Laser Power & Energy Measurement Laser Beam Analysis

2018

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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
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Thermal Sensors
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Computer Interfaces
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EA-1
Ethernet

Pulsar
1 ,2 ,4 channels

Power Meters
with USB/RS232

StarBright
added features

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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

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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

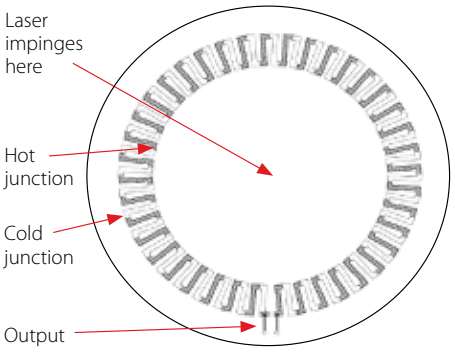
Ophir provides two types of power sensors: Photodiode sensors and Thermal sensors. Photodiode sensors are used for low powers from picowatts up to hundreds of milliwatts and as high as 3W. Thermal sensors are for use from fractions of a milliwatt up to thousands of watts. Thermal sensors can also measure 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.

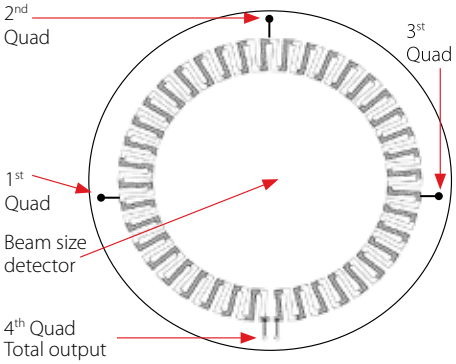
Thermal Sensors

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



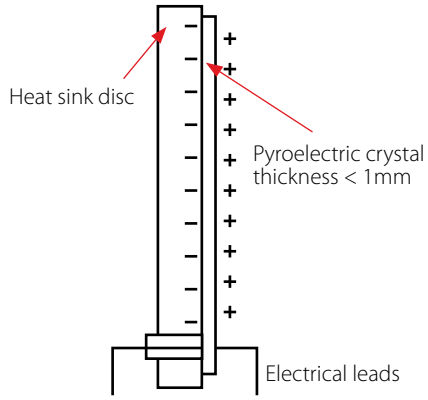
Using Power Sensors to Measure Single Shot Energy

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

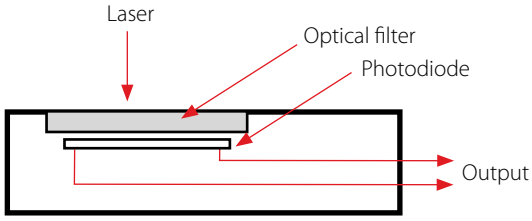
Pyroelectric Sensors

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.



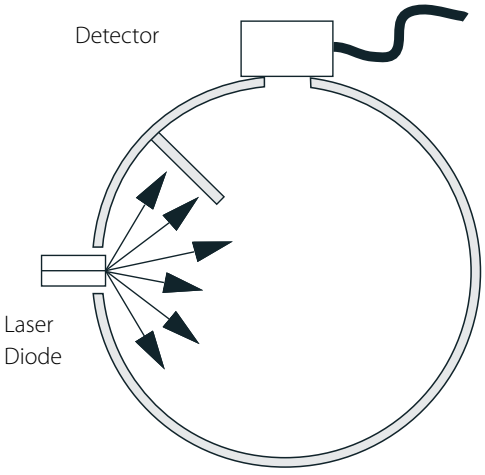
Photodiode Sensors for Lower Powers

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.

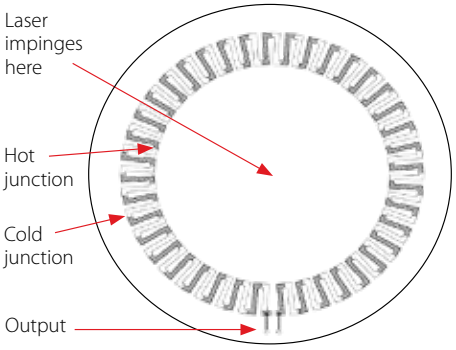


Power sensors

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

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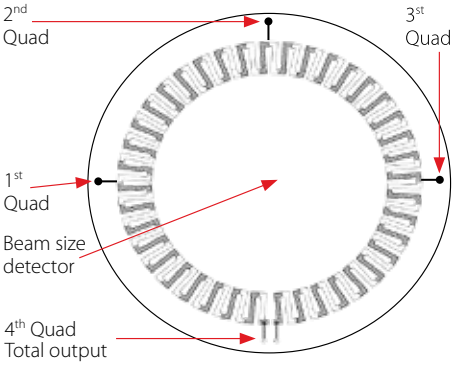
BeamTrack Power / Position / Size sensors

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

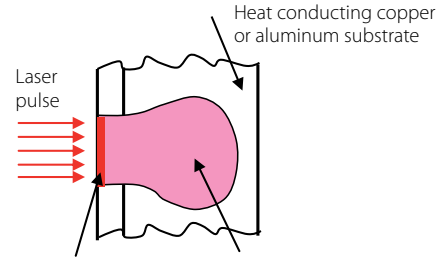
The traditional surface absorbers have a much lower damage threshold at > 1000W, where they can damage at 2-3 kW/cm^2. Ophir has developed coatings that improve the damage threshold for high power lasers. These coatings are denser and have higher heat conductivity than previous coatings. This LP2 coating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

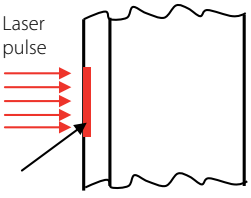
Long laser pulse (>100µs) or continuous

(A) Surface absorber



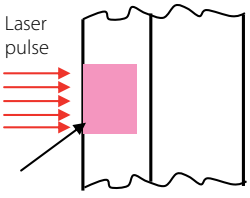
Short laser pulse <10µs

(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

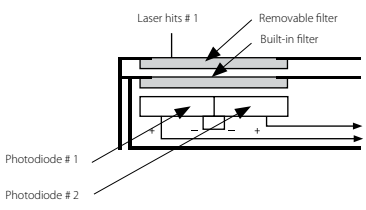
Photodiode Sensors

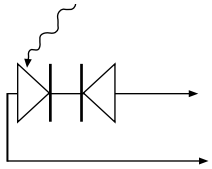
A photodiode sensor is a semiconductor device that produces a current proportional to light intensity and has a high degree of linearity over a large range of light power levels - from fractions of a nW to about 2mW. Above that light level, corresponding to a current of about 1mA, the electron density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

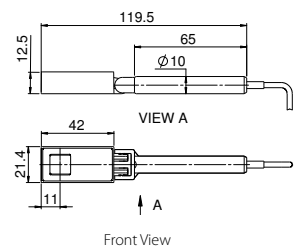
Model	PD300			PD300-1W			PD300-3W			PD300-TP		
Use	**General**			**Powers to 1W**			**Powers to 3W**			**Thin profile for tight fit**		
Detector Type	silicon			silicon			silicon			silicon		
Aperture	10x10mm			10x10mm			10x10mm			10x10mm		
Filter mode	Filter out		Filter in	Filter out		Filter in	Filter 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

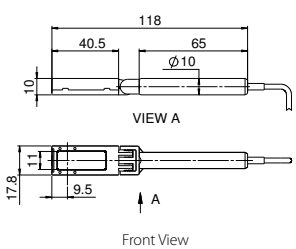
* For graphs see page 28-29

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

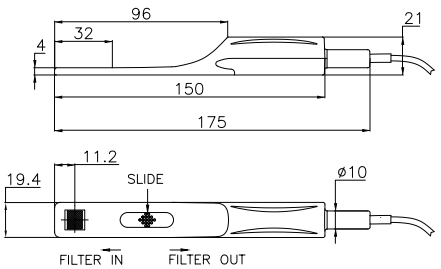
PD300 / PD300-1W filter installed



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

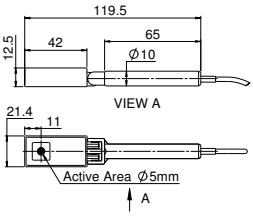
PD300-UV / PD300-IR with filter installed

PD300-IRG with fiber input

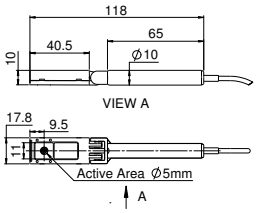
Model	**PD300-UV/ PD300-UV-193**				**PD300-IR**				**PD300-IRG**			
Use	**Lowest powers from 200-1100nm**				**Low powers from 700-1800nm**				**Telecom wavelength fiber and free space measurements**			
Detector Type	silicon				germanium				InGaAs			
Aperture	10x10mm				Ø5mm				Ø5mm for free space beams			
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

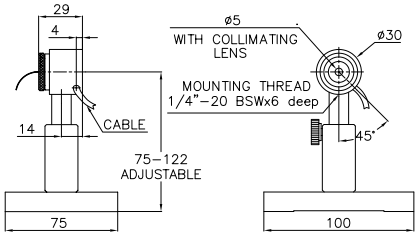
PD300-UV / PD300-IR filter installed
(Ø5mm for PD300-IR only)



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

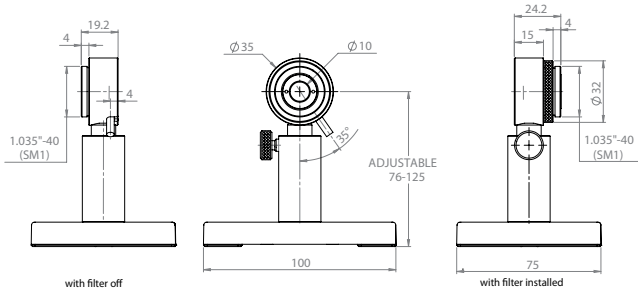
PD300R Filter Off

PD300R Filter installed

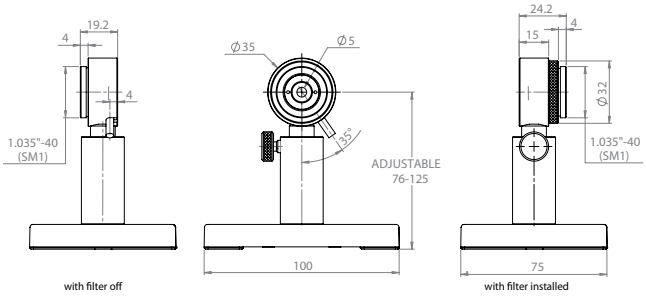
Model	PD300R		PD300R-3W		PD300R-UV		PD300R-IR	
Use	General		Powers to 3W		Lowest powers from 200-1100nm		IR wavelengths 700-1800nm	
Detector Type	silicon		silicon		silicon		germanium	
Aperture	Ø10mm		Ø10mm		Ø10mm		Ø5mm	
Filter mode	Filter out	Filter in	Filter out	Filter in	Filter out	Filter in	Filter 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:

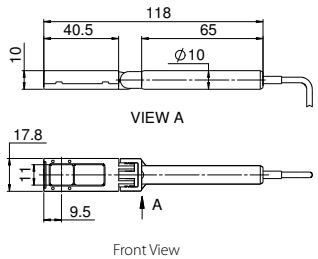
(a) Swivel stand for BC20 sensor P/N 1Z09004

(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

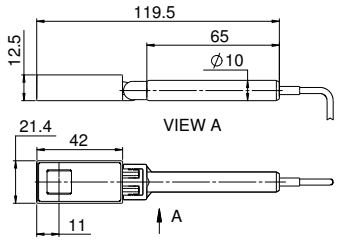
* For graphs see page 28-29

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



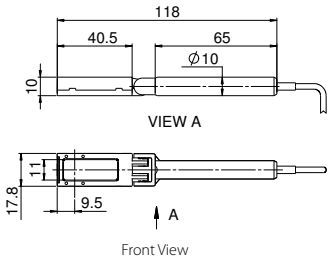
Front View

PD300-BB-50mW with filter installed



Front View

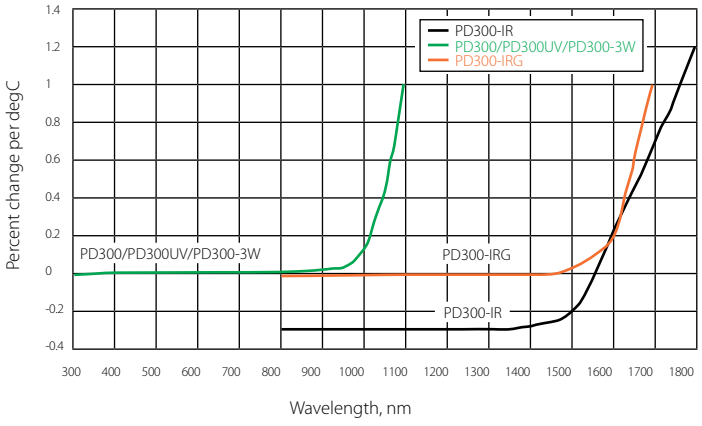
BC20



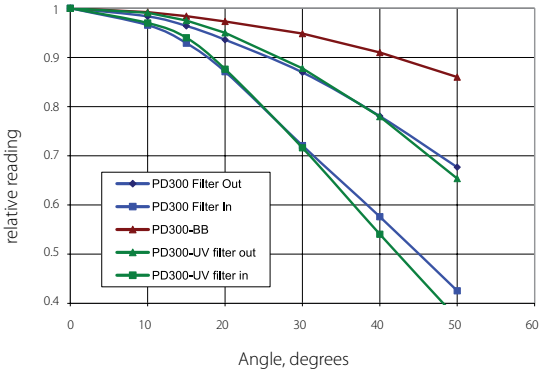
Front View

1.1.1.4 Graphs

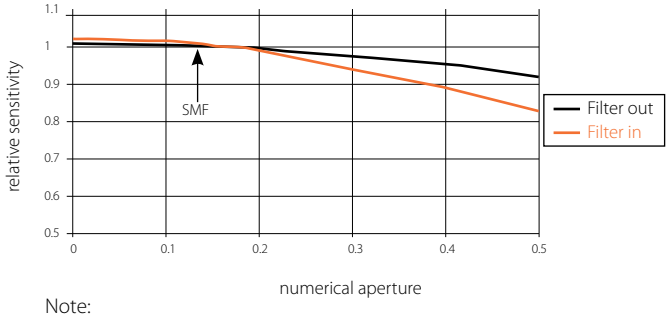
Temperature Coefficient of Sensitivity



PD300 Angle Dependence



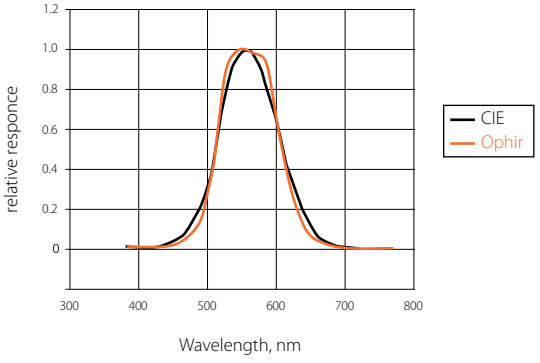
Dependence of Sensitivity on Numerical Aperture (PD300 - IRG)



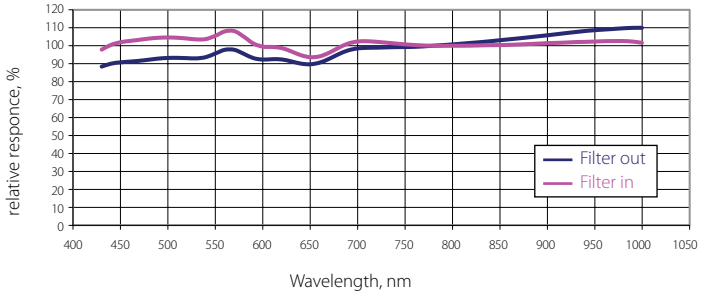
Note:

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

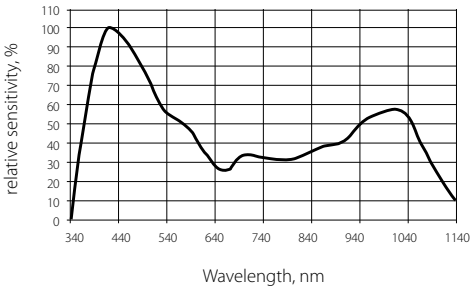
PD300-CIE Spectral Response vs. CIE Curve



Typical Sensitivity Curve of PD300-BB Sensors



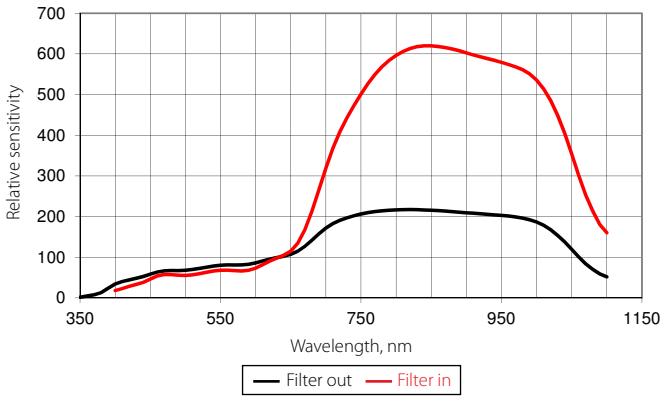
Relative Spectral Response of BC20



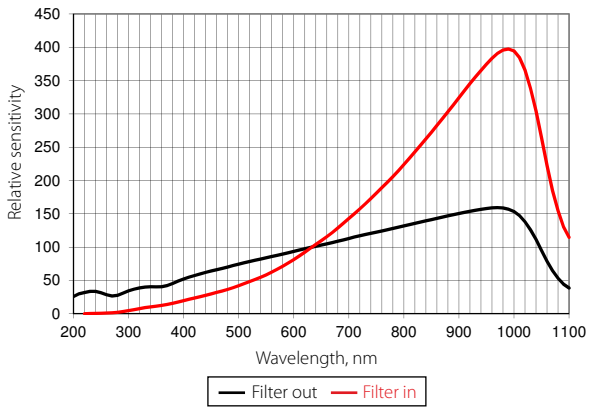
Approximate Spectral Response

Relative to 633nm or 1550nm

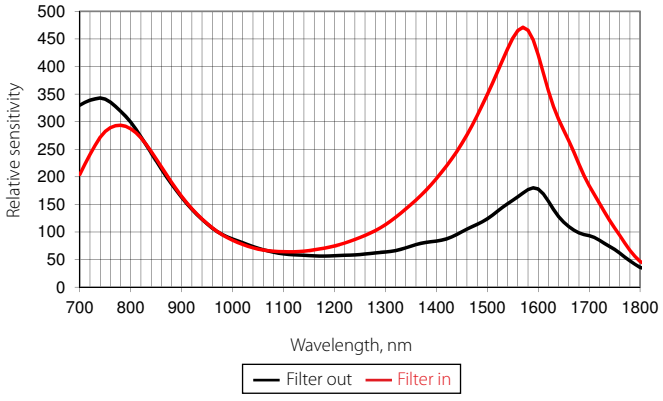
PD300 / PD300R



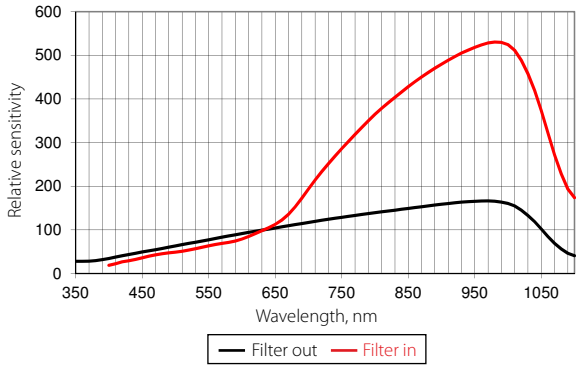
PD300-UV / PD300R-UV



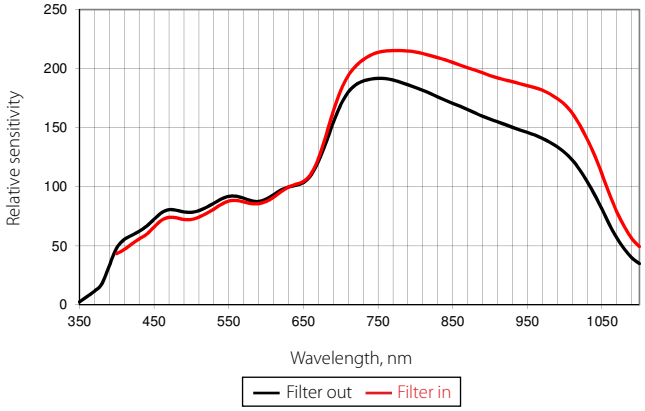
PD300-IR / PD300R-IR



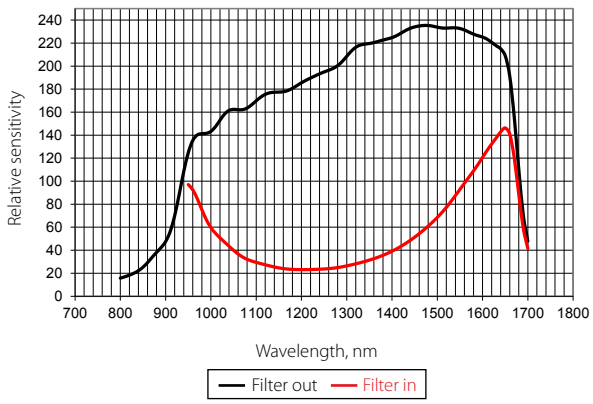
PD300-TP



PD300-3W / PD300R-3W



PD300-IRG



1.1.1.5 Integrating Spheres

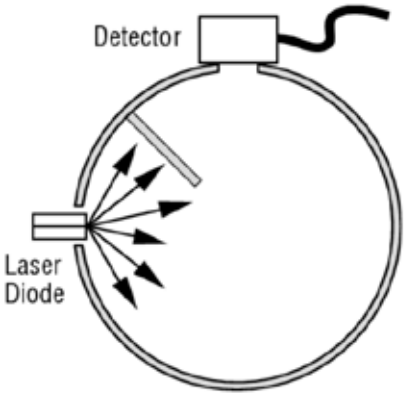
Introduction

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.

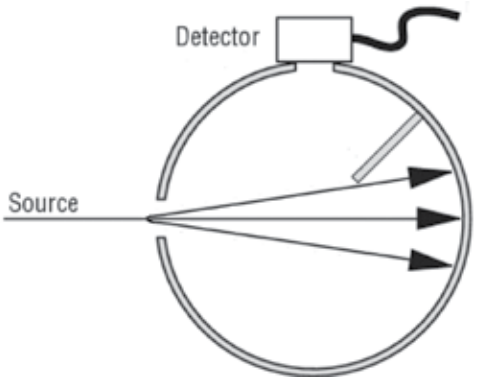
Ophir integrating spheres have a highly reflecting diffuse white coating for high efficiency and readings that are independent of beam size, position and divergence.

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

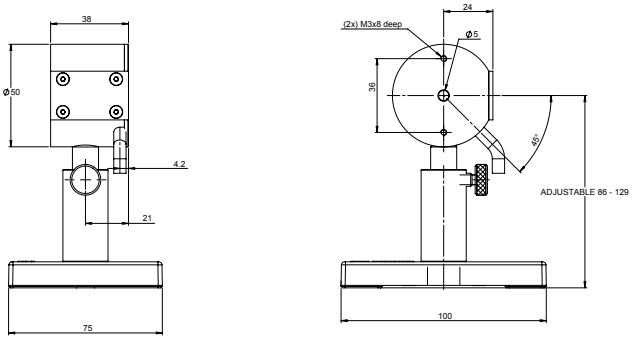
3A-IS

3A-IS-IRG

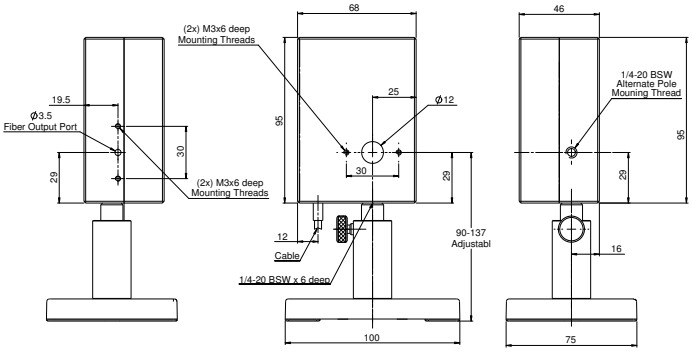
Model	IS-1	IS-1-2W	3A-IS	3A-IS-IRG
Use	**Divergent beams to 20mW for UV to NIR**	**Divergent beams to 2W for visible and NIR**	**Divergent beams to 3W for visible and NIR**	**Divergent beams to 3W for IR**
Detector Type	Si	Si	Si	InGaAs
Input Port Aperture mm	∅5mm	∅5mm	∅12mm	∅12mm
Spectral Range µm	0.20 - 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

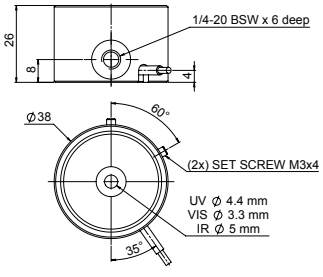
In the detector versions, the IS6 with detector comes with a calibrated wavelength curve.

	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							

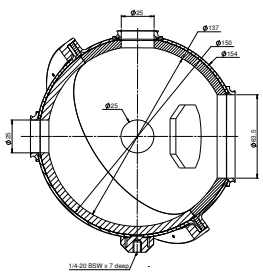
IS6-D with detector for divergent beams

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

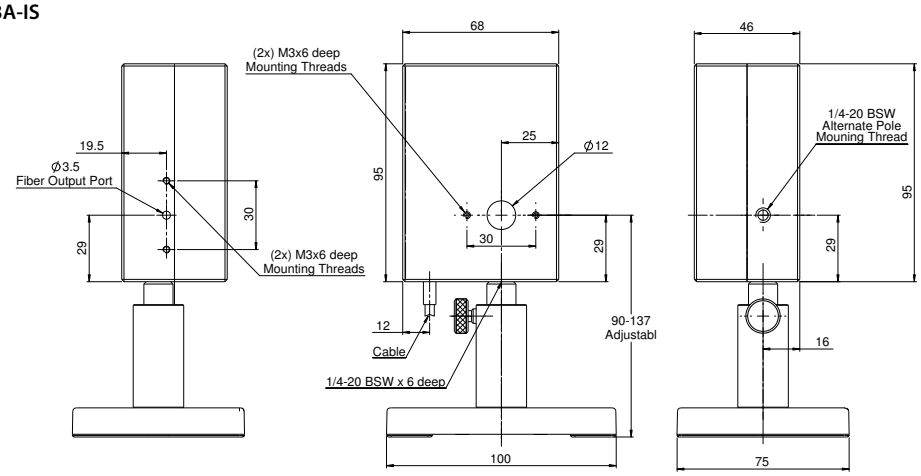
3A

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**

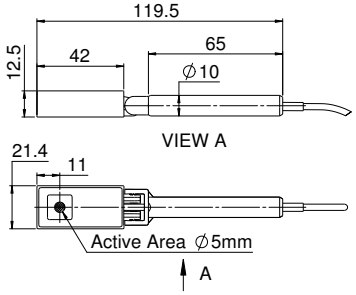
Notes: (a) One fiber output port available with output = 2E-4 of input power/mm^2 of fiber area.

* For sensors drawings please see page 35

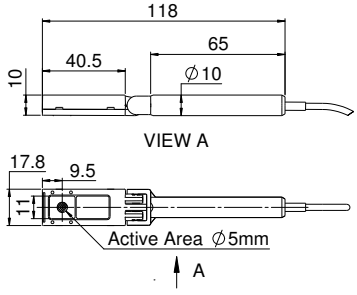
3A-IS



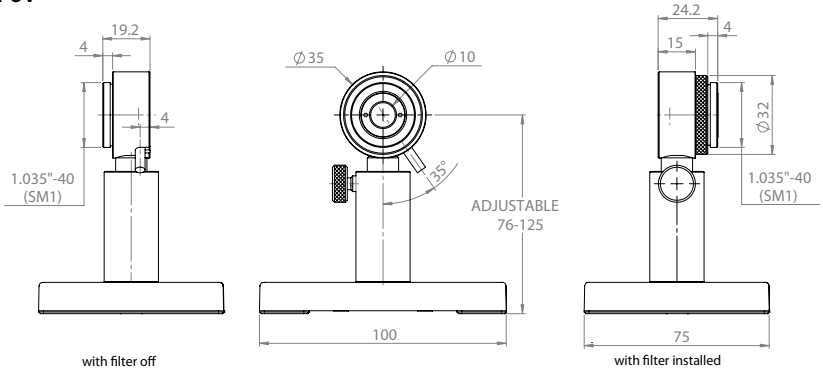
PD300-UV / PD300-IR Filter installed
(Ø5mm for PD300-IR only)



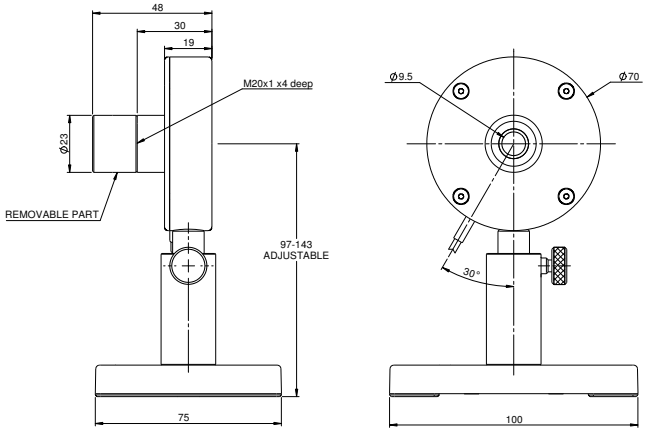
PD300-UV / PD300-IR Filter off
(Ø5mm for PD300-IR only)



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

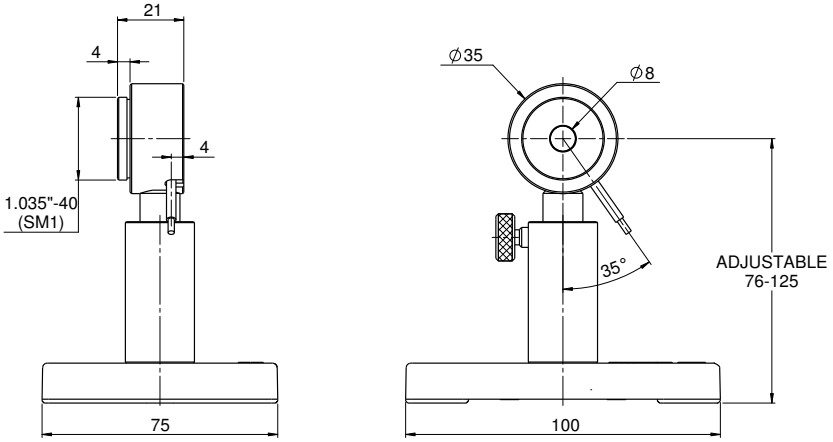
Model	PD300RM-UV	PD300RM-8W
Detector Type	Silicon	Silicon
Input Port Aperture mm	Ø8	Ø8
Spectral Range nm	200-850	350-850
Functions	Irradiance [W/cm²] Dosage [J/cm²]	Irradiance [W/cm²] Dosage [J/cm²]
Irradiance Range	15nW/cm² – 300mW/cm²	0.2µW/cm² – 8W/cm² (c)
Irradiance Scales	300mW/cm² to 300nW/cm² (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

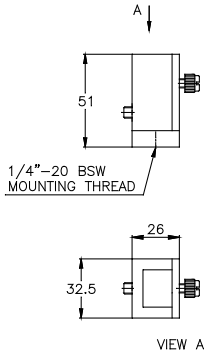
PD300 with F.O. Adapter Mounted

Accessories and Fiberoptic Adapters for PD300 series

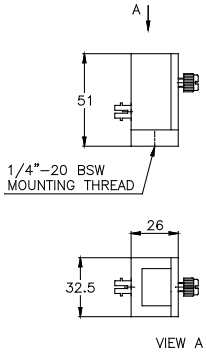
Accessory	Description	Part number			
PD300-CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300	7Z02418			
PD300-CDRH-3.5mm	Ø3.5mm aperture adapter for CDRH measurements for PD300	7Z08336			

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

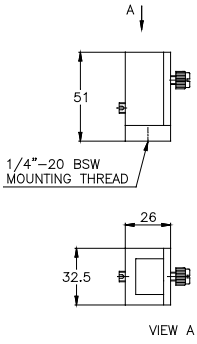
PD300-FO-SMA



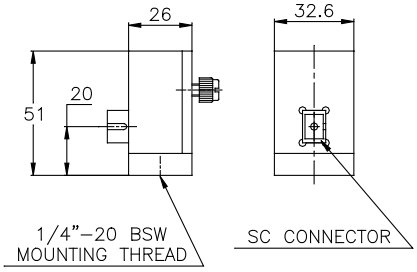
PD300-FO-ST



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

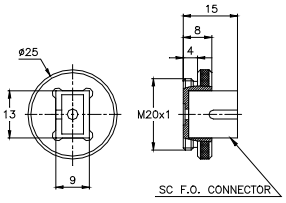
FC fiber adapter

SMA fiber adapter

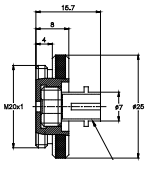
Accessory	Description	Part number			
PD300R-CDRH-7mm	Ø7mm aperture adapter for CDRH measurements for PD300R	7Z08347			

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

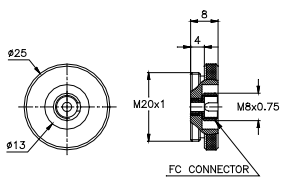
SC fiber adapter



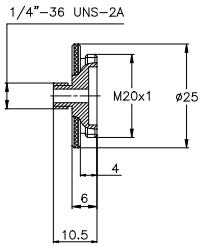
ST fiber adapter



FC fiber adapter



SMA fiber adapter

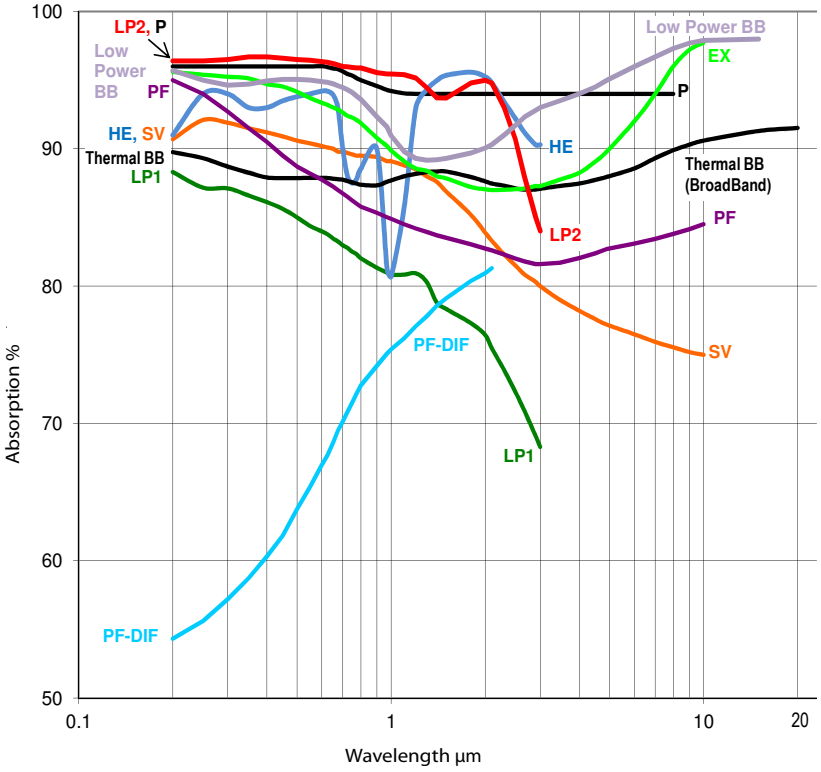


Female SM1 to SM1 Adapter

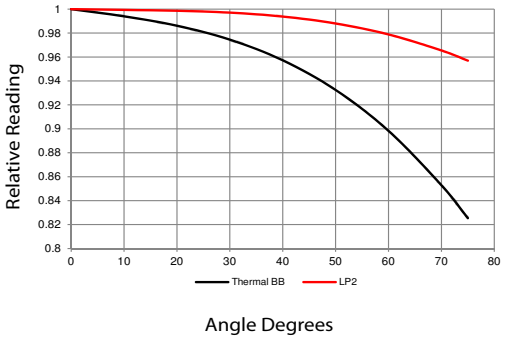
1.1.2 Thermal Power Sensors

Absorption, Angle Dependence and Damage Graphs for Thermal Sensors

Absorption vs. Wavelength

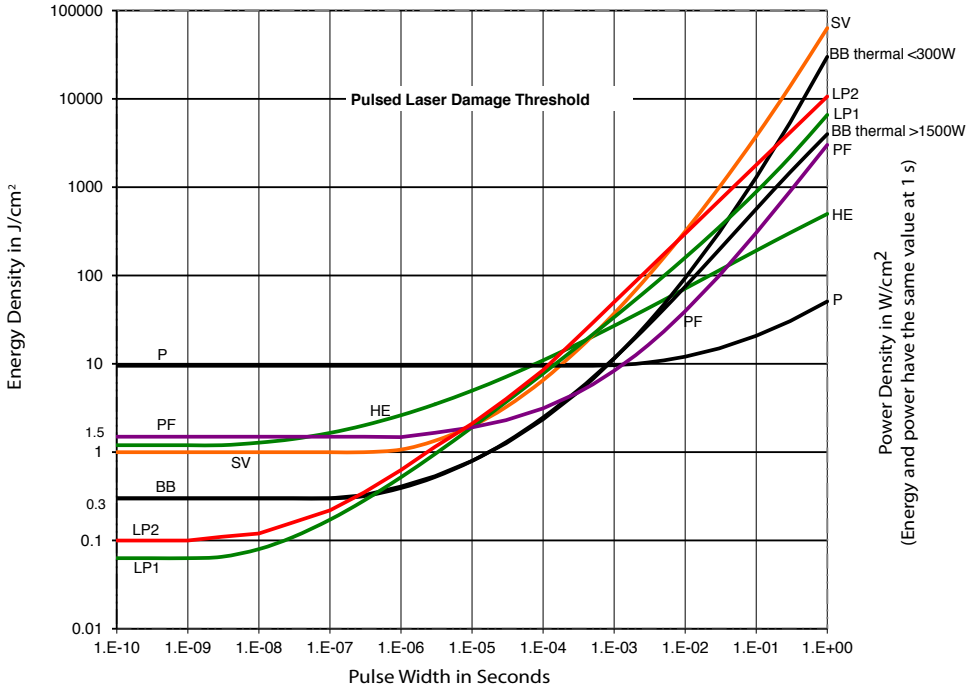


Response vs. Incidence Angle



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

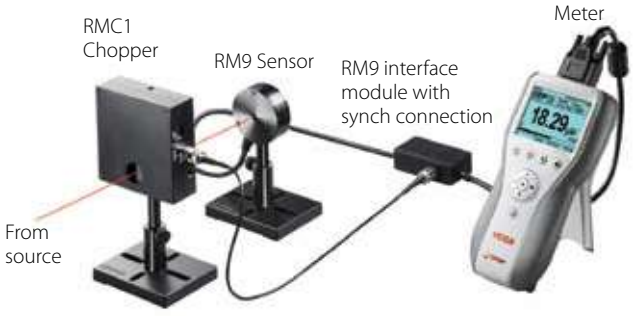


1.1.2.1 Low Noise Lock In Power Sensors

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

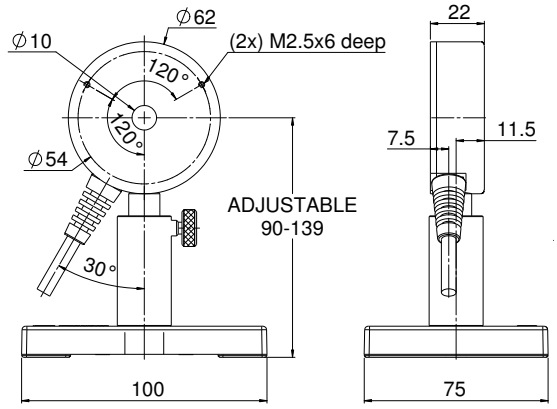
Notes: (g) The sensor is calibrated for 0.7, 1.5, 2.5, 4 and 10THz. Response at other frequencies can be interpolated from the graph on page 40. Stated accuracy is for frequencies or interpolated frequencies in the range 0.7 – 5THz. For 5 – 10THz, the calibration uncertainty is 15% and for frequencies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

* For drawings please see page 40

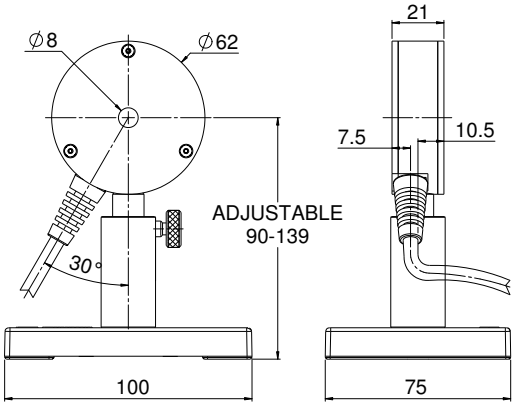
Model	**RMC1 Chopper**
Use	**Chopper for RM9 Series**
Aperture	Ø22mm
Chopping Frequency (a)	18Hz
Power Consumption	85mA
Connections:	
1. BNC to interface module	
2. 12V wall cube power supply (included)	
3. Mini USB connector (factory use only)	

Notes: (a) not adjustable by user.

