		10kHz	
Noise on Lowest Range nJ	0.05		0.1		0.001		0.01	
Additional Error with Frequency %	±1% to 20kHz [c]		±1.5% to 10kHz		±1% to 20kHz [d]		±1.5% to 10kHz	
Linearity with Energy for > 10% of full scale [b]	±1.5%		±1.5%		±1.5%		±1.5%	
Damage Threshold J/cm²	0.1		0.1		0.1		0.1	
Maximum Average Power mW	50 at 800nm		6		0.5		0.2	
Maximum Average Power Density W/cm²	50		50		5		5	
Maximum Energy vs. Wavelength	Wavelength	Max Energy	Wavelength	Max Energy	Wavelength	Max Energy	Wavelength	Max Energy
	<300nm	15µJ	800 - 900nm	600nJ	<300nm	150nJ	800 - 900nm	20nJ
	350 - 550nm	8µJ	1000 - 1300nm	200nJ	350 - 550nm	75nJ	1000 - 1300nm	8nJ
	>800nm	5µJ	1300 - 1400nm	170nJ	>800nm	50nJ	1300 - 1400nm	7nJ
			1480 - 1560nm	150nJ			1480 - 1560nm	6nJ
			>1650nm	600nJ			>1650nm	20nJ
Fiber Adapters Available (see page 99)	ST, FC, SMA, SC		ST, FC, SMA, SC		ST, FC, SMA, SC		ST, FC, SMA, SC	
Weight kg	0.25		0.25		0.25		0.25	
Version								
Part number	**7Z02944**		**7Z02955**		**7Z02945**		**7Z02946**	
Note: (a) This is basic calibration accuracy. In certain wavelength regions calibration there is additional error as tabulated here.	<250nm	add ±3%	<900nm	add ±2%	<250nm	add ±2%	<900nm	add ±2%
	>950nm	add ±2%	>1700nm	add ±2%	>950nm	add ±2%	>1700nm	add ±2%

Note: (b) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PD-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments.
For further information, see the FAQs on our Website.

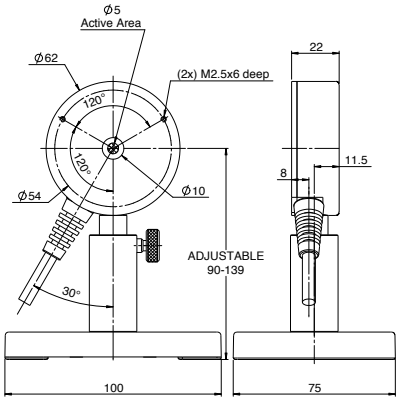
Note: (c) Additional Error with Frequency of ±1% on ly for energies up to 2µJ. For higher energies ±1% up to 10kHz, -4% at 20kHz.

Note: (d) Additional Error with Frequency of ±1% only for energies up to 20nJ. For higher energies ±2% up to 10kHz, -5% at 20kHz.

PD10-C / PD10-pJ-C



PD10-IR-C / PD10-IR-pJ-C



1.2.2 Pyroelectric Energy Sensors

0.1µJ to 1mJ

Features

- Ø8mm aperture
- Repetition rates up to 20,000Hz
- High sensitivity sensors
- Pulse widths up to 20µs

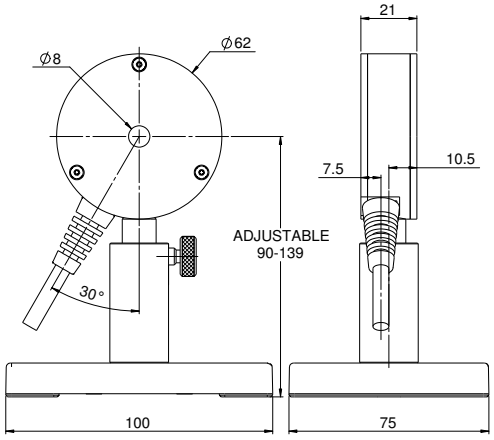
PE9-C / PE9-ES-C

Model	PE9-C			PE9-ES-C		
Use	**Very Sensitive**			**Most Sensitive**		
Aperture mm	Ø8			Ø8		
Absorber Type	metallic			metallic		
Spectral Range µm [a]	0.15 - 12			0.15 - 12		
Surface Reflectivity % approx.	50			50		
Calibration Accuracy +/-% [a]	3			3		
Max Pulse Width Setting [c]	1µs	2µs	20µs	1µs	2µs	20µs
Energy Scales	1mJ to 2µJ	1mJ to 2µJ	1mJ to 20µJ	200µJ to 200nJ	200µJ to 200nJ	200µJ to 2µJ
Lowest Measurable Energy µJ [b]	0.5	<0.2	0.5	0.1	<0.1	0.1
Max Pulse Width µs	1	2	20	1	2	20
Maximum Pulse Rate pps	25kHz	15kHz	10kHz	20kHz	15kHz	10kHz
Noise on Lowest Range µJ	0.04	0.05	0.1	0.01	0.01	0.02
Additional Error with Frequency %	±1% to 15kHz, ±6% to 25kHz	±1% to 15kHz	±1% to 10kHz	±1.5% to 20kHz	±1.5% to 15kHz	±1.5% to 10kHz
Damage Threshold J/cm²						
<100ns	0.1			0.1		
1µs	0.2			0.2		
300µs	3			3		
Linearity with Energy [b]	±1%			±1.5%		
Maximum Average Power W	2			2		
Maximum Average Power Density W/cm²	30			30		
Fiber Adapters Available (see page 99)	ST, FC, SMA, SC			ST, FC, SMA, SC		
Weight kg	0.25			0.25		
Version						
Part Number	**7Z02933**			**7Z02949**		
Note: (a) Calibrated curve is checked and adjusted at the following wavelengths (µm)	0.193, 0.355, 1.064, 1.48-1.6			0.355, 1.064, 1.48-1.6		
For other wavelengths in the curve there is additional calibration error as stated.	240-800nm add ±4%, 2-3µm add ±8%, 10.6µm add ±15%.			240-800nm add ±4%, 2-3µm add ±8%, 10.6µm add ±15%. <240nm not calibrated		

Note: (b) For >7% (>10% for PE9-ES-C) of full scale, with the "user threshold" setting set to minimum. For other settings, the spec is for >7%/>10% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments.
For further information, see the FAQs on our Website.

Note: (c) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter, only 2 out of 3 pulse widths settings are available; the 1µs (displayed as "10µs") and the 2µs (displayed as "20µs").

PE9-C / PE9-ES-C



1.2.2 Pyroelectric Energy Sensors

1µJ to 10mJ

Features

- Ø12mm apertures
- Repetition rates up to 25,000Hz
- High sensitivity sensors
- Pulse widths up to 5ms

PE10-C / PE10BF-C

Model	**PE10-C**		**PE10BF-C**	
Use	**Sensitive**		**High damage threshold**	
Aperture mm	Ø12		Ø12	
Absorber Type	metallic		BF	
Spectral Range µm [a]	0.15 - 12		0.15 - 3, 10.6 [d]	
Surface Reflectivity % approx.	50		20	
Calibration Accuracy +/-% [a]	4		3	
Max Pulse Width Setting [e]	1µs	30µs	1ms	5ms
Energy Scales	10mJ to 2µJ	10mJ to 20µJ	10mJ to 20µJ	10mJ to 200µJ
Lowest Measurable Energy µJ [c]	1	1	7	20
Max Pulse Width µs	1	30	1000	5000
Maximum Pulse Rate pps	25kHz	5kHz	250Hz	50Hz
Noise on Lowest Range µJ	0.1	0.15	1	5
Additional Error with Frequency %	±2% to 15kHz, ±3% to 25kHz	±1% to 5kHz	±1%	±1%
Damage Threshold J/cm²				
<100ns	0.1		0.8 [b]	
1µs	0.2		1 [b]	
300µs	3		4 [b]	
Linearity with Energy [c]	±1.5%		±2%	
Maximum Average Power W	2		3	
Maximum Average Power Density W/cm²	50		50	
Fiber Adapters Available (see page 99)	ST, FC, SMA, SC		ST, FC, SMA, SC	
Weight kg	0.25		0.25	
Version				
Part Number	**7Z02932**		**7Z02938**	
Note: (a) Calibrated curve is checked and adjusted at the following wavelengths (µm)	1.064, 0.355		0.193, 0.248, 0.355, 0.532, 1.064	
For other wavelengths in the curve there is additional calibration error as stated.	240 - 800nm add ±4%, 2-3µm add ±8%, 10.6µm add ±15%. <240nm not calibrated		0.2-3µm ±2%, 10.6µm ±5%	

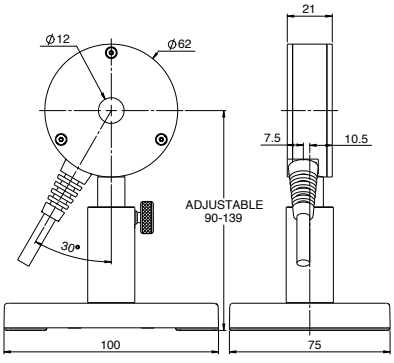
Note: (b) For wavelenghts below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.

Note: (c) For >7% of full scale, with the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. For further information, see the FAQs on our Website.

Note: (d) The absorption at 675nm is approximately the same as at 10.6µm. Therefore, to measure a CO_2 laser, set to the 675nm setting. The additional error for measuring 10.6µm is ±5%.

Note: (e) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter, for the PE10-C model the 1µs pulse width setting is displayed as "10µs".

PE10-C / PE10BF-C



1.2.2 Pyroelectric Energy Sensors

8µJ to 10J

Features

- Ø24mm apertures
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE25-C

PE25BF-C

Energy Sensor with optional heat sink

Model	**PE25-C**					**PE25BF-C**				
Use	**High rep rate**					**High damage threshold**				
Aperture mm	Ø24					Ø24				
Absorber Type	metallic					BF				
Spectral Range µm [a]	0.15 - 3					0.15 - 3, 10.6 [e]				
Surface Reflectivity % approx.	50					20				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [d]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ
Lowest Measurable Energy µJ [c]	8	10	60	80	100	60	100	400	400	400
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	0.5	1	6	10	20	10	20	40	40	50
Additional Error with Frequency %	±2% to 5kHz ±4% to 10kHz	±1.5%	±2% to 750Hz	±1.5% to 400Hz	±1.5% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	0.1					0.8				
1µs	0.2					1				
300µs	2					4				
2ms	6					10				
Maximum Average Power W	15, 25 with optional heat sink					15, 25 with optional heat sink				
Maximum Average Power Density W/cm²	20					20				
Uniformity over surface	±2% over central 50% of aperture					±2% over central 50% of aperture				
Fiber Adapters Available (see page 99)	ST, FC, SMA, SC					ST, FC, SMA, SC				
Weight kg	0.25					0.25				
Version										
Part Number	**7Z02937**					**7Z02935**				
Note: (a) Calibration curve is verified and adjusted at specified wavelengths. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 248-266nm, 355nm, 1064nm and 2940nm. Max additional error at other wavelengths: ±2%. <240nm not calibrated					Specified wavelengths: 193nm, 248 266nm, 355nm, 532nm and 1064nm. Max additional error at 2940nm ±3%. Max additional error at other wavelengths: ±2%.				
Note: (b)						For wavelengths below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.				

Note: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments.
For further information, see the FAQs on our Website.

Note: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter, only 2 out of 5 pulse widths settings are available; for the PE25-C model the 2µs (displayed as "10µs") and 1ms settings, and for the PE25BF-C model the 1ms and 10ms settings.

Note: (e) If the sensor is set to the 1064nm wavelength, then when measuring 10.6µm pulses, the reading will be approximately 1.19X the correct reading. If you use the attenuate function and set the attenuation to read 0.84, then you will have the correct reading at 10.6µm. The additional error at 10.6µm is +/-5%.

* For drawings please see page 96

1.2.2 Pyroelectric Energy Sensors

10µJ to 10J

Features

- Ø46mm apertures
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE50-C

PE50BF-C

Energy Sensor with optional heat sink

Model	**PE50-C**					**PE50BF-C**				
Use	**High rep rate**					**High damage threshold**				
Aperture mm	Ø46					Ø46				
Absorber Type	metallic					BF				
Spectral Range µm [a]	0.15 - 3					0.15 - 3, 10.6 [e]				
Surface Reflectivity % approx.	50					20				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [d]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ
Lowest Measurable Energy µJ [c]	10	10	60	80	100	120	300	600	600	600
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	0.5	1	6	10	20	30	60	100	100	100
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±2% to 750Hz	±2% to 400Hz	±1% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	0.1					0.8				
1µs	0.2					1				
300µs	2					4				
2ms	6					10				
Maximum Average Power W	15, 25 with optional heat sink					15, 25 with optional heat sink				
Maximum Average Power Density W/cm²	20					20				
Uniformity over surface	±2% over central 50% of aperture					±2% over central 50% of aperture				
Fiber Adapters Available (see page 99)	ST, FC, SMA, SC					ST, FC, SMA, SC				
Weight kg	0.25					0.25				
Version										
Part Number	**7Z02936**					**7Z02934**				
Note: (a) Calibration curve is verified and adjusted at specified wavelengths. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 248-266nm, 355nm and 1064nm. Max additional error at 2940nm ±3%. Max additional error at other wavelengths: ±2%. <240nm not calibrated					Specified wavelengths: 193nm, 248-266nm, 355nm, 532nm and 1064nm. Max additional error at 2940nm ±3%. Max additional error at other wavelengths: ±2%.				
Note: (b)						For wavelengths below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.				

Note: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater.
The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error.
The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments.
For further information, see the FAQs on our Website.

Note: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter, only 2 out of 5 pulse widths settings are available; for the PE50-C model the 2µs (displayed as "10µs") and 1ms settings, and for the PE50BF-C model the 1ms and 10ms settings.

Note: (e) If the sensor is set to the 1064nm wavelength, then when measuring 10.6µm pulses, the reading will be approximately 1.19X the correct reading. If you use the attenuate function and set the attenuation to read 0.84, then you will have the correct reading at 10.6µm. The additional error at 10.6µm is +/-5%.

* For drawings please see page 96

1.2.3 High Energy Pyroelectric Sensors

20µJ to 10J

Features

- Sensors with diffuser for high energies and high energy densities
- Metallic coating for high rep rates
- BF coating for highest damage threshold
- Wide spectral range. Measure YAG and harmonics and many more.
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE50-DIF-C

PE25BF-DIF-C

Model	**PE50-DIF-C**					**PE25BF-DIF-C**				
Use	**High rep rate. Complete calibration curve**					**Complete calibration curve. High damage threshold**				
Aperture mm	Ø35					Ø20				
Absorber Type	Metallic with diffuser					BF with diffuser				
Spectral Range µm [a]	0.19 - 2.2, 2.94					0.24 - 2.2				
Surface Reflectivity % approx.	25					25				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [d]	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ
Lowest Measurable Energy µJ [c]	20	20	100	120	200	100	150	200	200	300
Max Pulse Width ms	0.002	0.03	0.5	1	5	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	900Hz	450Hz	100Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	1	2	20	20	40	15	30	40	40	60
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±1% to 750Hz	±2% to 400Hz	±1% to 80Hz	±1%	±1%	±1%	±1%	±2%
Linearity with Energy for >7% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	1					4				
1µs	2					5				
300µs	20					20				
2ms	40					60				
Maximum Average Power W	25, 40 with optional heat sink					20, 30 with optional heat sink				
Maximum Average Power Density W/cm²	100					120				
Uniformity over surface	±2.5% over central 20mm					±2.5% over central 10mm				
Weight kg	0.25					0.25				
Version										
Part Number	**7Z02939**					**7Z02941**				
Notes: (a) Calibration curve is verified and adjusted at specified wavelengths. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 193nm, 248-266nm, 532nm, 1064nm and 2100nm. Max additional error at 193nm ±4%. Max additional error at other wavelengths not specified above: ±2%. 193nm reading may need 1min irradiation to stabilize.					Specified wavelengths: 248-266nm, 355nm, 532nm, 1064nm and 2100nm. Max additional error at other wavelengths not specified above: ±2%.				
Notes: (b)	For wavelengths >2.1µm, derate to 40% of above values. For beam size <=5mm. For 10mm beam, derate to 40% of above value.					For wavelengths below 600nm, derate to 60% of given values. For wavelengths below 240nm, derate to 1J/cm². For beam size <=4mm. For 8mm beam, derate to 50% of above values.				

Notes: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. For further information, see the FAQs on our Website.

Notes: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter, only 2 out of 5 pulse widths settings are available; for the PE50-DIF-C model the 2µs (displayed as "10µs") and 1ms settings, and for the PE25BF-DIF-C model the 1ms and 10ms settings.

* For drawings please see page 96

1.2.3 High Energy Pyroelectric Sensors

100µJ to 40J

Features

- Sensors with diffuser for high energies and high energy densities
- BF coating for highest damage threshold
- BB coating for spectral flatness
- Wide spectral range. Measure YAG and harmonics and many more.
- Rep rates up to 250Hz
- Measure lasers with pulse widths up to 20ms
- PE50BF-DIFH-C sensor - highest damage threshold

PE50BF-DIF-C / PE50BF-DIFH-C

PE50BB-DIF-C

DIFFUSER IN

DIFFUSER OUT

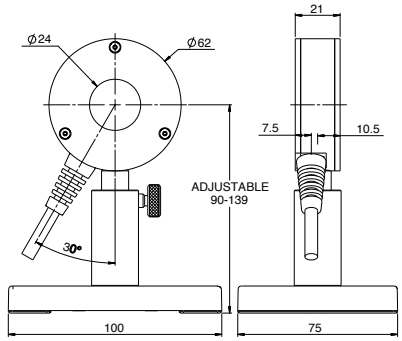
Model	**PE50BF-DIF-C / PE50BF-DIFH-C**					**PE50BB-DIF-C**					
Use	**Complete calibration curve. Highest damage threshold**					**Removable diffuser. Spectrally flat**					
Diffuser	Fixed					Diffuser out			Diffuser in		
Aperture mm	Ø35					Ø46			Ø33		
Absorber Type	BF with diffuser					BB			BB with diffuser		
Spectral Range µm [a]	0.19 – 2.2, 2.94					0.19 – 20			0.4 – 2.5		
Surface Reflectivity % approx.	25					5			15		
Calibration Accuracy +/-% [a]	3					3			3		
Max Pulse Width Setting [d]	1ms	2ms	5ms	10ms	20ms	3ms	10ms	20ms	3ms	10ms	20ms
Energy Scales	10J to 2mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	40J to 8mJ	40J to 8mJ	40J to 8mJ
Lowest Measurable Energy mJ [c]	0.2	0.4	0.8	0.8	0.8	0.1	0.1	0.2	0.5	5	5
Max Pulse Width ms	1	2	5	10	20	3	10	20	3	10	20
Maximum Pulse Rate pps	250Hz	100Hz	50Hz	40Hz	20Hz	40Hz	10Hz	5Hz	40Hz	10Hz	5Hz
Noise on Lowest Range µJ	40	80	200	200	200	15	15	20	40	60	80
Additional Error with Frequency %	±1%	±1%	±1%	±2%	±2%	±1%	±1%	±1%	±1%	±1%	±1%
Linearity with Energy for >7% of full scale [c]	±2%					±2%					
Damage Threshold J/cm² [b]	PE50BF-DIF-C		PE50BF-DIFH-C			Diffuser out			Diffuser in		
<100ns	4		6			0.3			3		
1µs	5		8			0.3			3		
300µs	20		30			1			10		
2ms	60		90			2			20		
Maximum Average Power W	25, 40 with optional heat sink					10, 15 with optional heat sink			30, 50 with optional heat sink		
Maximum Average Power Density W/cm²	200					10			500		
Uniformity over surface	±2.5% over central 20mm					±2% over 70% of diameter			±2.5% over central 20mm		
Weight kg	0.25					0.25					
Version											
Part Number	**7Z02940**		**7Z02943**			**7Z02947**					
Notes: (a) Calibration accuracy at various wavelengths as specified here. At other wavelengths, there may be an additional error up to the value given.	Specified wavelengths: 355nm, 532nm, 1064nm and 2100nm. Additional uncertainty at other wavelengths in the range 248nm – 2100nm and 2940nm is ±2%. <240nm not calibrated.					Calibrated at 1064nm Max additional error at other wavelengths is ±2%			Calibrated at 1064nm, 532nm and 2100nm only. Calibration accuracy at 2100nm, ±5%.		
Notes: (b)	For wavelengths >2.1µm, derate to 10% of above values. For wavelengths below 600nm, derate to 60% of given values (for DIFH 50% of given values). For wavelengths below 240nm, derate to 1J/cm². For beam size <=5mm. For 10mm beam, derate DIF to 80% and DIFH to 70% of above.										