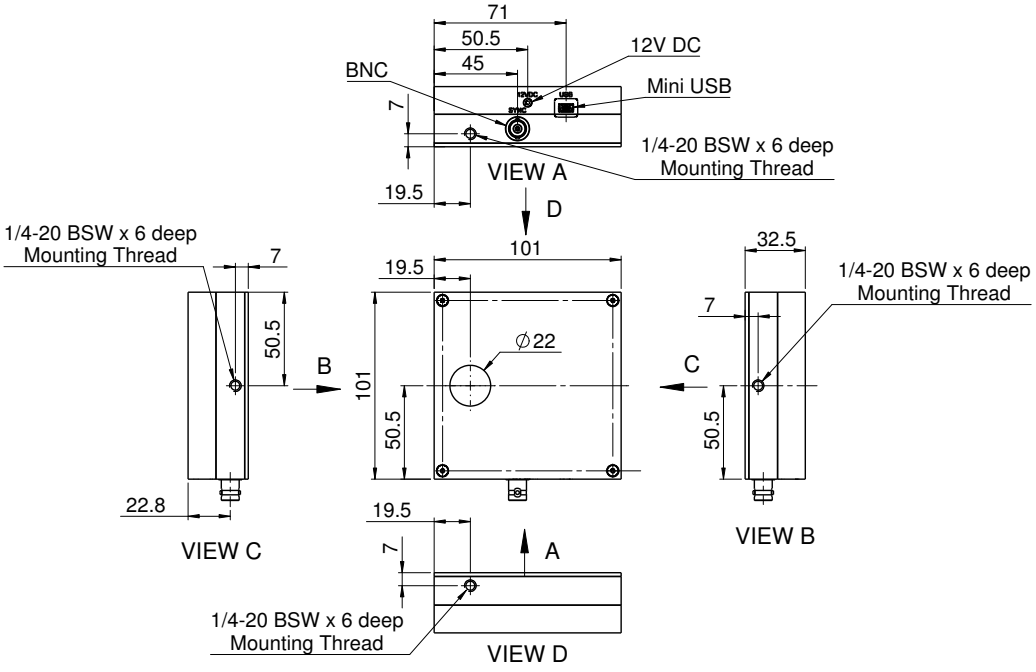
RM9-PD Sensor



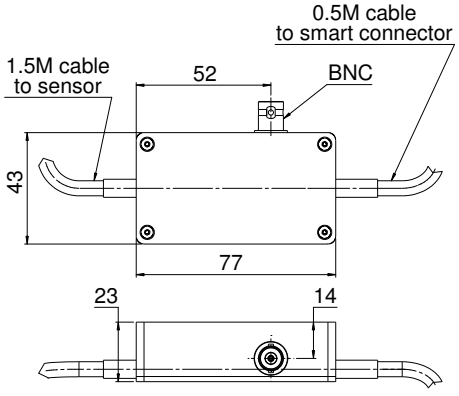
RM9 / RM9-THz Sensors



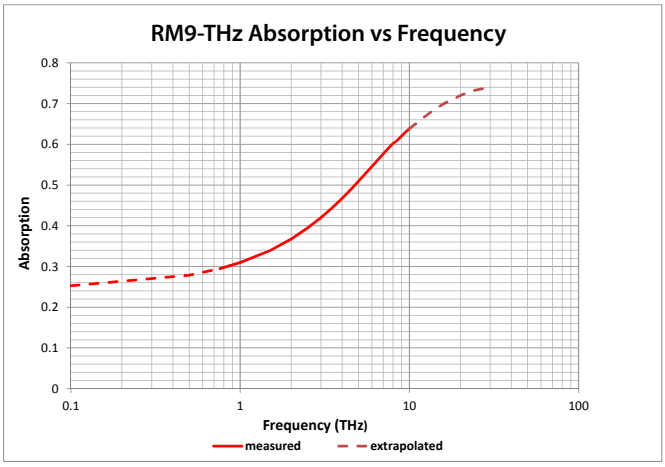
Radiometer-Chopper



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.

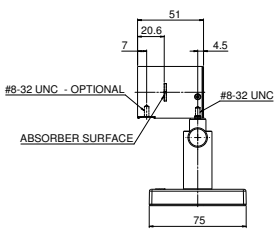
Note: (b) **For P and PF types** and shorter wavelengths derate maximum energy density as follows:

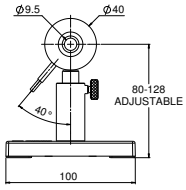
Wavelength	P type Derate to value	PF type Derate to value
1064nm	Not derated	Not derated
532nm	Not derated	Not derated
355nm	40% of stated value	70% of stated value
266nm	5% of stated value	15% of stated value
193nm	10% of stated value	5% of stated value

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

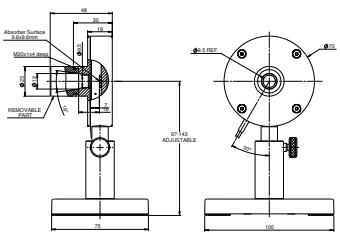
Note: (d) The 3A and 2A-BB-9 sensors have a relatively large spectral variation in absorption and has a calibrated spectral curve at all wavelengths in its spectral range to the above specified accuracy. Nova, Orion and LaserStar meters do not support this feature and when used with those meters, the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

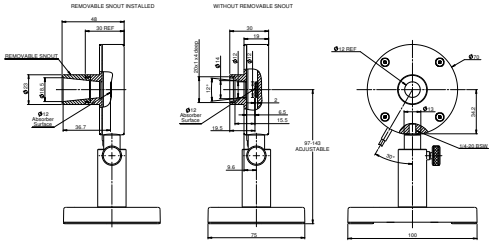




3A



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.

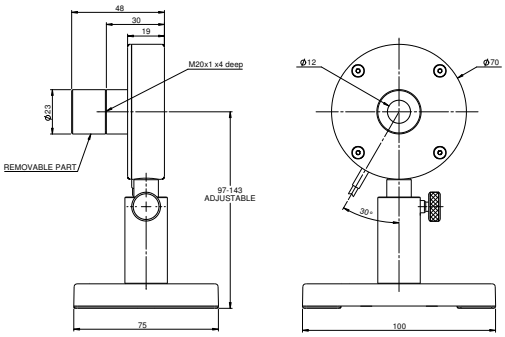
Note: (d) Back reflections from meter can sometimes cause interference effects with source. Unit should be tilted ~10° in this case

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

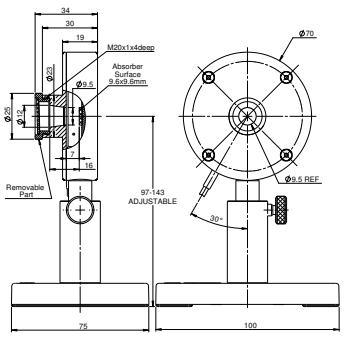
Wavelength	Derate to value
1064nm	Not derated
532nm	Not derated
355nm	40% of stated value
266nm	5% of stated value
193nm	10% of stated value

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

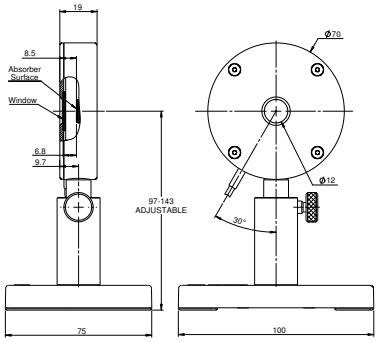
3A-P-THz



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**	

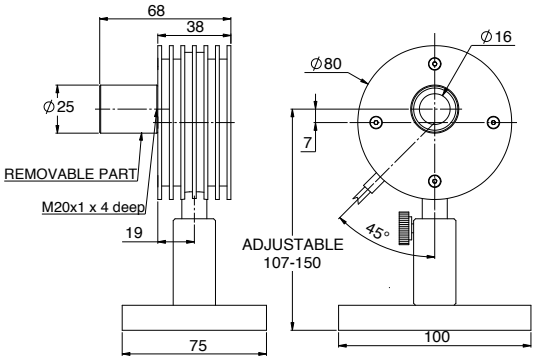
Notes: (a) Depending on room airflow and temperature variations

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

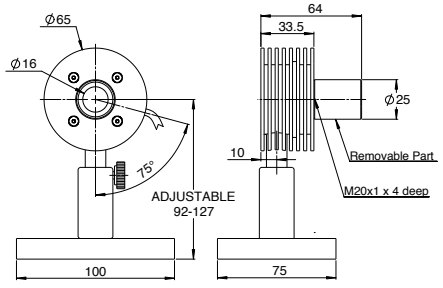
30A-BB-18

L30A-10MM

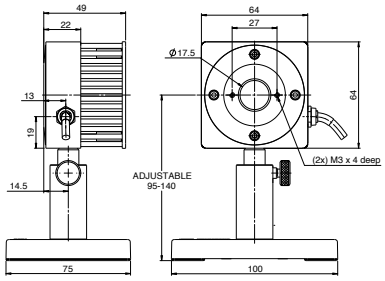
50(150)A-BB-26

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**

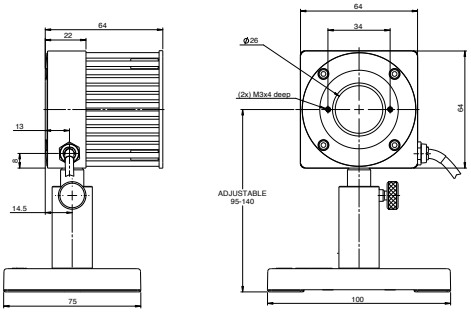
10A



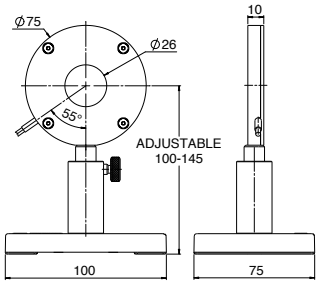
30A-BB-18



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

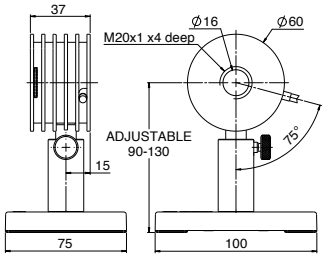
30A-N-18

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**

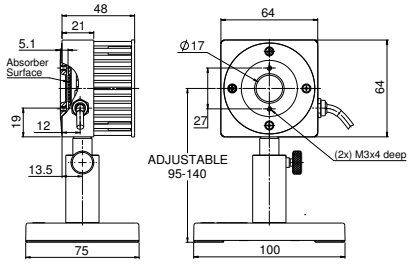
Note: (a) For shorter wavelengths derate maximum energy density as follows:

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.

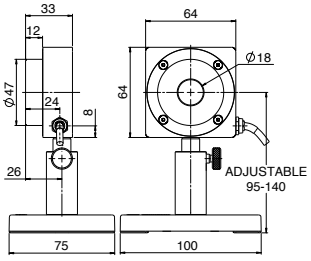
10A-P



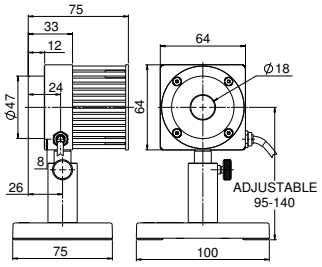
30A-P-17



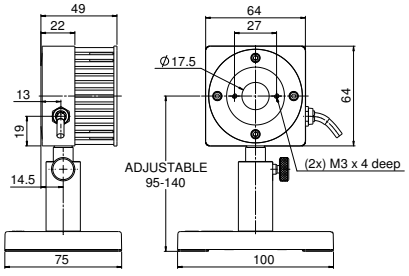
15(50)A-PF-DIF-18



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.

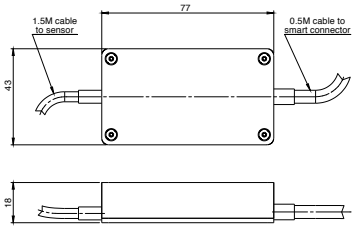
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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

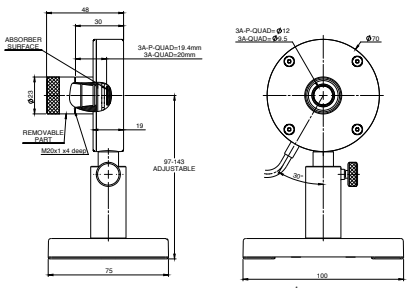
Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

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.

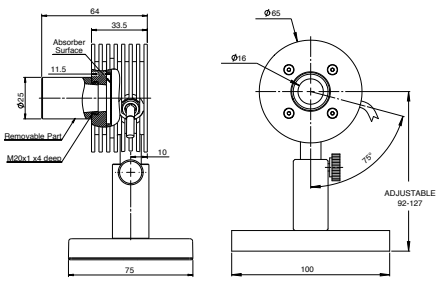
Interface Module on cable



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

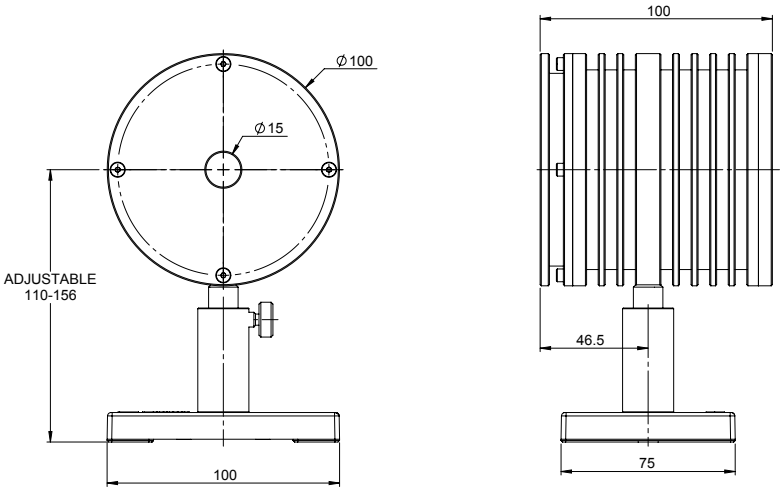
Features

- 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.

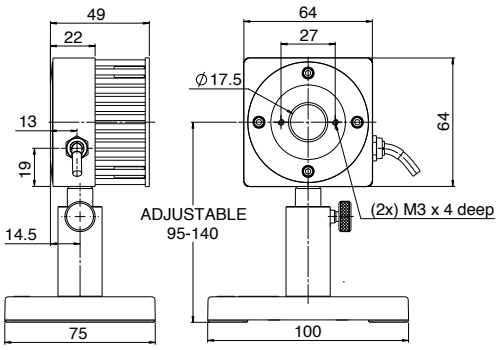
(b) Calibrated for 0.25 – 2µm, 10.6µm

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

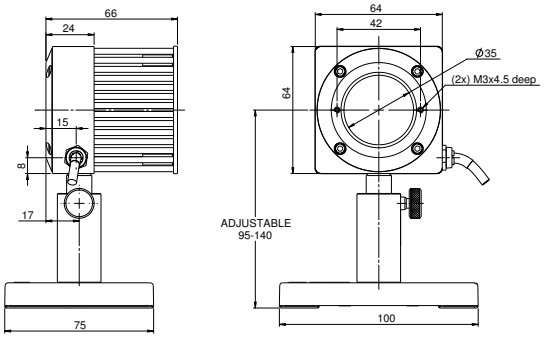
Wavelength	Derate to value
1064nm	Not derated
532n	Not derated
355n	70% of stated value
266nm	15% of stated value
193nm	10% of stated value

(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

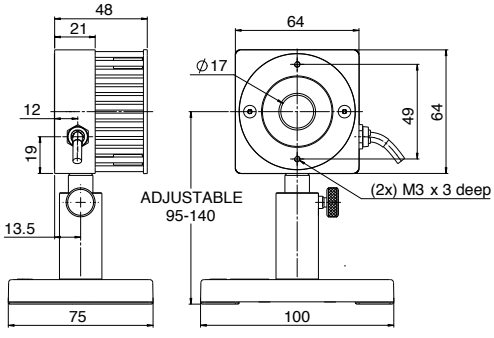
Model	**30(150)A-SV-17**			**30(150)A-HE-17**			**30(150)A-HE-DIF-17**		
Use	**High power and energy density**			**High energy and average power pulsed lasers**			**Concentrated beam pulsed lasers - has removable diffuser**		
Absorber Type	SV			HE			HE		
Spectral Range µm	0.19 - 12			0.19 - 0.625, 1.064, 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:

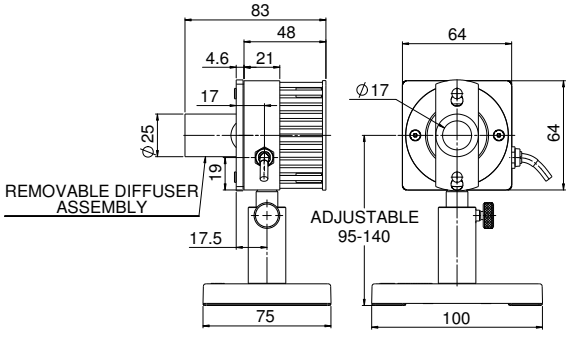
(a) At 1064nm. For shorter wavelengths derate maximum energy density to:
355nm 50% of above values
266nm 50% of above values
193nm 10% of above values

(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.

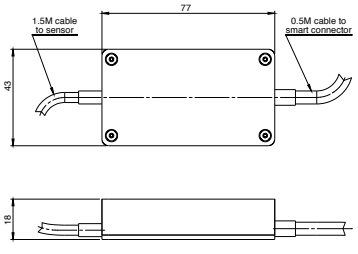
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

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.

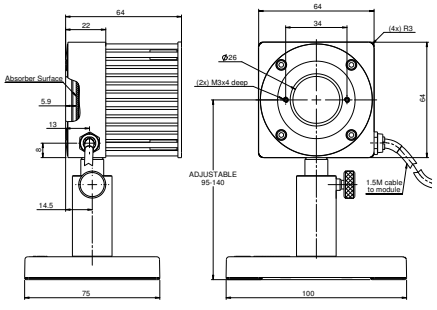
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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%.

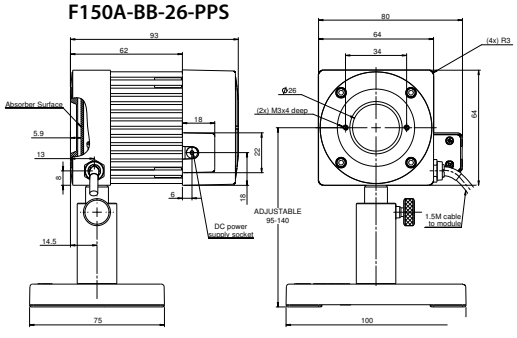
Interface Module on cable



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

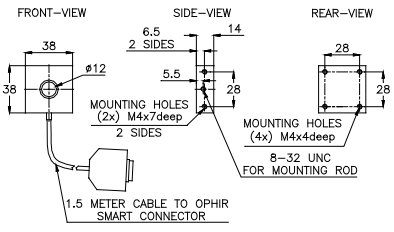
Note: (b) Above 1.1µm there is an additional calibration uncertainty of up to 2%

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

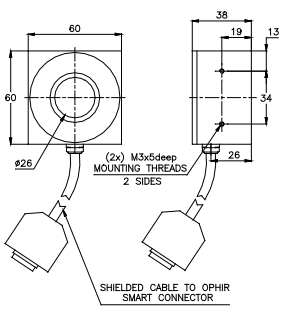
Note: (d) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses.
Total energy for a series of measurements should not exceed 2kJ. Recommended time between shots 12s.

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

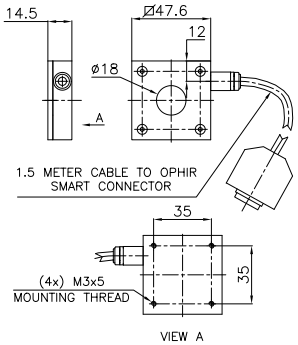
20C-SH



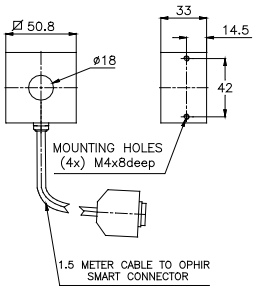
L30C-SH / L30C-LP2-26-SH



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**

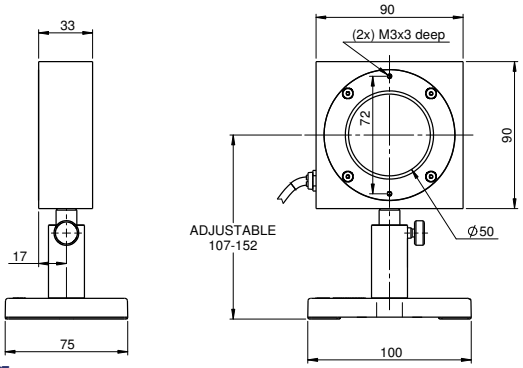
Notes: (a) Above 1.1µm there is an additional calibration uncertainty of up to 2% except at the additional calibration point of 2.94µm where the additional uncertainty is 1%.

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

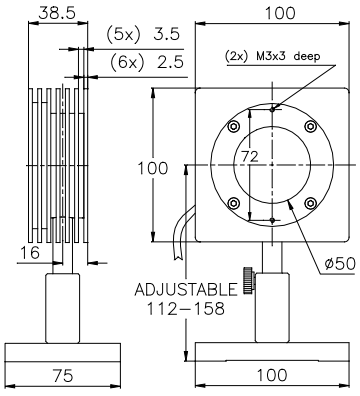
Notes: (c) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses. Total energy for a series of measurements should not exceed 20kJ. Recommended time between shots 12s.

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%.

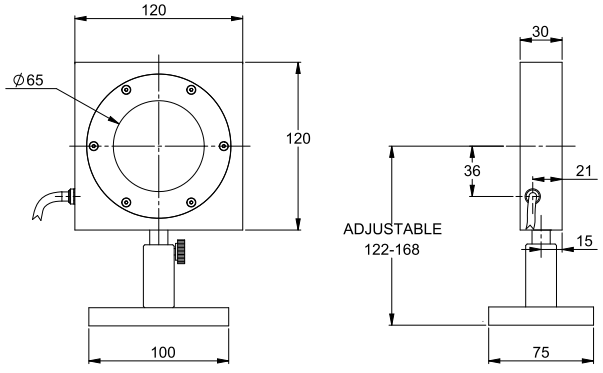
(b) Calibrated for 0.25 – 2µm, 10.6µm

(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

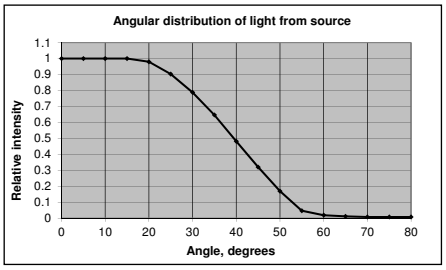
Model	L50(300)A-IPL	L40(150)A-IPL	L50(300)A-LP2-65
Use	**Gel and Air coupled IPL and laser sources**	**Gel coupled IPL sources and laser sources**	**Air coupled IPL and laser sources**
Absorber Type	LP2 + coated window [a]	LP2 + pyramid coupling to capture large output light angles	LP2
Spectral Range 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**

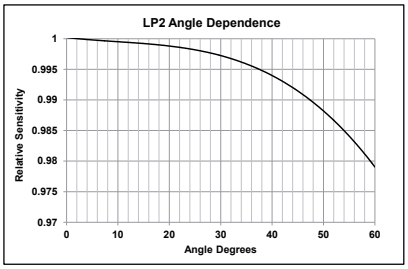
Notes: (a) Sensor has a window for gel coupled IPL sources where IPL source is coupled to window with gel or water for measurement. Can also measure air coupled IPLs

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

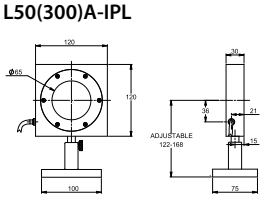
Notes: (d) Accurate measurement of air coupled sources due to low angular dependence of LP2 coating. See graph below.
Notes: (e) Above 1.1µm there is an additional calibration uncertainty of up to 2%.

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

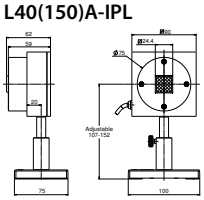




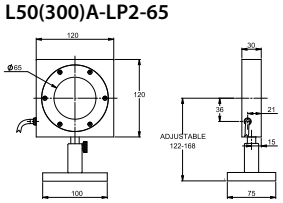
L50(300)A-IPL



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.

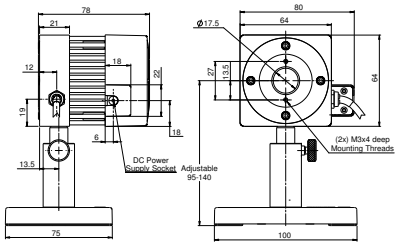
Notes: (b) For shorter wavelengths derate maximum energy density as follows: Wavelength Derate to value:

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

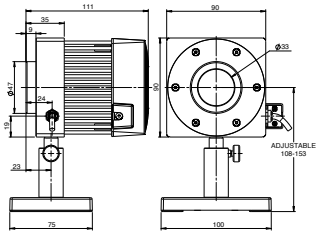
Notes: (c) Calibrated at specified wavelengths only: 266nm, 355nm, 532nm, 1064nm and 2100nm only

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

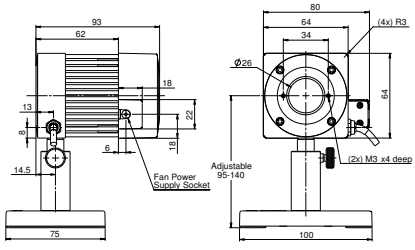
F50A-BB-18



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**

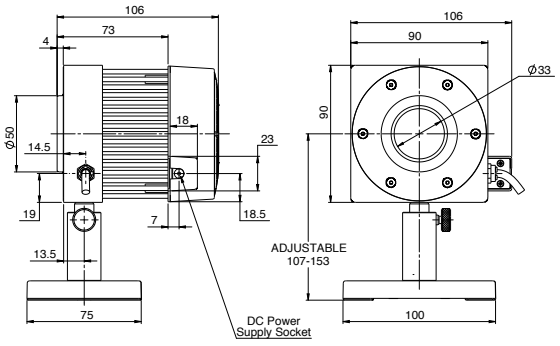
Notes: (a) Calibrated at specified wavelengths only: 532nm, 755nm, 1064nm and 2940nm

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

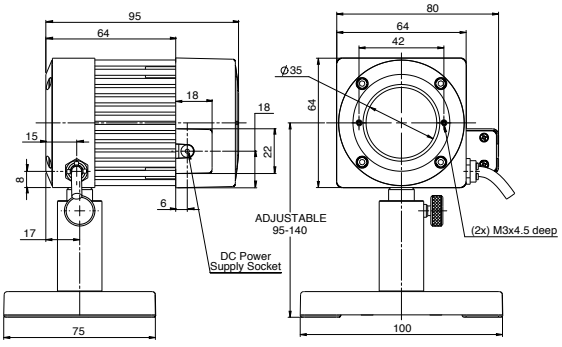
Notes: (c) For lower powers up to 30W it is recommended to work with the fan off and then the noise level is ~5 times lower. It is also recommended to measure energy with the fan off

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

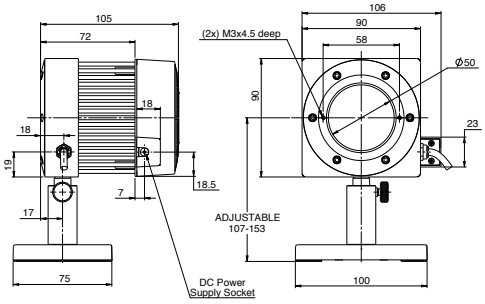
FL400A-LP2-50

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

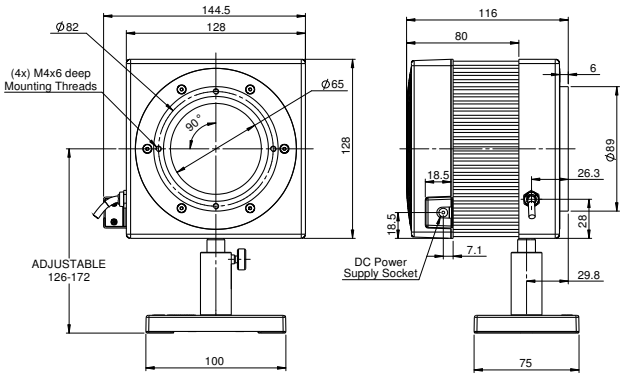
Model	FL600A-BB-65	FL600A-LP2-65	FL1100A-BB-65	FL1100A-LP2-65
Use	**General purpose**	**Long pulses**	**Highest power fan cooled**	**Long pulses**
Absorber Type	Broadband	LP2	Broadband	LP2
Spectral Range µm	0.19 - 11	0.35 – 2.2	0.19 - 11	0.35 – 2.2
Absorption	~88%	>94% from 0.35 to 1.1µm	~88%	>94% from 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.

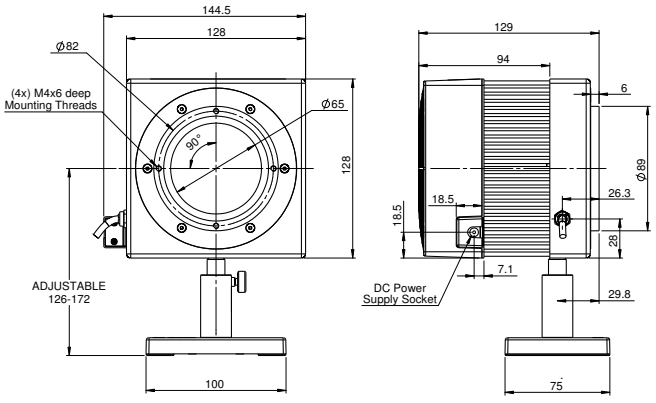
Notes: (b) Above 1.1µm there is an additional calibration uncertainty of up to 2%.

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.

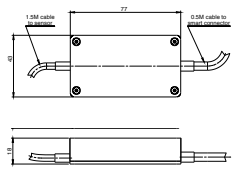
Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

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

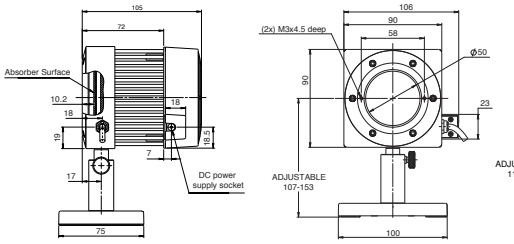
Notes: (g) Water temperature range 18-30°C, Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa.

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.

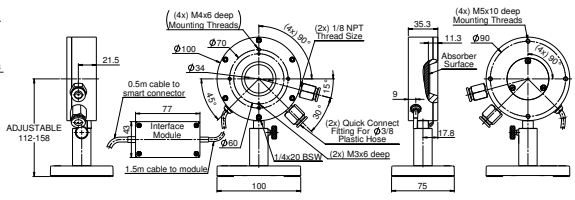
Interface Module on cable



FL250A-BB-50-PPS



1000W-BB-34-QUAD



1.1.2.7 High Power Thermal Sensors

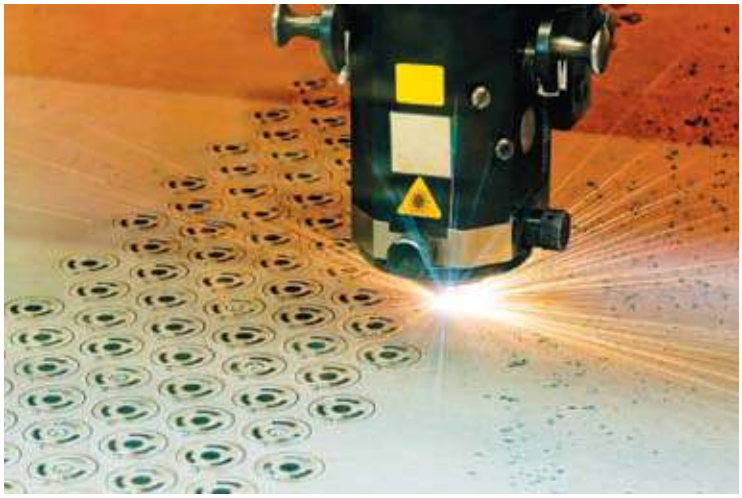
1.1.2.7.1 Introduction

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

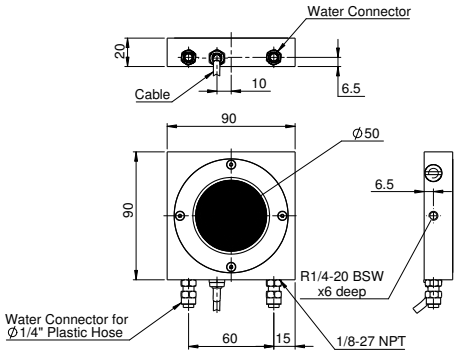
- High powers
- Water cooled
- Up to 300W
- Ø50mm aperture

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

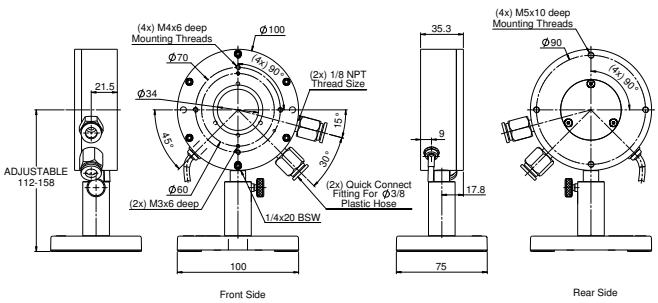
1000W-BB-34

1000WP-BB-34

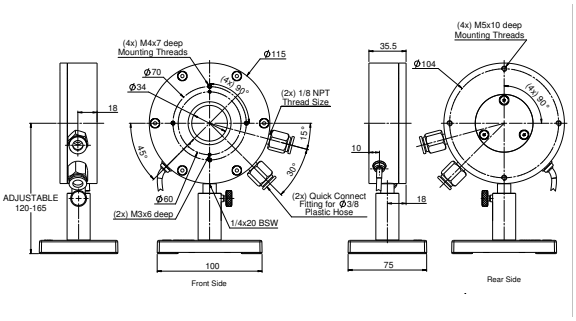
1000W-LP2-34

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

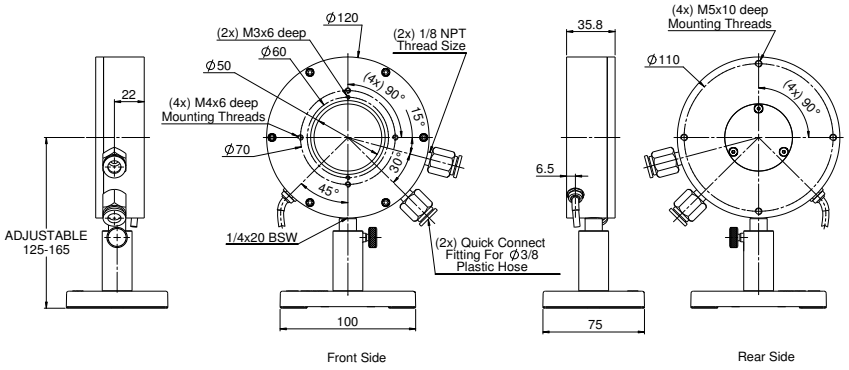
- High powers
- Water cooled
- Up to 1500W
- Ø50mm aperture

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

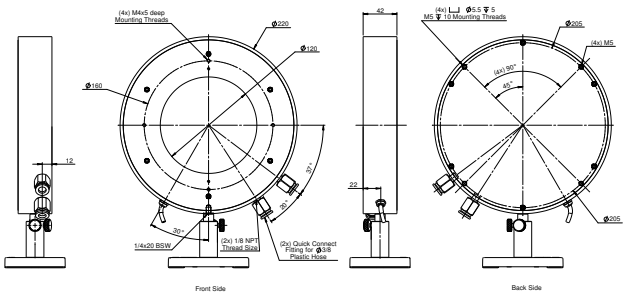
- Very large aperture
- Broadband or Pulsed absorber
- Up to 2000W
- Ø120mm aperture

L2000W-BB-120

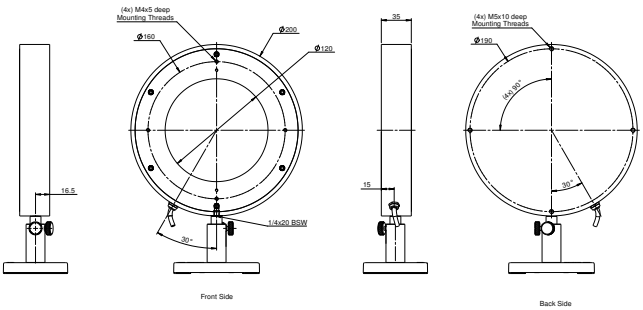
L100(500)A-PF-120

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

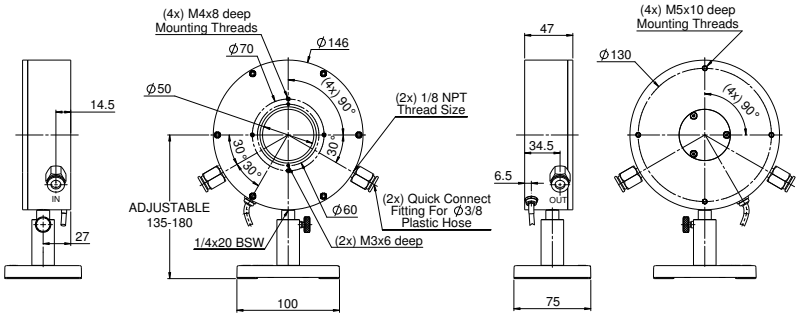
- Powers up to 5000W
- Water cooled
- Ø50mm aperture

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

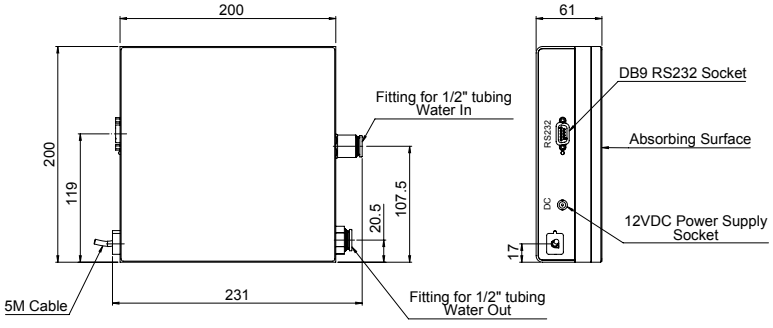
Features

- 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.

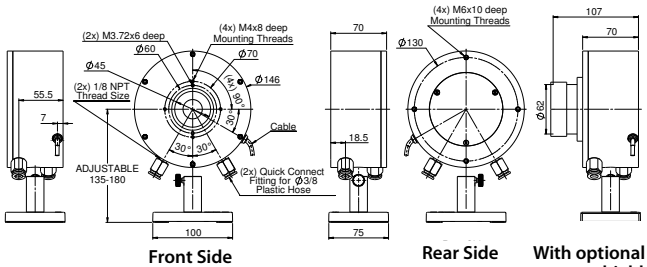
Notes: (d) Water temperature range 15-30°C. Water temperature rate of change <1°C/min

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)

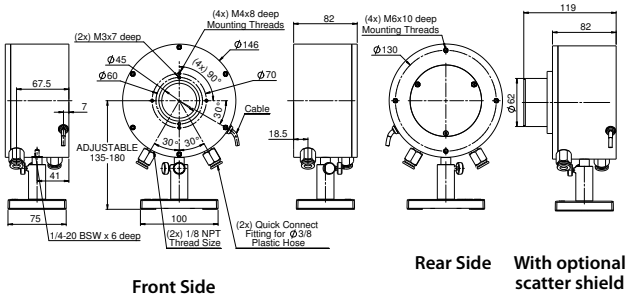
Beam diameter	Max power density	Max energy density		
		1ms pulse width	3ms pulse width	10ms pulse width
<15mm	10kW/cm²	30J/cm²	60J/cm²	150J/cm²
15 - 20mm	7kW/cm²	20J/cm²	40J/cm²	100J/cm²
20 - 40mm	5kW/cm²	15J/cm²	30J/cm²	70J/cm²
40 - 45mm	4kW/cm²	12J/cm²	25J/cm²	60J/cm²

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

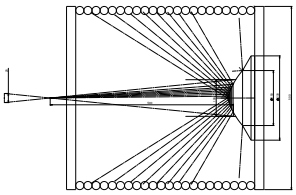
1.1.2.7.4 Very High Power Water Cooled Thermal Sensors

100W to 120kW

Features

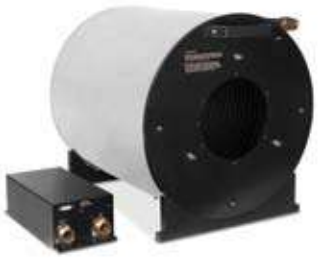
- Highest powers
- Water cooled
- Up to 120kW
- Ø200mm aperture

30K-W-BB-74



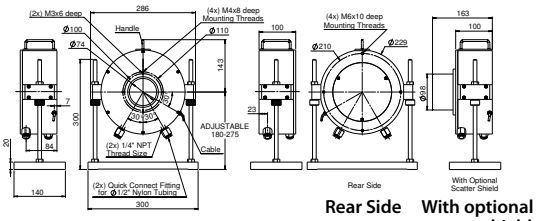
Laser Beam Path

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

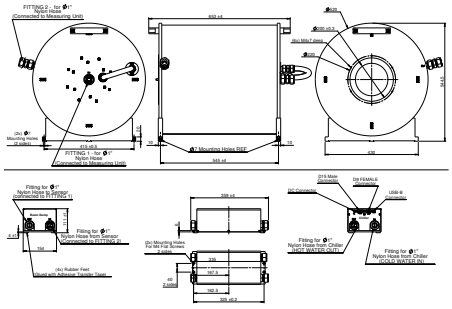


Front Side

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

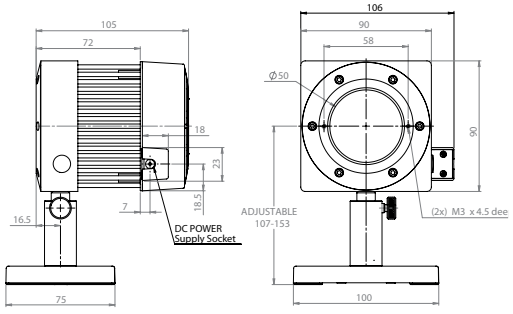
Model	BDFL500A-BB-50	BDFL1500A-BB-65	BD5000W-BB-50	BD10K-W
Use		**General purpose High power beam dump**		
Absorber Type	Broadband	Broadband	Broadband	Beam Deflector + Broadband
Spectral Range µm	0.19 - 20	0.19 - 20	0.19 - 20	0.8 - 20
Typical Absorption		86% for 600 to 2500nm, 82% for 10.6µm		
Aperture 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.