Notes: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >7% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. For further information, see the FAQs on our Website.

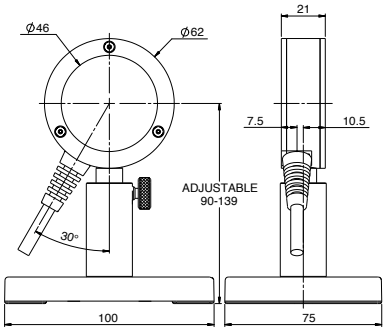
Notes: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the pulse width settings are available. For the PE-BF models the 1ms and 10ms settings and for the PE-BB model the 3ms and 10ms settings. Furthermore, with the diffuser mounted, the sensor may saturate at lower than the maximum energy in some cases. Therefore it is recommended to use these sensors with the newer meters/PC interfaces.

* For drawings please see page 96

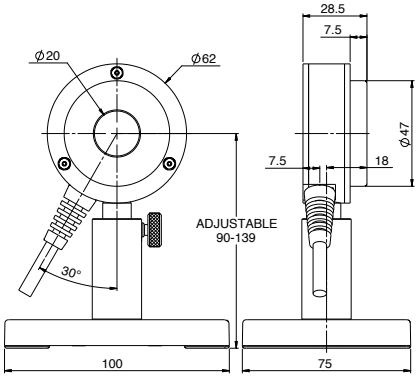
PE25-C / PE25BF-C



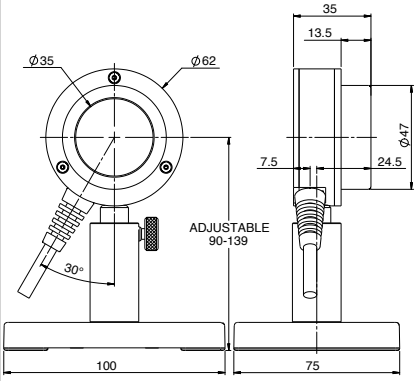
PE50-C / PE50BF-C



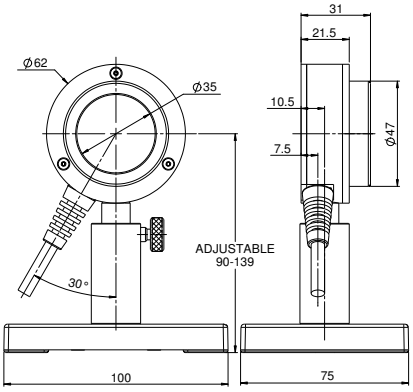
PE25BF-DIF-C



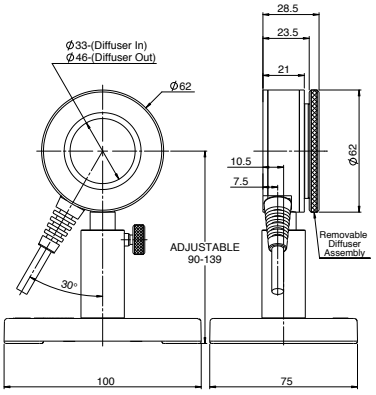
PE50BF-DIF-C / PE50-DIF-C



PE50BF-DIFH-C



PE50BB-DIF-C



1.2.3 High Energy Pyroelectric Sensors

10µJ to 40J

Features

- Removable diffusers
- PE50-DIF-ER-C mainly for NIR lasers
- PE100BF-DIF-C for very large beams
- Rep rates up to 10kHz
- Measure lasers with pulse widths up to 20ms

PE50-DIF-ER-C

DIFFUSER IN DIFFUSER OUT

PE100BF-DIF-C

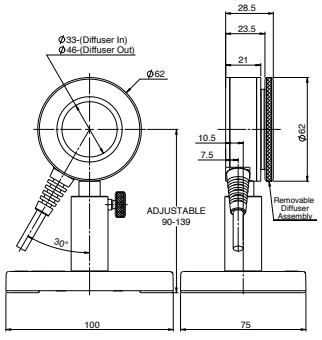
DIFFUSER IN DIFFUSER OUT

Model	**PE50-DIF-ER-C**										**PE100BF-DIF-C**									
Use	**Mainly for 1064nm, 2.1µm and 2.94µm**										**Very large aperture**									
Diffuser	Diffuser out					Diffuser in					Diffuser out					Diffuser in				
Aperture mm	Ø46					Ø33					Ø96					Ø85				
Absorber Type	Metallic					Metallic with diffuser					BF					BF with diffuser				
Spectral Range µm [a]	0.19 - 3					0.4 - 3					0.15 - 3					0.4 - 2.5				
Surface Reflectivity % approx.	50					50					20					50				
Calibration Accuracy +/-% [a]	3					4					3					4				
Max Pulse Width Setting [c]	2µs	30µs	500µs	1ms	5ms	2µs	30µs	500µs	1ms	5ms	1ms	2ms	5ms	10ms	20ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	10J to 200µJ	10J to 200µJ	10J to 2mJ	10J to 2mJ	10J to 2mJ	30J to 600µJ	30J to 600µJ	30J to 6mJ	30J to 6mJ	30J to 6mJ	10J to 2mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	10J to 20mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ
Lowest Measurable Energy mJ [b]	0.01	0.01	0.06	0.08	0.1	0.05	0.05	0.3	0.4	0.5	0.4	0.7	1.5	1.5	1.5	2	3	5	5	5
Max Pulse Width ms	0.002	0.03	0.5	1	5	0.002	0.03	0.5	1	5	1	2	5	10	20	1	2	5	10	20
Maximum Pulse Rate pps	10kHz	5kHz	800Hz	400Hz	100Hz	10kHz	5kHz	800Hz	400Hz	100Hz	200	100	50	35	25	200	100	50	35	25
Noise on Lowest Range µJ	1	1	6	10	20	5	5	30	50	100	80	150	250	200	200	300	500	1000	600	600
Additional Error with Frequency %	±2% to 2kHz ±4.5% to 5kHz	±2%	±2%	±2%	±1% to 80Hz	±2% to 2kHz ±4.5% to 5kHz	±2%	±2%	±2%	±1% to 80Hz	±1%									
Linearity with Energy for > 10% of full scale [b]	±1.5%										±1%									
Damage Threshold J/cm²																				
<100ns	0.1					1.5					0.8					3				
1µs	0.2					3					1					3				
300µs	2					20					5					10				
2ms	6					60					10					25				
Maximum Average Power W	15, 25 with optional heat sink					40, 60 with optional heat sink					25					50				
Maximum Average Power Density W/cm²	20					500					20					500				
Weight kg	0.3										1.2									
Version																				
Part Number	**7Z02948**										**7Z02942**									
Notes: (a)	Calibrated at 532nm and 1064nm only					Calibrated at 1064nm, 2100nm and 2940nm					Calibrated at 532nm and 1064nm only					Calibrated at 532nm, 1064nm and 1550nm only				

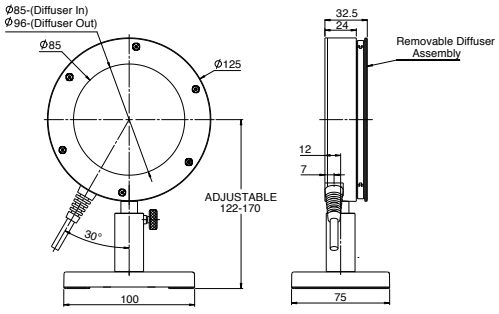
Notes: (b) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater. For use with StarBright, StarLite, Nova II, Vega, Juno and EA-1. The sensors will operate with older Ophir meters and PC interfaces but do not support the threshold function and may give inaccurate readings with the diffuser in and therefore it is not recommended to use these sensors with older Ophir meters and PC interfaces. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments. For further information, see the FAQs on our Website.

Notes: (c) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the 5 pulse width settings are available. For the PE50-DIF-ER-C, the 30µs and 1ms settings and for the PE100BF-DIF-C, the 1ms and 10ms settings. Furthermore, with the diffuser mounted, the sensor may saturate at lower than the maximum energy in some cases. Therefore it is recommended to use these sensors with the newer meters/PC interfaces.

PE50-DIF-ER-C



PE100BF-DIF-C



1.2.3 High Energy Pyroelectric Sensors

1mJ to 40J

Features

- Fan or conduction cooled for high average power capability
- BF coating with diffuser for highest damage threshold
- Wide spectral range. Measure YAG and harmonics and many more
- Rep rates up to 250Hz
- Measure lasers with pulse widths up to 20ms

FPE80BF-DIF-C

PE80BF-DIF-C

Model	**FPE80BF-DIF-C**					**PE80BF-DIF-C**				
Use	**High average power pulsed lasers**					**Large aperture pulsed lasers**				
Diffuser	Fixed					Fixed				
Aperture mm	Ø53					Ø67				
Absorber Type	BF with diffuser					BF with diffuser				
Spectral Range µm [a]	0.19 – 2.2, 2.94					0.19 – 2.2, 2.94				
Surface Reflectivity % approx.	25					25				
Calibration Accuracy +/-% [a]	3					3				
Max Pulse Width Setting [d]	1ms	2ms	5ms	10ms	20ms	1ms	2ms	5ms	10ms	20ms
Energy Scales	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ	40J to 40mJ
Lowest Measurable Energy mJ [c, f]	1	1	1	2	2	4	4	4	4	4
Max Pulse Width ms	1	2	5	10	20	1	2	5	10	20
Maximum Pulse Rate pps	250Hz	100Hz	50Hz	40Hz	20Hz	250Hz	100Hz	50Hz	40Hz	20Hz
Noise on Lowest Range µJ	200	300	300	300	300	100	200	200	200	200
Additional Error with Frequency %	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%	±1.5%
Linearity with Energy for >10% of full scale [c]	±1.5%					±2%				
Damage Threshold J/cm² [b]										
<100ns	4					4				
1µs	8					5				
300µs	30					20				
2ms	50					60				
Maximum Average Power W	200					40				
Maximum Average Power Density at Maximum Power W/cm²	120 [e]					200 [e]				
Uniformity over surface	±2% over central 40mm					±2% over central 60mm				
Cooling	fan (see page 100 for details)					conduction				
Weight kg	1.2					0.5				
Version										
Part Number	**7Z02950**					**7Z02954**				

Notes: (a) Calibration accuracy at various wavelengths as specified here. At other wavelengths, there may be an additional error up to the value given.
Specified wavelengths:
248-266nm, 355nm, 532nm, 1064nm, 2100nm and 2940nm.
Max additional error at other wavelengths not specified above: ±5%. <240nm not calibrated.