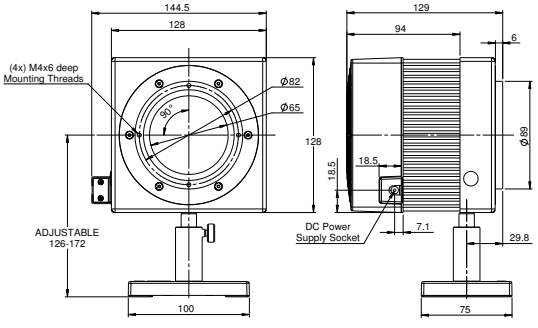
Notes: (b): Max power and energy density

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

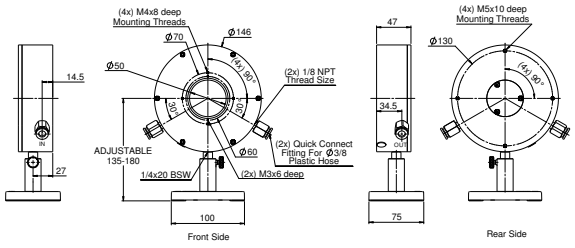
BDFL500A-BB-50



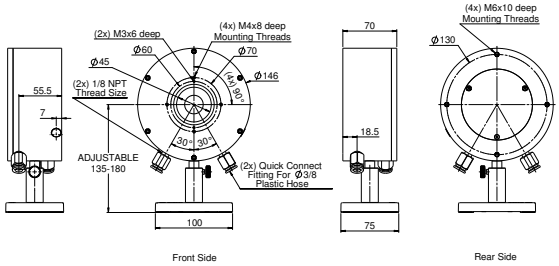
BDFL1500A-BB-65



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

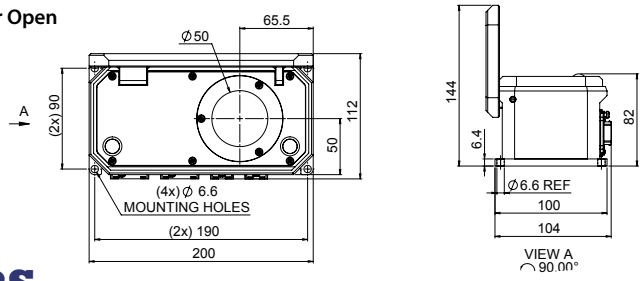
- No water cooling, up to 12000W
- Profinet and RS232 interface
- Remote actuated protective cover

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.

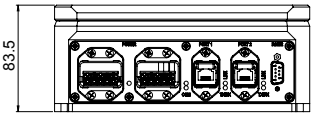
Model	**Helios**					
Use	**High power industrial laser measurement**					
Absorber Type	LP2, absorption ~94%					
Power Range	200W - 12kW					
Energy Range	200J - 5kJ					
Exposure Time (see table below)	0.3- 4s [a]					
Wavelength	860 - 1100nm [b]					
Aperture	50mm					
Max Beam Diameter	35mm					
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

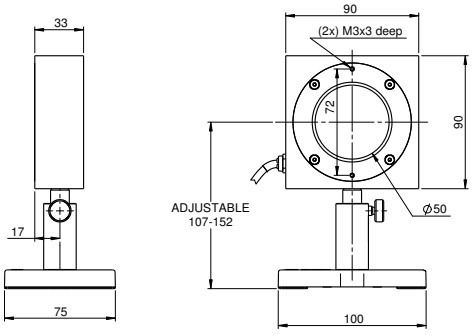
L30C-LP2-26-SH

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

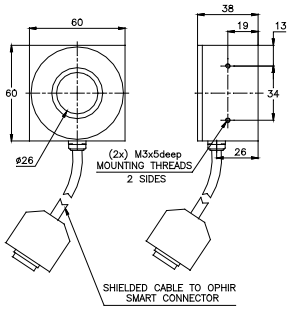
Model	**L40(150)A-LP2-50**			**L30C-LP2-26-SH**		
Absorber Type	LP2			LP2		
Spectral Range	0.25 – 2.2µm			0.25 – 2.2µm		
Absorption	>94% from 0.25 to 1.1µm			>94% from 0.25 to 1.1µm		
Power Range for CW use	300mW - 150W			10W free standing, 100W heat sinked		
Maximum Intermittent CW power	150W for 4min, 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

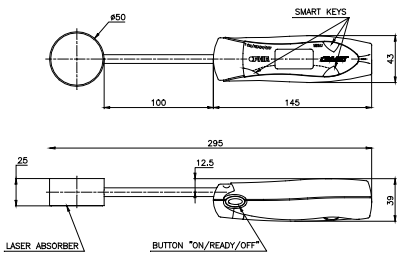
Comet 1K

Comet 10K

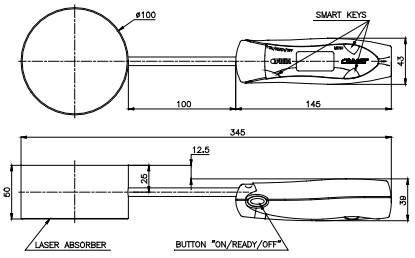
Comet 10K-HD

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**		

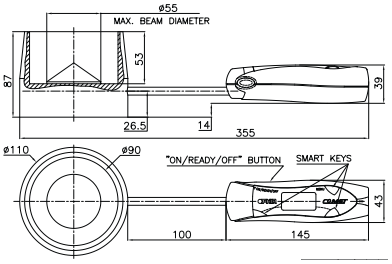
Comet 1K



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)

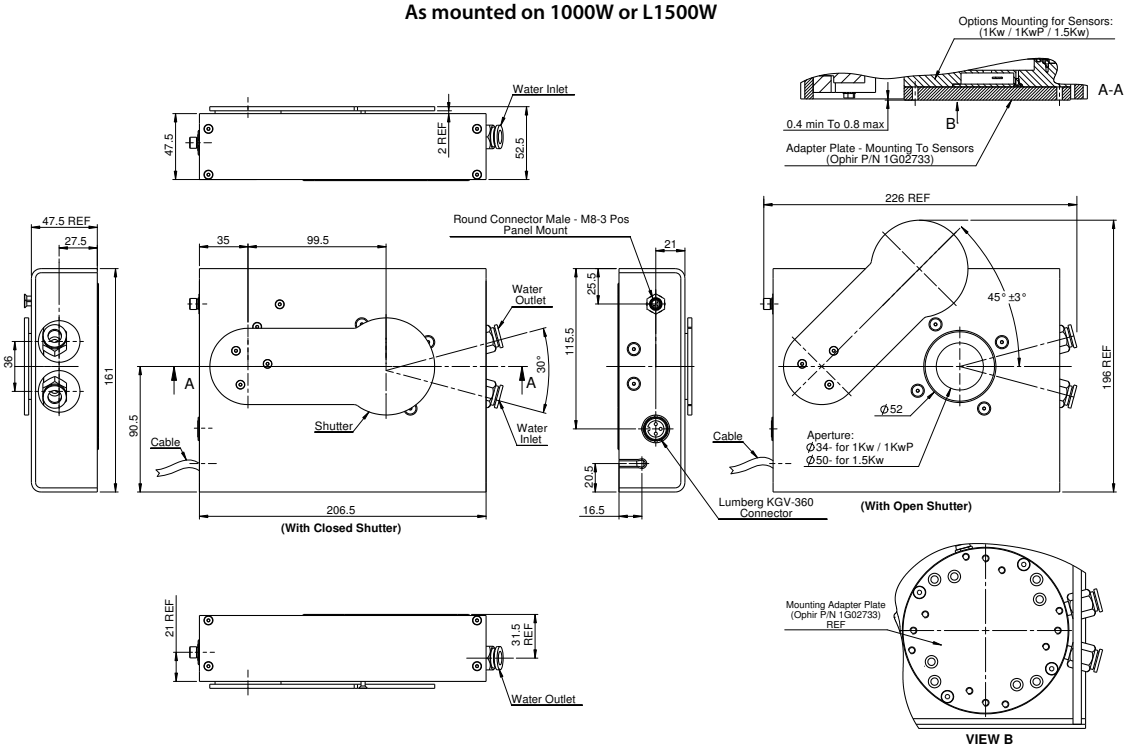
Protective Housing for 1000W / L1500W
Mounted on Sensor (shutter closed)
Front view (water connectors)

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)

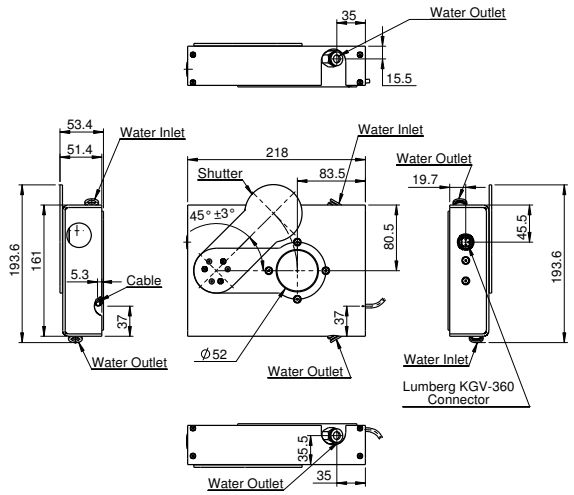
Model	**5000W / 10K-W / 15K-W Protective Housing**
Use	**Protection from debris of material working process**
Sensors Supported	For 5000W, 10K-W and 15K-W. Needs threaded front flange [a]
Aperture	Exposes full aperture of sensors
Solenoid Actuating Power	24VDC 1A, Shutter is normally Closed [b]
Electrical 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.

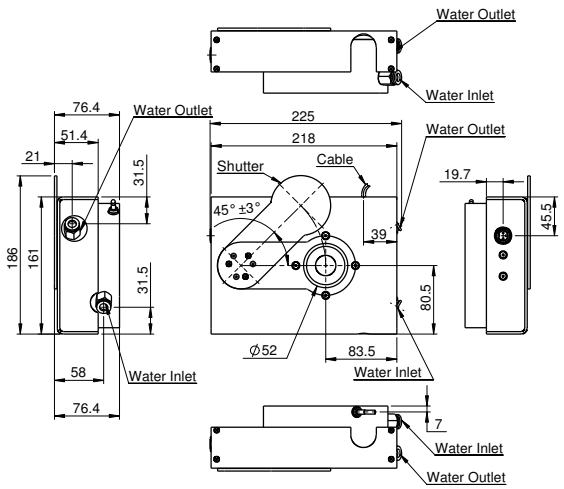
Notes: (b) In order to prevent possible damage to the shutter, it is recommended to safety interlock the shutter and laser so that if the shutter is closed (no power to the solenoid), the laser will not be directed at the sensor.

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.

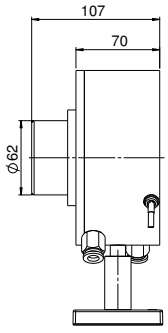
Since some of the light is reabsorbed, the power reading is 1-1.5% higher than without the shield, so an additional laser setting is given for use when the shield is mounted to adjust for this difference.

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

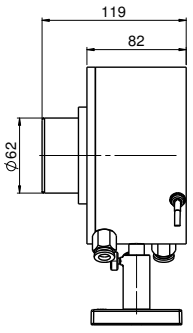
Scatter Shield with protective cover

Scatter Shield without protective cover

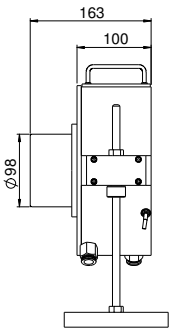
10K-W with Scatter Shield



15K-W with Scatter Shield



30K-W with Scatter Shield



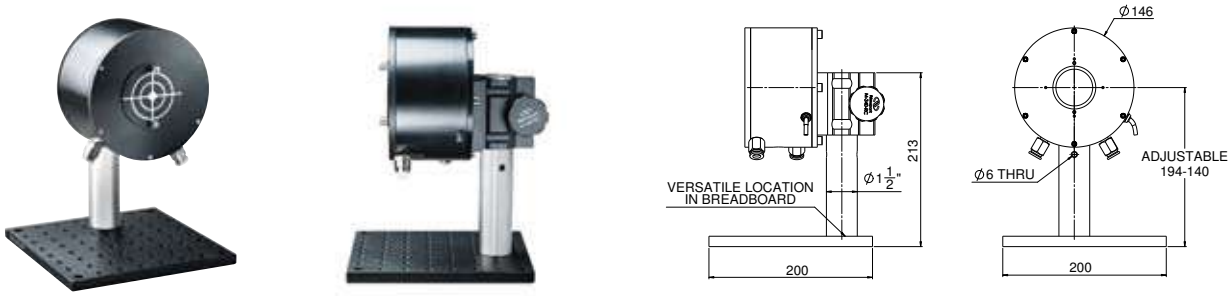
Model	10K-W / 15K-W Scatter Shield	30K-W Scatter Shield
Wavelength range of use	0.8 – 2µm	0.8 – 2µm
Laser setting with and without shield	with NIRS, without NIR	with 107S, without 107
Backscatter with and without shield	with 0.9%, without 3.2%	with 1.4%, without 4.3%
Part number	**7Z08295**	**7Z08293**

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).

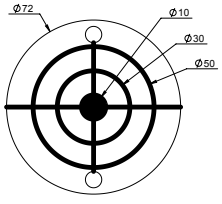
Protective Cover	For use with	Part Number
10K-W Protective Cover	15K-W, 10K-W, 5000W, L1500W, 1000W without scatter shield	1G01332
10K-W / 15K-W Scatter Shield Cover	10K-W and 15K-W with Scatter Shield	7Z08345
30K-W Protective Cover	30K-W without Scatter Shield	1G02406
30K-W Scatter Shield Cover	30K-W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

Sensor with 10K-W Protective Cover

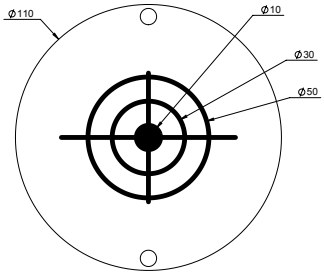
Sensor with 30K-W Protective Cover

Protective Cover on Scatter Shield

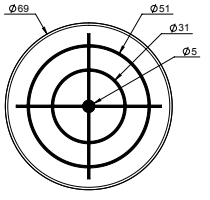
10K-W Protective Cover



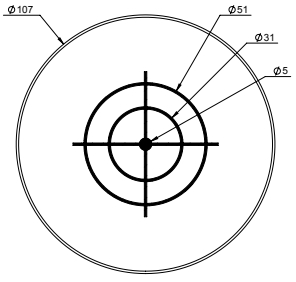
30K-W Protective Cover



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



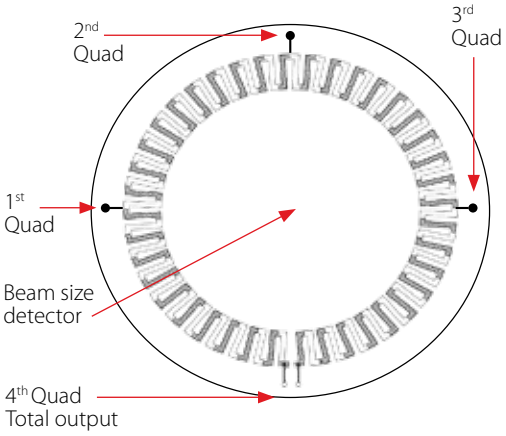
30K-W Scatter Shield Cover



1.1.3 BeamTrack Power / Position / Size Sensors

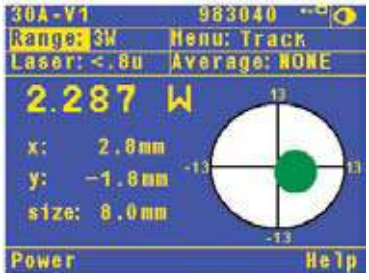
1.1.3.1 Introduction

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.

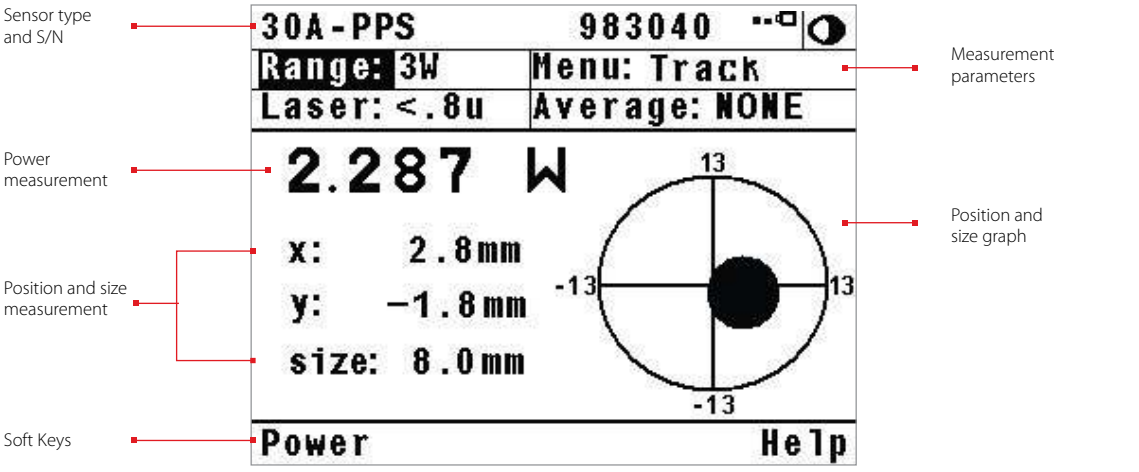
Model	Sensor Type	Max Power [W]	Position	Size
3A-QUAD	TH	3	√	
3A-P-QUAD	TH	3	√	
10A-PPS	TH	10	√	√
50(150)A-BB-26-QUAD	TH	50 (150 intermittent)	√	
50(150)A-BB-26-PPS	TH	50 (150 intermittent)	√	√
F150A-BB-26-PPS	TH	150	√	√
FL250A-BB-50-PPS	TH	250	√	√
1000W-BB-34-QUAD	TH	1000	√	

PD = Photodiode, TH = Thermal

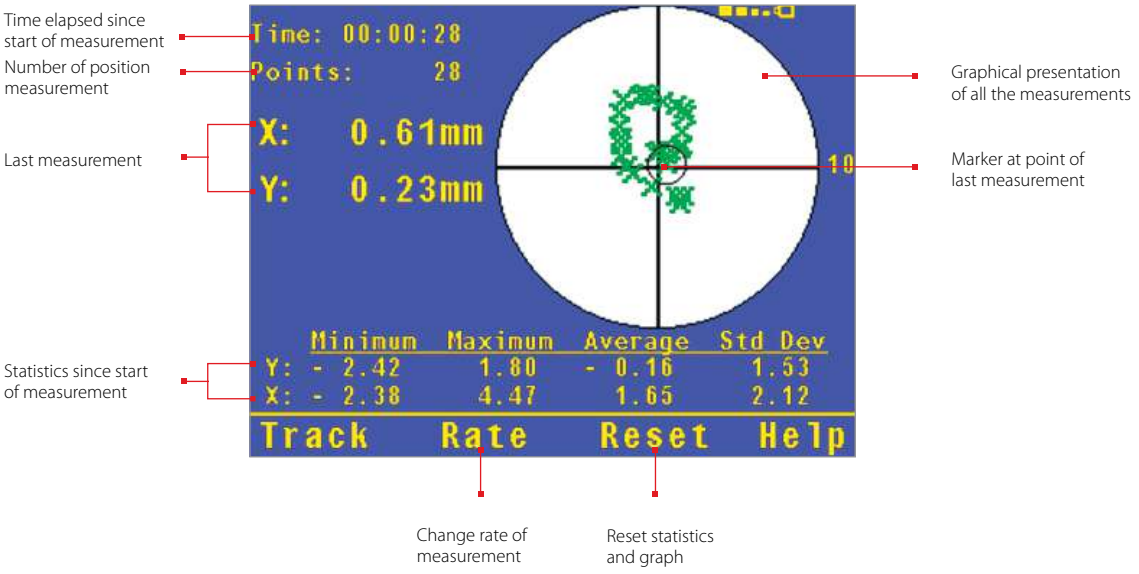
1.1.3.2 BeamTrack Device Software Support

- 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

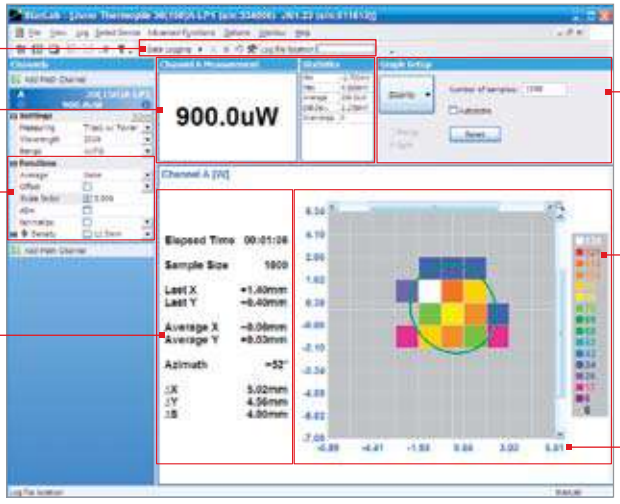


1.1.3.3 BeamTrack PC Software Support

- 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)

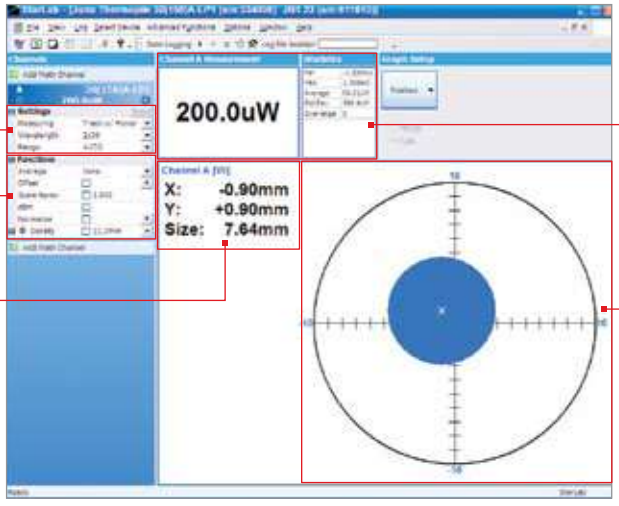
Statistics of the stability sample

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.

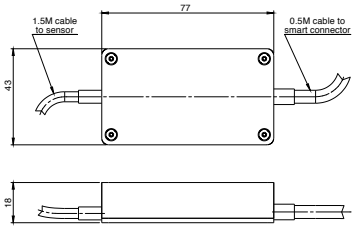
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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

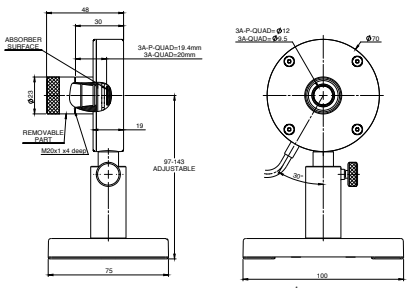
Wavelength	Derate to value
1064nm	not derated
532nm	not derated
355nm	40% of stated value
266nm	10% of stated value
193nm	10% of stated value

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.

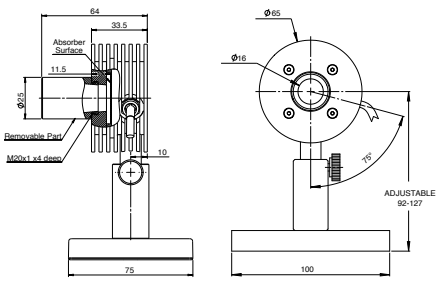
Interface Module on cable



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.

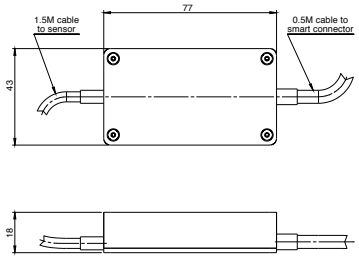
Notes: (b) For powers up to 30W it is recommended to work with the fan off and then the noise level is ~3 times lower. It is also recommended to measure energy with the fan off.

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.

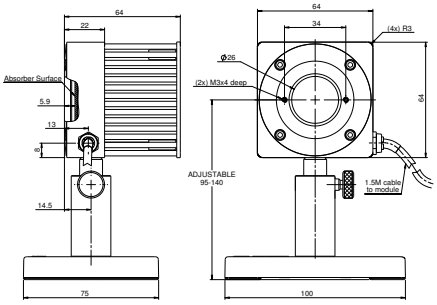
Notes: (d) Assumes laser beam with Gaussian (TEM_{00}) distribution. For other modes, size measurement is relative.

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%.

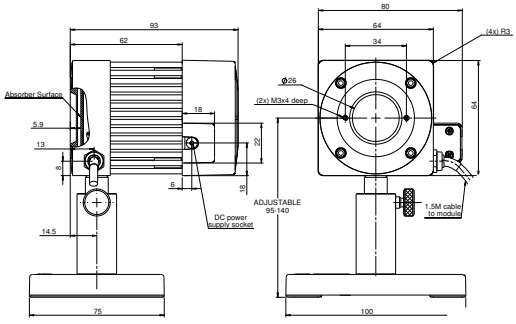
Interface Module on cable



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.

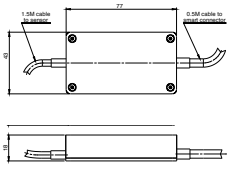
Notes: (e) Accuracy spec will be maintained for beams from 6 to 35mm not deviating from center more than 15% of beam diameter.

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

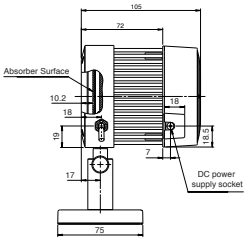
Notes: (g) Water temperature range 18-30°C, Water temperature rate of change <1°C/min. Pressure drop across sensor 0.03MPa.

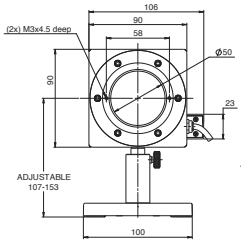
Notes: (h) Position accuracy for the central 10 mm of the aperture as limited by beam position resolution. Position measuring center corresponds to geometrical center within <1mm. Position center can be software reset to geometric center or other desired position with StarBright or StarLab.

Interface Module on cable

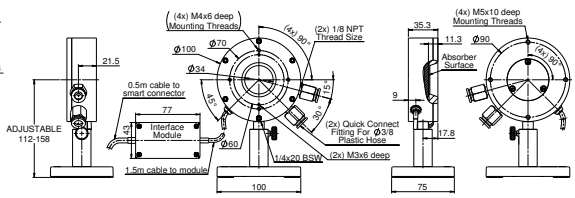


FL250A-BB-50-PPS





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

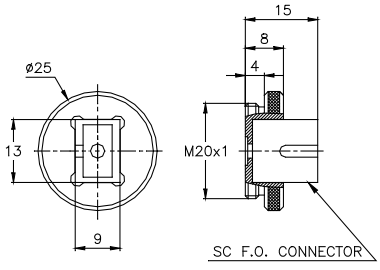
FC fiber adapter

SMA fiber adapter

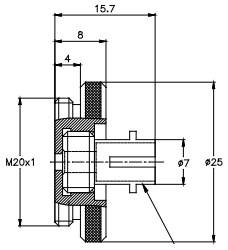
Sensor Series	Fiber adapter mounting bracket (1 bracket fits all fiber adapters)	SC fiber adapter	ST fiber adapter	FC, FC/APC fiber adapter	SMA fiber adapter
Thermal Sensors					
2A-BB-9 / 3A / 3A-QUAD / 3A-P / 3A-P-QUAD / 3A-PF-12 / 3A-FS / 3A-P-THz	not needed				
10A / 10A-PPS / 10A-P	not needed				
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

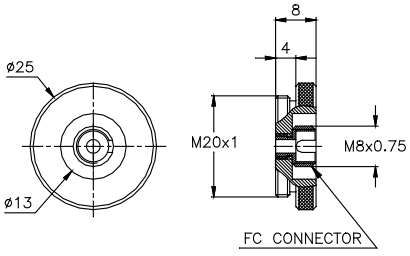
SC fiber adapter



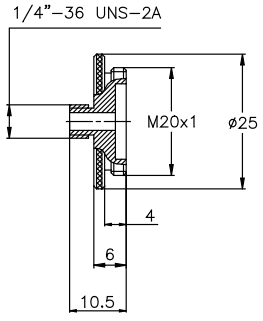
ST fiber adapter



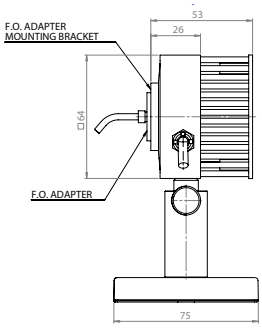
FC fiber adapter



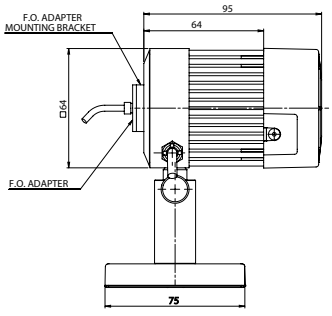
SMA fiber adapter



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

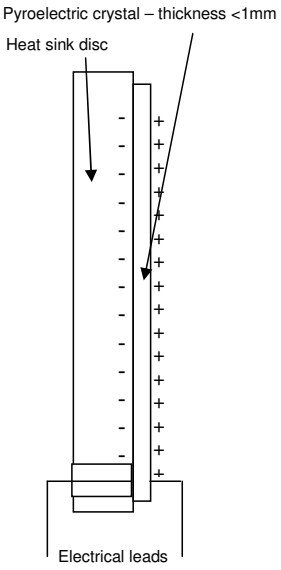
Energy sensors

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.

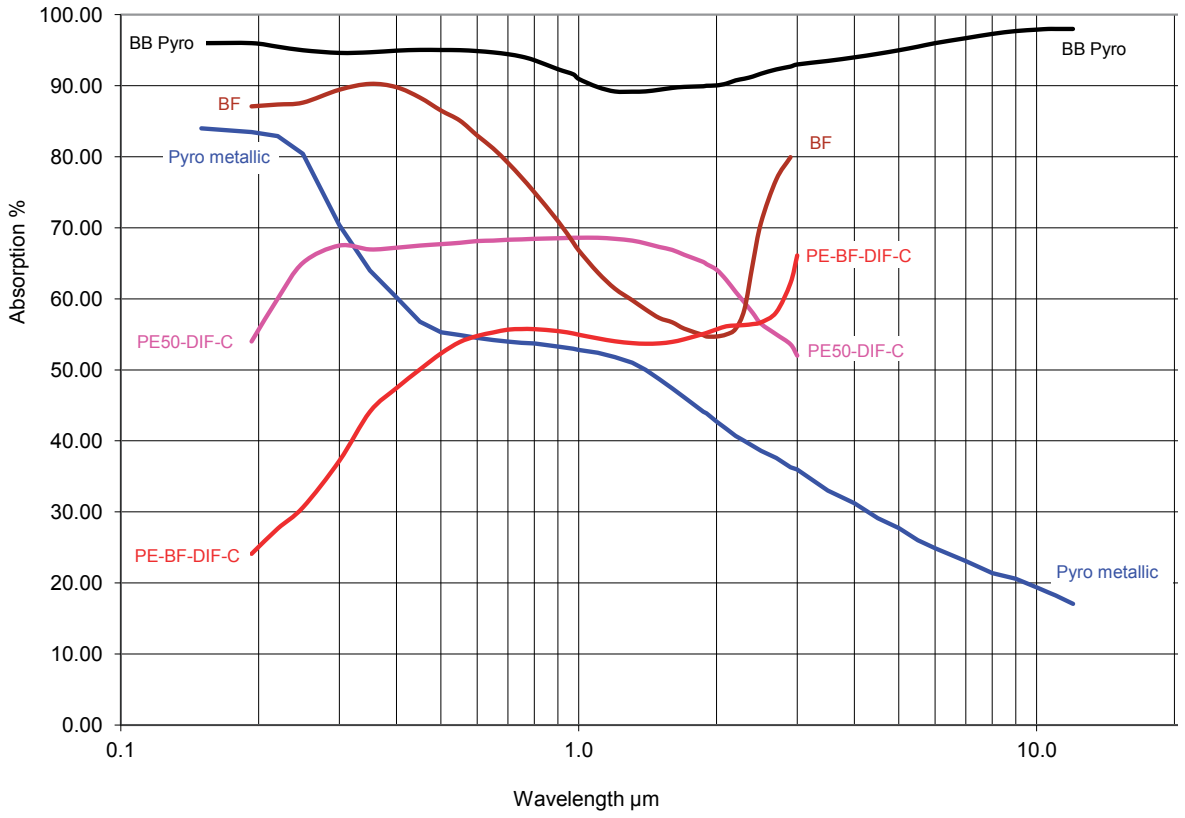
Pyroelectric Sensors



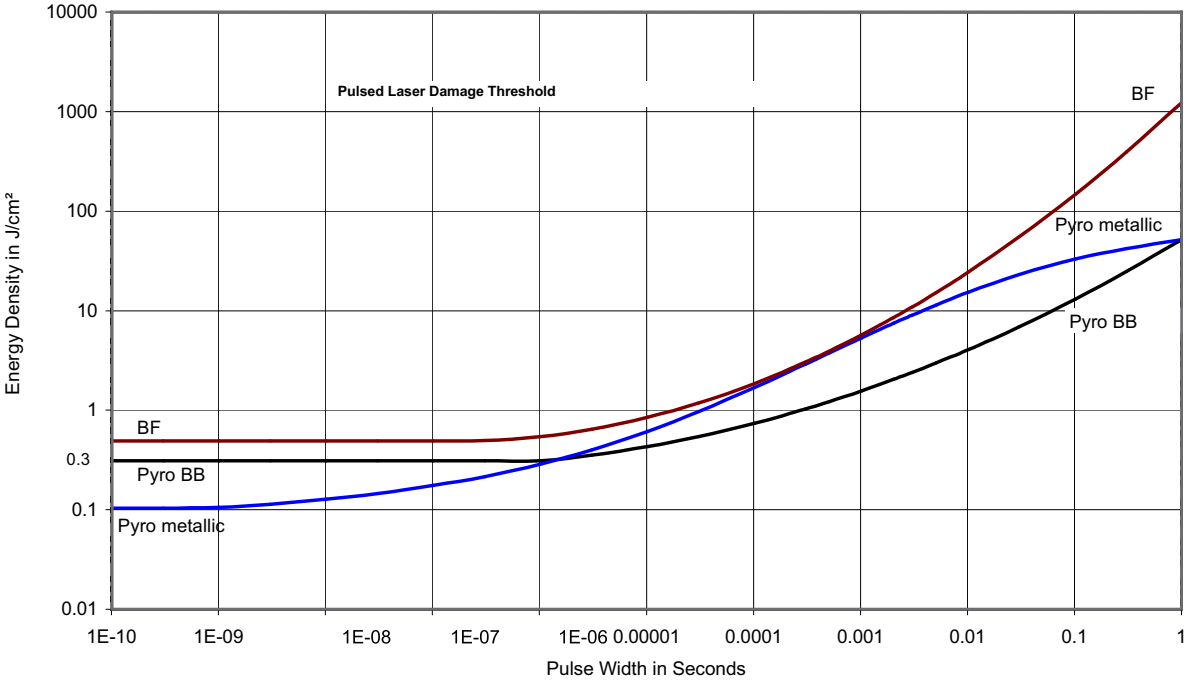
Pyroelectric type sensors are useful for measuring the energy of repetitively pulsed lasers at up to 25,000Hz and are sensitive to low energies.
They are less durable than thermal types and therefore should not be used whenever it is not necessary to measure the energy of each pulse and average power 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

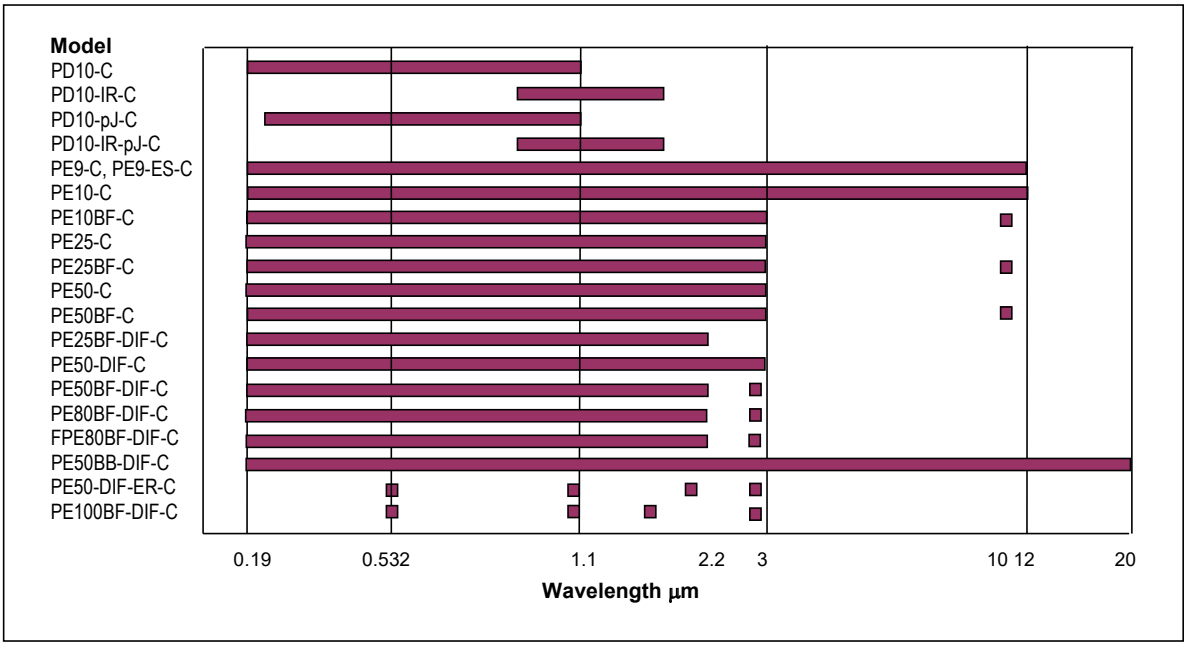


Damage Threshold vs. Pulse Width

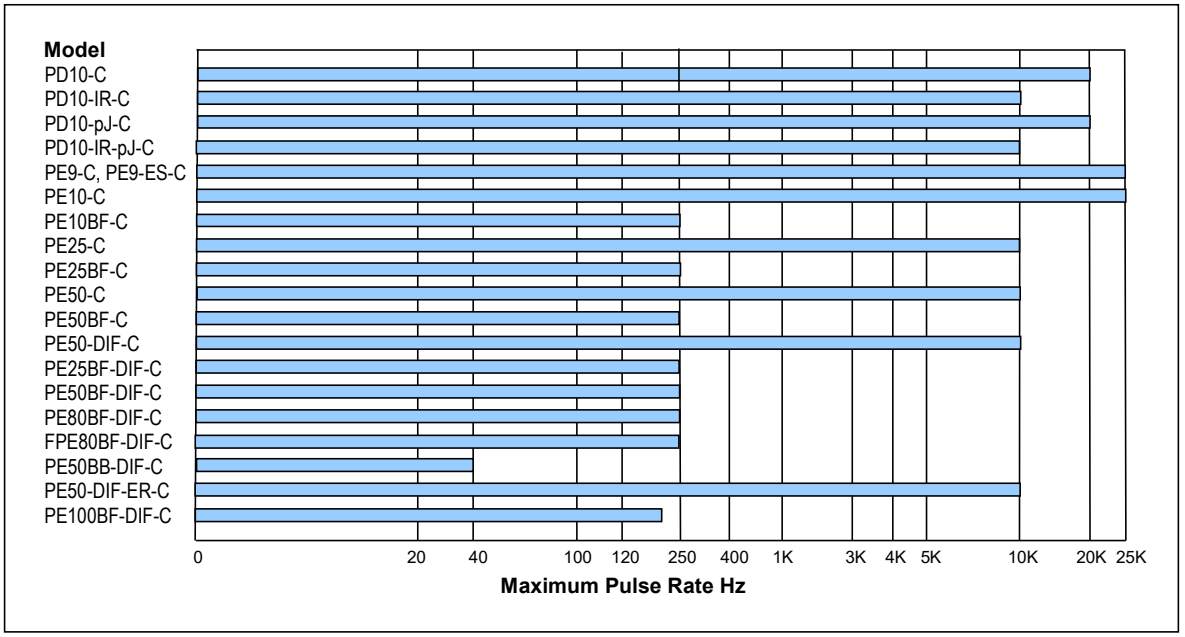


Wavelength Range and Repetition Rate for Energy Sensors

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

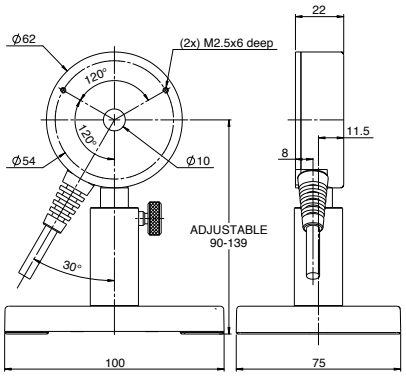
Model	PD10-C		PD10-IR-C		PD10-pJ-C		PD10-IR-pJ-C	
Use	**Low energies**		**Infrared**		**Lowest energies**		**Infrared, lowest energies**	
Aperture mm	Ø10		Ø5		Ø10		Ø5	
Absorber Type	Si photodiode		Ge photodiode		Si photodiode		Ge photodiode	
Spectral Range µm [a]	0.19 - 1.1		0.7 – 1.8		0.2 - 1.1		0.7 - 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.

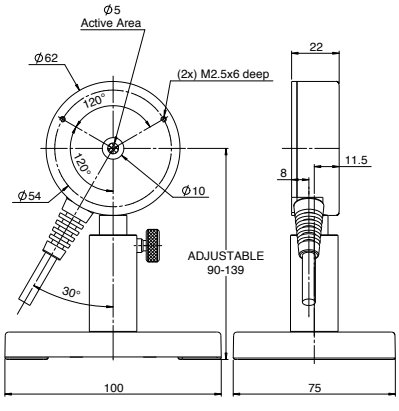
Note: (c) Additional Error with Frequency of ±1% on ly for energies up to 2µJ. For higher energies ±1% up to 10kHz, -4% at 20kHz.

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

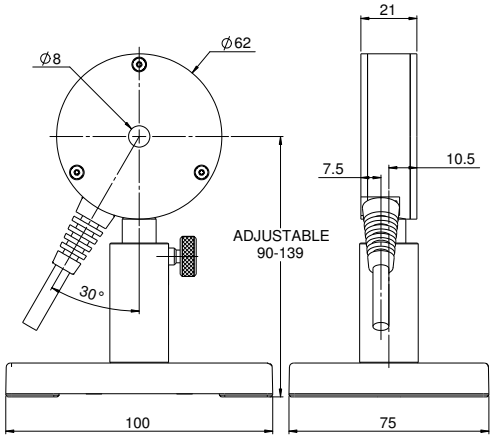
PE9-C / PE9-ES-C

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%	

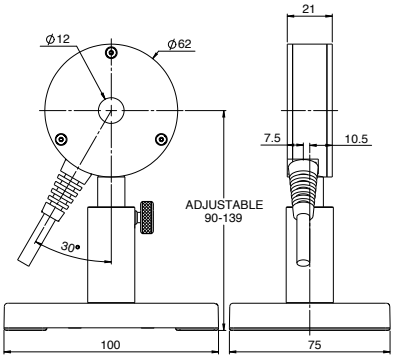
Note: (b) For wavelenghts below 600nm, derate damage threshold to 60% of given values. Below 300nm, derate to 40% of given values.

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

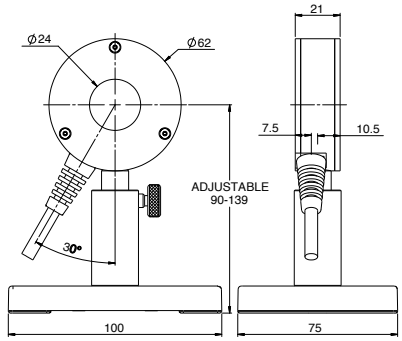
Model	**PE50BF-DIF-C / PE50BF-DIFH-C**					**PE50BB-DIF-C**					
Use	**Complete calibration curve. Highest damage threshold**					**Removable diffuser. Spectrally flat**					
Diffuser	Fixed					Diffuser out			Diffuser in		
Aperture mm	Ø35					Ø46			Ø33		
Absorber Type	BF with diffuser					BB			BB with 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.

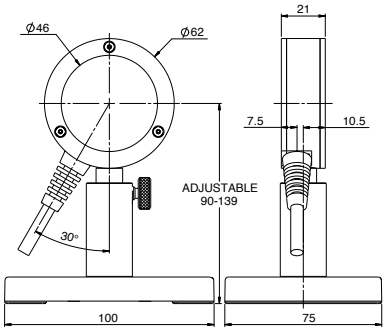
Notes: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the pulse width settings are available. For the PE-BF models the 1ms and 10ms settings and for the PE-BB model the 3ms and 10ms settings. Furthermore, with the diffuser mounted, the sensor may saturate at lower 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

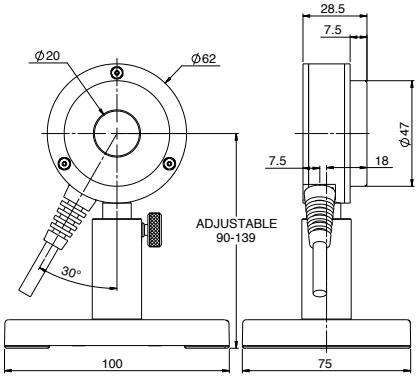
PE25-C / PE25BF-C



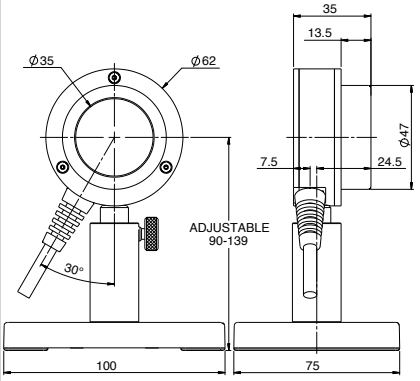
PE50-C / PE50BF-C



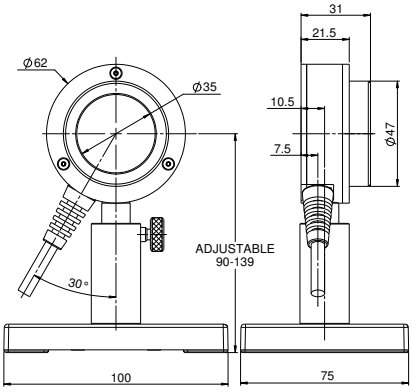
PE25BF-DIF-C



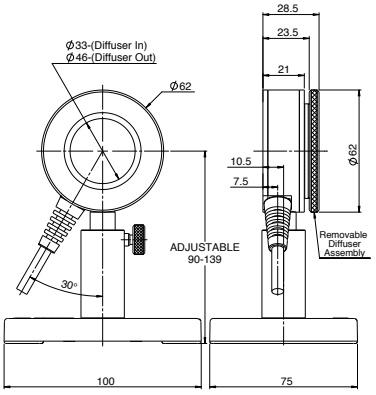
PE50BF-DIF-C / PE50-DIF-C



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

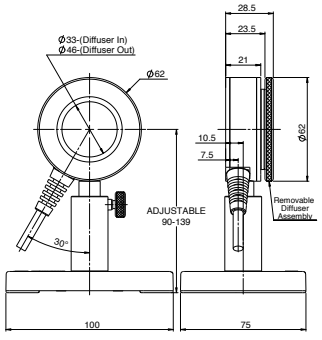
DIFFUSER IN DIFFUSER OUT

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				

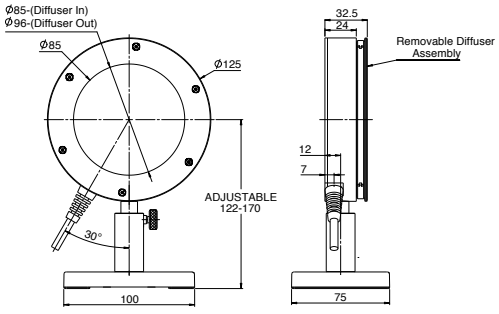
Notes: (b) With the "user threshold" setting set to minimum. For other settings, the spec is for >10% of full scale or greater than twice the "user threshold", whichever is greater. For use with StarBright, StarLite, Nova II, Vega, Juno and EA-1. The sensors will operate with older Ophir meters and PC 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.

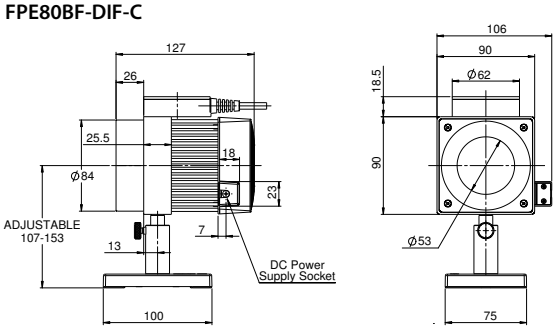
Notes: (d) With the Laserstar, Pulsar, USBI, Quasar and Nova/Orion with adapter only 2 of the pulse width settings are available, the 1ms and 10ms settings.

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

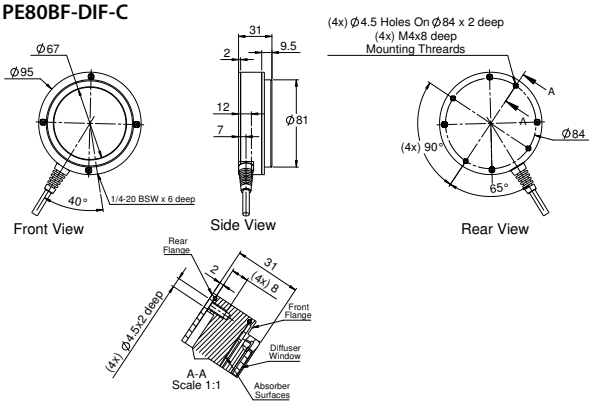
Notes: (f) For powers below 50W it is recommended to work with the fan off. If working with the fan on, the threshold must be set to 6% and the lowest measurable energies will be as follows:

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

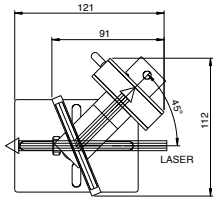
1.2.4.1 Accessories for Pyroelectric Sensors

Fiberoptic Adapter for Pyroelectric Sensors

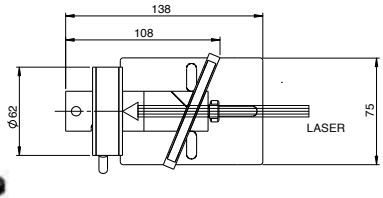
Oscilloscope Adapter for Pyroelectric Sensors

Heat Sink for PE-C Series Sensors

Beam Splitter Assembly



Beam splitter installed – reflected beam on sensor

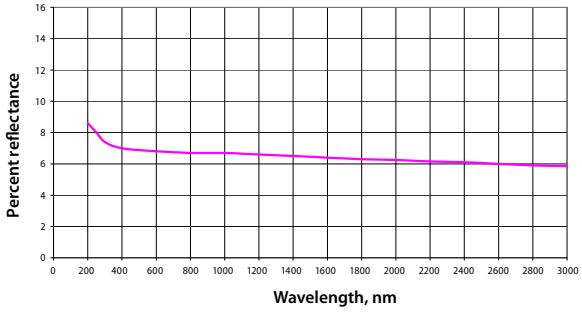


Beam Splitter removed – direct beam on sensor

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



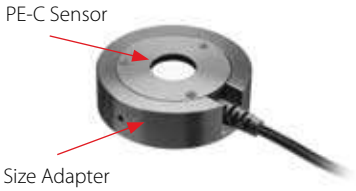
Accessory	Description	Part number			
Heat Sink	Heat sink that screws onto rear of PE25 and PE50 series sensors and allows working at over 50% higher average powers.	7Z08267			
Scope Adapter	Plugs in between the PE sensor and power meter. Provides BNC output to scope to see every pulse up to the maximum 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

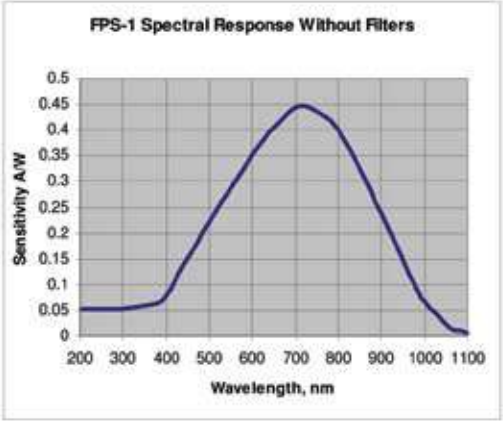
The FPS-1 fast photodetector is a compact easy to use very fast photodetector with wide spectral response. It is used to measure the temporal pulse shape of laser pulses.

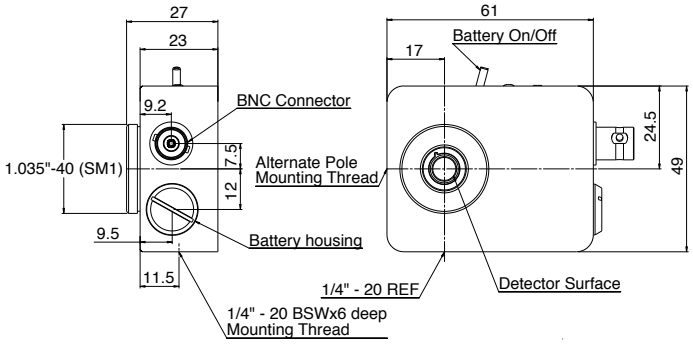
It has two modes of operation: Into 50Ohm load for ns high peak power pulses and 10kOhm load for longer lower peak power pulses.

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

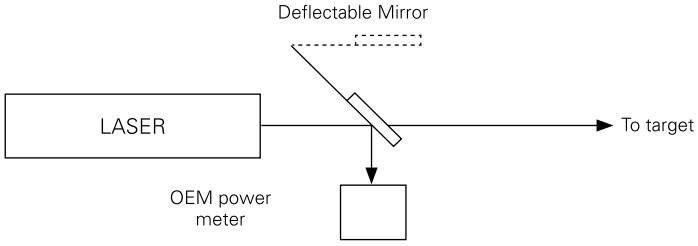
1.3.2.1 Sensor Usage

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:

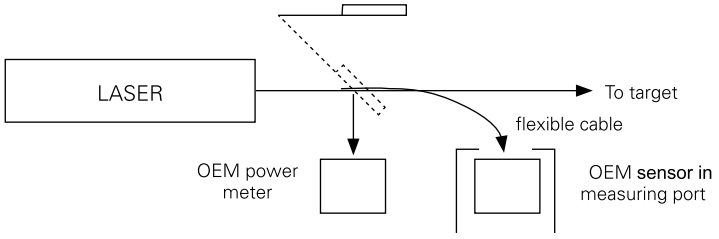
1. Beam Dump Mode

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**

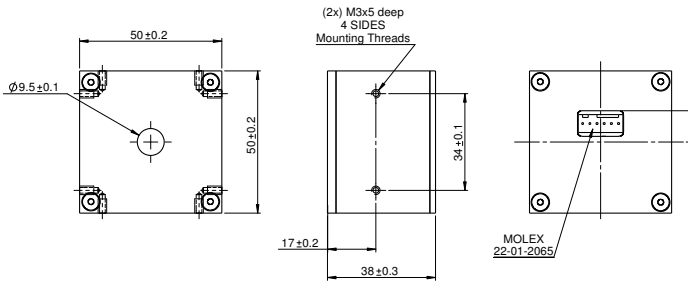
Note: (a) With analog "UA/UAS" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage.

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

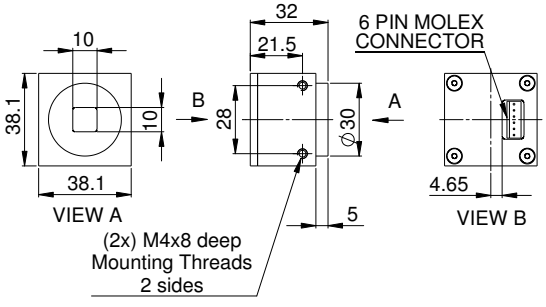
Note: (c) Calibrated at customer selected wavelength or wavelengths

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

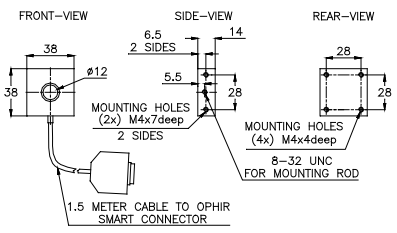
- Conduction cooled
- Thermal sensors are spectrally flat
- Analog, RS232 or USB compatible output

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

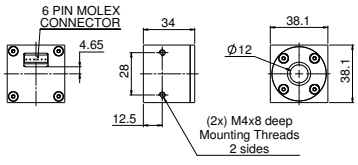
These specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

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		

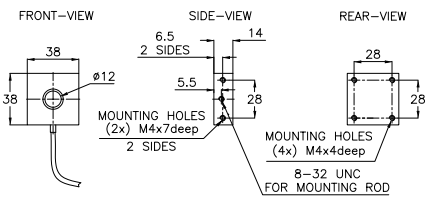
20C-SH



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%

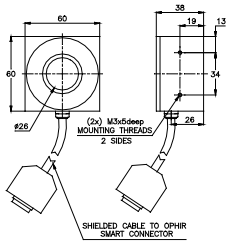
Note: (e) From 20J to 2000J

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

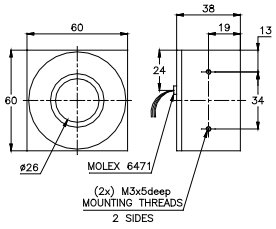
Note: (g) Recommended exposure times and 1/e² Gaussian beam diameters for very long pulses.
Total energy for a series of measurements should not exceed 2kJ. Recommended time between shots 12s.

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

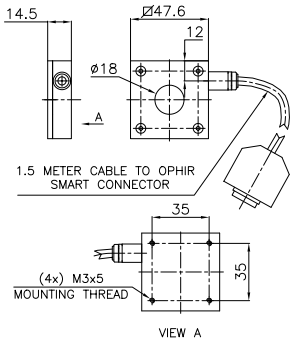
100C-SH / 100C-UA / 100C-UAU

100W-AXL-UAF

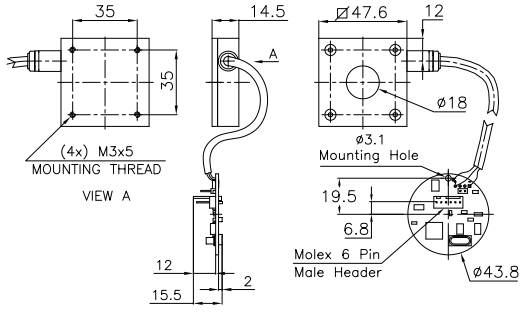
The following specifications refer to standard Customized Solutions (OEM) sensors, and are to be understood as generic, describing sensor families. Ophir will be happy to help you with a specific solution for your particular application.

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		

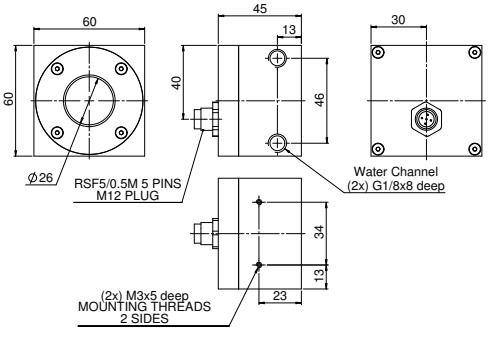
100C-SH



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

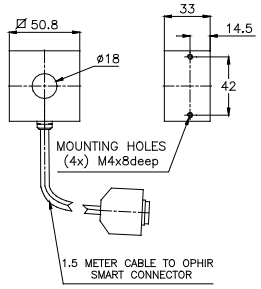
150W-UA / 150W-UAU

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.

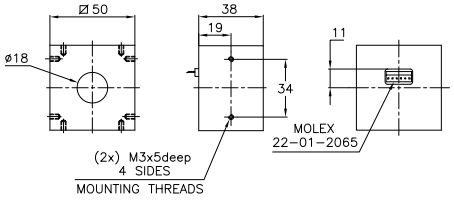
Model	**150C-SH**	**150C-UA**	**150W-UA**	**150C / W-UAU**
Type	**Smart sensor**	**Digital RS232 connection analog or digital output**	**Digital RS232 connection analog or digital output**	**Same as UA but with digital mini USB connection digital output only**
Features	**High power, smart sensor**	**High 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

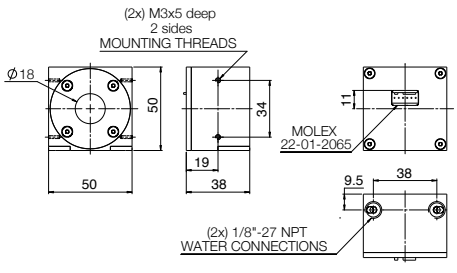
150C-SH



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**

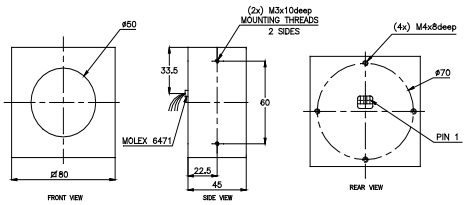
Note: (a) With analog "UA" version, maximum power is also limited by maximum output voltage where output voltage is at most 2V less than input voltage

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

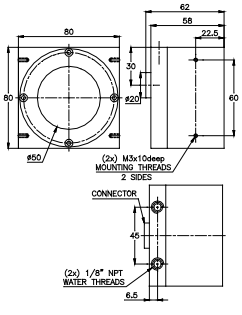
Note: (c) Calibrated at customer selected wavelength

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

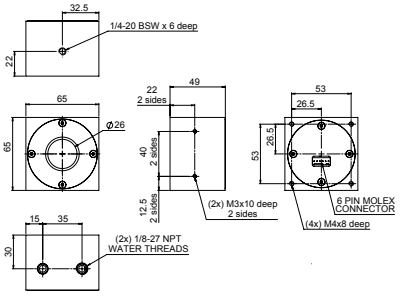
L150C-UA



L250W-UA / L300W-UA



600W-UA



1.3.2.4 EA-1 Compact Ethernet Adapter

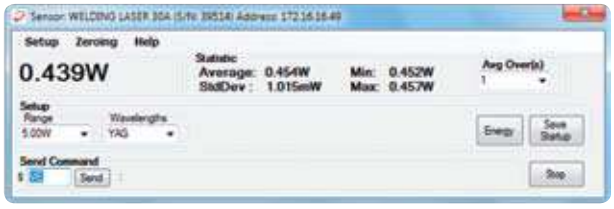
Connects your Ophir sensor to an Ethernet bus

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.

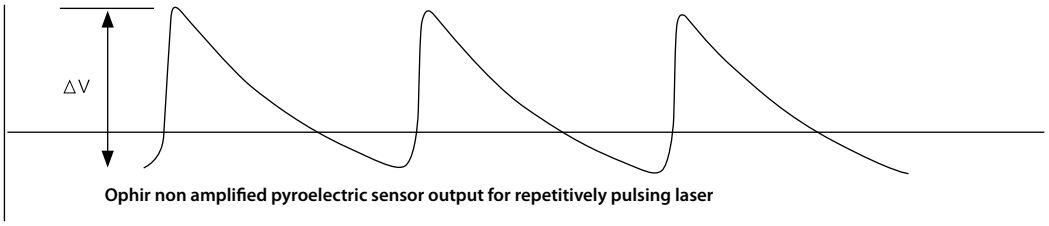
1.3.3 Pyroelectric Customized Solutions (OEM) Sensors

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

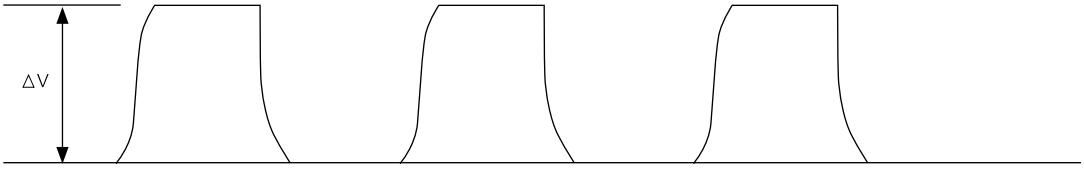
Typical output from a non amplified pyroelectric sensor appears as follows:



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

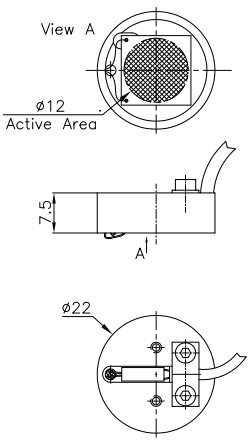
Features

- 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

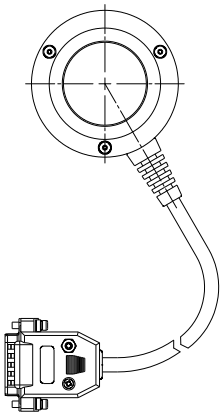
Pyroelectric Customized Solutions (OEM) products – Examples only – many variations are possible

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)

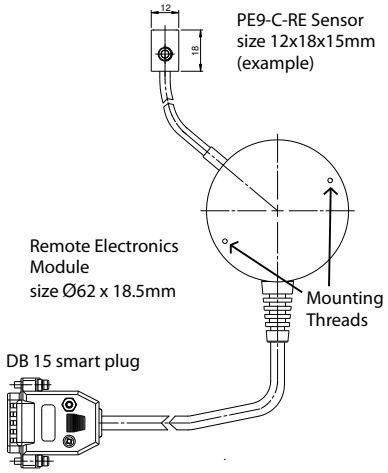


PE XX-C-RS232 (example)



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

Miniature PE9-C-RE (example)



Power Meters

2.0 Power Meters & Interfaces

Power Meter Finder

The table below lists the specs and features of Ophir Power Meters and PC Interfaces

Meters	StarBright	Vega	Nova II	StarLite	LaserStar Single & Dual Channel	Nova
Digital Display	Yes	Yes	Yes	Yes	Yes	Yes
Display Color	Color	Color	Monochrome	Monochrome	Monochrome	Monochrome
Analog Display	Yes	Yes	Yes	Yes	No	No
Rechargeable Battery	Yes	Yes	Yes	Yes	Yes	Yes
Detector Support (see compatibility table below)						
Thermal Sensors	Yes	Yes	Yes	Yes	Yes	Yes
Photodiode Sensors	Yes	Yes	Yes	Yes	Yes	Yes
Pyroelectric Sensors	Yes	Yes	Yes	Yes	Yes	Yes
BeamTrack Sensors	Yes	Yes	Yes	Yes	No	No
Measurement Options						
Average Power	Yes	Yes	Yes	Yes	Yes	Yes
Energy per Pulse (Pyro. Sensors)	Yes	Yes	Yes	Yes	Yes	Yes
Single Shot Energy (Thermal Sensors)	Yes	Yes	Yes	Yes	Yes	Yes
Statistics	Yes	Yes	Yes	No	Yes	Yes
Analog Out	1V,2V,5V,10V	1V,2V,5V,10V	1V,2V,5V,10V	1V	1V	1V
Trigger input & output	No	No	No	No	No	No
Real-Time Logging						
RS232	30Hz	30Hz	30Hz	N/A	30Hz	10Hz
GPIB	N/A	N/A	N/A	N/A	1500Hz	N/A
USB	5000Hz	2000Hz	2000Hz	20Hz*	N/A	N/A
Bluetooth	N/A	N/A	N/A	N/A	N/A	N/A
On-Board Data Storage	>10M**	250K	50K	No	50K	1K
Automation Interface	Yes for USB	Yes for USB	Yes for USB	Yes*	No	No
Labview VI's	Yes	Yes	Yes	Yes*	Yes	Yes
Part number	7Z01580	7Z01560	7Z01550	7Z01565	7Z01600/ 7Z01601	7Z01500
Page in the catalog	120	122	124	126	128	130

* With USB activation code (see page 127)

** Depends on size of USB Flash Drive

Compatibility Table

Meter / Interface / Sensor	StarBright	Vega/ Nova II	StarLite	LaserStar	Nova/ Orion	Juno	EA-1	Pulsar	USBI	Quasar
Standard Thermal sensors*	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
LP2 type Thermal sensors	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
LP1 type Thermal sensors	yes	yes	yes	Has discrete wavelengths only	Has discrete wavelengths only	yes	yes	yes	yes	yes
PF-DIF type Thermal sensors	yes	yes	yes	Has discrete wavelengths only	Has discrete wavelengths only	yes	yes	yes	yes	yes
BeamTrack Sensors	yes	yes	yes	Power/ energy only	Power/ energy only	yes	yes	Power/ energy only	Power/ energy only	Power/ energy only
Standard Photodiode sensors**	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
BC20 sensor	yes	yes	Measures static beams only	Has discrete wavelengths only	Has discrete wavelengths only	yes	no	Measures static beams only	Measures static beams only	Measures static beams only
PD300-CIE sensor	yes	yes	no	yes	yes	yes	no	no	no	no
PD300RM sensors	yes	no	yes	no	no	no	no	no	no	no
PE-C Pyroelectric sensors	yes	yes	yes	Limited functions. See catalog notes	Needs adaptor (P/N 7Z08272) Limited functions. See catalog notes	yes	yes	Limited. See notes in sensor page	Limited. See notes in sensor page	Limited. See notes in sensor page
Previous generation Pyroelectric Sensors (non PE-C)	no	yes	no	yes	yes	yes	no	yes	yes	yes
RP sensors	no	no	no	yes	no	no	no	no	yes (with RP-USB s/w)	no

* Meaning all thermal sensors not listed as exceptions in above table.

** Meaning all photodiode sensors not listed as exceptions in above table.





PC Interfaces Juno	EA-1	Pulsar-1/2/4	USBI	Wireless Interface Quasar
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
Powered from USB	No	No	Powered from USB	Yes
Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes
Yes	Yes	No	No	No
Yes	Yes	Yes	Yes	Yes
Yes	N/A	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes
No	No	No	1V	No
No	No	Yes	No	No
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
10,000Hz	N/A	25,000Hz	2000Hz	N/A
N/A	N/A	N/A	N/A	500Hz
No	N/A	No	No	No
Yes	Yes for Ethernet	Yes	Yes	No
Yes	No	Yes	Yes	No
7Z01250	7Z08296	7Z01203 / 7Z01202 / 7Z01201	7Z01200	7Z01300
134	135	136	136	137

Ophir power meters are true plug-and-play instruments. With all sensor information and calibration stored in the sensor plug, just plug in any one of over 150 Ophir sensors and the instrument is calibrated and configured to measure laser power and energy with that sensor.

Comparison of Hand Held Meters

Meter	StarBright	Vega	Nova II	StarLite	Nova
Supported Sensors					
Standard Thermopile, Photodiode, PyroC sensors	X	X	X	X	X (with adaptor)
BeamTrack	X	X	X	X	
BC20	X	X	X		X
PD300-CIE	X	X	X		X
PD300RM	X			X	
Measurement Capabilities					
Parameter Configuration	X	X	X	X	X
Power, Energy	X	X	X	X	X
Exposure with PyroC Sensor	X	X	X		X
Position and Size with BeamTrack Sensors	X	X	X	X	
Beam Stability with BeamTrack Sensors	X	X	X		
Pulsed Power with Thermopile Sensors	X				
Irradiance and Dosage	X			X	
Exposure with Photodiode Sensors	X				
Density	X	X	X		X
Scale Factor	X	X	X		X
Normalize	X	X	X		
Fixed Offset	X				
Mixing Functions Together	X				
Showing Function Results in Graphical Display	X				
Graphical Displays Available at All Times					
Bargraph	X	X	X	X	X
Simulated Analog Needle	X	X	X	X	
Pass/Fail	X	X	X		
Line Graph for Both Power and Energy	X				
Pulse Chart for Both Power and Energy	X				
Real Time Statistics (not just when logging)	X				
Screen Specs					
Screen Size	3.5"	3.5"	4"	3.5"	2"
Color Screen	X	X			
Logging					
Total Log Size (shared between all files)	Unlimited	250000	50000	0	1000
Max Number of Files	Unlimited	10	10	0	1
TimeStamp in Logged Data	X				
Logging of Math Function Results	X				
PC Communications					
StarLab Support	X	X	X	X	
RS232	X	X	X		X
USB	X	X	X	X	
LabVIEW Library	X	X	X	X	X
Max Real Time Delivery	5000	2000	2000	20	15
Other Features					
Analog Output (in Volts)	1,2,5,10	1,2,5,10	1,2,5,10	1	1
Calibration Reminder	X	X	X		
Japanese	X	X	X	X	
Russian and Chinese	X			X	
Built in Help	X	X	X		

Power Meters and PC Interfaces

Ophir power meters and PC interfaces work on the smart plug principle. This means that almost any Ophir power meter or PC interface can work – plug and play – with almost any of the wide range of Ophir sensors. Ophir power meters are also the most sensitive, lowest noise, most precisely calibrated units on the market thus giving the utmost performance from our smart sensors.
As for ease of use, only Ophir power meters have smart keys to give the easiest and most convenient user interface. The units also come with a versatile range of software to use seamlessly either with the Ophir software or the user's own.

Photodiode Sensors
Powers pW to Watts

Thermal Sensors
Powers mW to kW and single shot energy

Pyroelectric Sensors
Energies pJ to Joules
Rep rates to 25kHz

Power Meters
with USB/RS232

Computer Interfaces
with USB/Bluetooth/Ethernet

StarBright
added features

Vega
color

Nova II
general

EA-1
Ethernet

Pulsar
1 ,2 ,4 channels

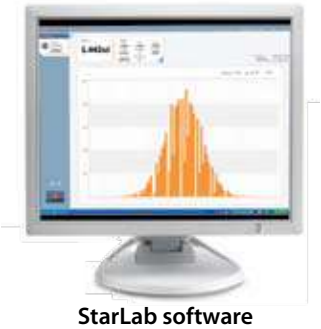
StarLite
basic

Nova
rugged

Laser Star
2 channel

Quasar
wireless

Juno
compact



StarLab software

Software Solutions
StarLab, LabVIEW, StarCom & COM Object

LabVIEW

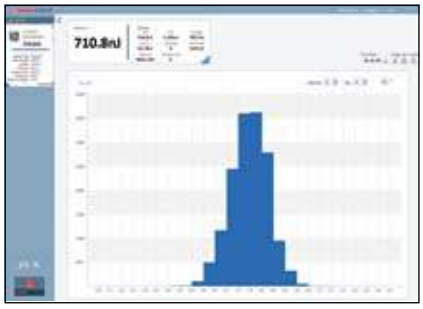
2.1 Power Meters

2.1.1 StarBright

Feature Rich Laser Power/Energy Meter

- Compatible only with all standard Ophir thermal, BeamTrack, pyroelectric (PE-C series only) and photodiode sensors
- Brilliant color large size TFT 320x240 display
- Choose between Digital with Bargraph, Analog Needle, Line Plot (for laser tuning), Pulse Chart, Pass/Fail, Position, Stability, Real Time Statistics displays
- Sophisticated power and energy logging, including logging every point at up to 5000Hz with Pyro sensors
- Math functions for advanced processing such as Density, Scale Factor, Normalize against base line, etc.
- Can mix functions together and display the results graphically. Function results can also be logged
- USB Flash Drive for nearly unlimited data storage
- USB and RS232 interfaces with StarLab PC applications and User Commands document
- LabVIEW driver and COM Object Interface
- New: Pulsed Power measurements with Thermopile detectors
- New: Exposure measurement (Energy Summing) with Photodiode detectors
- Select between English, Japanese, Russian, and Chinese interfaces
- Soft keys and menu driven functions with context sensitive help
- Compact handheld design with rubberized bumpers and optimized kickstand
- Backlighting and rechargeable battery
- Scalable Analog Output

StarBright is the most feature rich handheld laser power/energy meter on the market. Just plug in one of the many Ophir sensors and you have a whole measurement laboratory at your fingertips. The bright color display gives unparalleled legibility and ease of interpreting information. StarBright has many on board features such as laser tuning, data logging, graphing, normalize, power or energy density, attenuation scaling, max and min limits. StarBright can also display the power or energy as a high resolution simulated analog needle display.



StarBright can be either battery operated or from an AC source with the charger plugged in at all times. Its bright display and user-selectable color format enables ease of use in dark room conditions or when wearing protective glasses.

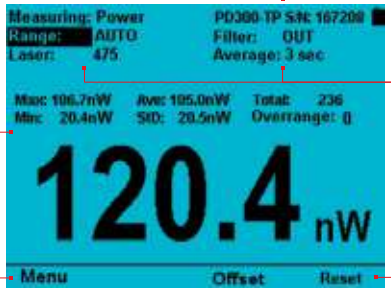
The built-in USB and RS232 interfaces and StarLab PC software allow display and processing of data either in real time or from previously stored data. Results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers, a COM Object Interface and demo source code are provided.

StarBright Screen Layout

StarBright screen ergonomics raise the user experience to new levels. The display is carefully designed to provide easy reading of the laser measurement, quick access to configuration parameters as well as the ability to set up for more advanced work.

Select measurement mode (power, energy, etc.)

Sensor name and serial number



Configuration parameters for laser measurement. These settings are sensor specific and saved in the sensor's memory.

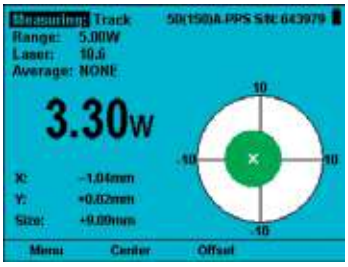
Measurement display area. User can select the display type. In this example, the user has chosen large numeric readout with real time statistics.

Softkeys for additional display functionality. In this example, press Offset to remove background noise from the measurement. Press Reset to clear the statistics and start over.

Press the Menu key to access additional StarBright functions including logging, pass/fail inspection and math processing.

Selected Screens

Analog needle display of power Persistence and min/max tracking.

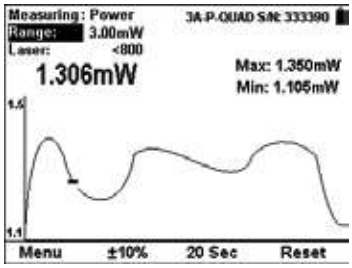


Power, Position, and Size measured with a BeamTrack sensor.

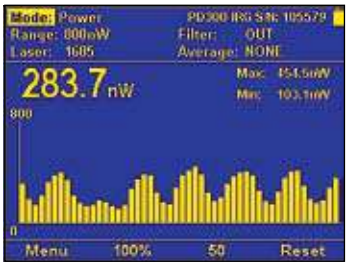
Bargraph display of energy. Colors set for work with protective glasses.

Power density measured after rescaling the power measurement.

Data logs filed to USB Flash Drive. Can be viewed in StarLab or Excel.

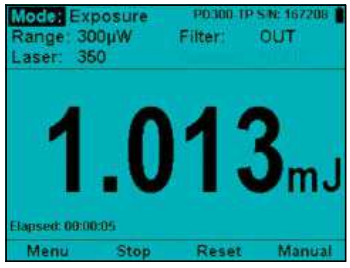


Line graph display of power. Wraps back to start for continuous display.



Pulse chart display of power.

Power measurement of laser pulse. For use with high-power pulsed lasers.



Exposure measurement (energy summing) with photodiode sensor.

Specifications

Power Meter	Brilliant color TFT 320 x 240 pixel graphics LCD. Large 16mm digits.
Features	Many screen features including power with multicolor bar graph, energy, average, exposure, frequency, graphs, scaling, special units, and more.
Outputs	USB, RS232 and user selectable 1, 2, 5 and 10 Volt full scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with optimized angle kickstand. Rubberized sides for easy grip and protection against damage.
Size	Folds to a compact 213mm L x 113mm W x 40mm H
Battery	Rechargeable Li-ion batteries with typically 8 hours between charges. The charger can be ordered from your local distributor. The charger also functions as an AC adapter.
Data Handling	Data can be viewed on board or transmitted to PC On Board: Data stored to USB Drive (Thumb Drive) at rates up to 5000 points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric (PE-C series) and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors. Works with our new PD300RM sensors.
Program Features	Preferred start up configuration can be set by user. User can recalibrate power, energy, response time and zero offset.

Ordering Information

Item	Description	Ophir P/N
StarBright	StarBright universal power meter for Thermal, BeamTrack, Pyroelectric and Photodiode sensors	7Z01580
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to 3 sensors	1J02079
StarBright USB Cable	USB-A to MICRO-B cable for field upgrade support (1 unit supplied with StarBright)	7E01279
StarBright RS232 Cable	D9 to 3.5mm plug cable (1 unit supplied with StarBright)	7E01213
StarBright Battery Pack	Replacement battery pack for StarBright	7E14008
P Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A P-1.35x3.5 (1unit supplied with StarBright)	7E05047
Standard Analog Output Connector	2.5mm mono jack (1unit supplied with StarBright)	7E02008

2.1.2 Vega

Color Screen Laser Power/Energy Meter

- Compatible with all standard Ophir thermal, BeamTrack, pyroelectric and photodiode sensors
- Brilliant color large size TFT 320x240 display
- Compact handheld design with rubberized bumpers and optimized 2 position kickstand
- Choice of digital or analog needle display
- Illuminated keys for working in the dark
- Analog output
- Log every point at up to 4000Hz with pyro sensors
- Non volatile data storage up to 250,000 points
- Laser tuning screen and power and energy log
- USB and RS232 interfaces with StarLab and StarCom PC applications, LabVIEW driver and COM Object Interface (see pages 139-145)
- Soft keys and menu driven functions with on line help
- Many software features such as density, min/max, scaling etc.

The Vega is the most versatile and sophisticated handheld laser power/energy meter on the market. Just plug in one of the many Ophir sensors and you have a whole measurement laboratory at your fingertips. The bright color display gives unparalleled legibility and ease of interpreting information. The Vega has many on board features such as laser tuning, data logging, graphing, normalize, power or energy density units, attenuation scaling, max and min limits. The Vega can also display the power or energy with a high resolution simulated analog needle display.

The Vega can be operated either by battery or from an AC source with the charger plugged in at all times. Its bright display and backlit keys allow easy use in dark room conditions or with laser glasses on.

The built-in USB and RS232 interfaces and StarLab and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers and COM Object Interface are provided.

StarLab Software

Selected Screens

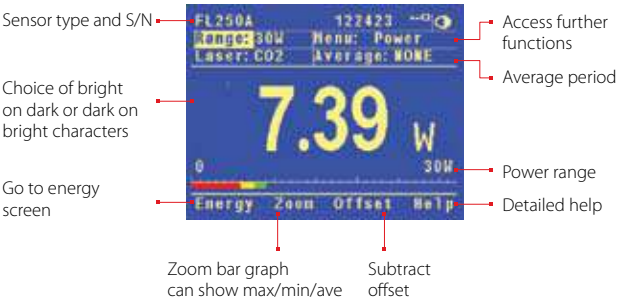
Digital Power Screen and Color Functions

- Choice of bright on dark or dark on bright characters
- Optimize colors for use with laser eye protection glasses
- Can average over selected period. Useful for unstable lasers
- Bar graph can show max / min / average in different colors

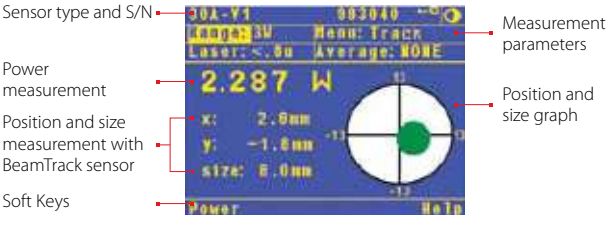
BeamTrack Power/Position/Size Screen

- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Beam position and wander
- All the other features of standard power/energy meters

Standard Power Screen

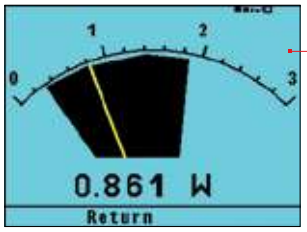


BeamTrack Power/Position/Size Screen



Analog Power Screen

- Perfect for adjusting and maximizing laser power
- Persistent graphical display allows tracking of minimum maximum values measured
- Large analog needle with small digital display as well



Choice of smaller display with range, menu, laser and average headers.