Notes: (b)
For wavelengths >2.1µm, derate to 10% of above values. For wavelengths below 600nm, derate to 60% of given values. For wavelengths below 240nm, derate to 1J/cm². For beam size <=16mm. For 32mm beam, derate to 50% of above values.

Notes: (c) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater. The user threshold is not available with Laserstar, Nova/Orion, Pulsar, USBI and Quasar. For these meters, the threshold is set to minimum and the linearity spec is >10% of full scale. The PE-C series will only operate with Nova or Orion meters with an additional adapter Ophir P/N 7Z08272 (see page 100). The adapter can introduce up to 1% additional measurement error. The user threshold feature allows adjustment of the internal threshold up to 25% of full scale if desired to avoid false triggering in noisy environments.
For further information, see the FAQs on our Website.

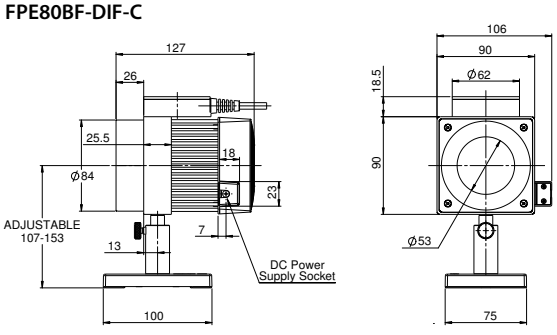
Notes: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the pulse width settings are available, the 1ms and 10ms settings.

Notes: (e) For maximum power. For lower powers the damage threshold is correspondingly higher.

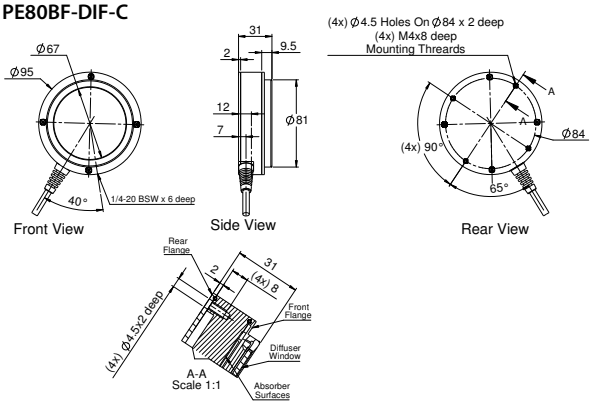
Notes: (f) For powers below 50W it is recommended to work with the fan off. If working with the fan on, the threshold must be set to 6% and the lowest measurable energies will be as follows:

Max Pulse Width Setting	1ms	2ms	5ms	10ms	20ms
Lowest Measurable Energy mJ	4mJ	4mJ	4mJ	4mJ	4mJ

FPE80BF-DIF-C



PE80BF-DIF-C



1.2.4 Energy Sensors Accessories

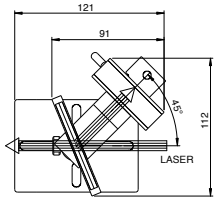
1.2.4.1 Accessories for Pyroelectric Sensors

Fiberoptic Adapter for Pyroelectric Sensors

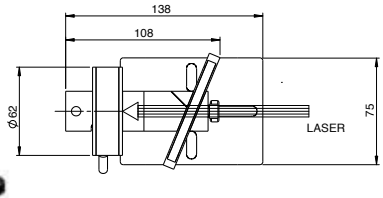
Oscilloscope Adapter for Pyroelectric Sensors

Heat Sink for PE-C Series Sensors

Beam Splitter Assembly



Beam splitter installed – reflected beam on sensor

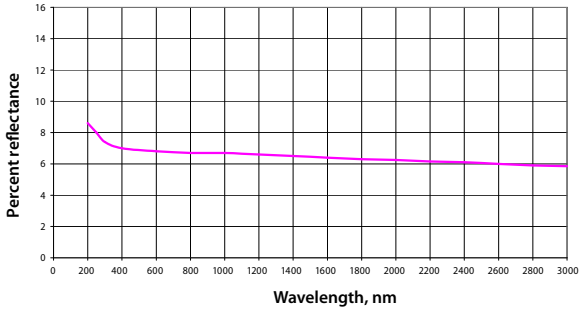


Beam Splitter removed – direct beam on sensor

Beam Splitter Specifications

Material	UV grade fused silica	
Spectral range	0.19 - 2.2µm	
Aperture	Ø60mm	
Damage threshold for pulses	< 10ns PW 5J/cm²	>300µs PW >200J/cm²
Fraction split off	See graph	

F.S. Beam Splitter, 2 sided reflection unpolarized light



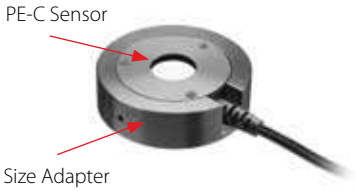
Accessory	Description	Part number			
Heat Sink	Heat sink that screws onto rear of PE25 and PE50 series sensors and allows working at over 50% higher average powers.	7Z08267			
Scope Adapter	Plugs in between the PE sensor and power meter. Provides BNC output to scope to see every pulse up to the maximum frequency of the sensor.	7Z11012			
Fiber Adapters	To mount fibers to sensors you need an adapter bracket and fiber adapter. All fiber adapters are compatible with the adapter bracket selected.				
Fiber Adapter Brackets	Mounting brackets to allow mounting fiber adapters to pyroelectric sensors.				
PE Sensor Family Type		Bracket P/N		Distance from fiber to detector	
PD10-C / PD10-IR-C / PD10-pJ-C / PD10-IR-pJ-C		7Z08275		10mm	
PE50-C / PE50BF-C		7Z08270		15mm	
PE9-C / PE9-ES-C / PE10-C / PE10BF-C / PE25-C / PE25BF-C		7Z08269		10mm	
Fiber Adapters	Fiber adapters for mounting to above brackets	SC type	ST type	FC type	SMA type
For all PE sensors above		7Z08227	7Z08226	7Z08229	1G01236
Beam Splitter Assembly	Beam Splitter Assembly to measure pulsed laser sources too energetic for direct measurement. The reading with the Beam Splitter can be calibrated by setting the laser to a lower energy that will not damage the sensor and then taking a measurement with the beam splitter and without and taking the ratio.	7Z17001			

1.2.4.1 Accessories for Pyroelectric Sensors - Continued

Damage Threshold Test Plates

Nova PE-C Adapter

PE-C to PE Size Adapter



Negative Polarity Power Supply/Charger

Accessory	Description	Part number		
Damage Threshold Test Plates	Test plates with same absorber coating as the sensor. For testing that laser beam is not above damage threshold	Metallic type	BF type	THz type
		7E06031A	7E06031D	7E06031F
Nova PE-C Adapter	The adapter plugs between the Nova D15 socket and the smart plug of the PE-C sensor to allow the Nova to operate with PE-C series sensors. See PE-C spec sheet for details.	7Z08272		
PE-C to PE Size Adapter	The newer PE-C series sensors have a Ø62mm diameter. The older PE series sensors have a Ø85mm diameter. This adapter allows using the PE-C type sensors in jigs and setups that were originally designed for PE sensors.	7Z08273		
N Polarity Power Supply/Charger AC/DC 12V 2A N-2.1x5.5	For FPE80BF-DIF-C sensor (1 unit supplied with the sensor)	7E05029		

1.2.4.2 Fast Photodetector Model FPS-1

Features

- Fast 1ns response time
- Measure temporal pulse shape of short or long pulses
- Wide spectral range 193 – 1100nm
- Optional attenuators and fiber adapters available
- Battery or wall cube operation

Description

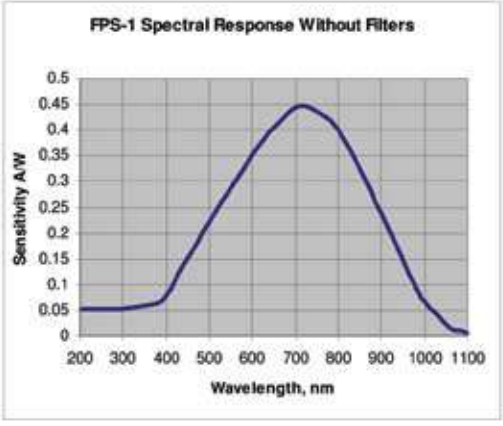
The FPS-1 fast photodetector is a compact easy to use very fast photodetector with wide spectral response. It is used to measure the temporal pulse shape of laser pulses.