Energy/Limits Screen

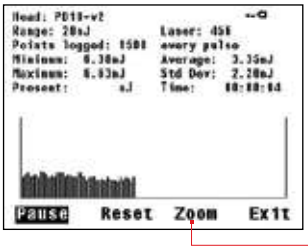
- Pulsed energy sensors (single or repetitive) and thermal sensors (single shot only).
- Frequency measurement with pulsed energy sensors.
- Limits screen with bright colored warning

Energy threshold

Energy range

Energy Logging Screen

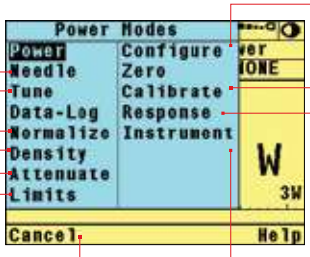
- Pyroelectric and thermal sensors
- Continuous scroll with up to 100 points on screen
- Full statistics
- Store data onboard and recall



Enlarge variation pulse to pulse

Additional Functions

- Press the menu choice on the main screen and many more options pop up as shown



Choose analog needle screen

Laser tune screen with continuous graph

Normalize so present reading is 1.00

Enter beam diameter and read in units of W/cm^2 or J/cm^2

Put in factor to read input power with attenuator or beam splitter

Set for alarm if preset min or max limits exceeded

Return to previous menu

Set startup configuration

Adjust sensor calibration

Adjust sensor response time

Adjust power meter parameters

Specifications

Power Meter	Brilliant color TFT 320 x 240 pixel graphics LCD. Large 16mm digits. High resolution analog needle also can be chosen.
Features	Many screen features including power with multicolor bar graph, energy, average, exposure, frequency, graphs, scaling, special units, and more. Complete on line context sensitive help screens.
Outputs	USB, RS232 and user selectable 1, 2, 5 and 10 Volt full scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with optimized angle two level kickstand. Rubberized sides for easy grip and protection against damage.
Size	Folds to a compact 208mm L x 117mm W x 40mm H
Battery	Rechargeable NiMH batteries with typically 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as an AC adapter.
Data Handling	Data can be viewed on board or transmitted to pc: On Board: Non volatile storage of up to 250,000 data points in up to 10 files. Max data logging rate 4000[(a)] points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred start up configuration can be set by user. User can recalibrate power, energy, response time and zero offset.
Notes: (a)	The above refers to the rate of logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.

Ordering Information

Item	Description	Ophir P/N
Vega	Vega color universal power meter for standard thermal, BeamTrack, pyroelectric and photodiode sensors	7Z01560
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to 3 sensors	1J02079
USB Cable for Vega	USB to mini DIN cable (1 unit supplied with Vega)	7E01205
RS232 Cable for Vega	D9 to mini DIN cable (1 unit supplied with Vega)	7E01206
Battery Pack for Vega	Replacement battery pack for the Vega	7E14007
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with Vega)	7E05029
Standard Analog Output Connector	2.5mm mono jack (1 unit supplied with Vega)	7E02008

2.1.3 Nova II

Versatile Laser Power/Energy Meter

- Compatible with all standard Ophir thermal, BeamTrack, pyroelectric and photodiode sensors
- Large high definition LCD display
- Choice of digital or analog needle display
- 2 position kickstand
- Backlighting and rechargeable battery
- Analog output
- Log every point at up to 4000Hz with pyro sensors
- Non volatile data storage up to 59,400 points
- Laser tuning screen and power and energy log
- USB and RS232 interfaces with StarLab and StarCom PC applications, LabVIEW driver and COM Object Interface (see pages 139-145)
- Soft keys and menu driven functions with on-line help
- Many software features such and density, min/max, scaling etc.

The Nova II is the most versatile and sophisticated handheld laser power/energy meter on the market. Just plug in one of the many Ophir sensors and you have a whole measurement laboratory at your fingertips. The Nova II has many on-board features such as laser tuning, data logging, graphing, normalize, power or energy density units, attenuation scaling, max and min limits. The Nova II can also display the power or energy with a high resolution simulated analog needle display.

The Nova II can be operated either by battery or from an AC source with the charger plugged in at all times. Its backlight allows illumination of the power meter in low light conditions.

The built-in USB and RS232 interfaces and StarLab and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers and COM Object Interface are provided.

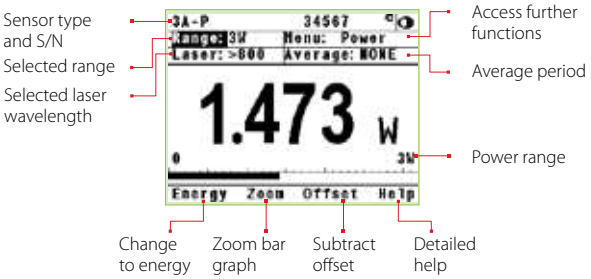
StarLab Software

Selected Screens

Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to Multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers
- Fast response bar graph

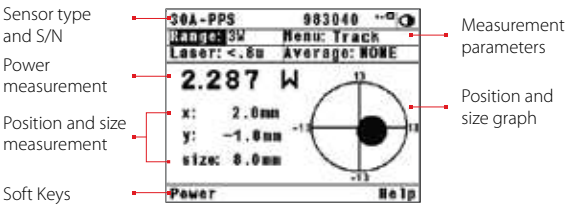
Standard Power Screen



BeamTrack Power/Position/Size Screen

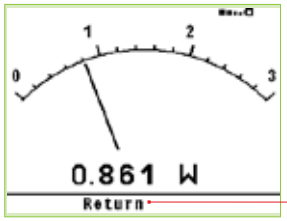
- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Beam position and wander
- All the other features of standard power/energy meters

BeamTrack Power/Position/Size Screen



Analog Power Screen

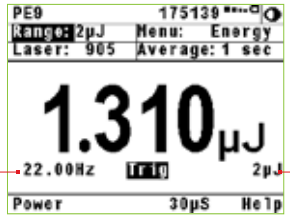
- Perfect for adjusting and maximizing laser power
- Large analog needle with small digital display as well



Choice of smaller ,display with range menu, laser and average headers

Energy Screen

- Pulsed energy sensors (single or repetitive) and thermal sensors (single shot only)
- Frequency measurement with pulsed energy sensors

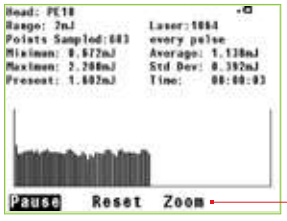


Frequency

Energy range

Energy Logging Screen

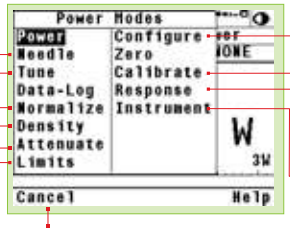
- Pyroelectric and thermal sensors
- Continuous scroll with up to 100 points on screen
- Full statistics
- Store data onboard and recall



Enlarge variation pulse to pulse

Additional Functions

- Press the menu choice on the main screen and many more options pop up as shown



Choose analog needle screen

Laser tune screen with continuous graph

Normalize so present reading is 1.00

Enter beam diameter and read in units of W/cm^2 or J/cm^2

Put in factor to read input power with attenuator or beam splitter

Set for alarm if preset min or max limits exceeded

Set startup configuration

Adjust sensor calibration

Adjust sensor response time

Adjust power meter parameters

Return to previous menu

Specifications

Power Meter	High legibility 320 x 240 pixel graphics LCD with switchable electroluminescent backlight. Large 18mm digits. High resolution analog needle also can be chosen.
Features	Many screen features including power with bar graph, energy, average, exposure, frequency, graphs, scaling, special units, and more. Complete on line context sensitive help screens.
Outputs	USB, RS232 and 1, 2, 5 and 10 volt full scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with two level kickstand.
Size	Folds to a compact 208mm Lx 117mm Wx 40mm H
Battery	Rechargeable NiMH batteries with typically 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as an AC adapter.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Non volatile storage of up to 54000 data points in up to 10 files. Max data logging rate 4000 [(a)] points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with Thermopile, BeamTrack, Pyroelectric and Photodiode sensors. Automatic continuous background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred startup configuration can be set by user. User can recalibrate power, energy, response time and zero offset.
Notes: (a)	The above refers to the rate of logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.

Ordering Information

Item	Description	Ophir P/N
Nova II	Nova II universal power meter for standard thermal, BeamTrack, pyroelectric and photodiode sensors	7Z01550
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to three sensors	1J02079
Nova II USB Cable	USB to mini DIN cable (1 unit supplied with Nova II)	7E01205
Nova II RS232 Cable	D9 to mini DIN cable (1 unit supplied with Nova II)	7E01206
Battery Pack	Replacement battery pack for the Nova II	7E14007
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with Nova II)	7E05029
Standard Analog Output Connector	2.5mm mono jack (1 unit supplied with Nova II)	7E02008

2.1.4 StarLite

Low Cost Laser Power / Energy Meter

- Compatible with all standard Ophir Thermal, BeamTrack, Pyroelectric (PE-C series only) and Photodiode sensors
- Brilliant large size TFT 320x240 display
- Compact handheld design with rubberized bumpers and optimized kickstand
- Choice of digital or analog needle display
- Analog output
- Easy to use soft keys
- Easy measurement configuration with context sensitive help
- Backlighting and rechargeable battery
- Single shot energy measurement with thermal sensors
- Power averaging
- Resizable Screen graphics
- EMI rejection
- Optional software package for USB communication with our StarLab PC suite

StarLite is a low cost power / energy meter capable of measuring power or energy from pJ and pW to hundreds of Joules and thousands of Watts. It also supports position and size measurement with the BeamTrack family of sensors. StarLite can also display the power or energy with a high resolution simulated analog needle display.

All StarLite measurement screens can be configured to either show the measurement parameters or to hide them in order to maximize the graphical and numeric displays.

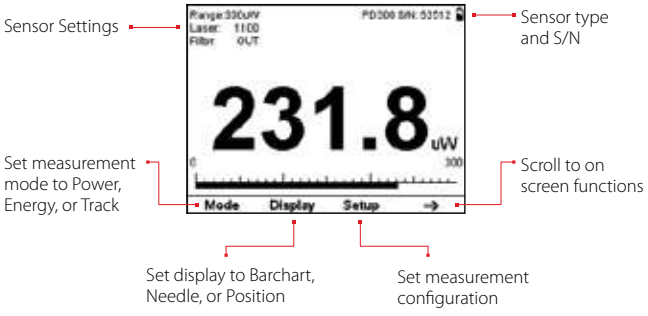
StarLite can be operated either by battery or from an AC source with the charger plugged in at all times. Its backlight allows illumination of the power meter in low light conditions.

Selected Screens

Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to Multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers.
- Fast response bar chart

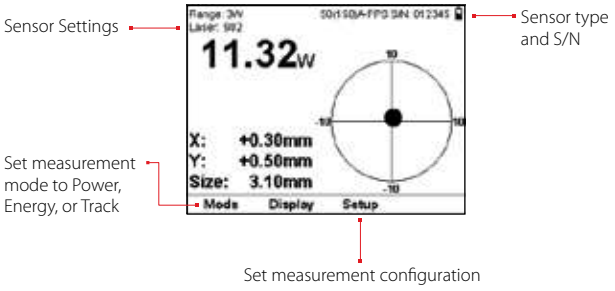
Barchart Display of Power Measurement



BeamTrack Power/Position/Size Screen

- Monitoring of laser beam size
- Accurate tracking of beam position to fractions of a mm
- Power measured at the same time

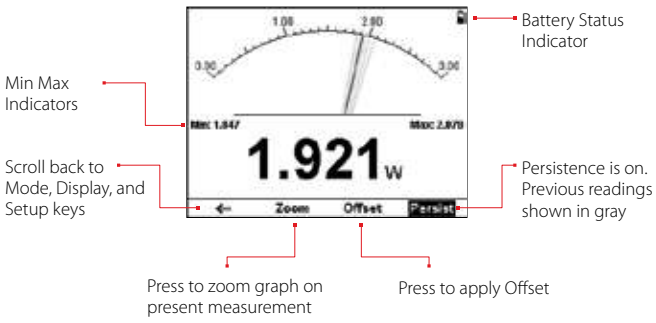
BeamTrack Position and Size Screen



Analog Needle Screen

- Perfect for adjusting and maximizing laser power or energy
- Persistent graphical display allows tracking of minimum maximum values measured
- Large analog needle with small digital display as well

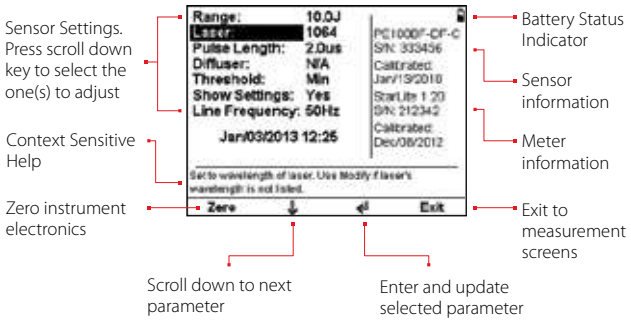
Large Analog Needle with Persistence



Configuration Screen

- Easy adjustment of all measurement configuration parameters
- Context sensitive help for selected parameter
- Sensor and meter information provided

Configuration Screen



Specifications

Power Meter	High legibility TFT 320 x 240 pixel graphics LCD. Large 16mm digits. High resolution analog needle also can be chosen.
Features	Power, single shot energy, energy and frequency of high rep rate lasers, position, and size.
Outputs	1V Full Scale analog output.
Screen Refresh	15 times/sec
Case	Molded high impact plastic with optimized angle kickstand. Rubberized sides for easy grip and protection against damage.
Size	Folds to a compact 213mm L x 113mm W x 40mm H
Battery	Rechargeable Li-ion batteries with typically 8 hours between charges. The charger can be ordered from your local distributor. The changer also functions as an AC adapter.
Sensor Features	Automatic continuous background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.
Sensor Compatibility	Works with standard Thermopile, BeamTrack, Photodiode and PE-C Pyroelectric sensors (does not support previous non C series Pyroelectric sensors).

Ordering Information

Item	Description	Ophir P/N
StarLite	StarLite universal power meter for Thermal, BeamTrack, Pyroelectric and Photodiode sensors	7Z01565
Carrying Case	Carrying case 38x30x11 cm. For power meter and up to 3 sensors	1J02079
StarLite USB Activation Code	Software Activation Code that enables the StarLite meter to communicate in USB with our StarLab software suite	7Z11049
USB Cable for StarLite	USB-A to MICRO-B cable for field upgrade support (1 unit supplied with StarLite)	7E01279
Battery Pack for StarLite	Replacement battery pack for the StarLite	7E14008
P Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A P-1.35x3.5 (1 unit supplied with StarLite)	7E05047
Standard Analog Output Connector	2.5mm mono jack (1 unit supplied with StarLite)	7E02008

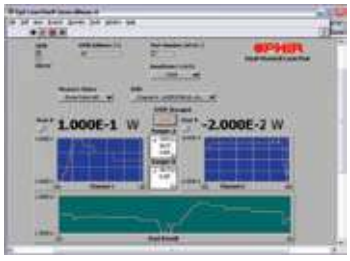
2.1.5 Laserstar

Versatile Laser Power/Energy Meter

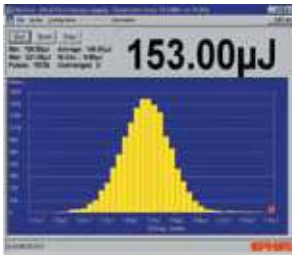
- Two models available: dual and single channel
- Single channel model can be upgraded to dual channel
- Compatible with all standard Ophir thermopile, pyroelectric, photodiode and RP sensors
- Large LCD display
- Backlighting and rechargeable battery
- Screen graphics and statistics (std dev. min, max)
- Analog output
- Built-in RS232 interface
- Log every data point at >1500Hz with pyroelectric sensors
- Non-volatile data storage up to 59,400 points
- Laser tuning screen and power log
- Audio sound for laser tuning and low battery
- RS232 interface with StarCom PC application software and LabVIEW driver (see pages 139-145)
- GPIB option (IEEE488.1)
- NIST traceable
- CE marked
- Soft keys, menu-driven

IEEE 488 GPIB Cable for LaserStar

The dual channel model enables user to simply plug in any of Ophir's thermal, pyroelectric, photodiode or RP sensors and measure two channels independently, or the ratio or difference between them in real time.
Up to 10 data files (54,000 points total) can be stored for onboard review or downloading to computer even if Laserstar has been switched off. The built-in RS232 interface and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers are provided.



LabVIEW

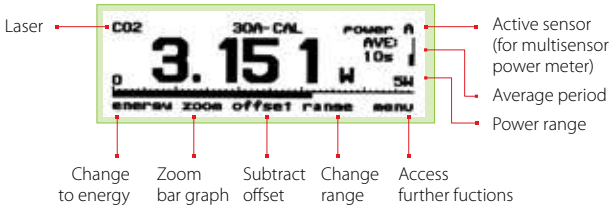


StarCom Software

Selected Screens

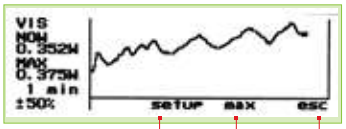
Digital Power Screen

- CW industrial, medical and scientific lasers
- pW to multi kW with appropriate sensors
- Can average over selected period. Useful for unstable lasers
- Fast response bar graph



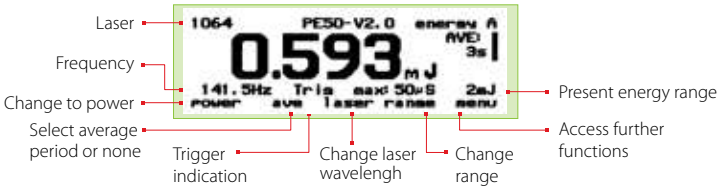
Laser Tuning Screen or Power Log Screen (not shown)

- Maximizing laser power
- User selected time period and zoom
- Option of audio tune tone for maximizing laser power



Energy Measurement Screen

- Pyroelectric and thermal sensors - single pulse
- Pyroelectric frequency measurement

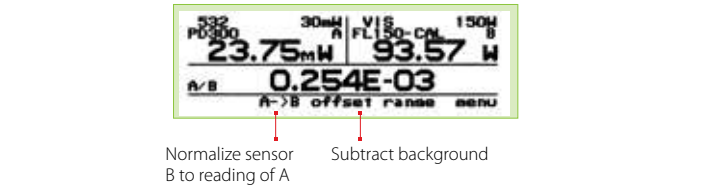


Energy Log Screen

- Pulsed energy sensors
- Thermal sensors - successive single pulses
- Continuous scroll
- Energy statistics

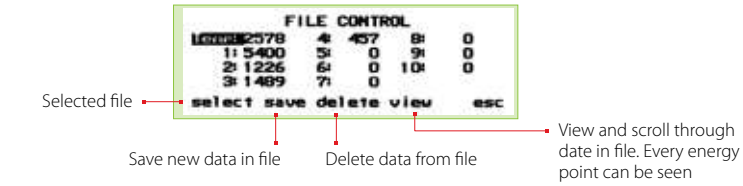
Ratio Screen

- Two independent sensors
- Measure ratio, sum, difference
- Normalize one sensor to the other



Data Storage and Transmission

- Non-volatile storage of power and energy logging data
- Store in up to 10 files and transmit to PC
- PC using StarCom Windows program provided



Specifications

Power Meter	High legibility 64 x 240 pixel graphics supertwist LCD with switchable, electroluminescent backlight which operates from charger or battery. Large 17mm digits. Screen refresh 15Hz.
Features	Many screen features including: power with bargraph, energy, average, exposure, frequency, graphs and more.
Outputs	RS232 and analog output 1V f.s.
Screen Refresh	15 times /sec
Case	Molded high-impact plastic with swivel display and EMI conductive shielding, to allow use even in proximity to pulsed lasers.
Size	Folds to a compact 228mm W x 195mm L x 54mm H.
Battery	Rechargeable 18 hours between charges. The charger can be ordered from your local distributor. The charger also functions as AC adapter.
Multisensor Option	Two sensors can be connected and measure independently, or the ration, sum or difference of the two can be displayed.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Non volatile storage of up to 54,000 data points in up to 10 files. Max data logging rate >1500 points/s. Transmitted to PC: Data transmission rate of ~500 points/s. RS232 baud rate of 38400.
Sensor Features	Works with standard thermal, pyroelectric, photodiode and RP sensors. Automatic, continuous, background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with pulsed energy sensors.
Program Features	Preferred startup configuration can be set by user. User can recalibrate power, energy, response time and zero offset.

Ordering Information

Item	Description	Ophir P/N
Laserstar	Laserstar single channel universal power meter for thermal, pyroelectric, photodiode and RP sensors	7Z01600
Laserstar 2 Channel	Laserstar with dual channel capability including ratio and difference measurement	7Z01601
RS232 Cable for Laserstar	Cable RS232 D9 - D25 (1 unit supplied with Laserstar)	7E01121
Laserstar Battery Pack	Laserstar NiMH Battery update Kit	7Z14006A
Laserstar IEEE Option	IEEE GPIB adapter for Laserstar (see page 132)	7Y78300 [a]
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with LaserStar)	7E05029
LaserStar Analog Output Connector	Analog Output plug for LaserStar (1 unit supplied with LaserStar)	7Z11004
Note: (a)	P/N 7Y78300 replaces P/N 78300	

2.1.6 NOVA

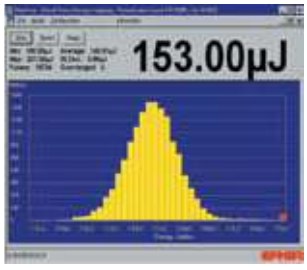
Compact and Durable Power / Energy Meter

- Compact and durable
- Compatible with all standard Ophir sensors: thermal, pyroelectric* and photodiode
- Single shot energy measurement with thermal sensors
- Optional RS232 interface with StarCom PC application and LabVIEW driver (see pages 139-145)
- Power and energy logging with graphical display and statistics
- Power averaging
- Easy to use soft keys, menu-driven
- Screen graphics
- Backlight and rechargeable battery
- Analog output
- EMI rejection

RS232 cable for Nova

Compatible with the complete range of Ophir thermal (power and energy), pyroelectric and photodiode sensors, Nova is truly versatile:measuring power or energy from pJ and pW to hundreds of Joules and thousands of Watts. With the optional scope adapter, you can connect your pyro sensor to an oscilloscope and see every pulse up to the maximum frequency permitted by the sensor.
Smart connector sensors automatically configure and calibrate Nova when plugged in. Soft keys guide you through the screen graphics. Finished working? Your configuration can be saved for future use.
Nova's exclusive autoranging tune screen displays laser power graphically and displays maximum power. Zoom and time scale can be adjusted by user.

The optional RS232 interface and StarCom PC software allow on-line processing of data or processing previously stored data; results are displayed graphically on a PC. To support PC interfacing, LabVIEW drivers are provided.



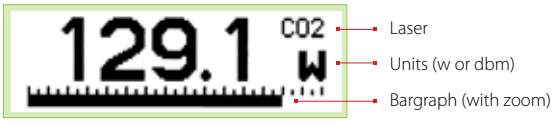
StarCom Software

LabVIEW

Selected Screens

Digital Power Screen

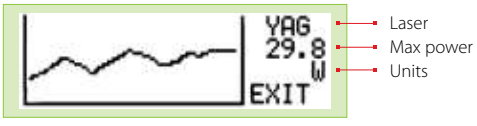
- CW industrial, medical and scientific lasers
- pW to multi kW with appropriate sensors



Press Menu button or soft keys to make legends visible (not shown).

Laser Tuning Screen or Power Log Screen (not shown)

- Maximizing laser power
- User selected time period and zoom

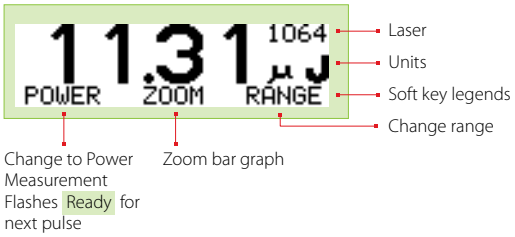


Press Menu button or soft keys to make legends visible.

* PE-C series of pyroelectric sensors are compatible with Nova, when used with an additional adapter (P/N 7Z08272) – see page 100.

Energy Measurement Screen

- Pyroelectric and thermopile sensors-single pulse
- Pyroelectric frequency measurement (not shown)



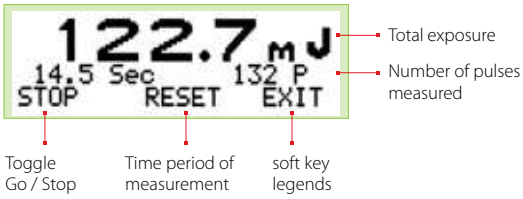
Energy Log Screen

- Pyroelectric sensors
- Thermopile sensors-successive single pulses
- Continuous scroll
- Energy statistics

Press Menu button or soft keys to make legends visible (not shown)

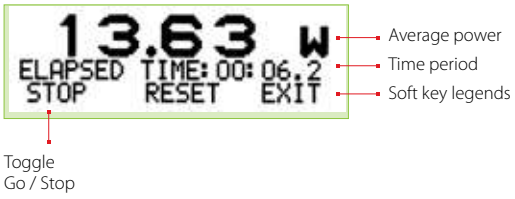
Pyroelectric Exposure Screen

- Sum or average energies over user selected time period / number of pulses
- Medicine, photolithography



Average Screen

- Thermopile, photodiode and pyroelectric sensors (Does not operate with PE-C series of pyroelectric sensors)
- Periodic (1/3 sec to 30 sec) or continuous (10 sec to 1 hour) average for fast-changing or slow-changing laser



Specifications

Power Meter	High legibility 32 x 122 pixel graphics supertwist LCD with switchable electroluminescent backlight. Large 12mm digits.
Features	Many screen features: including power with bar graph, energy, average, exposure, frequency, graphs, and more.
Outputs	RS232 and analog output 1V f.s. (optional)
Screen Refresh	15 times / sec.
Case	Molded high-impact plastic with kickstand and EMI conductive shielding, to allow use even in proximity to pulsed lasers.
Size	Very compact: 205 x 95 x 39mm.
Battery	Rechargeable 12 volts. 22 hours use between charges. The charger can be ordered from your local distributor. The charder also functions as AC adapter.
Data Handling	Data can be viewed on board or transmitted to PC: On Board: Max data logging rate >10 points/s Transmitted to PC: Data transmission rate of ~50 points/s. RS232 baud rate of 19200
Sensor features	Works with thermopile, pyroelectric, and photodiode sensors. Automatic, continuous, background cancellation with PD300 sensors. Submicrojoule and multikilohertz capability with model PE sensors. All sensors use smart connector containing configuration information.
Program features	Preferred startup configuration can be set by user. User can recalibrate power or energy. Response time. Zero offset.

Ordering Information

Item	Description	Ophir P/N
Nova	Nova universal power meter for standard thermal, pyroelectric and photodiode sensors	7Z01500
Nova PE-C Adapter	Adapter to allow Nova to operate with PE-C series pyroelectric sensors. Plugs between Nova D15 socket and PE-C D15 plug	7Z08272
Carrying Case	Carrying case 38x30x11cm. For display and up to three sensors	1J02079
Nova RS232 assemblies - allow Nova power meter to communicate with PC and be controlled by PC		
Nova RS232 Assembly	RS232 adapter with standard 2 meter cable (including software) (see page 132)	7Y78105 [a]
Nova RS232 Assembly	RS232 adapter with 5 meter cable (including software)	7Y71052 [b]
Nova RS232 Assembly	RS232 adapter with 8 meter cable (including software)	7Y71051 [c]
Battery Pack	Replacement battery pack for Nova	7Z11200
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with Nova)	7E05029
Standard Analog Output Connector	2.5mm mono jack (1 unit supplied with Nova)	7E02008
Note: (a)	P/N 7Y78105 replaces P/N 78105	
Note: (b)	P/N 7Y71052 replaces P/N 781052	
Note: (c)	P/N 7Y71051 replaces P/N 781051	

2.1.7 Accessories

Power Supply/Charger

Negative Polarity Power Supply/Charger for Vega, Nova II, Laserstar, Nova, EA-1, Pulsar and Quasar
Positive Polarity Power Supply/Charger for StarBright and StarLite.

Analog Output Connectors

Replacement standard analog output plug for most Ophir meters.
Replacement analog output plug for Laserstar.

Standard Analog Output Connector

Laserstar Analog Output Connector

StarLite USB Activation Code

Software Activation Code that enables the StarLite meter to communicate in USB with our StarLab software suite.

RS232 Module for Nova

Plug in module allows transfer of power and energy data to PC and remote control of power meters from PC. Includes manual and StarCom application program (refer to page 144).

IEEE488 GPIB for Laserstar

Option available with Laserstar power meter allowing Laserstar to operate with GPIB protocol.
The option comes with StarCom software and also LabVIEW VIs to build LabVIEW applications.

Carrying Cases

Carrying case for StarBright, StarLite, Vega, Nova II or Nova power meters and up to 3 sensors.

Ordering Information

Item	Description	Ophir P/N
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5	7E05029
P Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A P-1.35x3.5	7E05047
Standard Analog Output Connector	2.5mm mono jack	7E02008
Laserstar Analog Output Connector	Analog Output plug for Laserstar	7Z11004
StarLite USB Activation Code	Software Activation Code that enables the StarLite meter to communicate in USB with our StarLab software suite	7Z11049
Nova RS232 Assembly	RS232 adapter with standard 2 meter cable (including software)	7Y78105 (a)
Nova RS232 Assembly	RS232 adapter with 5 meter cable (including software)	7Y71052 (b)
Nova RS232 Assembly	RS232 adapter with 8 meter cable (including software)	7Y71051 (c)
Laserstar IEEE Option	IEEE GPIB adapter for Laserstar	7Y78300 (d)
Carrying Case for StarBright, StarLite, Vega, Nova II and Nova	Carrying case 38x30x11 cm. For power meter and up to three sensors	1J02079
Note: (a)	P/N 7Y78105 replaces P/N 78105	
Note: (b)	P/N 7Y71052 replaces P/N 781052	
Note: (c)	P/N 7Y71051 replaces P/N 781051	
Note: (d)	P/N 7Y78300 replaces P/N 78300	

2.2 PC Interfaces

2.2.1 PC Connectivity Options for Power/Energy Measurement

Ophir Pyroelectric, Thermal and Photodiode sensors measure at up to 25,000 points per second

Sample data with Ophir power meter at up to 4000 points per second

Ophir power meter capable of on board storage of data of up to 250,000 points and data storage rate of up to 4000 points per second

Ophir sensor to USB interfaces with up to 4 channel connectivity

Ophir EA-1 interface with Ethernet connectivity

Ophir Quasar interface with wireless connectivity

Transmit real time data to PC at 500 points per second via Bluetooth

Transmit real time data to PC at up to >25,000 points/s (sensor limited) via Ethernet

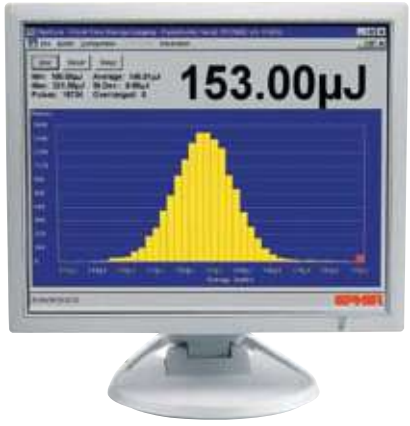
Transmit real time data to PC at up to 25,000 points/s per channel (sensor limited) via USB

Transmit stored data or real time data to PC via USB or RS232

StarLab software (data transmitted via USB, Ethernet or Bluetooth)

StarCom software (data transmitted via RS232)

StarLab software



StarCom software

2.2.2 Compact Juno USB Interface

Convert your laptop or desktop PC into an Ophir sensor power/energy meter

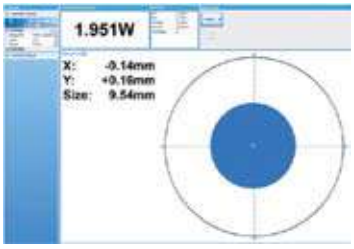
- From sensor to interface to PC - no power source needed
- Plug and play with all standard Ophir smart sensors
- Position & size measurement with BeamTrack sensors
- Record every energy pulse at up to 10kHz
- Log power and energy, average, statistics, histograms and more with included StarLab application
- LabVIEW VIs and COM Object interface
- Very compact - is just an extension of the smart plug

Smart Sensor to Juno to PC

Ophir's basic smart compact Juno module turns your PC or laptop into a full fledged Ophir laser power/energy meter.
Just install the software, plug the sensor into the Juno module and connect the Juno with a standard USB cable to the PC USB port.
Using the Juno, you can connect several sensors to the PC by using one Juno module for each sensor and, if necessary, a USB hub.

LabVIEW

Juno operating with StarLab software



Juno with BeamTrack sensor and StarLab showing beam power, position and size

Specifications

Power Measurement	
Power log period	5s to 500hr.
Energy Measurement	
Max real time data logging to PC	10,000Hz (a)
Trigger input and output	N.A.
Timing	Supports time stamp for each pulse - resolution 10µs
General	
Number of sensors supported	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC
Compatible sensors	Supports all standard Ophir pyroelectric, thermal, BeamTrack and photodiode sensors (b)
Power supply	Powered from USB
Dimensions	76 x 55 x 22mm
Notes:	(a) This is the data logging rate for every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point (b) Not including RP and PD300-CIE

Ordering Information

Item	Description	Ophir P/N
Juno	Compact module to operate one Ophir sensor from your PC USB port. Comes with software. Max repetition rate for every pulse 10kHz. Powered from PC USB port	7Z01250
Juno USB cable	USB-A to MINI-B Cable (1 unit supplied with Juno)	7E01217

2.2.3 EA-1 Compact Ethernet Adapter

Connects your Ophir sensor to an Ethernet bus

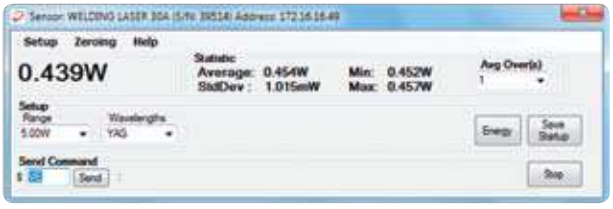
- From sensor direct to Ethernet with no PC connection
- Powers directly from the Ethernet bus or 12V power supply
- Supports thermal and photodiode smart sensors
- Software support via StarLab application or 'Ophir Ethernet App' PC application software package, both included
- Allows remote monitoring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

DB15 connector

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

Smart Sensor to EA-1 to Ethernet to PC

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. 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, HTTP and UDP 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 energy and changing measurement scales or wavelengths. Configuration of the IP address is via the Ethernet or a 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-1device.

Specifications

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
Notes: (a)	BeamTrack functions are only supported via user commands but not with the PC application

Ordering Information

Item	Description	Ophir P/N
EA-1	Compact module to operate Ophir sensors over the Ethernet. Comes with basic PC software	7Z08296
EA-1 USB Cable	USB-A to MINI-B Cable (1 unit supplied with EA-1)	7E01217
EA-1 Ethernet Cable	Ethernet Cross Cable (1 unit supplied with EA-1)	7E01192
N polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with EA-1)	7E05029

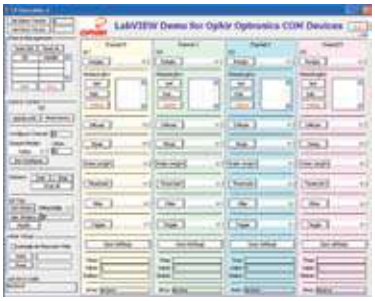
2.2.4 Pulsar Multichannel and Triggered USB Interfaces

Convert your laptop or desktop PC into a multichannel power/energy meter

- From sensor to interface to PC
- 1,2 and 4 channel models
- Plug and play with most Ophir sensors
- Record every energy pulse at up to 25kHz
- Measure missing pulses & trigger output with external trigger
- Log power and energy, average, statistics, histograms and more with included StarLab application
- LabVIEW VIs and COM Object Interface included

Smart Sensor to Pulsar to PC

Ophir's 1-4 channel Pulsar interface turns your PC or laptop into a full fledged Ophir multi-channel laser power/energy meter. Just install the software, plug the sensor into the Pulsar and the USB cable from the Pulsar to the PC USB port. With the Pulsar series, you can connect up to 4 sensors to each module, monitor each pulse at up to 25kHz and utilize external trigger.



LabVIEW

Pulsar-4 operating with StarLab software

Specifications

Power Measurement	
Power log period	5s to 500hr.
Energy Measurement	
Max real time data logging to PC	25,000Hz [a]
Trigger input and output	BNC trigger input to enable measurement of missing pulses or to select specific pulses. Can also be configured to give trigger output
Timing	Supports time stamp for each pulse - resolution 1µs
General	
Number of sensors supported	4 / 2 / 1 sensors per unit. Can combine several units with software for display of up to 8 sensors on one PC
Compatible sensors	Supports all standard Ophir pyroelectric, thermal and photodiode sensors [b]
Power supply	12V wall cube power supply plugs into jack on rear. The power supply can be ordered from your local distributor.
Dimensions	189 x 103 x 33mm
Notes:	(a) Limited by the maximum repetition rate of the sensor. (b) Not including RP, PD300-CIE and BC20 sensors

Ordering Information

Item	Description	Ophir P/N
Pulsar-4	Module to operate up to 4 Ophir sensors from your PC USB port. Comes with software. Max repetition rate for every pulse 25kHz. Has external trigger capability. Powered from wall cube power supply (can be ordered from your local distributor)	7Z01201
Pulsar-2	Same as above but for 2 channels only	7Z01202
Pulsar-1	Same as above but for 1 channel only	7Z01203
Pulsar USB Cable	USB-A to B cable (1 unit supplied with Pulsar)	7E01202
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with Pulsar)	7E05029
USB Interface (USBI) legacy	Legacy smart sensor to USB interface with similar performance to Juno but larger size (155 x 90 x 34mm). Has analog output. See pages 116 & 117 for more information. See full USBI product page in the Ophir website.	7Z01200

2.2.5 Quasar Wireless Bluetooth Interface

Straight from your measuring sensor to your laptop or PC with no cables

- Quasar wireless interface connects to any Ophir sensor and broadcasts to your PC
- Wireless range of 10-30 meters depending on surroundings
- Operates from rechargeable battery with typically >40 hours lifetime
- Powerful USB interface with StarLab PC application software included
- Converts your PC into a complete laser power/energy meter
- Log power and energy, average, statistics, histograms and more
- Monitor up to 7 Quasars simultaneously on one PC

Quasar Bluetooth Wireless Sensor to PC Interface

Quasar module connects to any Ophir sensor, thermal, pyroelectric or photodiode

Any PC or laptop connects to Quasar module via Bluetooth adapter and operates as a power/energy meter/data logger

Specification

Sensor Compatibility	All Ophir standard sensors, thermal, photodiode and pyroelectric [a]
Number of Sensors on One PC	Up to 7 Quasars can operate simultaneously and be displayed at the same time on one PC
Operating Range	10-30 meters depending on surroundings when used with built in laptop Bluetooth or Ophir recommended adapter
Power	Powered by rechargeable NiMH battery. Battery life typical 40 hours, 20 hours for pyro sensors. Automatically goes into sleep mode when not connected to PC. Low batt indication. Charges from 12VDC either polarity. The charger can be ordered from your local distributor.
LED Indicator	LED indicator indicates whether connected, in standby or off
Bluetooth Standard	Bluetooth class 1. Connection to PC is transparent to user. Will work with built in laptop Bluetooth and most add on USB to Bluetooth adapters. Ophir recommended USB to Bluetooth adapter Ophir P/N 7E10039 (see table below)
Data Transfer Rate for Pyro Sensors	500Hz
Dimensions	96mm W x 95mm D x 36mm H not including antenna
Connections	15 pin D type sensor connector standard Ophir 12V charger input
Notes:	(a) Not including RP, PD300-CIE and BC20 sensors

Ordering Information

Item	Description	Ophir P/N
Quasar Bluetooth Interface	Module to operate one Ophir sensor from your PC via Bluetooth wireless interface. Comes with software. Max repetition rate for every pulse 500Hz. Powered from built in rechargeable battery. Comes with power supply. Bluetooth adapter required when not available on PC. See next line	7Z01300
USB to Bluetooth adapter	Adapter for PC or Laptop not equipped with built in Bluetooth. This adapter works with Quasar on Windows 7/8/10 - not on XP. Quasar is not guaranteed to work with all other adapters on the market	7E10039
Battery Pack for Quasar	Replacement battery pack for Quasar	7E14007
N Polarity Power Supply/Charger	Power Supply/Charger AC/DC 12V 2A N-2.1x5.5 (1 unit supplied with Quasar)	7E05029

2.2.6 Summary of Computer Options for Ophir Meters and Interfaces

Communications

With Ophir RS232, USB, Bluetooth and GPIB communication options you can transfer data from the sensor to the PC in real time or offline. You can also control your Ophir power meter from the PC.