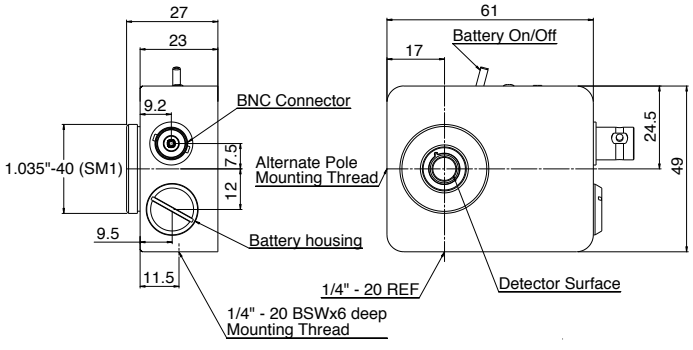
It has two modes of operation: Into 50Ohm load for ns high peak power pulses and 10kOhm load for longer lower peak power pulses.

In order to adjust the input intensity to the level appropriate for the detector, you may scatter the laser light off of a white matte surface and back off till the appropriate intensity is reached. Alternatively, or in addition, you may procure the ND attenuators listed below which may be stacked.

Specifications of the FPS-1 Fast Photodetector

Detector	Silicon PIN photodiode		
Spectral Range	193nm – 1100nm		
Detector Area	0.8mm^2		
Wavelength of Peak Sensitivity	720nm		
Spectral Response	See graph below		
Performance Specs	Into 50Ω load	Into 10kΩ load	
Sensitivity at Peak Wavelength	0.15V for 1W/cm^2 input	60V for 1W/cm^2 input	
Risetime 10-90%	1.5ns	3µs	
Maximum Output Voltage	10V		
Power Supply	12V A23 alkaline battery (40 hours lifetime). Also can be operated from 12VDC wall cube power supply. The power supply can be ordered from your local distributor.		
Input	Direct beam or from fiber connection.		
Dimensions	See drawing		
Thread	Front flange is threaded with male SM1 thread.		
Sensor Part Number	FPS-1 fast photodiode	7Z02505	
Optional Accessories and P/N	ND1 nom. x10 attenuator	7Z08200	
	ND2 nom. x50 attenuator	7Z08201	
	Fiber adapters	SMA	1G01236
		FC	7Z08229
		SC	7Z08227
		ST	7Z08226
	SM1 to M20 adapter (1 necessary for above adapters and/or attenuators)	1G02259	





1.3 Customized Solutions (OEM)

Ophir – The World Leading Source for Custom Designed Laser Measurement Solutions

1.3.1 Introduction

Many laser systems manufacturers need to have a measuring capability built into their systems.
Ophir is the world's leading supplier of Customized Solutions (OEM) laser power/energy measurement instrumentation which can be built into host systems (such as medical, industrial, etc). With extensive experience accumulated in the field, Ophir offers the largest variety of Customized Solutions (OEM) products **both off the shelf and custom designed** and is therefore best able to satisfy customer requirements.

Many configurations possible

A Customized Solutions (OEM) product is usually needed to monitor laser performance in the system, and possibly to provide fast feedback for system control. Depending on your application, various configurations can be used, such as:

- Just a sensor, with raw analog output
- Sensor with electronics providing an amplified analog or digital output
- Complete instrument, including numeric display and/or PC interface
- Custom designed solution for special requirements

In the following pages, you will see a range of "standard" Customized Solutions (OEM) sensors available; these are actually families of existing Customized Solutions (OEM) sensors with typical specifications shown. They can be tailored as needed to fit your specific requirements.

In addition to the products described below, Ophir has developed hundreds of other Customized Solutions (OEM) products. Simply contact your Ophir representative who is likely to have just the right solution to your needs.

1.3.2 Thermal and Photodiode Customized Solutions (OEM) Sensors

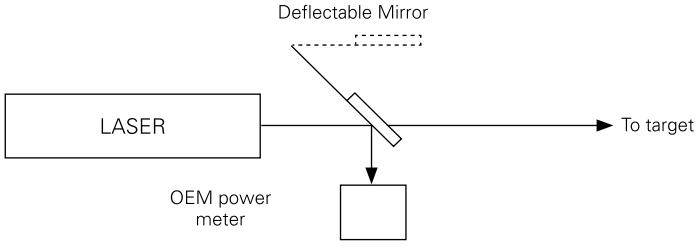
1.3.2.1 Sensor Usage

Ophir pioneered compact self-contained laser power meter sensors with built-in amplifiers. These sensors are easy to install and give a calibrated voltage proportional to power. They contain all the electronics needed including a speed up circuit to increase the speed of response of the sensor to the order of 1s, 0-95%. Connections to the sensors are simple, with the host providing DC power and the sensor providing a voltage or digital output proportional to power.

In most cases, the sensor is used in one of three ways:

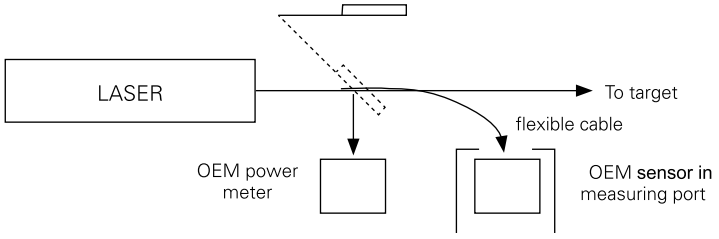
1. Beam Dump Mode

For lasers, such as surgical lasers, which are used in short bursts, the sensor is a beam dump with full power on it at all times except for the short periods of beam use when the beam is deflected to the work area.



2. Sampling Mode

In this mode, the laser is usually available to the user and is only deflected to the monitor for short times when the beam is sampled by the sensor. Sampling is performed with a deflection mirror or with an output fiber optic cable which is inserted into the measuring port from time to time.



3. Rear Leak Mode

In this mode, a small fraction (0.5-2%) of the laser beam "leaks" out of the rear mirror of the laser and is constantly monitored by the sensor.

1.3.2.2 Advantages of Ophir Thermal and Photodiode Customized Solutions (OEM) Sensors

Compactness

Available in sizes down to 38x38x25mm or 48x48x15mm or even smaller with special designs.

Versatility

Ophir offers Customized Solutions (OEM) sensors for almost any type of laser, for any power or configuration. Although the power measured with thermal sensors usually ranges from 1-150 watts, the sensors can measure from nW or µJ to Kilowatts or hundreds of Joules, and can be cooled with water, air or conduction. Ophir offers a large selection of standard Customized Solutions (OEM) sensors at competitive prices and with excellent delivery times. If required, the package, including the connectors, can be customized to customer specifications.

Reliability and accuracy

Ophir's thermal measuring sensors use the reliable and accurate thermopile disc principle: the output is a low impedance voltage proportional to power. The thermopile disc samples the entire beam, making it more accurate than silicon detectors that sample only part of the beam. Suitable absorbers which will not burn out or change reading with high power density lasers are available for any application. The Ophir photodiode Customized Solutions (OEM) sensors have very wide dynamic range and with software switchable ranges, one can easily cover 5 decades of intensity.

Calibration

Ophir sensors can be factory calibrated at all required wavelengths.

In addition to the sensors described below, Ophir offers a number of other Customized Solutions (OEM) sensors with larger aperture, diffusers in front, special absorbers, single sided amplifiers (± voltage and ground is not required, only + voltage and ground) and other special features. Ophir also offers a Customized Solutions (OEM) version of the Nova power meter consisting of just circuit boards with no casing.

Possible configurations of thermal or photodiode Customized Solutions (OEM) products include:

- **Sensor with either raw or amplified analog output** – purchasing a sensor mounted into a housing with amplifier reduces noise and allows you to get a factory calibrated unit with optimized response time acceleration
- **Sensor with RS232 interface** – for direct RS232 interface of the Customized Solutions (OEM) sensor with the host computer
- **Sensor with USB interface** – for direct USB interface of the Customized Solutions (OEM) sensor with the host computer
- **Complete solution including sensor and meter** – this provides a visual display for the operator (numeric, Go/No Go, etc). This can also be in addition to the RS232 or USB output
- **Disc with raw analog output** – the lowest cost solution when there is no need for an amplified signal, and a relative measurement is enough. Typical output voltage is on the order of mV/W
- **Disc with separate amplifier board** – when space is critical, and amplified analog output is needed

1.3.2.3 Standard Customized Solutions (OEM) Thermal and Photodiode Sensors

100pW to 3W

Features

- Conduction cooled
- Thermal sensors are Spectrally flat
- Analog or RS232 compatible output
- Wide dynamic range, switchable ranges
- Selectable wavelengths

3A-UA **PD300-UAS**

These specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**3A-UA**	**PD300-UAS**
Type	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**
Features	**Measures very low power, built in amplifier**	**Small size, built in amplifier, wide dynamic range, detector can be flush with top**
Absorber Type	Broadband	Photodiode
Spectral Range µm	0.19 – 20 [c]	0.2 – 1.1 [c]
Aperture mm	Ø9.5	10x10
Maximum Power [a]	3W	Up to 50mW
Power Mode		
Minimum Power	100µW	As low as 100pW
Power Noise Level	<8µW RMS [d]	As low as 1pW
Thermal Drift (over 30 minutes)	<±10µW [d]	
Maximum Average Power Density W/cm²	1000	~ 50
Response Time (0-95%), typ. (sec)	1.8	0.2
Power Accuracy +/-% at Calibrated Wavelength	3	3
Linearity with Power +/-%	1.5	1
Amplifier Power Supply (for UA, UAS versions)	+6V to +24V	+6V to +24V
Energy Mode		
Maximum Energy	2J	NA
Minimum Energy	20µJ	NA
Energy Accuracy +/-% at Calibrated Wavelength	5	NA
Maximum Energy Density J/cm²		
<100ns	0.3	NA
0.5ms	1	NA
2ms	2	NA
10ms	4	NA
Cooling	conduction	conduction
Output	6 pin Molex [b]	6 pin Molex [b]
Dimensions	50x50x38mm	38x38x32mm
Part number	**Consult Ophir representative**	**Consult Ophir representative**

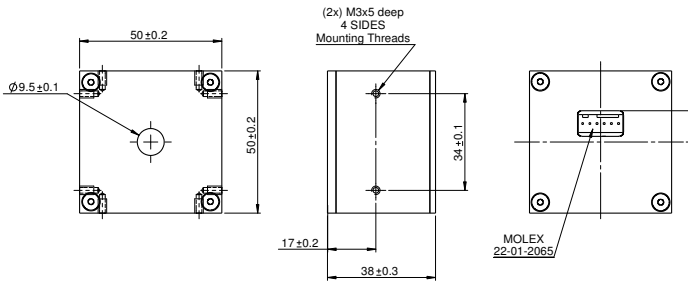
Note: (a) With analog "UA/UAS" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.

Note: (b) 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output

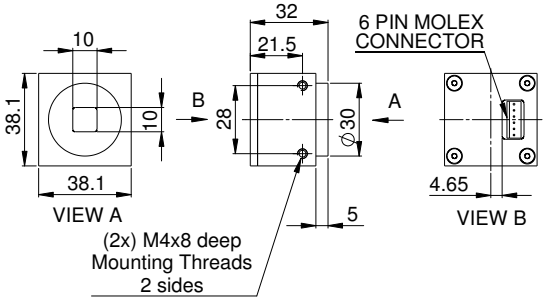
Note: (c) Calibrated at customer selected wavelength or wavelengths

Note: (d) In a quiet thermal environment with FOV limiting

3A-UA



PD300-UAS



1.3.2.3 Standard Customized Solutions (OEM) Thermal Sensors

10mW to 20W

Features

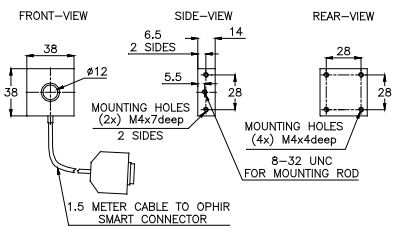
- Conduction cooled
- Thermal sensors are spectrally flat
- Analog, RS232 or USB compatible output

20C-SH **20C-UAS** **20C-UAU**

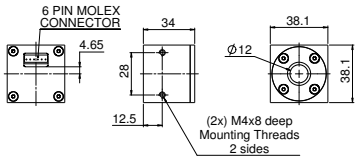
These specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**20C-SH**	**20C-UAS**	**20C-UAU**
Type	**Smart sensor**	**Digital RS232 connection Analog or digital output**	**Digital USB connection digital output.**
Features	**Compact smart sensor**	**Small size, built in amplifier**	**Small size, amplifier not built in**
Absorber Type	Broadband	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.19 - 20 (c)	0.19 - 20 (c)
Aperture mm	Ø12	Ø12	Ø12
Power Mode			
Maximum power (a) free standing	4W continuous, 20W for 1.8 min	4W continuous, 20W for 1.8 min	4W continuous, 20W for 1.8 min
heat sinked	20W	20W	20W
Minimum power	10mW	10mW	10mW
Power Noise Level	0.2mW	0.2mW	0.2mW
Maximum Average Power Density kW/cm²	23 at 20W 35 at 4W	23 at 20W 35 at 4W	23 at 20W 35 at 4W
Response Time (0-95%), typ. (sec)	0.8	0.8	0.8
Power Accuracy +/-% at calibrated wavelength	3	3	3
Linearity with Power +/-%	1	1	1
Amplifier power supply (for UA, UAS, UAU versions)	NA	+6V to +24V	Via host USB
Energy Mode			
Maximum Energy	10J	10J	10J
Minimum Energy	6mJ	6mJ	6mJ
Energy Accuracy +/-% at calibrated wavelength	5	5	5
Maximum Energy Density J/cm²			
<100ns	0.3	0.3	0.3
0.5ms	2	2	2
2ms	2	2	2
10ms	2	2	2
Cooling	conduction	conduction	conduction
Output	Ophir smart plug	6 pin Molex (b)	Mini B USB connector
Dimensions	38x38x14mm	38x38x34mm	38x38x14mm
Part number	**7Z02602**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "UA/UAS" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.		
Note: (b)	6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output		
Note: (c)	Calibrated at customer selected wavelength		

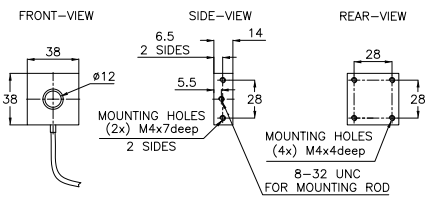
20C-SH



20C-UAS



20C-UAU



1.3.2.3 Standard Customized Solutions (OEM) Thermal Sensors

80mW to 100W

Features

- Conduction cooled
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

L30C-SH / L30C-UAU

L30C-LP2-26-SH

L30C-UA

These specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**L30C-SH**	**L30C-LP2-26-SH**	**L30C-UA**	**L30C-UAU**
Type	**Smart sensor**	**Smart sensor for high powers and energies**	**Digital RS232 connection analog or digital output**	**Digital USB connection digital output**
Features	**Medium aperture smart sensor**	**High pulse energy and intermittent power**	**Medium aperture, built in amplifier**	**Medium aperture, built in amplifier**
Absorber Type	Broadband	LP2	Broadband	Broadband
Spectral Range µm	0.19 - 20	0.25 – 2.2	0.19 - 20 (c)	0.19 - 20 (c)
Absorption	~88%	>94% from 0.25 to 1.1µm	~88%	~88%
Aperture mm	Ø26	Ø26	Ø26	Ø26
Power Mode				
Maximum power (a) free standing	10W continuous, 50W for 4 min	10W continuous, 100W for 2 min	10W continuous, 50W for 4 min	10W continuous, 50W for 4 min
heat sinked	50W	100W	50W	50W
Minimum power	80mW	300mW	80mW	80mW
Power Noise Level	4mW	15mW	4mW	4mW
Maximum Average Power Density kW/cm²	17 at 50W 28 at 10W	42 at 100W	17 at 50W 28 at 10W	17 at 50W 28 at 10W
Response Time (0-95%), typ. (sec)	1.5	1.5	1.5	1.5
Power Accuracy +/-% at calibrated wavelength	3	3 (d)	3	3
Linearity with Power +/-%	1	1.5	1	1
Amplifier power supply (for UA, UAU versions)	NA	NA	+6V to +24V	Via host USB
Energy Mode				
Maximum Energy	30J	2000J	100J	100J
Minimum Energy	30mJ	30mJ	30mJ	30mJ
Energy Accuracy +/-% at calibrated wavelength	5	5 (e)	5	5
Maximum Energy Density J/cm²				
<100ns	0.3	0.1	0.3	0.3
0.5ms	5	50	5	5
2ms	10	130	10	10
10ms	30	400	30	30
>300ms	NA	See below (f, g)	NA	NA
Cooling	Conduction	Conduction	Conduction	Conduction
Output	Ophir smart plug	Ophir smart plug	6 pin Molex (b)	Mini B USB connector
Dimensions	60x60x38mm	60x60x38mm	60x60x38mm	60x60x38mm
Part number	**773434**	**7Z02775**	**Consult Ophir representative**	**Consult Ophir representative**

Note: (a) With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage

Note: (b) 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output

Note: (c) Calibrated at customer selected wavelength

Note: (d) Above 1.1µm there is an additional calibration uncertainty of up to 2%

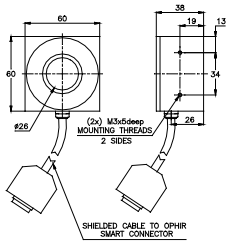
Note: (e) From 20J to 2000J

Note: (f) This mode is used to measure power of high power lasers by measuring the energy of a short exposure. The StarBright meter has a Pulsed Power mode where the user may specify the pulse width and get a reading directly in units of power for a short exposure energy measurement. See page 71

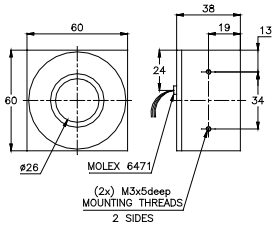
Note: (g) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses.
Total energy for a series of measurements should not exceed 2kJ. Recommended time between shots 12s.

Laser Power W	Recommended Exposure s	Number of shots before cooling down	Min 1/e² beam dia. mm
100	4	20	9
500	1	20	9
1000	1	10	13
2000	1	5	17
4000	0.5	5	22

L30C-SH / L30C-LP2-26-SH



L30C-UA



1.3.2.3 Standard Customized Solutions (OEM) Thermal Sensors

60mW to 100W

Features

- Conduction cooled
- Spectrally flat
- "UAF" axial thermopile has very fast response time – 50ms
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

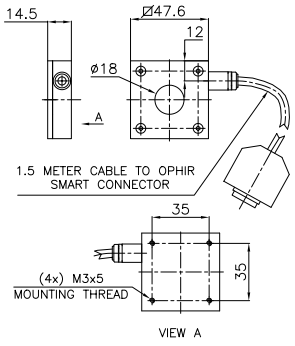
100C-SH / 100C-UA / 100C-UAU

100W-AXL-UAF

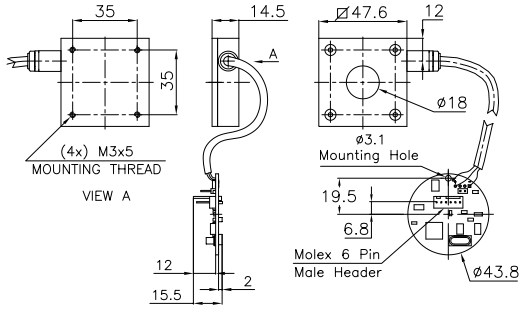
The following specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**100C-SH**	**100C-UA / 100C-UAU**	**100W-AXL-UAF**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**
Features	**Low profile, smart sensor**	**Low profile, separate amplifier**	**Very fast response ~50ms**
Absorber Type	Broadband	Broadband	PF
Spectral Range µm	0.19 - 20	0.19 - 20 (c)	0.19 - 20 (c)
Aperture mm	Ø18	Ø18	Ø26
Power Mode			
Maximum power (a) free standing	4W	4W	100W water cooled only
heat sinked	100W	100W	
Minimum power	60mW	60mW	400mW
Power Noise Level	3mW	3mW	20mW
Maximum Average Power Density kW/cm²	30 at 4W 14 at 100W	30 at 4W 14 at 100W	0.4
Response Time (0-95%), typ.	1.2s	1.2s	50ms 0-90%
Power Accuracy +/-% at calibration wavelength	3	3	3 for beam diameter >8mm
Linearity with Power +/-%	1	1	2
Amplifier power supply (for UA, UAU, UAF versions)	NA	+6V to +24V / Via host USB	+12V to +24V
Energy Mode (where applicable)			
Maximum Energy	NA	NA	NA
Minimum Energy	NA	NA	NA
Maximum Energy Density J/cm²			
<100ns	0.3	0.3	1.5
0.5ms	5	5	7
2ms	10	10	15
10ms	30	30	40
Cooling	conduction	conduction	water
Output	Ophir smart plug	6 pin Molex (b) / Mini B USB connector	6 pin Molex (b)
Dimensions	48x48x14.5mm	48x48x14.5mm	60x60x45mm
Part number	**7Z02680**	**Consult Ophir representative**	**Consult Ophir representative**
Note: (a)	With analog "UA" and "UAF" versions, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.		
Note: (b)	6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output		
Note: (c)	Calibrated at customer selected wavelength		