- USB on Nova II, Vega, StarBright (optional on StarLite) power meters and Juno, Pulsar and USBI PC interfaces
- Bluetooth wireless on Quasar interface
- RS232 on Laserstar, Nova II, Vega and StarBright optional on Nova
- GPIB optional on Laserstar
- Ethernet on EA-1 interface

Ophir Power Meter and Interface Specifications

Model	StarBright	Nova II / Vega	StarLite	Laserstar	Nova	Juno	Pulsar-1, 2 or 4	EA-1	Quasar Bluetooth
Communication method	USB / RS232	USB / RS232	USB [c]	RS232 / GPIB	RS232	USB	USB	Ethernet	Bluetooth
Power Measurement									
Power log period	1s to 1000hr.	12s to 600hr.	N.A	12s to 600hr.	5s to 24hr.	5s to 500hr.	5s to 500hr.	5s to 500hr.	5s to 500hr.
Max points stored onboard	unlimited	Nova II 5400 Vega 27000	N.A	5400	300	N.A	N.A	N.A	N.A
Max points direct on PC	unlimited	unlimited	N.A	unlimited	unlimited	unlimited	unlimited	unlimited	unlimited
Analog output	1V, 2V, 5V, 10V F.S.	1V, 2V, 5V, 10V F.S.	1V F.S.	1V F.S.	1V F.S.	N.A	N.A	N.A	N.A
Energy Measurement									
Max real time data logging to PC	5000Hz USB 30Hz RS232	>2000Hz USB[a] >30Hz RS232	20Hz [c]	>30Hz RS232 >1500Hz GPIB[a]	>10Hz	10,000Hz [a]	25,000Hz [a]	>25,000Hz [a]	500Hz
Max onboard data logging rate	5000Hz	4000Hz [a]	N.A	>1500Hz [a]	>10Hz	N.A	N.A	N.A	N.A
Data transfer rate of a data file from instrument to PC	~500 points/s	~500 points/s	N.A	~500 points/s	~50 points/s	N.A	N.A	N.A	N.A
Max points stored onboard	unlimited	Nova II 59,400 Vega 250,000	N.A	59,400	1000	N.A	N.A	N.A	N.A
Trigger input and output	N.A	N.A	N.A	N.A	N.A	N.A	BNC trigger input to enable measurement of missing pulses. Can also be configured to give trigger output	N.A	N.A
Timing - time stamp for each pulse	resolution 1µs	N.A	N.A	N.A	N.A	resolution 10µs	resolution 1µs	resolution 1µs	resolution 10ms
General									
Automation interface	yes	yes	yes [c]	no	no	yes	yes	yes	no
LabVIEW VIs	yes	yes	yes [c]	yes	yes	yes	yes	no	no
Maximum baud rate	115200	38400	N.A	38400	19200 [b]	N.A.	N.A.	N.A.	N.A.
PC file format	Text files, spreadsheet compatible ASCII								
Number of sensors supported	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit for single channel mode. Two sensors per unit for dual channel mode.	One sensor per unit.	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	4 / 2 / 1 sensors per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 8 sensors on one PC	One sensor per unit. Can combine several units with software for display of up to 7 Quasars on one PC
Compatible sensors	Supports most Ophir pyroelectric, thermal and photodiode sensors								
Power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from internal rechargeable battery power supply	Powered from USB	12V wall cube plugs into jack on rear	12V wall cube plugs into jack or PoE	Powered from internal rechargeable battery power supply
Dimensions	213 x 113 x 40mm	208 x 117 x 40mm	213 x 113 x 40mm	228 x 195 x 54mm	205 x 95 x 39mm	76 x 55 x 22mm	189 x 103 x 33mm	73 x 93 x 29mm	96 x 95 x 36mm

Notes:
(a) The above refers to the rate for logging every single point in turbo mode. Above that rate, the instrument will sample points but not log every single point.
(b) For pyroelectric sensors, maximum guaranteed baud rate is 9600.
(c) StarLite must be USB enabled in order to work with StarLab. If your StarLite has not been USB enabled, please contact your Ophir distributor in order to obtain a USB Activation Code.

2.3 Software Solutions

2.3.1 StarLab

StarLab turns your PC into a laser power/energy multi-channel station

Extensive Graphic Display of Data

- Line Plot, Histogram, Bar chart, Simulated Analog Needle
- Multiple data sets on one graph or separate graphs on the same screen

Advanced Measurement Processing

- Power/Energy Density, Scale Factor, Normalize against a reference
- Multi-channel comparisons
- User defined mathematical equations: channels A/B, (A-B)/C etc.
- Position & size measurement with BeamTrack sensors

Data Logging for Future Review

- Can be displayed graphically or saved in text format
- Easily exported to an Excel spreadsheet

Fully supports StarBright, StarLite, Vega, Nova-II, Pulsar, Juno, Quasar, EA-1 and USBI devices with all standard Ophir sensors

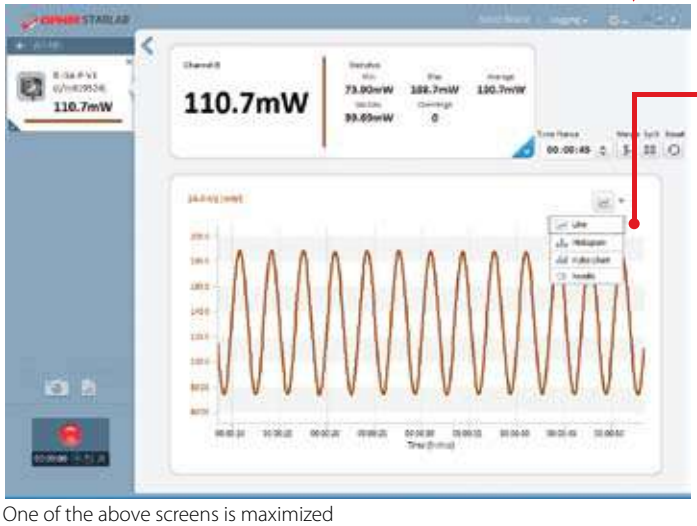
Flexible Display Options with StarLab

Choose which channels to display

Setup screen

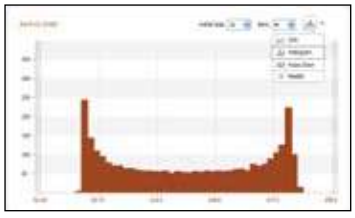
You may choose to display them separately

Maximize one of the sources

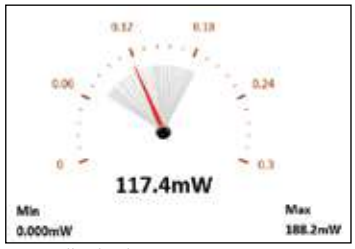


One of the above screens is maximized

Choose line graph

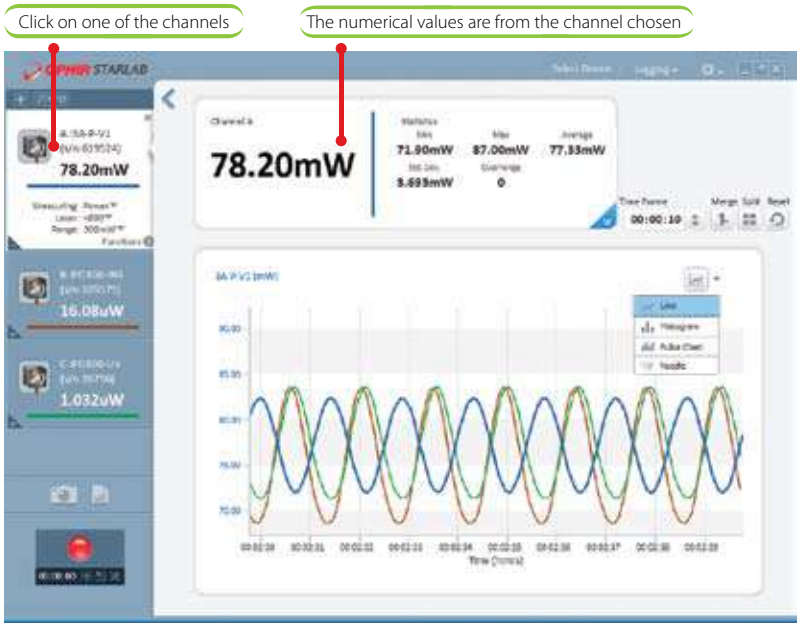


or histogram

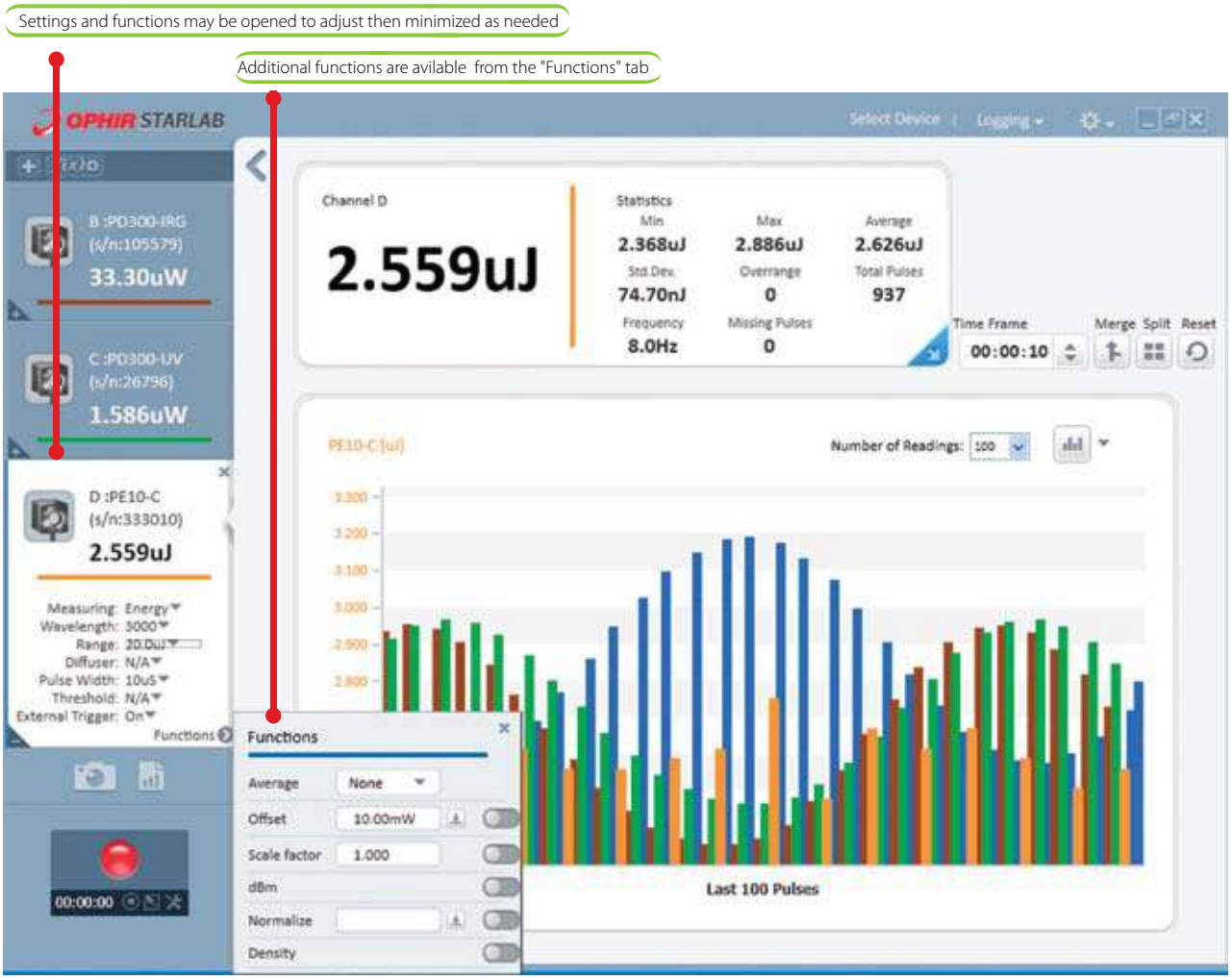


or needle display

Multiple Sensors displayed together



Here multi line graph display has been chosen



Here multi line histogram display has been chosen

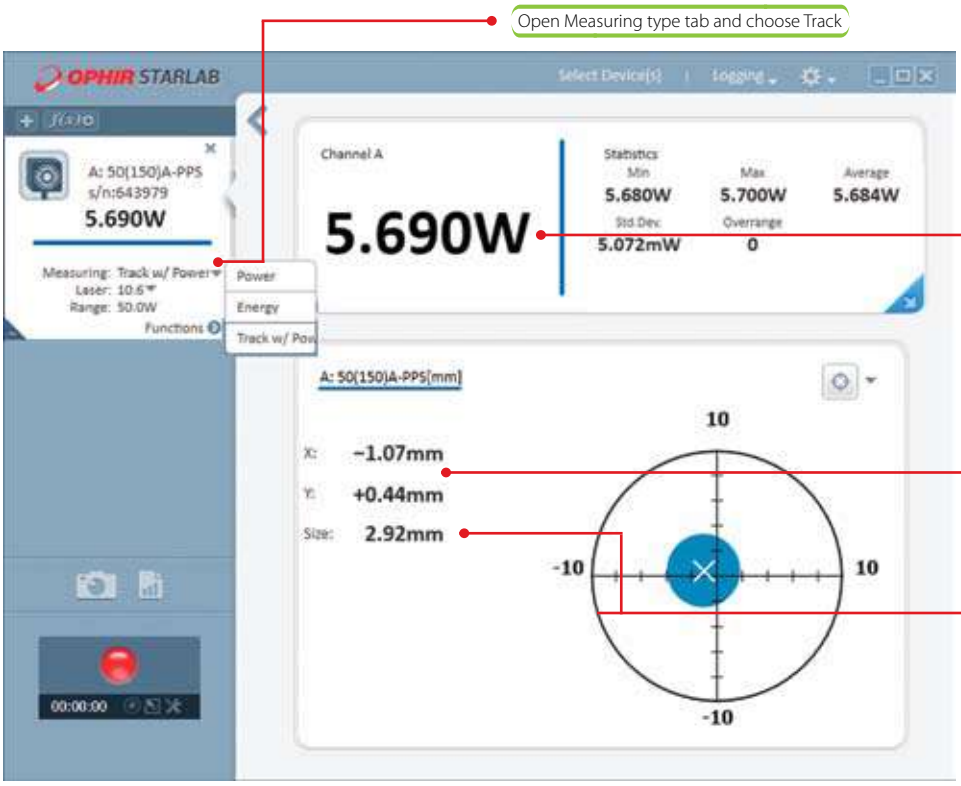
Functions and Logging

Functions

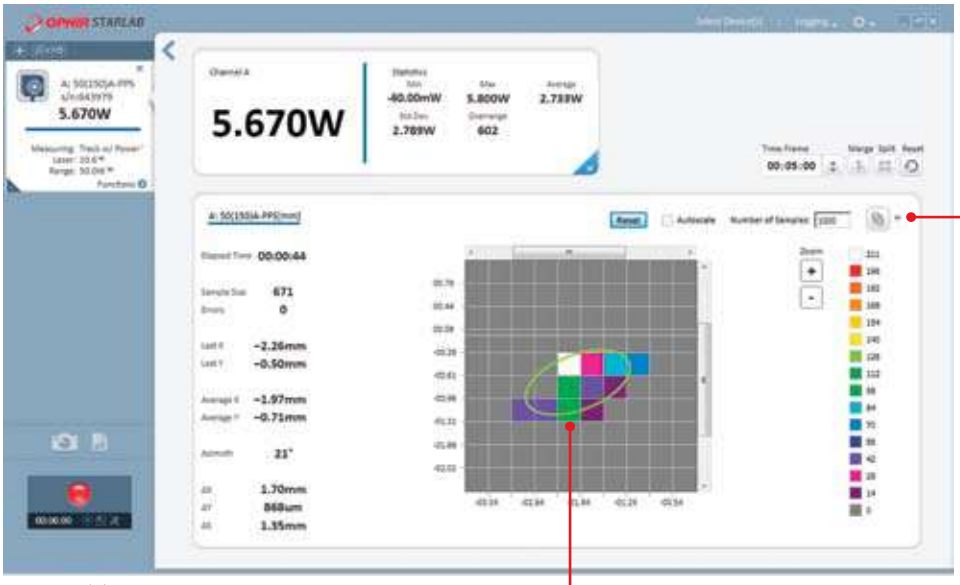
Logging


```
:PC Software:StarLab Version 3.00 Build 19
:Logged:25/05/2014 at 09:33:22
:Channel B:Vega Thermopile 3A-P-V1 (s/n:999999)  VG2.31 (s/n:657028)
:Channel A:Juno Photodiode PD300 (s/n:694646)  JN1.24 (s/n:6061180)
:Math M:(A-B)^2

:Channel B:Statistics
:Min:3.440mW
:Max:12.22mW
:Average:7.882mW
:Std.Dev.:3.070mW
:Overrange:0

:First Pulse Arrived : 25/05/2014 at 09:33:22.562000
 Timestamp      Channel B      F(B)           Channel A      Math M
         0.000  1.762e-002  6.620e-003
         0.064  1.830e-002  7.360e-003
         0.128  1.911e-002  8.110e-003
         0.136                             1.067e-002     6.554e-006
         0.193  1.986e-002  8.860e-003
         0.203                             8.480e-003     1.444e-007
         0.256  2.057e-002  9.570e-003
         0.269                             6.540e-003     9.181e-006
         0.321  2.123e-002  1.023e-002
         0.354                             4.900e-003     2.841e-005
         0.384  2.182e-002  1.082e-002
         0.406                             3.550e-003     5.285e-005
         0.449  2.232e-002  1.132e-002
         0.865  2.291e-002  1.191e-002
         0.870                             3.400e-004     1.339e-004
         0.928  2.258e-002  1.158e-002
         0.936                             3.600e-004     1.259e-004
         0.993  2.216e-002  1.116e-002
         1.003                             4.800e-004     1.141e-004
         1.056  2.164e-002  1.064e-002
         1.070                             7.600e-004     9.761e-005
         1.120  2.104e-002  1.004e-002
         1.136                             1.340e-003     7.569e-005
         1.184  2.038e-002  9.380e-003
         1.203                             2.370e-003     4.914e-005
         1.664  1.558e-002  4.580e-003
```

BeamTrack Power/Position/Size Screens



Power / Position / Size screen



Position stability screen

2.3.2 System Integrator Solutions

Besides their use as stand-alone, fully featured laser power/energy meters, Ophir devices are easily incorporated into larger end-user applications. This allows system integrators to leverage Ophir's excellence in measurement capabilities with legacy analysis packages.

Communication Protocols

All Ophir devices support one or two forms of communication with the PC.

Device	USB	RS232	GPIB	Bluetooth	Ethernet
StarBright	●	●			
Vega	●	●			
Nova II	●	●			
StarLite*	●				
Laserstar		●	●		
Nova		●			
Juno	●				
EA-1					●
Pulsar	●				
USBI	●				
Quasar				●	

* With USB activation code

USB

Ophir provides a common interface for communication and control of all of our USB speaking devices. OphirLMMeasurement is a COM object that is included as part of the StarLab installation (StarLab 2.10 and higher) that allows the system integrator to take control of the StarBright, StarLite, Juno, Nova-II, Pulsar, USBI and Vega devices; integrating them into his in-house measurement and analysis package.

For communication via USB, device drivers and additional support software must be installed on your PC. These components are installed as part of the StarLab application's installation process.

RS232

RS232 communication is the simplest to integrate into your Customized Solutions (OEM) application. Integrated Development Environments (IDE's) such as Microsoft Visual Studio provide functions and methods for accessing the PC's com port.

The following is all that you need to get your RS232 applications up and running

- User Commands document contains an alphabetical listing and detailed description of all commands available with the StarBright, Vega and Nova II devices.
- Appendix A5 of the StarCom User Manual (P/N 1J06025) contains an alphabetical listing and detailed description of all commands available with the Nova and LaserStar devices.
- Appendix A4 of the StarCom User Manual (P/N 1J06025) gives an example of polling the Nova device for measurements. This was written in VB6.
- An appropriate RS232 assembly
- Nova RS232 Assembly (P/N 7Y78105[a]) for use with the Nova device
- Nova II / Vega RS232 cable (P/N 7E01206) for use with the Nova-II and Vega devices (included with the Nova II / Vega)
- Laserstar RS232 cable (P/N 7E01121, included with the LaserStar)
- StarBright RS232 cable (P/N 7E01213, included with the StarBright)

GPIB

Besides RS232, the Laserstar can also communicate via GPIB (IEEE 488.1). Using the SDK supplied by the vendor of your GPIB controller hardware, a Laserstar IEEE cable (P/N 7Y78300[b]) and the StarCom User Manual, you can integrate the Laserstar into your GPIB solution.

Bluetooth

Bluetooth system integration for the Quasar is easily accomplished, in a similar way to our RS232 devices. For more information (and a list of commands), please contact Ophir.

Ethernet

The EA-1 Ethernet Adapter device provides system integration using a Telnet connection over an Ethernet network. A list of user commands is provided, similar to the RS232 commands described above. See the EA-1 User Manual for more details, available on the website.

System Integrators will need the following components:

- OphirLMMeasurement COM Object.pdf. lists and describes the methods and events available for configuring, controlling and uploading measurements from Ophir devices.
- OphirLMMeasurement.dll. COM object component developed and supplied by Ophir for communication with the StarBright, StarLite, Juno, Nova-II, Pulsar, USBI and Vega devices. The COM object is registered when the application is installed. OphirLMMeasurement COM Object.pdf describes how to register it on another PC where the Ophir application has not been installed.
- Standard USB cable for use with the Pulsar and USBI devices (included).
- Standard mini-B USB cable for use with the Juno device (included).
- Nova II / Vega USB cable (P/N 7E01205) for use with the Nova-II and Vega devices (included with the Nova II / Vega).

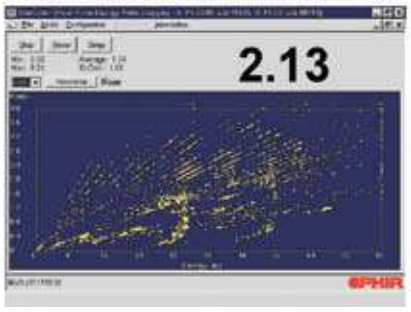
Ophir provides example projects of COM Object clients in VC#, VB.NET and LabVIEW. These are found in the Automation Examples subdirectory of our StarLab PC Application.

Note: (a) P/N 7Y78105 replaces P/N 78105

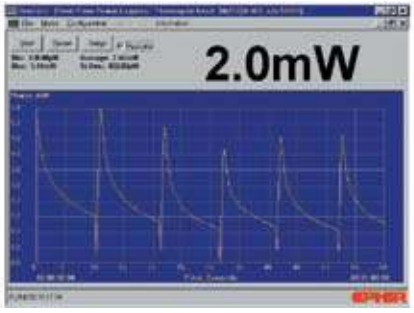
Note: (b) P/N 7Y78300 replaces P/N 78300

2.3.3 StarCom

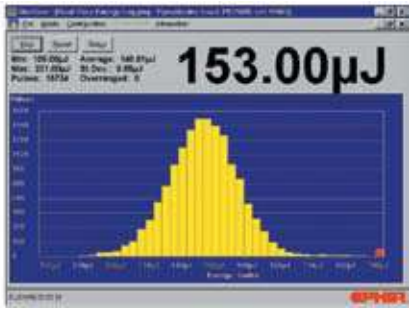
This software is supplied with the Nova II, Laserstar, Vega and Nova with RS232 option. It allows you to measure, analyze and record power and energy from any Ophir sensor.
You can log the data from each sensor simultaneously to file.



Plot of ratio of energy B/A vs. energy A



Plot of power vs. time



Histogram plot of energy distribution

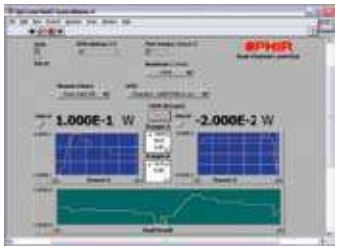
2.3.4 LabVIEW Solutions

Ophir has long recognized the growing LabVIEW community of developers. For over 10 years, we have been providing LabVIEW libraries for all of our devices. These are full open-source applications that can be used as is or tailored by the LabVIEW programmer to his specific needs.

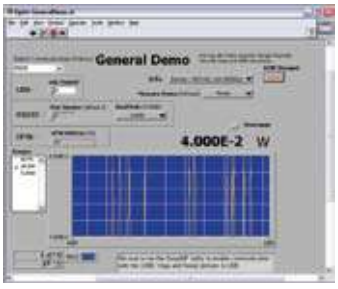
These starter applications are basic software only that allows the LabVIEW programmer to experiment freely to fully feel the strength of our devices' respective command sets.
These applications contain VIs (Virtual Instruments) to control the instrument. You can combine VIs to create successively larger and more versatile larger VIs by simply connecting them together. Users can create sophisticated, custom applications in minutes. In most cases, applications can be built and tested even before the instrument even arrives. The versatility of these tools is limitless.

All of our LabVIEW libraries can be downloaded from our web site: www.ophiropt.com

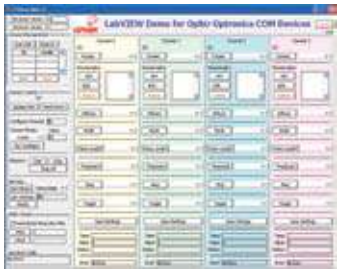
VI Libraries
Ophnova.llb
Library supplied for use with the Nova. Communication is in RS232 and is based on NI-VISA.



Ophlstrd.llb
Library supplied for use with the Dual-Channel LaserStar. Communication can be set to RS232 or GPIB and is based on NI-VISA.



OphInstr.llb
This library can be configured to work with the Nova-II, Vega, USBI or Single-Channel LaserStar devices. It can also work with the Juno with a Thermopile or Photodiode sensors. It can be set to RS232, USB or GPIB. It is based on NI-VISA for all 3 communication protocols.



LabVIEW COM Demo.llb
Library supplied for use with all of our USB speaking devices (StarBright, StarLite, Juno, Nova-II, Pulsar, USBI, Vega). Makes use of our COM object. Included with our StarLab application.

Laser Beam Analysis

3.1 Choosing a Beam Profiler

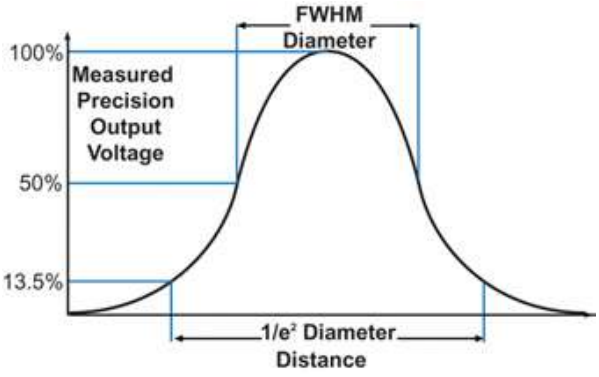
A laser beam profiler will increase your chance of success anytime you wish to design or apply a laser or when you find your laser system is no longer meeting specifications. You would never think of trying to build a mechanical part without a micrometer. So why attempt to build lasers or laser systems with only a power meter? You will produce the desired results more quickly if you can measure basic things like beam width or size, beam profile and power.

We believe as Lord Kelvin said: "You cannot improve it if you cannot measure it".

3.1.1 Four Basic Questions

When choosing a laser beam profiler there are a plethora of choices to do the job, including CCD and CMOS cameras, scanning slit sensors, InGaAs and pyroelectric cameras, pinhole, and knife edge sensors to mention some. How does one decide which is the proper solution for one's application and from which company to obtain the profiler system? When making the selection there are four basic questions about the laser application that one must answer.

Wavelength?



The first question is: *What wavelength(s) do you intend to measure?* The answer to this question determines the type of detector needed, and what the most cost effective approach may be. For the UV and visible wavelength range from <193nm up to the very near infrared at around 1300nm, silicon detectors have the response to make these measurements. The largest number of cost effective solutions exist for these wavelengths including CCD cameras and silicon detector-equipped scanning aperture systems. Which of these is the best will be determined by the answers to the other three questions.
For the near infrared, from 800 to 1700nm, the choices become less abundant. In the lower end of this range from 800–1300nm the CCD cameras may still work, but InGaAs arrays become necessary above 1300nm. These are more expensive; four to five times the cost of the silicon CCDs. Scanning slit systems equipped with germanium detectors are still quite reasonably priced, within a few hundred dollars of their silicon-equipped cousins. At the mid and far infrared wavelengths the pyroelectric cameras and scanning slits sensors with pyroelectric detectors provide viable alternatives, again the best approach being determined by the answers to the subsequent questions.

Beam Size?

The second question is: *What beam width or spot size do you wish to measure?* This question can also impact the profiler type choices. Arrays are limited by the size of their pixels. At the current state-of-the-art pixels are at best around 4µm for silicon arrays, and considerably larger, 30um to 80um with InGaAs and pyroelectric cameras. This means that a UV-NIR beam should be larger than 50µm or roughly 10 pixels in diameter to ensure that enough pixels are utilized to make an accurate measurement. Beams with spot sizes smaller than 50um can be optically magnified or expanded to be measured with a camera. InGaAs camera pixels are around 30µm, limiting the minimum measurable beam size to 300µm; pyroelectric array pixels are even larger at 80µm, meaning the beams need to be at least 0.8mm to yield accurate results. Scanning slit profilers can measure with better than 3% accuracy beams that are four times the slit width or larger, putting the minimum beam sizes at around 8µm without magnification. Those investigators who want to measure their beams directly without additional optics could find this to be an advantage.

Power?

The third question is: *What is the power of the beam?* This determines the need for attenuation, and/or beam splitting, as well as the detector type. Array detectors, such as silicon CCD, CMOS, InGaAs and Pyroelectric cameras will usually need attenuation when measuring lasers. Scanning slit type profilers can measure many beams directly without any attenuation, due to the natural attenuation of the slit itself. Detector arrays and knife-edge profilers, by their nature, will allow the entire beam to impact the detector at some point in the measurement, leading to detector saturation unless the beam is appropriately attenuated. Lasers of any wavelength with CW powers above 100mW can be measured with the pyroelectric detector-equipped scanning slit profiler, making it the easiest profiler for many applications. Scanning slit profilers can directly measure up to kilowatts of laser power, depending on the spot size or power density.

CW or Pulsed?

The final question is: *Is the laser continuous wave (CW) or pulsed?* Lasers that operate pulsed at repetition rates less than ~10 kHz are best profiled with an array. Scanning apertures cannot measure many beam sizes at this repetition rate effectively in real time . CW and pulsed beams with repetition rates above ~10 kHz can be measured with scanning slits if the combination of the repetition rate and the beam size are sufficient to have enough laser pulses during the transit time of the slits through the beam to obtain a good profile. Knife-edge profilers are only able to measure CW beams. Pulsed beams have other considerations when selecting a beam profiling instrument, particularly pulse-to-pulse repeatability, and pulse-energy damage thresholds of the slit material or in the case of array detectors, beam sampling optics.

3.1.2 One More Question

Besides these four questions about the physical nature of the laser to be measured, there is one more that needs to be asked: How accurate does the measurement need to be? Not all profilers or profiler companies are equal in this regard. Properly designed, maintained and calibrated camera and slit - based profilers can provide sub-micron precision for both beam width and beam position (centroid) measurements.

A state-of-the-art CCD array with 4µm pixels can provide ±2% beam width accuracy for beams larger than 50µm. Accuracy for smaller beams may be worse due to the effects of insufficient resolution or pixilation. In addition, the effects of attenuation optics, noise and proper baseline zeroing or offset compensation can have dramatic impact on the accuracy of the measurement. Cameras that are not designed specifically for profiling may be much worse due to the presence of a cover glass and/or IR cut-off filter covering the array. These optical elements must be removed for laser profiling to prevent interference fringes or distortion of the beam being tested. Camera arrays provide a true two-dimensional picture of the beam and will show fine structure and hot and cold spots, which a slit will integrate out. Some applications do not require a map of the laser power distribution within the spot: spot size and spot location are sufficient. Other applications require that a careful mapping of the complete mode structure is made. These applications require 2D, array based sensors. The accuracy requirement is a question of what the data is to be used for. Accurate collimation or focus control requires the highest beam size accuracy. Checking the laser for hot spots, uniformity or beam shape dictates that the 2D sensor is employed and is as important as absolute size measurement accuracy.

How and where a profiler is to be used is also an important consideration in the equation. Profilers used by research and development scientists are often specialized. Ease-of-use and high throughput may be of no consequence if the purpose is to characterize specific optical systems that are well understood by the investigator. On the other hand, when a profiler needs to be used on the factory floor for quality assurance of the manufacturing process, ease-of-use, high throughput, and reproducibility become paramount. In this case the profiler requiring the least "fiddling" is generally the best fit. Here there is a competition between the intuitive and the ease-of-use. Some people find the 2-dimensional camera array to be the most intuitive, because they can relate to the idea of "taking a picture" of the laser beam; X-Y scanning slits may seem less intuitive. For any process that uses or works with CW or high frequency pulsed lasers the scanning slit will have the advantage of measuring the beam directly, possibly even at its focus point, without additional attenuation optics. The dynamic range of these systems is also broad enough to measure both the focused and the unfocused beam without changing the level of attenuation. Camera arrays, on the other hand will require attenuation adjustment.

Conversely, if the important aspect of the measurement is the two-dimensional image of the beam, or if the laser is pulsed at a low repetition rate, the array will be the solution; even if it means attenuation optics.

Also, many factory applications may want to 'embed' the beam profiler into a manufacturing cell or a piece of automation so the measurements and possibly pass/fail results are completed automatically. If so, look for a system that has this ability. Automation capability typically means the laser beam profile system communicates to other applications through LabView, Excel or .NET.

Whether choosing a camera or scanning slit system the user must first determine the laser beam measurement environment and what measurements are the most important to the success of the application. Ease of use and absolute spot size favors the scanning slit system while knowing about the hot and cold spots or the image of the beam under test, or any low repetition pulsed laser, requires a camera based beam profiling system. The assistance of knowledgeable product specialists is required to provide analysis of the measurement requirements of your laser application as well as to describe the features and benefits of available products.

Slit-based Beam Profiler Camera-based Beam Profiler

3.1.3 User Guide for Choosing the Optimum Beam Profiling System

Laser Wavelength	Power			Minimum Beam Size				
	<100mW	100mW-100W	>100W	<20µm	>20 <50µm	>50µm	>500µm	>1mm
UV-Vis	NS-Si	NS-Pyro		NS-Si/3.5/1.8	NS-Si/9/5	NS-Si/9/5	NS-Si /9/5	NS-Si /9/5
	SP928	SP928	NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
	LT665	LT665	SP928			SP928	SP928	SP928
			LT665			LT665	LT665	LT665
NIR 1000-1100nm	NS-Ge	NS-Pyro		NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5
	SP928	SP928	NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
	LT665	LT665	SP928			SP928	SP928/SP907	
Industrial & Additive								
Fiber	BC	BC	BC, BW		BC	BC, BW	BC, BW	BC
CO2	Pyrocam	Pyrocam	MC					Pyrocam, MC
Telecom and Eye-Safe 1100-1800nm	NS-Ge	NS-Pyro		NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5	NS-Ge/9/5
			NS-Pyro		NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
						XEVA	XEVA	XEVA
	Pyrocam	Pyrocam	Pyrocam				Pyrocam	Pyrocam
1500-1600nm	NS-Ge	NS-Ge	NS-Ge	NS-Ge/3.5/1.8	NS-Ge/9/5	NS-Ge/9/5	Pyrocam	NS-Ge/9/5
	SP928-1550	SP928-1550	SP928-1550			SP928-1550	XEVA	SP928-1550
	LT665-1550	LT665-1550	LT665-1550			LT665-1550	SP928-1550	XEVA
							LT665-1550	LT665-1550
MIR & FIR	Pyrocam	NS-Pyro		Pyrocam w/ Beam Expansion	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5
		Pyrocam	NS-Pyro				Pyrocam	Pyrocam
			Pyrocam					
			ModeCheck					

Abbreviations:

FIR	Far Infrared	**NIR**	Near Infrared	**BC**	BeamCheck
Ge	Germanium	**Si**	Silicon	**BW**	BeamWatch
HP	High Power	**SP**	Indicates camera profiler	**MC**	ModeCheck
MIR	Mid-Infrared	**NS**	NanoScan		
UV-Vis	Ultraviolet - Visible				

Laser Wavelength	Minimum Beam Size		CW or Pulsed			Customer Priority				
	>5mm	>10mm	CW	Pulsed <1kHz	Pulsed >1kHz	Price	2D/3D	No optics	Speed	Ease of use
UV-Vis	Pyrocam	NS-Pyro		Pyrocam w/ Beam Expansion	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS-Pyro/9/5	NS	NS
		Pyrocam	NS-Pyro				Pyrocam	Pyrocam		
			Pyrocam							
NIR 1000-1100nm	NS-Ge/12/25		NS	SP928	SP928	SP928	SP928	NS	NS	NS
	NS-Pyro/20/25	NS-Pyro/20/25	SP928	LT665	NS		LT665			
	LT665	L11059	LT665		LT665					
		LT665								
Industrial & Additive										
Fiber	Pyrocam	Pyrocam	Pyrocam	Pyrocam	Pyrocam	NS/Pyrocam	Pyrocam	NS/Pyrocam	Pyrocam	Pyrocam
CO2	MC	MC	MC	MC	MC	MC	MC	NS/Pyrocam	MC	MC
Telecom and Eye-Safe 1100-1800nm	NS-Ge/12/25		NS	XEVA	XEVA	NS	XEVA	NS	NS	NS
	NS-Pyro/20/25	NS-Pyro/20/25			NS		Pyrocam			
	Pyrocam									
1500-1600nm	NS-Ge/12/25	NS-Pyro/20/25			NS					
	SP928-1550	LT665-1550	XEVA	XEVA	XEVA	SP928-1550	SP928-1550	NS	NS	NS
	LT665-1550			LT665-1550	LT665-1550		LT665-1550			
MIR & FIR	NS-Pyro/20/25	NS-Pyro/20/25	NS	Pyrocam	NS	NS	Pyrocam	NS	NS	NS
	Pyrocam		Pyrocam		Pyrocam					

Abbreviations:

FIR	Far Infrared
Ge	Germanium
HP	High Power
MIR	Mid-Infrared
UV-Vis	Ultraviolet - Visible
NIR	Near Infrared
Si	Silicon
SP	Indicates camera profiler
NS	NanoScan
BC	BeamCheck
BW	BeamWatch
MC	ModeCheck

3.2 Benefits of Beam Profiling

You can get more out of your laser

- Figure 1 shows an industrial Nd: YAG laser, near Gaussian beam, with 100 Watts output power and 1.5kW/cm^2 power density. Figure 2 is the same Nd: YAG beam at greater power, 170 Watts, but it split into 2 peaks producing only 1.3kW/cm^2 power density. The power density of the beam decreased 13% instead of increasing by the 70% expected. Without measuring the beam profile and beam width, you would not know what happened to your power density, and why the performance did not improve.

Laser cavities become misaligned

- Figures 3 & 4 are beam profiles of CO_2 lasers used for ceramic wafer scribing in the same shop. The second laser with the highly structured beam produced mostly scrap parts, until the laser cavity was aligned.

Off axis delivery optics

- Figures 5 & 6 show an industrial Nd:YAG laser with misaligned turning mirror, before and after adjustment.

Alignment of devices to lenses

- Figures 7 & 8 show beam profiles during alignment of a collimating lens to a laser diode. The first profile shows poor alignment of the lens to the diode, which can easily be improved when seeing the profile in real time.

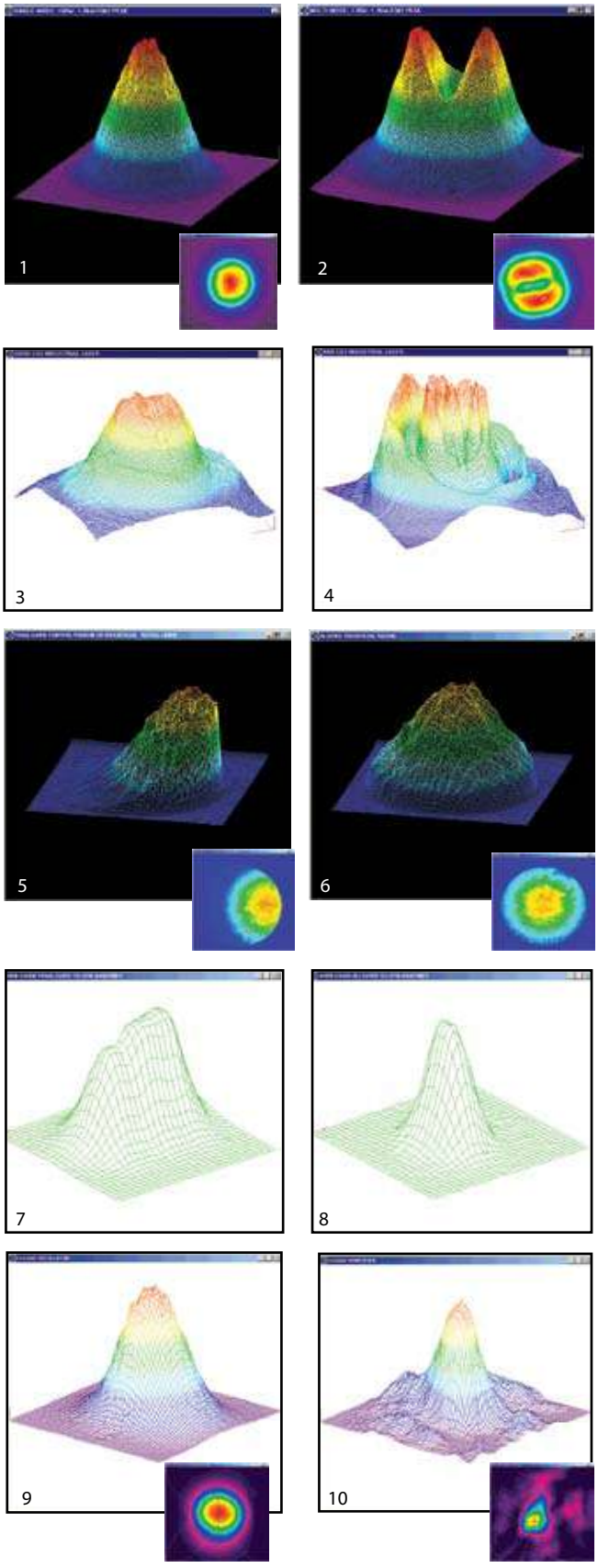
Laser amplifier tuning

- Figures 9 & 10 show a Cr:LiSAF femtosecond laser oscillator beam with a near Gaussian output, and what happens to the oscillator beam with poor input alignment

All these examples illustrate the need for beam monitoring

- If the beam has problems, you must (or should) measure the beam and you must (or should) see the profile of the beam to make corrections.
- Most laser processes can be improved
- Scientific experiments can be more accurate
- Commercial instruments can be better aligned
- Military devices can have greater effectiveness
- Industrial processing produces less scrap
- Medical applications are more precise

Just knowing the beam profile can make the difference between success and failure of a process.