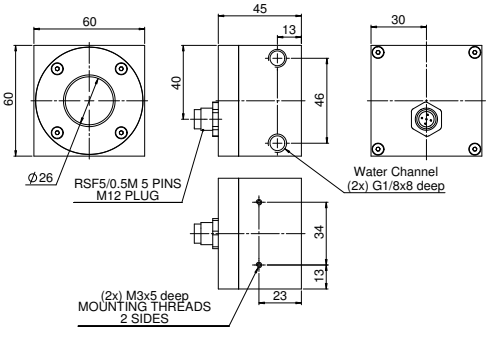
100C-SH



100C-UA



100W-AXL-UAF



1.3.2.3 Standard Customized Solutions (OEM) Thermal Sensors

60mW to 150W

Features

- Conduction or water cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

150C-SH

150C-UA / 150C-UAU

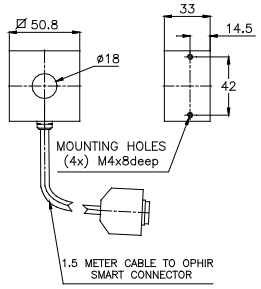
150W-UA / 150W-UAU

The following specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

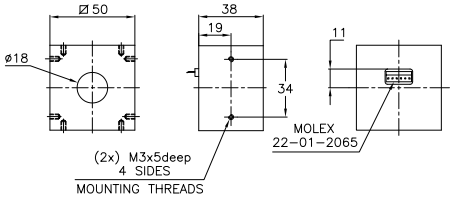
Model	**150C-SH**	**150C-UA**	**150W-UA**	**150C / W-UAU**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Same as UA but with digital mini USB connection digital output only**
Features	**High power, smart sensor**	**High power, built-in amplifier**	**High power, built-in amplifier, water cooled**	
Absorber Type	Broadband	Broadband	Broadband	
Spectral Range µm	0.19 - 20	0.19 - 20 [c]	0.19 - 20 [c]	
Aperture mm	Ø18	Ø18	Ø18	
Power Mode				
Maximum power [a] free standing	5W continuous, 150W for 1 min	5W continuous, 150W for 1 min	150W water cooled	
heat sinked	60W conduction cooled	60W conduction cooled	NA	
Minimum power	60mW	60mW	100mW	
Power Noise Level	3mW	3mW	5mW	
Maximum Average Power Density kW/cm²	30 at 5W 20 at 60W	30 at 5W 20 at 60W	12 at 150W	
Response Time (0-95%), typ. (sec)	1.2	1.2	1.2	
Power Accuracy +/-% at calibration wavelength	3	3	3	
Linearity with Power +/-%	1	1	1	
Amplifier power supply (for UA, UAU versions)	NA	+6V to +24V	+6V to +24V	Via host USB
Energy Mode (where applicable)				
Maximum Energy	100J	100J	100J	
Minimum Energy	20mJ	20mJ	50mJ	
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.3	
0.5ms	2	5	5	
2ms	2	10	10	
10ms	2	30	30	
Cooling	Conduction	Conduction	Water	
Output	Ophir smart plug	6 pin Molex [b]	6 pin Molex [b]	Mini B USB connector
Dimensions	50.8x50.8x33mm	50x50x38mm	50x50x38mm	
Part number	**7N77023** [d]	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**

Note: (a) With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.
Note: (b) 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output
Note: (c) Calibrated at customer selected wavelength
Note: (d) P/N 7N77023 replaces P/N 77023

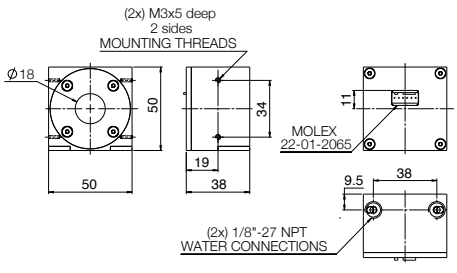
150C-SH



150C-UA



150W-UA



1.3.2.3 Standard Customized Solutions (OEM) Thermal Sensors

0.2W to 600W

Features

- Conduction and water cooled
- Spectrally flat
- "UA" version can give analog voltage output or digital RS232 output and can measure power or energy. Can also have multiple switchable ranges and/or multiple switchable wavelengths
- "UAU" version is similar to the UA version but operates via the USB terminal of the PC

L150C-UA / L150C-UAU

L250W-UA / L250W-UAU
L300W-UA / L300W-UAU

600W-UA / 600W-UAU

The following specifications refer to standard OEM sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

Model	**L150C-UA**	**L250W-UA / L300W-UA**	**600W-UA**	**UAU versions**
Type	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Same as UA but with digital mini USB connection digital output only**
Features	**Large aperture, built-in amplifier**	**Large aperture, built-in amplifier, water cooled**	**High power, built-in amplifier, water cooled**	
Absorber Type	Broadband	Broadband	LP2	
Spectral Range µm	0.19 - 20 (c)	0.19 - 20 (c)	0.35 - 2.2	
Absorption	~88%	~88%	>94% from 0.35 to 1.1µm	
Aperture mm	Ø50	Ø50	Ø26	
Power Mode				
Maximum power (a) free standing	20W for 3 minutes	250W / 300W water cooled	600W water cooled	
heat sinked	150W			
Minimum power	0.2W	0.3W / 0.5W	5W	
Power Noise Level	10mW	15mW / 25mW	200mW	
Maximum Average Power Density kW/cm²	27 at 20W 12 at 150W	10 / 9 at max power	11 at max power	
Response Time (0-95%), typ. (sec)	2.5	2.5	2.5	
Power Accuracy +/-% at calibration wavelength	3	3	3	
Linearity with Power +/-%	1	2	2	
Amplifier power supply (for UA, UAU versions)	±6V to ±24V	±6V to ±24V	±6V to ±24V	Via host USB
Energy Mode (where applicable)				
Maximum Energy	100J	200J / 300J	300J	
Minimum Energy	80mJ	120mJ / 200mJ	500mJ	
Maximum Energy Density J/cm²				
<100ns	0.3	0.3	0.1	
0.5ms	5	5	50	
2ms	10	10	130	
10ms	30	30	400	
Cooling	conduction	water	water	
Minimum and Recommended water flow at full power (d)	NA	2 liter/min 4 liter/min	3 liter/min 4.5 liter/min	
Output	6 pin Molex (b)	5 pin Round connector	6 pin Molex (b)	Mini B USB connector
Dimensions	80x80x45mm	80x80x58mm	65x65x49mm	
Part number	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**

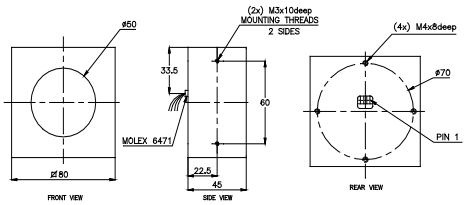
Note: (a) With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage

Note: (b) 6 pin Molex connections: RS232 input, Ground, +Voltage, Analog signal out, high/low voltage or switch input when used, RS232 output

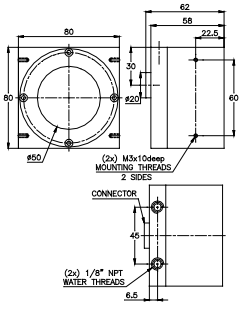
Note: (c) Calibrated at customer selected wavelength

Note: (d) Water temperature range 18-30°C. Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa. The recommended flow rate can be lowered proportionately at lower than full power but should not be below the minimum. When used at full power with substantially below the recommended flow rate, the damage threshold may be as much as 20% lower and the response time may not be optimum

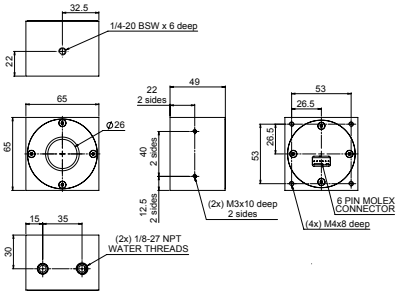
L150C-UA



L250W-UA / L300W-UA



600W-UA



1.3.2.4 EA-1 Compact Ethernet Adapter

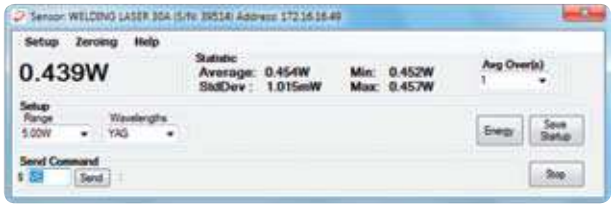
Connects your Ophir sensor to an Ethernet bus

The EA-1 is suitable for OEM customers who desire Ethernet connectivity and want to remotely monitor and control the sensor via their own custom software or the Ophir provided PC application.