3.3 Introduction to Camera-Based Profilers

Beam Attenuating Accessories

A camera-based beam profiler system consists of a camera, profiler software and a beam attenuation accessory. Spiricon offers the broadest range of cameras in the market to cope with wavelengths from 13nm, extreme UV, to 3000 µm, in the long infrared. Both USB and FireWire interfaces are available for most wavelength ranges providing flexibility for either laptop or desktop computers.

BeamGage®, the profiling software, comes in two versions: Standard and Professional. Each builds off of the next adding additional capability and flexibility needed for adapting to almost any configuration requirement.
Spiricon also has the most extensive array of accessories for beam profiling. There are components for attenuating, filtering, beam splitting, magnifying, reducing and wavelength conversion. There are components for wavelengths from the deep UV to CO2 wavelengths. Most of the components are modular so they can be mixed and matched with each other to solve almost any beam profiling requirement needed.

Acquisition and Analysis Software

The BeamGage software is written specifically for Microsoft Windows operating systems and takes full advantage of the ribbon-base, multi-window environment. The software performs rigorous data analyses on the same parameters, in accordance with the ISO standards, providing quantitative measurement of numerous beam spatial characteristics. Pass/Fail limit analysis for each of these parameters can be also applied.

- ISO Standard Beam Parameters
- Dslit, Denergy, D4σ
- Centroid and Peak location
- Major and Minor Axis
- Ellipticity, Eccentricity
- Beam Rotation
- Gaussian Fit
- Flat-top analysis / Uniformity
- Divergence
- Pointing stability

For data display and visualization, the user can arrange and size multiple windows as required. These may contain, for example, live video, 2D Topographic and 3D views, calculated beam parameters and summary statistics in tabular form with Pass/Fail limit analysis, and graphical strip chart time displays with summary statistics and overlays. Custom configured instrument screens with multiple views can be saved as configuration files for repeated use. Data can be exported to spreadsheets, math, process/ instrumentation and statistical analysis programs, and control programs by logging to files or COM ports, or by sharing using LabView or ActiveX Automation.

- Video Dual Aperture Profiles
- Beam Statistics
- 3D Profile View
- 2D Topographic View
- Time Statistics Charts
- Pointing / Targeting
- Hide measurements and features not in use for user simplicity
- Notes

3.3.1 BeamGage

See your beam as never before

3.3.1.1 BeamGage®-Standard Version

- Extensive set of ISO quantitative measurements
- Patented Ultracal™ algorithm for highest accuracy measurements in the industry
- Customizable user interface for 'ease of use'
- Auto-setup and Auto-exposure capabilities for fast set-up and optimized accuracy
- Statistical analysis on all calculated results displayed in real time
- New BeamMaker® beam simulator for algorithm self-validation

The performance of today's laser systems can strongly affect the success of demanding, modern laser applications.

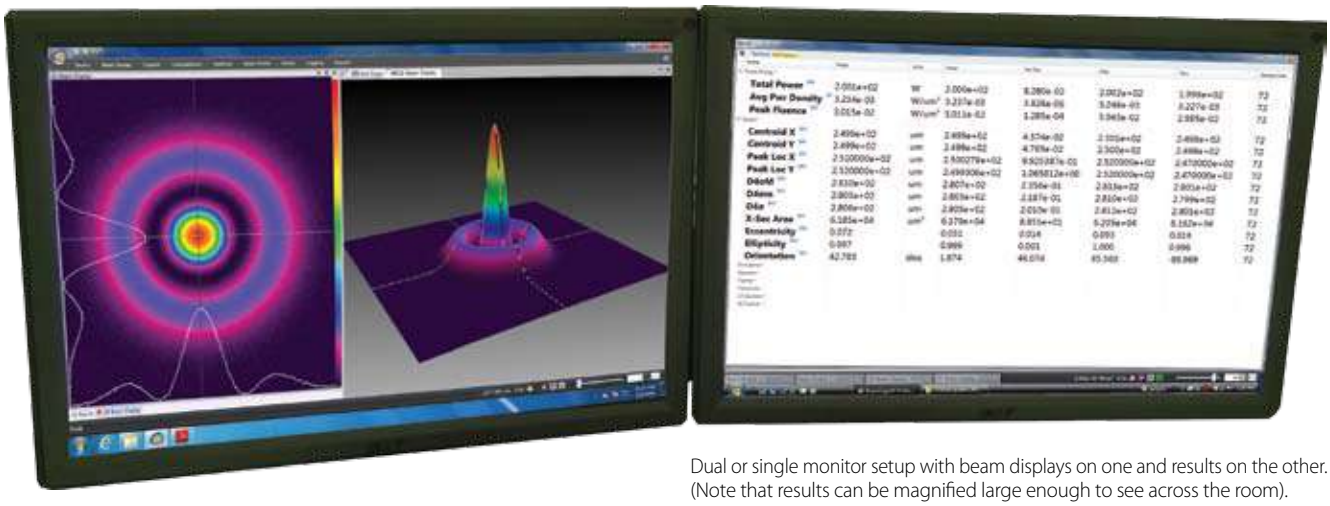
The beam's size, shape, uniformity or approximation to the expected power distribution, as well as its divergence and mode content can make or break an application. Accurate knowledge of these parameters is essential to the success of any laser-based endeavor. As laser applications push the boundaries of laser performance it is becoming more critical to understand the operating criteria.

For over thirty years Ophir-Spiricon has developed instruments to accurately measure critical laser parameters. Our LBA and BeamStar software have led the way.
Now with the introduction of BeamGage, Ophir-Spiricon offers the first "new from the ground up" beam profile analysis instrument the industry has experienced in over 10 years.

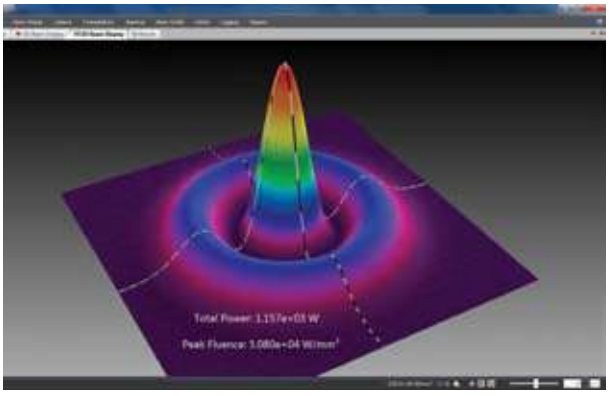
BeamGage includes all of the accuracy and ISO approved quantitative results that made our LBA software so successful. BeamGage also brings the ease-of-use that has made our BeamStar software so popular. Our patented UltraCal algorithm, guarantees the data baseline or "zero-reference point" is accurate to 1/10 of a digital count on a pixel-by-pixel basis. ISO 11146 requires that a baseline correction algorithm be used to improve the accuracy of beam width measurements. UltraCal has been enhanced in BeamGage to assure that accurate spatial measurements are now more quickly available.

See Your Beam As Never Before:

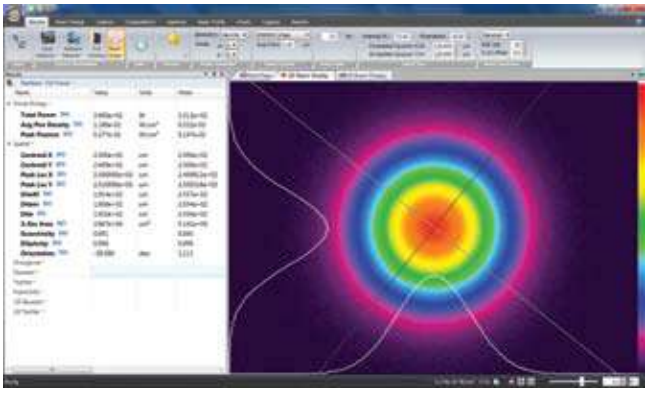
The Graphical User Interface (GUI) of BeamGage is new. Dockable and floatable windows plus concealable ribbon tool bars empowers the BeamGage user to make the most of a small laptop display or a large, multi-monitor desktop PC.



Dual or single monitor setup with beam displays on one and results on the other. (Note that results can be magnified large enough to see across the room).

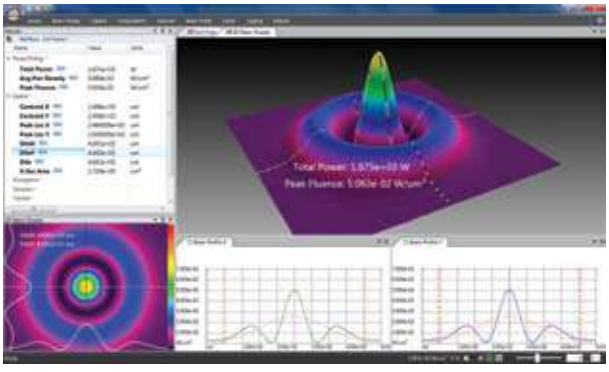


Beam only (Note results overlaid on beam profile).



Beam plus results

- 3D displays Rotate & Tilt. All displays Pan, Zoom, Translate & Z axis Zoom



Multiple beam and results windows.
(Note quantified profile results on 3D display & quantified 2D slices).

Measure Your Beam As Never Before:

Ultracal: Essential, or no big deal?

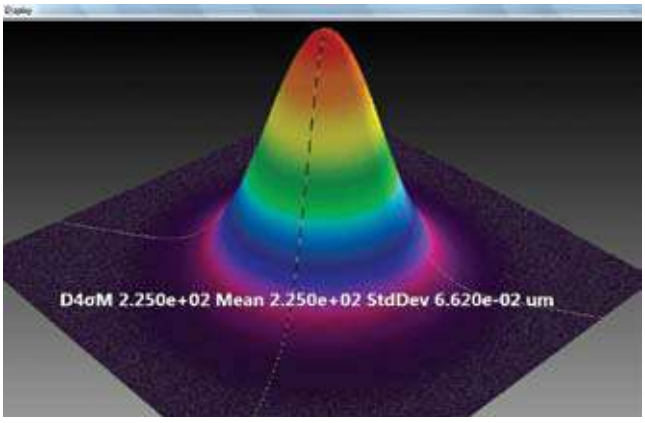
If you want accurate beam measurements, you want Ultracal.

What is Ultracal?

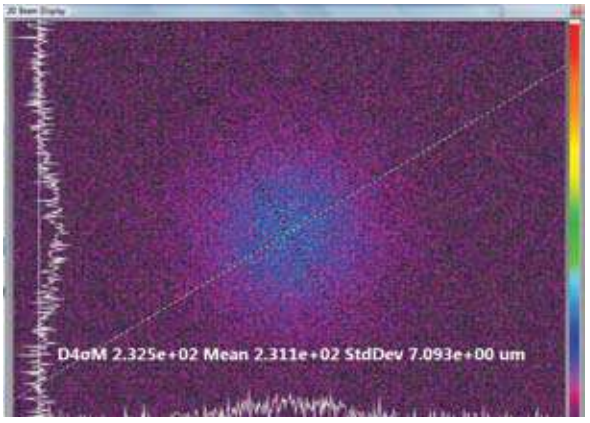
Our patented, baseline correction algorithm helped establish the ISO 11146-3 standard for beam measurement accuracy. The problems with cameras used in beam profile measurements are: a) The baseline, or zero, of the cameras will drift with time and temperature changes, and b) include random noise. Ultracal is the only beam profiler algorithm that sets the baseline to "zero", and, in the center of the noise. (Competitive products use other less sophisticated algorithms that perform a baseline subtraction, but truncate the noise below the "zero" of the baseline. This leaves only a "positive" component, which adds a net value to all beam measurements).

Try the following on any other beam profiler product to see the inherent error if you don't use Ultracal.

1. Measure a beam with full intensity on the profiler camera.
2. Insert a ND2 filter (100X attenuation) into the beam and measure it again.
3. Compare the results.
4. The Standard Deviation below is about 3%, which is phenomenal compared to the 100% or more of any beam profiler without Ultracal.



Beam at full intensity, Width 225µm, Std Dev 0.06µm



Beam attenuated 100X (displayed here in 2D at 16X magnitude zoom), Width 231µm, Std Dev 7µm

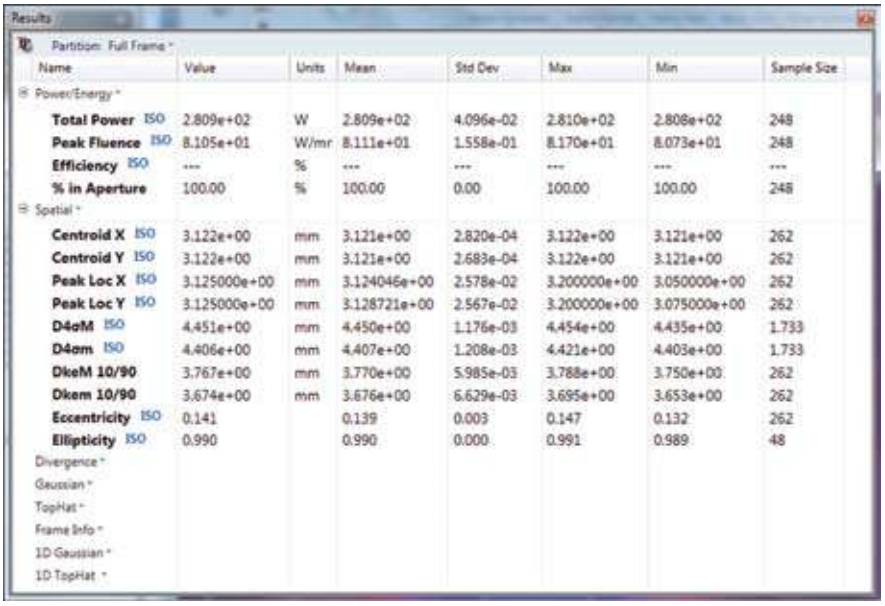
Adding the use of Automatic Aperture improves the accuracy to 1%. (The conditions of this measurement is a camera with a 50dB SNR).

5. You normally don't make measurements at such a low intensity. But occasionally you may have a drop in intensity of your beam and don't want to have to adjust the attenuation. Or, you may occasionally have a very small beam of only a few tens of pixels. In both of these cases, Ultracal becomes essential in obtaining accurate measurements.

Beam Measurements and Statistics

BeamGage allows you to configure as many measurements as needed to support your work, and comes standard with over 55 separate measurement choices. To distinguish between calculations that are based on ISO standards and those that are not, a graphical ISO logo is displayed next to appropriate measurements. You can also choose to perform statistical calculations on any parameter in the list.

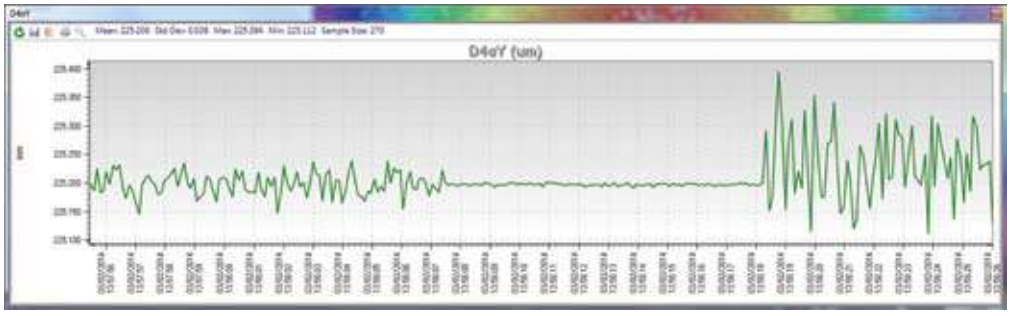
Small sample of possible measurements out of a list of 55



Sample of calculation results with statistics applied

Multiple Charting Options

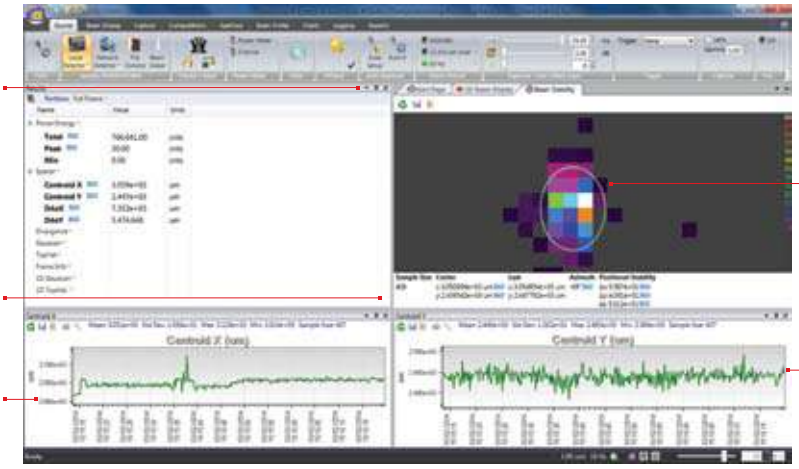
You can create strip charts for stability observations on practically any of the calculations options available. Charts enable tracking of short or long term stability of your laser.



Strip chart of beam D4sigma width. Note how changing conditions affects the width repeatability.
Beam intensity changed over 10db, making noise a significant factor in measurement stability.

Beam Pointing Stability

Open the Pointing Stability Window to collect centroid and peak data from the core system and display it graphically. View a chart recorder and statistical functions in one interface:



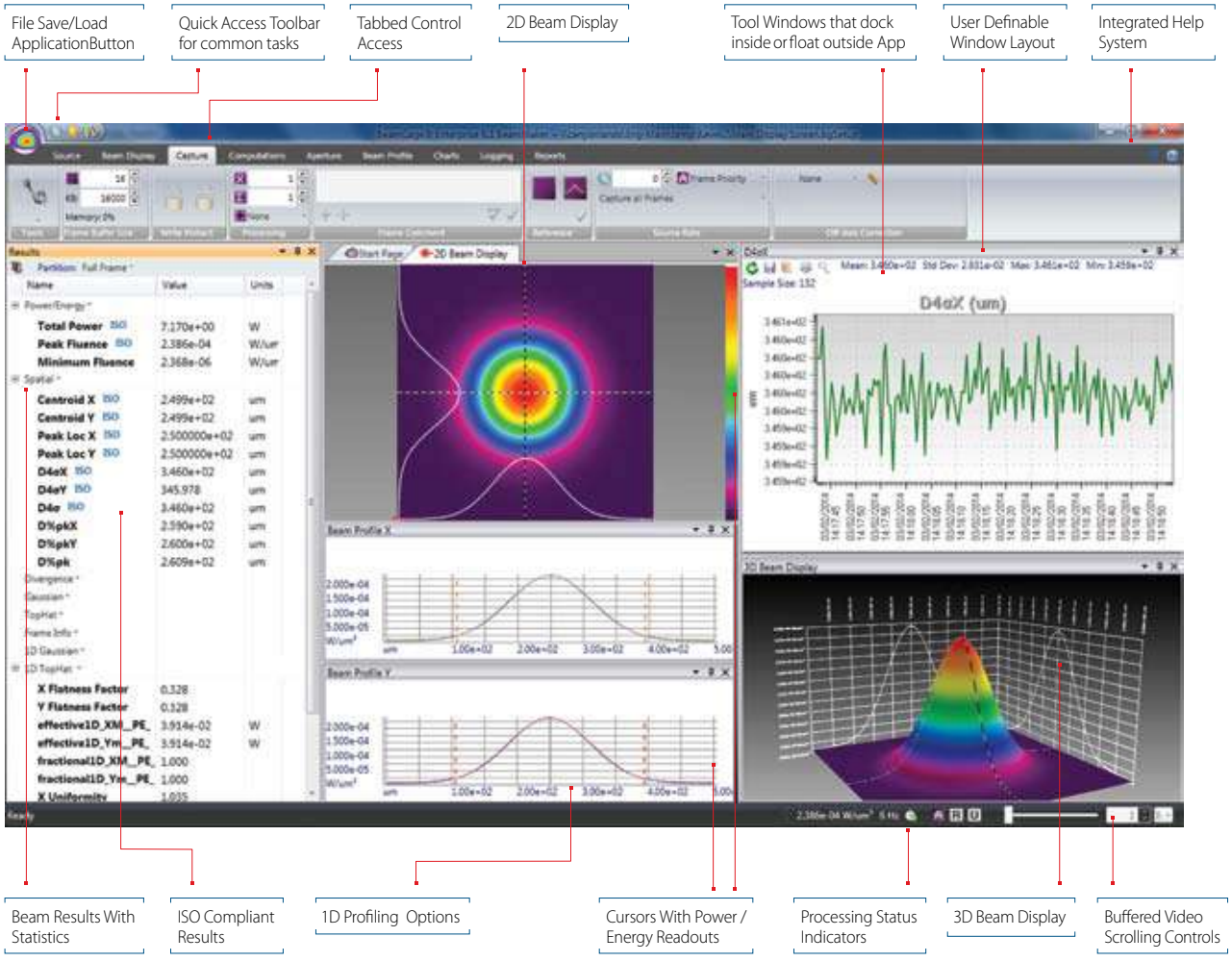
Easy to Use and Powerful

BeamGage is the only beam profiler on the market using modern Windows 7 navigation tools. The menu system of BeamGage is easy to learn and easy to use with most controls only one mouse click away. Some ribbon toolbar examples:

Some of the Beam Display options (Display access options under the Tools tab on the left).

Some of the Beam Capture options.

BeamGage Main Display Screen



Pass / Fail with Password Protection for Production Testing

BeamGage allows the user to configure the displayed calculations; set-up the screen layout and password protect the configuration from any changes. This permits secure product testing as well as data collection for Statistical Process Control (SPC), all while assuring the validity of the data.

Name	Value	Mean	Std Dev	Max	Min	Units
Power/Energy *						
Spatial *						
Centroid X ISO	7.831e+01	7.831e+01	2.849e-03	7.832e+01	7.830e+01	um
Centroid Y ISO	7.965e+01	7.965e+01	3.047e-03	7.966e+01	7.964e+01	um
Peak Loc X ISO	7.000000e+01	7.073199e+01	1.340173e+0	7.500000e+01	6.700000e+01	um
Peak Loc Y ISO	7.100000e+01	7.183659e+01	1.333245e+0	7.500000e+01	6.800000e+01	um
D4σX ISO	1.238e+02	1.238e+02	8.334e-03	1.239e+02	1.238e+02	um
D4σY ISO	124.041	124.053	0.008	124.079	124.027	um
D4σ ISO	1.239e+02	1.239e+02	6.395e-03	1.240e+02	1.239e+02	um

Failures (or successes) can be the impetus for additional actions including a TTL output signal or PC beep and the termination of further data acquisition.

Camera Compatibility

For lasers between 190-1100nm wavelengths, BeamGage interfaces to silicon CCD USB cameras. For applications between 1440-1605nm, BeamGage supports cost effective phosphor coated CCD cameras. For demanding applications between 900-1700nm, BeamGage supports an InGaAs camera. And for applications in the ultraviolet, 13-355nm, or far infrared or Terahertz range, 1.06-3000nm, BeamGage supports Spiricon's Pyrocam, pyroelectric array cameras.

190-1100nm*



Model	SP907	SP928	SP300
Spectral Response nm	190 - 1100nm*	190 - 1100nm*	190 - 1100nm*
Application	1/1.8" format, slim profile, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, high speed, CW & pulsed lasers, adjustable ROI
Number of Elements	964 x 724	1928 x 1448	1928 x 1448
Interface Style	USB 3.0	USB 3.0	USB 3.0
Windows OS support	Windows 7 (64) and Windows 10		

190-1100nm*


Model	LT665	L11059
Spectral Response nm	190 - 1100nm*	190 - 1100nm*
Application	12.5mm x 10mm, 1" format for large beams, CW & pulsed lasers, adjustable ROI	36mm x 24mm, 35mm format for large beams, CW & pulsed lasers, adjustable ROI
Number of Elements	2752 x 2192	4008 x 2672
Interface Style	USB 3.0	USB 2.0
Windows OS support	Windows 7 (64) and Windows 10	

* Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurements. We would suggest our XC13 InGaAs camera for these wavelengths to give you the best measurements.

1440-1605nm



Model	SP907-1550	SP928-1550	LT665-1550
Spectral Response nm	1440 - 1605nm	1440 - 1605nm	1440 - 1605nm
Application	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning	NIR wavelengths, 1/1.8" format, adjustable ROI and binning	12.5mm x 10mm, 1" format for large beams, CW & pulsed lasers, adjustable ROI
Number of Elements	964 x 724	1928 x 1448	2752 x 2195
Interface Style	USB 3.0	USB 3.0	USB 3.0
Windows OS support	Windows 7 (64) and Windows 10		

900-1700nm

Model	XEVA 100Hz
Spectral Response nm	900 - 1700nm
Application	High resolution InGaAS performance, NIR wavelengths
Number of Elements	320 x 256
Interface Style	USB 2.0
Windows OS support	Windows 7 (64) and Windows 10

13-355nm & 1.06-3000µm

Model	Pyrocam IIIHR	Pyrocam IV
Spectral Response nm	13-355nm & 1.06-3000µm	13-355nm & 1.06-3000µm
Application	UV & Far IR Only commercial array to view Terahertz	UV & Far IR Only commercial array to view Terahertz
Number of Elements	160 x 160	320 x 320
Interface Style	GigE	GigE
Windows OS support	Windows 7 (64) and Windows 10	

Unique Features of BeamGage - Standard

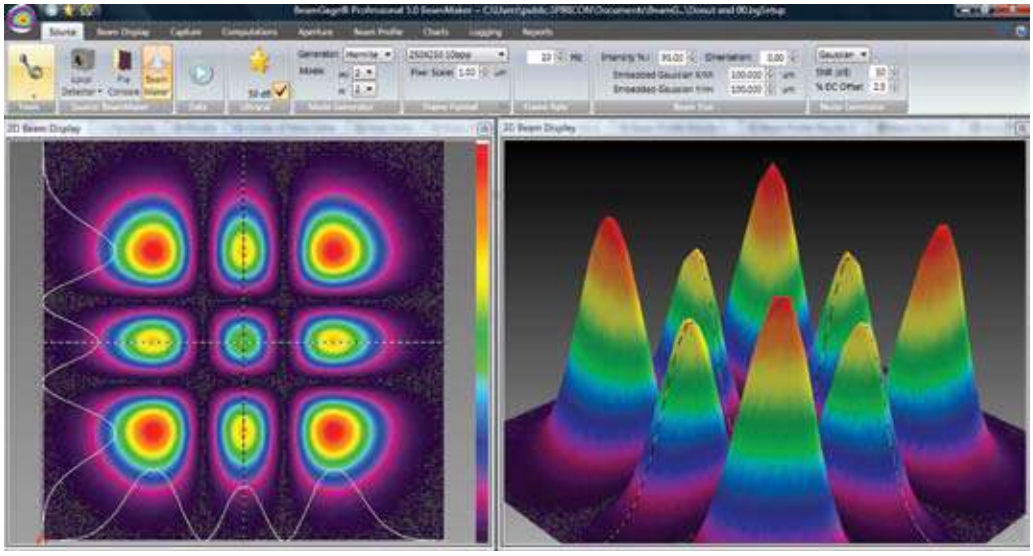
Power/Energy Calibration

Using the USB output from select Ophir power/energy meters, the BeamGage application will display measured power/energy values from the full range of Ophir thermopile, photodiode and pyroelectric sensors. Pulsed lasers can be synced up to 100Hz, or the frame rate of the triggered camera, whichever is less. This is the first time in the industry a laser power meter has been married to a laser beam profile system.

BeamGage is the only product to integrate profiling and power meter measurements

BeamMaker®; Numerical Beam Profile Generator

BeamGage contains a utility, BeamMaker, that can synthetically generate beam profile data by modeling either Laguerre, Hermite or donut laser beams in various modal configurations. BeamMaker permits the user to model a beam profile by specifying the mode, size, width, height, intensity, angle, and noise content. Once generated the user can then compare the theoretically derived measurements to measurements including experimental inaccuracies produced by the various measurement instruments and environmental test conditions. Users can now analyze expected results and confirm if measurement algorithms will accurately measure the beam even before the experiment is constructed. BeamMaker can help laser engineers, technicians and researchers understand a beam's modal content by calculating results on modeled beams for a better understanding of real laser beam profiles. BeamMaker is to laser beam analysis as a function generator is to an oscilloscope.



BeamMaker producing a synthetically generated Hermite TEM_{22} beam and displayed in both 2D and 3D

Integrated automatic Help linked into the Users Guide

Touch sensitive Tool tips are available on most all controls, and "What's This" help can provide additional details. Confused about what something is or forgot how it works, just go to the top right corner and touch the "What's This" help icon, then click on the control or menu item that you want more info about and you are taken to the explanation within the BeamGage Users Guide.

Multilingual

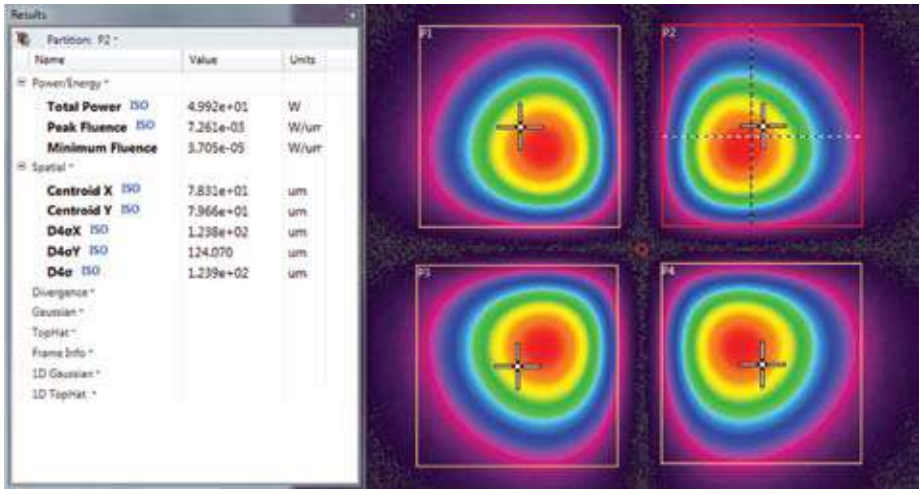
BeamGage comes with both Japanese and Chinese user interface. Country specific manuals can be downloaded from the ophiropt.com/photonics web site.

3.3.1.2 BeamGage®-Professional Version

Professional is an upgrade version of BeamGage-Standard that has all of the BeamGage-Standard features plus additional functionality.

Image Partitioning

Partitioning allows the user to subdivide the camera image into separate regions, called partitions, and compute separate beam results within each partition. When using partitioning special results items can be displayed that relate to delta values between the computed centroids or peaks of each partition. Partitioning is useful to enable separate analysis of individual beams when multiple beams impinge on the camera simultaneously. This feature is particularly useful when analyzing multiple fibers in a single bundle.



Shown is an example of the results for partition P2 and its related display frame. Observe that the selected partition is highlighted in RED. The crosshair in each partition is user controlled. The crosshair can be moved to a new position with the mouse or can be numerically positioned using the expanded controls that appear when a partition is created.

Automation Interface

BeamGage Professional provides an automation interface via .NET components to allow customers the ability to build custom applications' that incorporate the laser beam analysis and processing power of BeamGage. The BeamGage automation interface allows developers to control BeamGage programmatically via a set of "puppet strings" known as the automation interface. The automation interface was developed to provide the ability to base control decisions for a second application on results and behaviors recognized by BeamGage. With this ability users can quickly and efficiently meet their manufacturing/analysis goals with minimum human interaction.

The automation interface was designed to achieve two main goals. First, to allow the BeamGage user to programmatically do what they could otherwise do via the graphical user interface (GUI). Second, to expose stable interfaces to the user that will not change, causing breaks to their dependent code. Interface examples for LabVIEW, Excel and .NET VB are included.

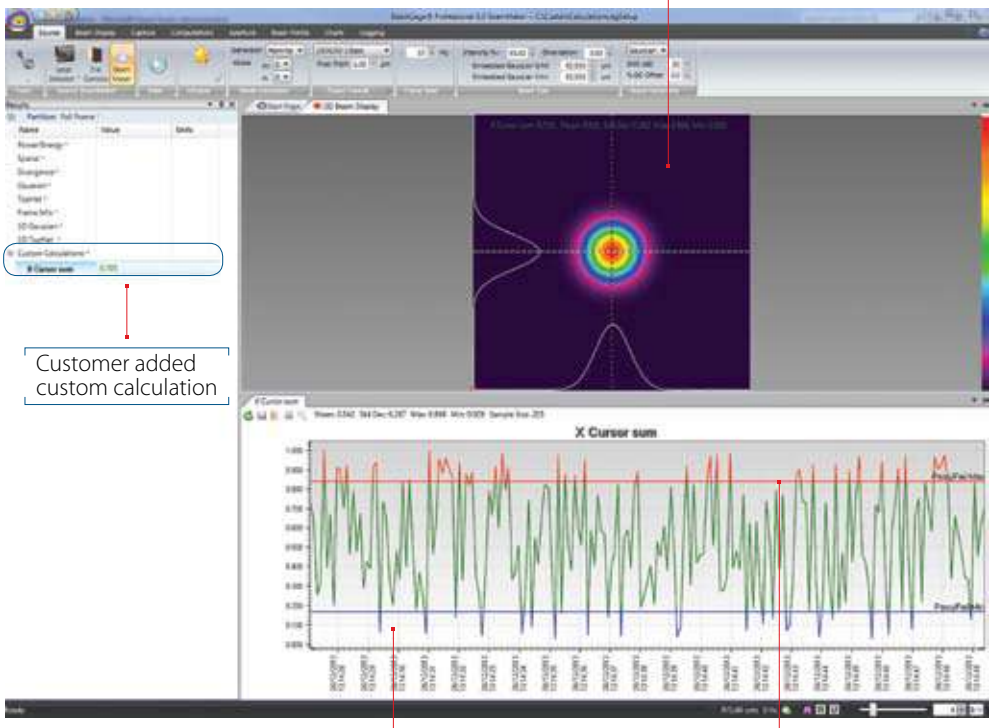
Custom Calculations

If BeamGage-Standard does not have the measurement you need the Professional and Enterprise versions permit the user to program-in their own set of calculations. User defined computations are treated the same as other BeamGage standard calculations.

These custom results are displayed on the monitor, logged with results, and included on hard copy print-outs as if they were part of the original application.

An example of a customer generated custom equation.

$$S = \frac{1}{\pi^2}\left|\int_0^{2\pi}\int_0^1 \exp(2\pi i \Delta W(\rho,\theta))\,\rho d\rho d\theta\right|^2$$


Custom results with statistics
Customer added custom calculation
X Cursor sum
Custom results being plotted
Custom results with pass/fail turned on

3.3.1.3 Software Comparison Chart

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
Features Overview	User selectable for either best "accuracy" or "ease of use"	
	Supports our patented Ultracal algorithm plus Auto-setup and Auto-exposure capabilities	
	Extensive set of ISO quantitative measurements	
	Support for USB, GigE and Pyrocam IIIHR and Pyrocam IV cameras	Supports InGaAs and large format L11059 cameras
	New Beam Maker® beam simulator for algorithm self validation. See below for more detailed description	
	Simultaneous 2D and 3D displays	
	Multi-instance, multi-camera use	
	Results synchronized to select models of Ophir power/energy meters. Supported products include: Vega, Nova II, Pulsar, USBI and Juno, in both 32 and 64bit OS. (Quasar is not supported)	
	Supports Satellite windows on multiple monitors	
	Continuous zoom scaling in both 2D and 3D	
		Window partitioning to allow analysis of multiple beams from a single camera image
	Camera ROI support on USB and Firewire cameras	
	Manual and Auto-aperturing to reduce background effects	
	Pass/Fail on all results items, w/multiple alarm options	
	Beam Pointing Stability scatter plot and stripchart results	
	Full featured logging capabilities in a reloadable industry standard data file format	
	Configurable Report Generator that allows cut and paste of results, images and settings	
		NET Automation interface that allows for remote control. Examples in LabView, Excel and .Net VB
	Supports English, German, Japanese and Chinese Windows 7 (64) and Windows 10	
	Multilingual GUI in English, Japanese and Chinese	
	Administrator can lock software options for non-administrators	
Quantitative Calculations; Basic Results	(per ISO 11145, 11146-1/-3, and 13694)	
Power/Energy Results	Total power or energy (Can be calibrated or sync'd to an external Ophir power/energy meter)	
	Peak power/energy density	
	Min. Fluence	
	Average pulse power	
	Peak pulse power	
	Device efficiency	
	% in Aperture	
Spatial Results	Peak and Centroid locations	
	Beam width	
	▪ Second Moment (D4s)	
	▪ Knife Edge 90/10	
	▪ Knife Edge (User selectable level)	
	▪ Percent of Peak (User selectable)	
	▪ Percent of Total Energy (User selectable)	
	▪ Encircled power smallest slit @ 95.4	
	▪ Moving slit (User selectable)	
	Beam diameter	
	▪ Average diameter (based on x/y widths)	
	▪ Second Moment (D4s)	
	▪ Encircled power smallest aperature 86.5	
	▪ Encircled power smallest aperture (User selectable level)	

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
	Elliptical Results	
	▪ Elliptical orientation	
	▪ Ellipticity	
	▪ Eccentricity	
	Distance Measurement	
	▪ Cursor to Crosshair	
	▪ Centroid to Crosshair	
	Area Results	
	Beam cross-sectional area	
Divergence	Focal Length method	
	Far-field two-point method	
	Far-field Wide Angle method	
Gaussian Fit	2D whole beam fits	
	1D line fits	
	Height	
	Width X/Y	
	Centroid	
	Goodness of fit	
	Roughness of fit	
Tophat Results	2D and 1D	
	Flatness	
	Effective Area	
	Effective Power/Energy	
	Fractional Effective Power/Energy	
	Effective Average Fluence	
	Uniformity	
	Plateau Uniformity	
	Edge Steepness	
	1D or 2D surface inclination	
Other Quantitative Items	Frame Averaging	
	Frame Summing	
	Frame Reference Subtraction	
	Image Convolution	
	Camera signal/noise calculator	
	Row and Column summing with results loggable	
		Scalable Intensity Histogram, exportable
		X or Y axial off axis image correction
Beam Stability Displays and Results	(per ISO 11670)	
	Pointing Stabilty of Centroid	
	▪ Scatter Plot display w/histogram	
	▪ Mean Centroid	
	▪ Azimuth angle of the scatter	
	▪ Stability (M'/m'/S)	
	▪ Max Radius	
	▪ X/Y centroid/peak Strip chart plots	
	▪ Sample/Time controlled	
	▪ Pass/Fail limits	
	▪ Auto scaling	
	▪ Beam Width/Diameter Strip Charts with Results	
	▪ X/Y M/m beam widths plots	
	▪ Beam Diameter plot	
	▪ Mean/Std Dev/Min/Max results displayed	
	▪ Power/Energy Strip Charts	
	▪ Total Power/Energy plot	
	▪ Peak fluence plot	
	▪ Avg Power plot	
	▪ Elliptical Results Strip Chart	
	▪ Elliptical orientation plot	
	▪ Ellipticity plot	
	▪ Eccentricity plot	
	▪ Mean/Std Dev/Min/Max results displayed	
Custom Calculations		User can program-in own set of calculations
Beam Profile Display Options	Utilizes advanced hardware accelerated graphics engines. All display windows can be satellited to utilize multiple display monitors.	
	Can open one each simultaneous 2D and 3D beam display windows	
	Common color palette for 2D and 3D displays	
	Can open X and/or Y 1D beam slice profiles overlaid onto the 2D or 3D displays or in separate windows	

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
	Continuous software zooming in both 1D, 2D and 3D displays	
	Pan to any detector location	
	Continuous Z axis display magnitude scaling	
	Multiple 128 color palettes user selectable	
	Results items can be pasted into 2D, 3D, 1D, Pointing stability or Chart display windows.	
		Able to partition the camera imager into multiple regions with separate results.
1D Features	Available overlaid with 2D and 3D or in separate windows	
	X any Y plots on separate or combined displays	
	1D displays with basic results and column row summing option	
	Tophat 1D displays with Tophat results	
	Gaussian 1D displays with Gaussian fit results	
	1D Profile display of the Gauss fit results on 1D, 2D and 3D displays	
2D Features	Continuously zoomable and resizable displays in satellitable window	
	Continuous Z axis display magnitude scaling	
	Zoomable to subpixel resolution for origin and cursor placements	
	Pixel boundaries delinated at higher zoom magnifications	
	Adjustable Cursors that can track peak or centroid	
	Adjustable Crosshairs that can track peak or centroid	
	Adjustable manual apertures	
	Viewable Auto-aperture placement	
	Displayed beam width marker	
	Integrated Mouse actuated pan/zoom controls	
	Separate 2D pan/zoom window to show current view in 2D beam display	
	Manual or fixed origin placement	
		Ability to create partitions using the manual aperture controls
3D Features	3D graphics utilize solid surface construction with lighting and shading effects	
	Integrated Mouse actuated pan/zoom/tilt/rotate controls	
	Selectable Mesh for drawing speed vs resolution control	
	Continuously zoomable and resizable displays in satellitable window	
	Continuous Z axis display magnitude scaling	
	User enabled backplanes with cursor projections	
Partitioning		Users can subdivide the imager into separate beam measurement regions. All enabled results are computed inside of each partition
		The manual aperture is used to define and create rectangular partition
		When partitioning is enabled some new results items will be enabled
		Centroid measurements between beams in each partition can be performed
		Partitioned imagers must have a single origin common to all partitions. All coordinate results are globally referenced to this single origin
Statistical Analysis	Performed on all measurement functions with on-screen display	
	▪ Choices of intervals	
	▪ Manual start/stop	
	▪ Time from 1 second to 1000 hours	
	▪ Frames from 2 to 99,999 Measurements reported	
	▪ Current frame data, Mean, Standard Deviation, Minimum, Maximum of each calculation performed	
	Controls integrated with beam stability results, scatter and strip chart plots	