Features

- From sensor direct to Ethernet with no PC connection
- Powers directly from the Ethernet bus or 12V power supply
- Supports thermal and photodiode smart sensors
- Software support via StarLab application or 'Ophir Ethernet App' PC application software package, both included
- Allows remote monitoring via Telnet, HTTP or UDP protocols

The EA-1 is designed to connect an Ophir smart sensor to your Ethernet. Standard thermopile, pyroelectric and photodiode sensors are supported. The unit is powered directly from the Ethernet bus if Power Over Ethernet (PoE) is available, or from a standard Ophir 12V power supply if not. The sensor can be monitored remotely over the Ethernet bus, allowing remote connections from distances far in excess of those allowed via RS232 or USB. The device is suitable for industrial or other environments where the bus of choice is Ethernet. Telnet, UDP and HTTP protocols are supported.
Installation and choosing an IP address are simplified via the simple Ophir Ethernet App PC application supplied with the unit. The PC application allows setup and basic functionality such as monitoring power and changing measurement scales or wavelengths. Configuration of the IP address is via Ethernet or separate USB connection. The PC operating screen is shown below measuring power and energy.



PC application power screen

PC application energy screen

Additional features such as logging power or energy graphically are provided by the StarLab PC application which also supports the EA-1 device.

Model	**EA-1 Ethernet Adapter**
Use	**Monitoring Ophir Sensors via Ethernet**
Measurement Parameters	As defined by sensor
Supported Sensors	Thermal [a], Photodiode and Pyroelectric
Number of Sensors Supported	One sensor per unit
Data Logging	Thermophile and Photodiode sensors: logging of power at 15Hz into log file Pyroelectric and PD-C sensors: via Ophir Ethernet App – logging of energy at up to ~400Hz into log file via StarLab or direct Ethernet connection – logging of energy at up to ~40kHz
Instruction Set	Supports entire Ophir instruction set for controlling and monitoring sensor
Power Supply	Power Over Ethernet or separate 12V power supply
Dimensions	73mm W x 93mm L x 29mm H
Weight kg	0.1
Part number	**7Z08296**
Notes: (a)	BeamTrack functions are only supported via user commands but not with the PC application

DB15 connector

Mini-USB connector;
Ethernet RJ45 connector;
12V power connector

1.3.2.5 Examples of Customized Solutions (OEM) for Thermal and Photodiode Products

In addition to the standard Customized Solutions (OEM) products described above, Ophir has accumulated over 25 years experience in developing products which are tailored to precise physical configurations provided by the Customized Solutions (OEM) customer. These products include custom discs (with or without electronics), specially configured thermal or photodiode-based power sensors, and much more. A number of these special Customized Solutions (OEM) products are shown below.

Flat Profile Thermal Sensor

This sensor with 50mm aperture is used as an exposure detector for photolithography and is only 10mm thick.

Super Compact Thermal Sensor

Thermal Customized Solutions (OEM) sensor designed to be cemented into user system. Dimensions are under 10mm x 20mm footprint and 4mm height. The sensor can be connected to an Ophir smart meter to measure power or energy or can be used directly with voltage output.

Compact, hand held thermal Smart Sensor

This thermal sensor is only 20mm thick to enable probing in hard-to-reach locations, and can measure up to 25W. It is designed specifically to be hand-held, and works with any Ophir Smart Meter.

Ultra Fast Customized Solutions (OEM) Thermal Power Sensor

Using an innovative new axial thermopile method, this water cooled sensor is designed to be built into an industrial laser for fast feedback to control the laser power stability. It has a response time of 50ms and power capacity of 100W.

Special Compact Photodiode Sensor for Clean Room Conditions

This amplified photodiode sensor is only 30x45x35mm in size. It is cleaned, assembled, calibrated and packed in controlled clean room conditions for use in controlled atmospheres.

OEM BeamTrack or Quad sensor with RS232 output

The BeamTrack sensor showing power, X position and Y position as well as size or Quad showing power, X position and Y position is now available as an OEM version with RS232 of all parameters.

Ordering Information:

The products shown above are examples of Customized Solutions (OEM) products developed for specific customer applications. Please consult your Ophir representative who will be happy to help you with any requirements you may have.

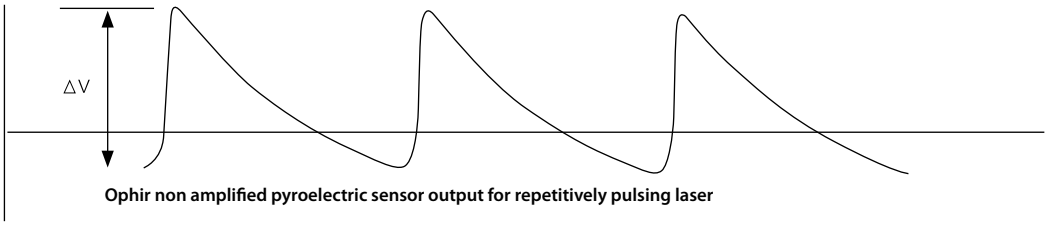
1.3.3 Pyroelectric Customized Solutions (OEM) Sensors

1.3.3.1 Pyroelectric Customized Solutions (OEM) Sensors - Introduction

Ophir manufactures three main types of pyroelectric Customized Solutions (OEM) sensors:

- Compact pyro sensors with no electronics with output connected to the host electronics. Since the energy of pyro sensors is proportional to the peak to valley voltage output and not the maximum voltage output, the user has to take this into account in designing the electronic interface (see below)
- Pyroelectric sensors identical with standard PE-C sensors but with RS232 or analog output instead of connection to smart sensor
- Compact smart PE-C sensors with the electronics in a separate electronics module

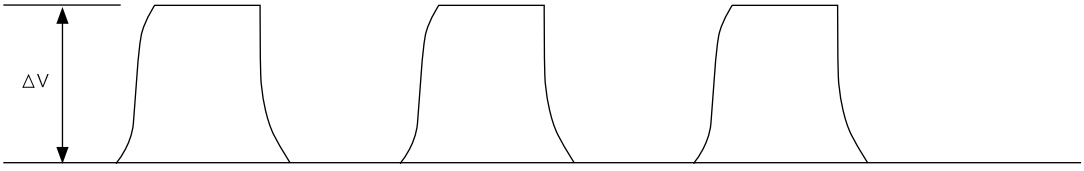
Typical output from a non amplified pyroelectric sensor appears as follows:



Ophir non amplified pyroelectric sensor output for repetitively pulsing laser

In the example shown above using a non amplified sensor, note that energy is proportional to ΔV and not to the voltage above the zero level. Note also that the peak rapidly decays and therefore the output depends on pulse rate and duration. It follows therefore that in order to measure pyroelectric pulses, the voltage level must be known before the pulse and must also compensate for pulse rate (or work at a low enough pulse rate for the correction to be rendered negligible).

When using a sensor with built-in electronics, typical output appears as follows:



Output from Ophir pyroelectric Customized Solutions (OEM) sensor with built-in signal conditioning

Note that the output voltage is now proportional to the energy and since the voltage is held for a fixed time, the output is much less dependent on pulse rate or duration.
In the above example, the user does not need to perform any signal conditioning but simply has to read the voltage level or get the ouput in digital form to determine the energy. The output is also available in digital form via RS232.

1.3.3.2 Standard Pyroelectric Customized Solutions (OEM) Sensors

<0.1µJ to 40J

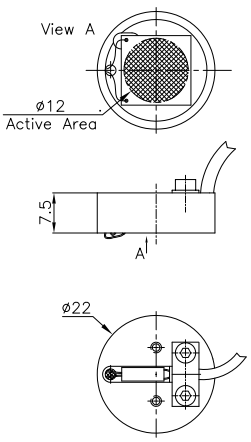
Features

- Performance identical to standard PE-C sensors (see section 1.2)
- Analog, RS232 or smart head output
- Wide dynamic range, switchable ranges
- Selectable wavelengths
- Compact non amplified versions available

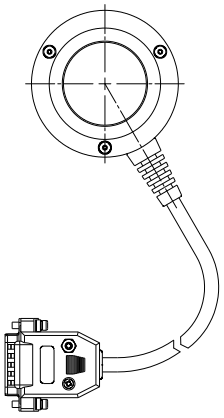
Pyroelectric Customized Solutions (OEM) products – Examples only – many variations are possible

Category	**Non amplified sensor. Can be very compact**	**Standard PE-C with built in digital or analog output. No need for meter or PC interface**	**PE-C smart sensor with remote electronics module allowing very compact sensor head**
Model	**PE10-C-RE**	**PE XX-C-RS232**	**PE-C-RE**
Features	**Very compact**	**Digital output with no need for meter or PC interface**	**Possibility of smart sensor with very compact sensing head**
Absorber Type	Metallic with AR coating	Choose from std PE-C	Metallic or BF
Aperture mm	Ø12	Choose from std PE-C	Usually 10mm
Spectral Range µm [a]	0.19 – 10.6µm	Same as std PE-C	0.19 – 10.6µm
Calibration Accuracy +/-% at calibrated wavelength	Usually customer calibrated	3	3
Max Pulse Width	Configurable [b]	Same as std PE-C	Same as similar std PE-C
Max Repetition Rate	Configurable [b]	Same as std PE-C	Same as similar std PE-C
Sensitivity	Typical 40V/J	Same as std PE-C	Same as similar std PE-C
Noise Equivalent Energy	~100nJ	Same as std PE-C	Same as similar std PE-C
Max energy density for 10ns pulses	100mJ/cm^2 typical	Same as std PE-C	Same as similar std PE-C
Max Average Power Density	50W/cm^2 typical	Same as std PE-C	Same as similar std PE-C
Power Supply Requirements	NA	7 – 12VDC (in special cases up to 24V)	Power supplied by smart meter or PC interface
Cooling	Conduction	Air or Conduction	Air or Conduction
Output	Flying leads typical	RS232 or analog	DB15 smart connector
Dimensions	Ø22 x 7.5mm	Same as std PE-C	Sensor head can be very small, see example below. Remote electronics module dimensions
Part Number	**Consult Ophir representative**	**Consult Ophir representative**	**Consult Ophir representative**
Notes: (a)	Unit can be calibrated for one or more wavelengths in this range		
Notes: (b)	By choosing circuit capacitance and resistance, maximum pulse rate and width can be optimized. This is usually limited by the condition (max pulse width)*(max pulse rate) < 0.1		

PE10-C-RE (example)



PE XX-C-RS232 (example)



DB 15 Connector Pinout:
Pin 2: RxD for PC
Pin 3: TxD for PC
Pin 5: Ground

Miniature PE9-C-RE (example)