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
File types	Industry Standard HDF5 data and setup file format which are compatible in third party applications such as MatLab and Mathmatica	
	Math program and Excel compatible ASCII-csv results files	
	Graphics in jpg file format	
	Legacy file Compatibility with LBA formats	
	A user defined single file output that can contain settings, beam displays, beam profiles, charts, results, etc. in either .pdf or .xps file formats	
Printing	Images, reports, results, graphs, charts, statistics and setup information	
	Option to print many frames in a single operation	
	WYSIWYG images	
Pass/Fail	Set Maximum/Minimum limits on all calculations and statistics	
	Red/Green font color indication on result items	
	Multiple choices for indication of failed parameters, including TTL pulse for external alarm	
	Master pass/fail which triggers alarm on any failure	
	USB signal, beep, stop, and log alarm options	
Logging	Video Data Logging Formats: HDF5, ASCII-csv	
	Results in ASCII-csv	
	Pictures 2D and 3D in jpg, gif, tiff, bmp, png file formats	
	Charts in ASCII-csv	
	Cursor Data in ASCII-csv	
	Row/Column summed in ASCII-csv	
	Continuous Logging	
	Time Interval Logging	
	Frame Count Logging	
	Periodic Sampling	
	Pass/Fail Sampling	
	Burst Sampling, after a user specified time interval, sample a user specified number of frames	
Exporting	Convert frame buffer data to third party format	
	Export a user specified number of frames from the buffer	
	Export Image Data: ASCII-cvs	
	Export Results: ASCII-csv	
	Export Picture: jpg, gif, tiff, bmp, png file formats supported	
	Export Cursor Data: ASCII-cvs	
	Export Row/Column summed: ASCII-cvs	
	Export Image Data in Aperture	
Automation Interface (.NET)		Automation Interface with examples in LabVIEW, Excel and Net VB
		Automate launch and termination of the application
		Automate start, stop, Ultracal, Auto-X and Auto Setup
		Automate the loading of application setups
		Automate control of most camera settings
		Automate a subset of the application features and controls
		Automate the capture of Binary Video Data
		Automate the acquisition of application results
		Automate the acquisition of application Images
Integrated Help	PDF Operators Manual	
	Context Sensitive (Whats this?) Help	
	Context Sensitive Hints	
Signal Conditioning for Enhanced Accuracy	Spiricon's patented Ultracal enables more accurate beam measurement and display. Ultracal takes a multi- frame average of the baseline offset of each individual pixel to obtain a baseline accurate to approximately 1/8 of a digital count. This baseline offset is subtracted from each frame, pixel by pixel, to obtain a baseline correction accurate to 1/8 digital count. Spiricon's Ultracal method retains numbers	

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
	less than zero that result from noise when the baseline is subtracted. Retaining fractional and negative numbers in the processed signal can increase the beam width measurement accuracy by up to 10X over conventional baseline subtraction and clip level methods. Spiricon's Ultracal conforms to the best method described in ISO 11146-3:2004	
Frame Averaging	Up to 256 frames can be averaged for a signal-to-noise ratio, S/N, improvement of up to 16X (Noise is averaged up to 1/256th [8 fractional bits]). Data is processed and stored in a 32bit format	
Frame Summing	Up to 256 frames can be summed to pull very weak signals out of the noise	
	Due to the precise nature of Ultracal baseline setting, (i.e., a retention of both positive and negative noise components) summing of frames can be performed without generating a large offset in the baseline	
Convolution (Adjacent Pixel Averaging)	Choice of 5 convolution algorithms for spatial filtering for both display and calculations. Spatial filtering improves the visual S/N	
Beam Maker®	Beam Maker is a new feature that allows the user to model both Laguerre-Gaussian and Hermite-Gaussian laser beams in various modal configurations. With these models you have verification and validation tools that allows not only OSI but also the end user to verify BeamGage's basic beam width measurement algorithms. It can also be used to model laser beams with special input conditions such as signal-to-noise, background offset, and bits per pixel resolution. This allows the user to better understand the accuracy of measurements made under both optimum and adverse conditions. This tool provides the user with a method to validate algorithms against current ISO standards and methods. It can also be used to validate third party algorithms by making the output data available for use in third party applications	
Camera Features	Camera features are governed by the capabilities of the various cameras that will interface with these software products, and second by which of these camera features are implemented in the software. This section will describe typical camera features supported in the application	
	Black Level Control (used by Ultracal and Auto-X and Auto-setup)	
	Gain Control (used by Auto-X and Auto-setup)	
	Exposure Control (used by Auto-X and Auto-setup)	
	User Programmable ROI	
	Pixel Binning	
	Pixel Sampling	
	Bits per pixel setting	
	External Trigger Input	
	Trigger Delay	
	Strobe Output	
	Strobe Delay	
	External Trigger Probe	
	Internal Trigger Probe	
Camera related features in the applications	These are features related to but not generally dependent upon the camera design	
	Gamma Correction	
	Gain Correction	
	Bad Pixel Correction	
	Lens Applied Option	
	Pixel scale settings	
	Magnification settings	
	Frame buffer settings	
	Ultracal	
	Enable Auto-X (auto exposure control)	
	Perform an Auto-Setup	
	8/10/12/14/16 bits per pixel	
	Select Format or ROI	
	Measure S/N ratio	
Trigger, Capture and Synchronization Methods	Capture methods are features related to the application while Synchronization methods relate more to the abilities of the specific camera. NOTE: Frame capture rates are determined by many factors and are not guaranteed for any specific operating configuration	

Features	BeamGage® Standard	Upgrade to BeamGage® Professional to include: (all features in Standard plus)
	Trigger modes	
	▪ CW - captures continuously, see Capture Options below	
	▪ Trigger-In from laser: Trigger pulses supplied to the camera	
	▪ Strobe-Out to laser: Strobe pulses output from the camera	
	▪ Video Trigger: Frame captured and displayed only when the camera sees a signal greater than a user set level	
	Capture options	
	▪ Capture options are redefined and are approached in a different manner than older products. The items listed below will allow for all of the previous methods but with more flexibility than ever before	
	▪ Results Priority: Results priority will slow the capture rate to be in sync with the computational results and display updates	
	▪ Frame Priority: Frame priority will slow results and display updating to insure that frames are collected and stored in the frame buffer as fast as possible (replaces block mode)	
	▪ Stop After: Will collect a set number of frames and then stop (replaces Single-Shot mode)	
	▪ Periodic: Will collect frame at a programmed periodic rate	
	▪ Periodic Burst: Will collect frames in a Burst at programmed periodic rates	
	Post processing is still available but is done via a different mechanism and is limited to only data file sources	
Video Playback	Video playback, post processing and post analysis	
	User customizable playback rates	
	Video file quick pan/search controls	
	Whole video file playback looping with sub-selection looping	
	Playback Video produced by logging	
	Almost all measurements can be performed on video files	
System Requirements	PC computer running Windows 7 (64) and Windows 10 Laptop or Desktop	
	Not all cameras run in all Microsoft OS versions, see camera section for specifics	
	GHz Pentium style processor, dual core recommended	
	Minimum 2GB RAM (4GB required for L11059 camera)	Minimum 3-4GB RAM
	Accelerated Graphics Processor	
	Hard drive space suitable to hold the amount of video data you expect to store (50-100 GB recommended)	

3.3.1.4 Ordering Information

Item	Description	P/N
190 - 1100nm BeamGage **Standard**: Beam Profiler Systems (camera and software)		
BGS-USB-SP907-OSI	BeamGage Standard software, software license, 1/1.8" format 964x724 pixel camera with 17.5mm C mount CCD recess. Comes with USB cable and 3 ND filters	SP90417
BGS-USB-SP928-OSI	BeamGage Standard software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Comes with USB cable and 3 ND filters	SP90421
BGS-USB3-SP300	BeamGage Standard software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Comes with USB 3.0 cable and 3 ND filters	SP90375
BGS-USB3-LT665	BeamGage Standard Edition software, software license, 1 inch format 2752x2192 pixel camera with 17.5mm C mount CCD recess. Comes with USB 3.0 cable and 3 ND filters	SP90377
190 - 1100nm BeamGage **Professional** Beam Profiler Systems (camera and software)		
BGP-USB-SP907-OSI	BeamGage Professional software, software license, 1/1.8" format 964x724 pixel camera with 17.5mm C mount CCD recess. Comes with USB cable and 3 ND filters	SP90418
BGP-USB-SP928-OSI	BeamGage Professional software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Comes with USB cable and 3 ND filters	SP90422
BGP-USB3-SP300	BeamGage Professional software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Comes with USB 3.0 cable and 3 ND filters	SP90376
BGP-USB3-LT665	BeamGage Professional Edition software, software license, 1 inch format 2752x2192 pixel camera with 17.5mm C mount CCD recess. Comes with USB 3.0 cable and 3 ND filters	SP90378
BGP-USB-L11059	BeamGage Professional software, software license, 35mm format 4008x2672 pixel camera. Comes with universal power supply, 5 meter USB A-B cable and 3 ND filters (1.0, 2.0 & 3.0, optimized for use in the region of 400-700nm; ND 3.0 filter is installed in the input aperture of the camera)	SP90320
1440 - 1605nm BeamGage **Standard**: Beam Profiler Systems (camera and software)		
BGS-USB-SP907-1550-OSI	BeamGage Standard software, software license, 1/1.8" format 964x724 pixel camera with 17.5mm C mount CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters	SP90419
BGS-USB-SP928-1550-OSI	BeamGage Standard software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters	SP90423
BGS-USB3-LT665-1550	BeamGage Standard Edition software, software license, 1 inch format 2752x2192 pixel camera with 17.5mm C mount CCD recess. Phosphor coated 1550nm sensor. Comes with USB 3.0 cable and 3 ND filters	SP90384
1440 - 1605nm BeamGage **Professional** Beam Profiler Systems (camera and software)		
BGP-USB-SP907-1550-OSI	BeamGage Professional software, software license, 1/1.8" format 964x724 pixel camera with 17.5mm C mount CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters	SP90420
BGP-USB-SP928-1550-OSI	BeamGage Professional software, software license, 1/1.8" format 1928x1448 pixel camera with 17.5mm C mount CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters	SP90424
BGP-USB3-LT665-1550	BeamGage Professional Edition software, software license, 1 inch format 2752x2192 pixel camera with 17.5mm C mount CCD recess. Phosphor coated 1550nm sensor. Comes with USB 3.0 cable and 3 ND filters	SP90385
900 - 1700nm BeamGage **Professional** Beam Profiler Systems (camera and software)		
BGP-USB-XC130	BeamGage Professional software, software license, 320x256 pixel InGaAs camera with C mount recess. 9 to 1.7um spectral band. Comes with universal power supply, USB cable, external trigger cable and 3 ND filters (consult factory for other camera options)	SP90241

Ordering Information

Item	Description	P/N
13 - 355nm & 1.06 - 3000µm BeamGage **Professional** and windowless bezel comes with the unit, other windows available for purchase		
PY-III-HR-C-A-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90405
Windows for Pyrocam IIIHR		
PY-III-HR-W-BK7-1.064	Pyrocam III-HR window assembly, BK7, A/R coated for 1.064µm	SP90365
PY-III-HR-W-SI-1.05-2.5	Pyrocam III-HR window assembly, Si, A/R coated for 1.05 to 2.5µm	SP90366
PY-III-HR-W-SI-2.5-4	Pyrocam III-HR window assembly, Si, A/R coated for 2.5 to 4µm	SP90367
PY-III-HR-W-GE-3-5.5	Pyrocam III-HR window assembly, Ge, A/R coated for 3 to 5.5µm	SP90368
PY-III-HR-W-GE-10.6	Pyrocam III-HR window assembly, Ge, A/R coated for 10.6µm	SP90369
PY-III-HR-W-GE-8-12	Pyrocam III-HR window assembly, Ge, A/R coated for 8 to 12µm	SP90370
PY-III-HR-W-ZNSE-10.6	Pyrocam III-HR window assembly, ZnSe, A/R coated for 10.6µm	SP90371
PY-III-HR-W-ZNSE-2-5	Pyrocam III-HR window assembly, ZnSe, A/R coated for 2 to 5µm	SP90372
PY-III-HR-W-BaF2-Uncoated	Pyrocam III-HR window assembly,BaF2 uncoated for 193 to 10µm	SP90373
PY-III-HR-W-POLY-THZ	Pyrocam III-HR window assembly, LDPE, uncoated for Terahertz wavelengths	SP90374
PY-IV-C-A-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90404
PY-IV-C-MIR PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90414
Windows for Pyrocam IV		
PY-IV-W-BK7-1.064	Pyrocam IV window assembly, BK7, A/R coated for 1.064µm	SP90301
PY-IV-W-SI-1.05-2.5	Pyrocam IV window assembly, Si, A/R coated for 1.05 to 2.5µm	SP90302
PY-IV-W-SI-2.5-4	Pyrocam IV window assembly, Si, A/R coated for 2.5 to 4µm	SP90303
PY-IV-W-GE-3-5.5	Pyrocam IV window assembly, Ge, A/R coated for 3 to 5.5µm	SP90304
PY-IV-W-GE-10.6	Pyrocam IV window assembly, Ge, A/R coated for 10.6µm	SP90305
PY-IV-W-GE-8-12	Pyrocam IV window assembly, Ge, A/R coated for 8 to 12µm	SP90306
PY-IV-W-ZNSE-10.6	Pyrocam IV window assembly, ZnSe, A/R coated for 10.6µm	SP90307
PY-IV-W-ZNSE-2-5	Pyrocam IV window assembly, ZnSe, A/R coated for 2 to 5µm	SP90308
PY-IV-W-ZNSE-UNCOATED	Pyrocam IV window assembly, ZnSe, uncoated	SP90336
PY-IV-W-POLY-THZ	Pyrocam IV window assembly, LDPE, uncoated for Terahertz wavelengths	SP90309
Software Upgrades		
BGS TO BGP UPGRADE	Upgrade BeamGage Standard Edition to Professional Edition. Requires a new camera key to activate	SP90233
Camera Accessories		
USB-Pass/Fail Cable	Output Pass/Fail signals when BeamGage is in output mode	SP90060
1100 Photodiode Trigger, Si	Optical trigger assembly which can be mounted on camera or separately to sense laser pulses and synchronize camera with pulses	SP90408
1800 Photodiode Trigger, InGaAs	Optical trigger assembly which can be mounted on camera or separately to sense laser pulses and synchronize camera with pulses	SP90409
Training		
Training	BeamGage training DVD	SP90429

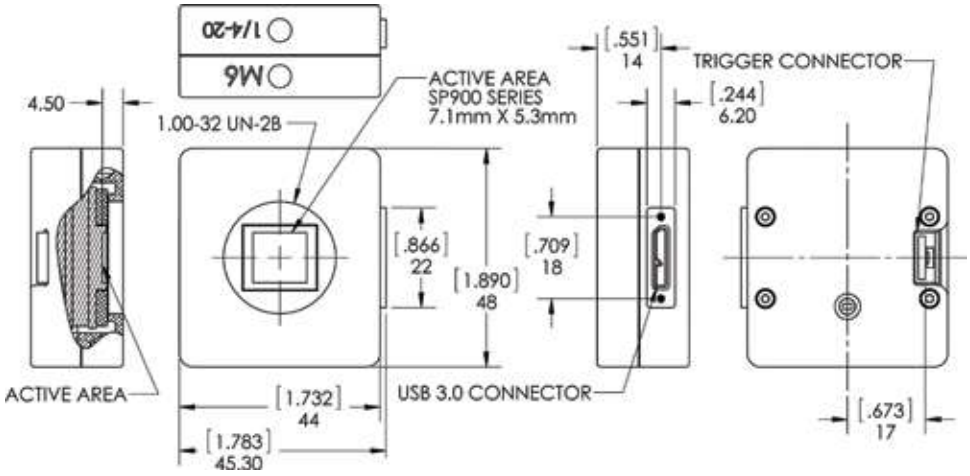
3.3.1.5 Cameras for BeamGage®

3.3.1.5.1 190-1100nm USB Silicon CCD Cameras

SP907 low resolution and SP928 high resolution

Features

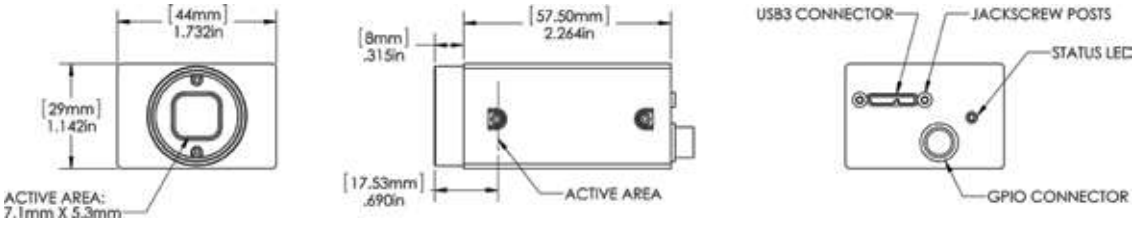
- 1/1.8 imager format
- Small camera size
- 56dB true dynamic resolution



SP300 High resolution, high speed

Features

- 1/1.8 imager format
- High resolution
- High speed
- 56dB true dynamic resolution



Item	Specification		
Model	**SP907**	**SP928**	**SP300**
Application	1/1.8" format	1/1.8" format	1/1.8" format
Spectral Response	190 - 1100nm (2)	190 - 1100nm (2)	190 - 1100nm (2)
Active Area	7.1mm x 5.3mm	7.1mm x 5.3mm	7.1mm x 5.3mm
Pixel spacing	7.38µm	3.69µm	3.69µm
Number of effective pixels	964 x 724	1928 x 1448	1928 x 1448
Minimum system dynamic range	56 dB	56 dB	56 dB
Linearity with Power	±1%	±1%	±1%
Accuracy of beam width	±2%	±2%	±2%
Frame rates in 12 bit mode (4)	23 fps at full resolution	13 fps at full resolution	26 fps at full resolution
Shutter duration	30µs to multiple frames	30µs to multiple frames	30µs to multiple frames
Gain control	0 dB to 24 dB	0 dB to 24 dB	0 dB to 24 dB
Trigger	Hardware/Software trigger & strobe out	Hardware/Software trigger & strobe out	Hardware/Software trigger & strobe out
Photodiode trigger	Si response: SP90408	Si response: SP90408	Si response: SP90408
Saturation intensity (1)	0.97µW/cm²	0.97µW/cm²	0.97µW/cm²
Lowest measurable signal (1)	1.2nW/cm²	1.2nW/cm²	1.2nW/cm²
Damage threshold	50W/cm² / 0.1J/cm² with all filters installed for < 100ns pulse width(3)		
Dimensions	48 mm x 44 mm x 20.2 mm	48 mm x 44 mm x 20.2 mm	44 mm x 29 mm x 58 mm
CCD recess	4.5 mm	4.5 mm	17.5 mm
Image quality at 1064nm	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good
Operation mode	Interline transfer CCD	Interline transfer CCD	Double tap interline transfer CCD
Software supported	BeamGage STD or PRO	BeamGage STD or PRO	BeamGage STD or PRO
PC interface	USB 3.0	USB 3.0	USB 3.0
OS Supported	Windows 7 (64) and Windows 10		

Notes:

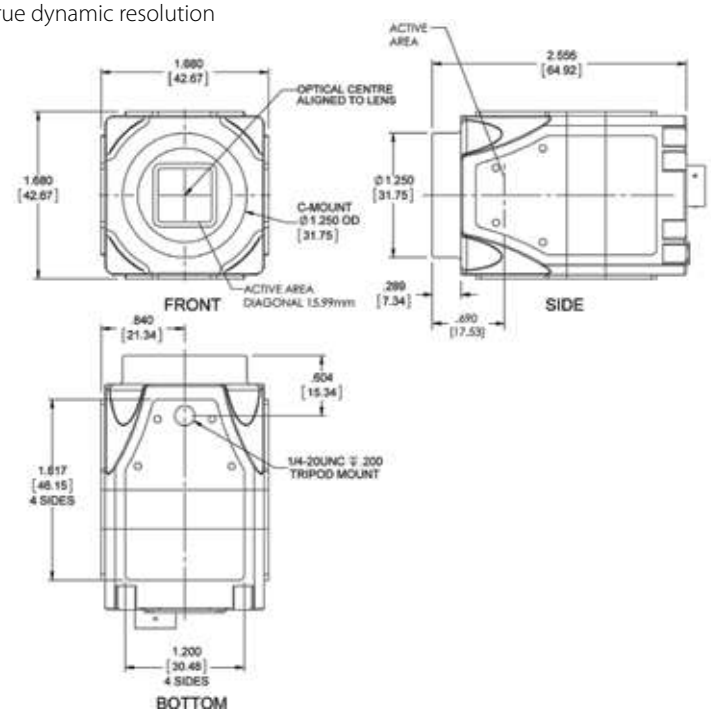
(1) Camera set to full resolution at maximum frame rate and exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.
(2) Camera may be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give the best measurements.
(3) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm².
(4) Highly dependent on PC processor and graphics adapter performance.

3.3.1.5.2 Large Format 190-1100nm USB Silicon CCD Cameras

LT665

Features

- Large 1" imager format
- High resolution
- High speed
- 54dB true dynamic resolution

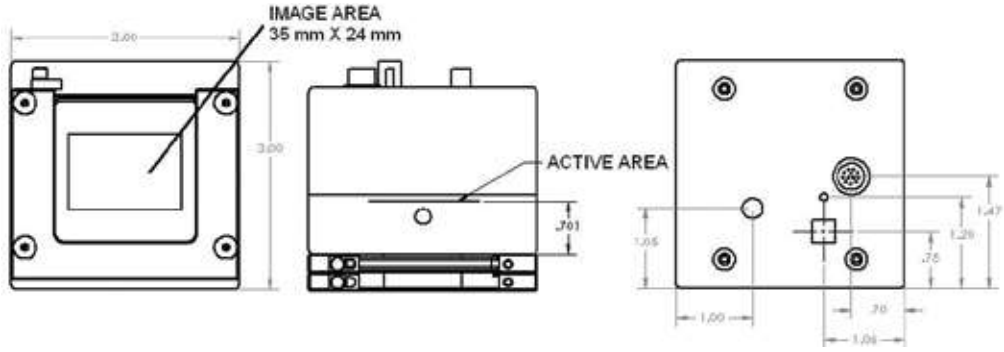


L11059

Features

- 35mm x 24mm imager format
- Highest resolution
- Programmable high speed electronic shutter
- 59bB true dynamic resolution

Comes with 3 ND filters (ND1, ND2, ND3) ND3 mounted in camera



Item	Specification	
Model	**LT665**	**L11059**
Application	1" format	35mm format
Spectral Response	190 - 1100nm (2)	190 - 1100nm (2)
Active Area	12.5mm x 10mm	35mm x 24mm
Pixel spacing	4.54µm x 4.54µm	9.0µm x 9.0µm
Number of effective pixels	2752 x 2192	4008 x 2672
Minimum system dynamic range	54 dB	59 dB
Linearity with Power	±1%	±1%
Accuracy of beam width	±2%	±2%
Frame rates in 12 bit mode (4)	27 fps at full resolution	3.1 fps at full resolution
Shutter duration	31µs to multiple frames	10µs to multiple frame
Gain control	0.8 dB to 56 dB	0.8 dB to 56 dB
Trigger	Hardware/Software trigger & strobe out	Supports both trigger & strobe out
Photodiode trigger	Si response: SP90408	Si response: SP90408
Saturation intensity (1)	1.3µW/cm²	0.15µW/cm²
Lowest measurable signal (1)	0.3nW/cm²	0.17nW/cm²
Damage threshold	50W/cm² / 0.1J/cm² with all filters installed for < 100ns pulse width(3)	0.15mW/cm²
Dimensions	43 mm x 43 mm x 65 mm	83 mm x 76 mm x 128 mm
CCD recess	17.5mm	18.8mm
Image quality at 1064nm	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good
Operation mode	Quad Tap interline transfer CCD	
Software supported	BeamGage STD and PRO	BeamGage PRO
PC interface	USB 3.0	USB 2.0
OS Supported	Windows 7 (64) and Windows 10	

Notes:

(1) Camera set to full resolution at maximum frame rate and exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.

(2) Camera may be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give the best measurements.

(3) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm².

(4) Highly dependent on PC processor and graphics adapter performance.

3.3.1.5.3 1440-1605nm Phosphor Coated CCD Cameras For NIR Response

Features

- 1440-1605nm Wavelengths
- NIR Telecom mode field analysis
- NIR Laser beam analysis

Available Models

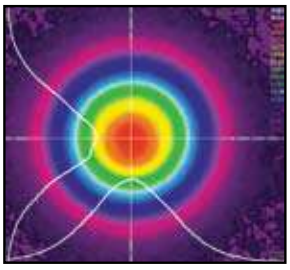
- USB models: SP907-1550
  SP928-1550
- Large Format: LT665-1550

SP907-1550
SP928-1550

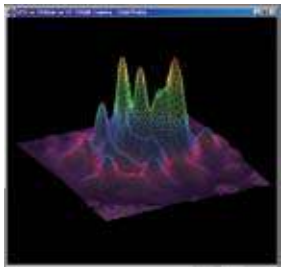
LT665-1550

Phosphor Coating Technology

The up-conversion from NIR to visible light in the 1550 series cameras is nonlinear. The anti-Stokes phosphor coating produces visible photons at a rate roughly the square of the input signal. This is shown dramatically where the camera total output increases dramatically faster than a linear output shown in the bottom line. The CCD camera saturation in the center of a beam, the up-converted visible signal drops as the square of the input signal. Thus the lower signal wings of a beam are suppressed, resulting in the appearance and measurement of a beam width much smaller than actual.

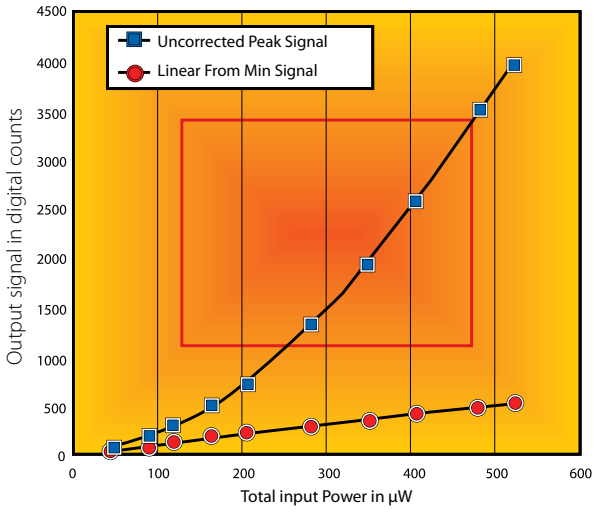


1550nm Fiber Output

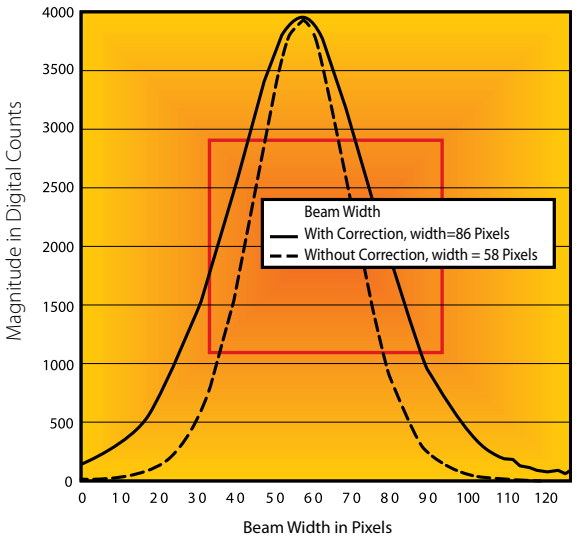


1610nm OPO Output

This illustration is a comparison of the cross-section of a beam with and without correction. As seen, the real width of the beam is much greater than would be observed without correction.



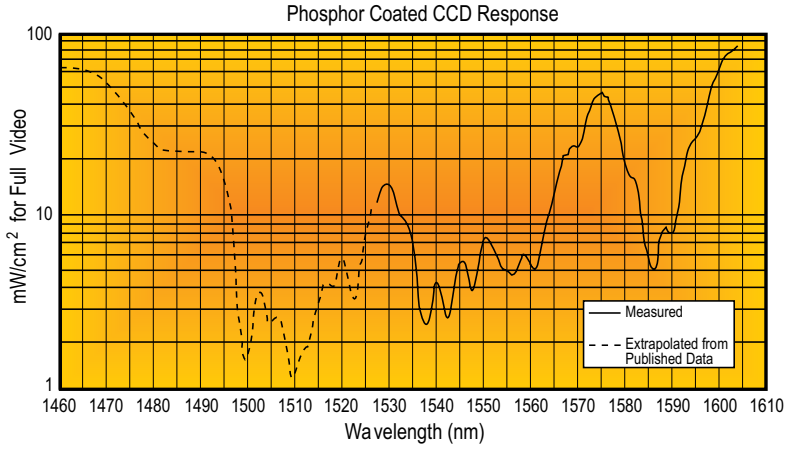
Non-Linearity of SP-1550M Camera at 1550nm



SP-1550M Camera: Comparison of Beam Shape with and without Correction Factor

Wavelength Response

The anti-Stokes up-conversion efficiency is very wavelength dependent. This graph shows the typical spectral response curve of a new, high response coating. As seen, we have calibrated the response from 1527nm to 1605nm. We have extrapolated the shorter wavelength region by comparing our measured response to data published over the entire range.

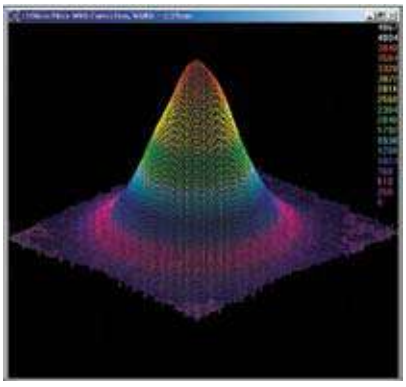


Signal required versus wavelength to achieve camera full signal illumination by anti-Stokes up conversion material.

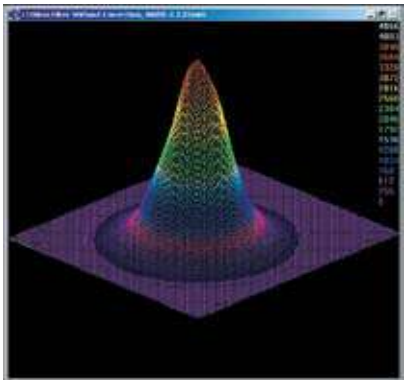
Phosphor Coated Cameras with Spiricon's BeamGage software

Spiricon's engineers have carefully measured the non-linearity of the signal generated by the Phosphor Coated series cameras. The software in the BeamGage incorporates an algorithm to correct for the non-linearity. This illustration shows the linearity obtained, showing in the top line that the low level signals drop linearly, rather than at the square of the input, seen in the lower line.

The two photos show the uncorrected and corrected camera beam shape in 3D. See the BeamGage section for additional information on the beam analyzer.



Beam profile of a fiber beam with non-linearity correction.



Beam profile of a fiber beam without non-linearity correction.

Specifications: Phosphor Coated For NIR Response

Item	Specification		
Model	**SP907-1550**	**SP928-1550**	**LT665-1550**
Application	NIR wavelengths, 1/1.8" format, low resolution	NIR wavelengths, 1/1.8" format, low resolution	NIR wavelengths, 1" format, higher resolution
Spectral Response	1440 - 1605nm	1440 - 1605nm	1440 - 1605nm
Active Area	7.1mm x 5.3mm	7.1mm x 5.3mm	12.5mm x 10mm
Pixel spacing (1)	7.38µm x 7.38µm	3.69µm x 3.69µm	4.54µm x 4.54µm
Number of effective pixels	964 x 724	1928 x 1448	2752 x 2192
Minimum system dynamic range (2)	~30 dB	~30 dB	~30 dB
Linearity with Power	±5%	±5%	±5%
Accuracy of beam width	±5%	±5%	±5%
Frame rates in 12 bit mode (3) (5)	23 fps at full resolution	13 fps at full resolution	27 fps at full resolution
Shutter duration	30µs to multiple frames	30µs to multiple frames	31µs to multiple frames
Gain control	0 dB to 24 dB	0 dB to 24 dB	0.8 dB to 56 dB
Trigger	Supports both trigger and strobe out	Supports both trigger and strobe out	Supports both trigger and strobe out
Photodiode trigger	InGaAs response: SP90409	InGaAs response: SP90409	InGaAs response: SP90409
Saturation intensity (1)	7mW/cm^2 at 1550nm		
Lowest measurable signal (1)	50µW/cm^2		
Damage threshold	50W/cm^2 / 0.1J/cm^2 with all filters installed for < 100ns pulse width (4)		
Dimensions	48mm x 44mm x 20.2mm	48mm x 44mm x 20.2mm	43mm x 43mm x 65mm
CCD recess	4.5mm	4.5mm	17.5mm
Operation mode	Interline transfer CCD	Interline transfer CCD	Quad Tap interline transfer CCD
Software supported	BeamGage STD and PRO	BeamGage STD and PRO	BeamGage STD and PRO
PC interface	USB 3.0	USB 3.0	USB 3.0

Notes:

(1) Despite the small pixel size, the spatial resolution will not exceed 50µm due to diffusion of the light by the phosphor coating.
(2) Signal to noise ratio is degraded due to the gamma of the phosphor's response. Averaging or summing of up to 256 frames improves dynamic range by up to 16x = +24 dB.
(3) In normal (non-shuttered) camera operation, the frame rate is the fastest rate at which the laser may pulse and the camera can still separate one pulse from the next. With electronic shutter operation, higher rate laser pulses can be split out by matching the laser repetition to the shutter speed.
(4) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm^2.
(5) Highly dependent on PC processor and graphics adapter performance.

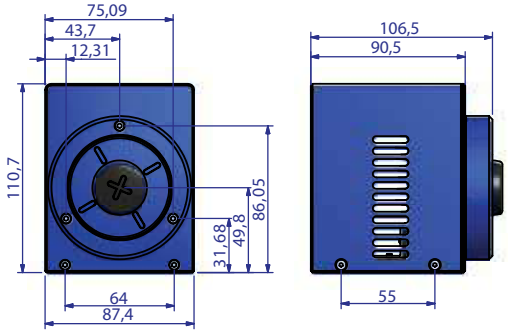
3.3.1.5.4 900-1700nm - InGaAs NIR Cameras

Models XC-130 100Hz

Features

- NIR performance at room temperature
- High resolution InGaAs array: 320x256
- 60dB true system dynamic range
- Exclusive Ultracal for ISO conforming accuracy
- Available with BeamGage software

XEVA 100Hz



USB Cameras for use with Laptop or Desktop PC

Model XEVA XC-130	Description
Application	NIR wavelengths, high resolution, ROI and binning
Spectral response	900-1700nm (consult factory for other options)
Element pitch	30µm square
Number or elements	320 x 256
Area	9.6 x 7.6mm
Lens	C-mount, (Optional)
Minimum system dynamic range	low gain 68dB, high gain 60dB
Saturation intensity	1.3 uW/cm^2 at 1550 nm
Frame rate (2)	100 Hz (1)
Non-uniformity correction	2-Point correction plus bad pixel correction, NUC files provided
Snap-shot mode	Via external TTL trigger, cable provided
Trigger	Supports both trigger and strobe out
Photodiode trigger	InGaAs response: SP90409
Exposure control	1us to 400 sec in Low Gain mode
Imager Cooling	Thermoelectric cooler plus forced convection
Ambient operating temperature	0 - 50° C
Dimensions, mm, HxWxD	111 x 87 x 107 mm
Weight, camera head	approx. 1.8 kg
Software supported	BeamGage PRO
PC interface	USB 2.0, special cable provided
Notes:	(1) The uncorrected rate, final corrected rate will be less. (2) Highly dependent on PC processor and graphics adapter performance.

3.3.1.5.5 13-355nm and 1.06-3000µm - Pyroelectric Array Camera

Pyrocam™ IIIHR & Pyrocam IV Series

Features

- Spectral ranges available from 13 to 355nm and 1.06 to >3000µm
- Image CO_2 lasers, telecom NIR lasers, THz sources and other infrared sources out to Far IR
- Solid state array camera with 1000:1 linear dynamic range for accurate profiling
- Integrated chopper for CW beams and thermal imaging
- Interchangeable windows available for a variety of applications
- Includes BeamGage® Laser Beam Analysis Software for quantitative analysis and image display

Pyrocam IIIHR

Pyrocam IIIHR Plus

Pyrocam IV

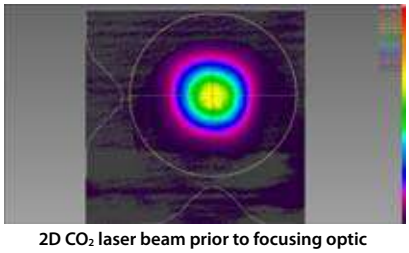
Spiricon has been the world leader in the manufacture of pyroelectric solid-state detector arrays and cameras. For over 25 years the Pyrocam has been the overwhelming camera of choice for Laser Beam Diagnostics of IR and UV lasers and high temperature thermal imaging. Precision, stability, reliability, and versatility have become its proud heritage.

The Pyrocam IIIHR offers a 1/2X1/2 inch detector array with easy Windows® camera setup and quantitative image display through the BeamGage software, 16 bit digitizer, versatile Gigabit Ethernet PC interface, and an integral chopper for CW beams and thermal imaging.

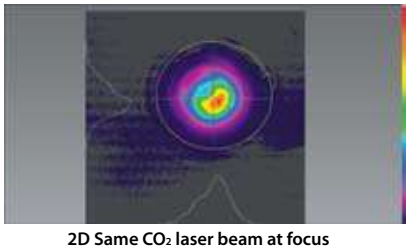
The Pyrocam IV offers a 1X1 inch detector array with easy Windows® camera setup and quantitative image display through the BeamGage software, 16 bit digitizer, with a high-speed Gigabit Ethernet PC interface, and an integral chopper for CW beams and thermal imaging.

See Your Beam As Never Before

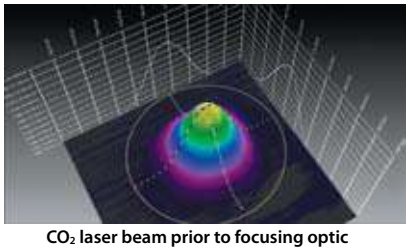
Both Pyrocam cameras create clear and illuminating images of your laser beam profile. Displayed in 2D or 3D views, you can immediately recognize beam characteristics that affect laser performance and operation. This instantly alerts you to detrimental laser variations. Instantaneous feedback enables timely correction and real-time tuning of laser parameters. For example, when an industrial shop foreman saw the CO_2 laser beam profile in Figure 1 he knew immediately why that laser was not processing materials the same as the other shop lasers, that had similar profiles shown in Figure 2.



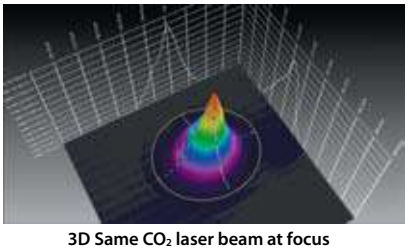
2D CO_2 laser beam prior to focusing optic



2D Same CO_2 laser beam at focus



CO_2 laser beam prior to focusing optic



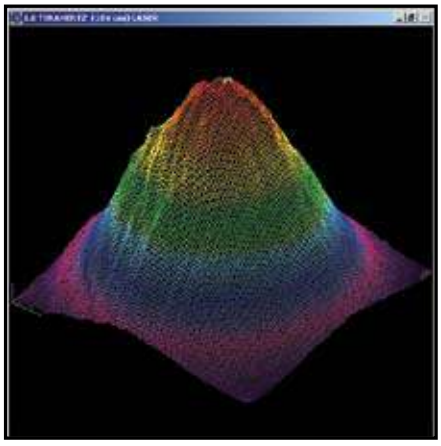
3D Same CO_2 laser beam at focus

Pulsed and CW Lasers

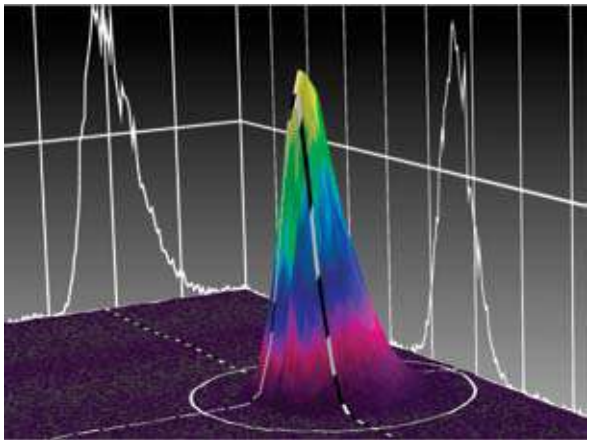
The Pyrocams measure the beam profile of both pulsed and CW lasers. Since the pyroelectric crystal is an integrating sensor, pulses from femtosecond to 12.8ms can be measured. The pyroelectric crystal only measures changes in intensity, and so is relatively immune to ambient temperature changes. Because CW laser beams must be chopped to create a changing signal, the Pyrocam contains an integral chopper.

Measuring Terahertz Beam Profiles

Spiricon's Pyrocam pyroelectric cameras are an excellent tool for measuring THz lasers and sources. The coating of the crystal absorbs all wavelengths including 1µm to over 3000µm (0.1THz to 300THz). For THz sources the sensitivity of the Pyrocam is relatively low, at about 1.5mW/cm^2 at full output. With a S/N of 1000, beams of 30mW/cm^2 are easily visible.
In addition, with Spiricon's patented Ultracal baseline setting, multiple frames can be summed to "pull" a signal out of the noise. Summing 256 frames enables viewing of beams as low as 0.5-1.0mW/cm^2.



Pyrocam III imaging THz laser beam at 0.2THz (1.55mm) 3mW input power; 19 frames summed



Pyrocam IV imaging THZ laser beam 0.5 THz (5mm) 5mW input power; single frame

Broad Wavelength Response

The Pyrocam detector array has a very broadband coating which enables operation at essentially all IR and UV laser wavelengths. The curve ends at 100nm in the UV, but X-ray operation has been observed. Likewise the curve ends at 100µm in the far IR, but the camera has been used at >3000µm.

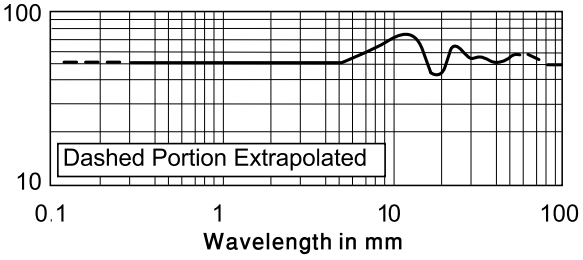
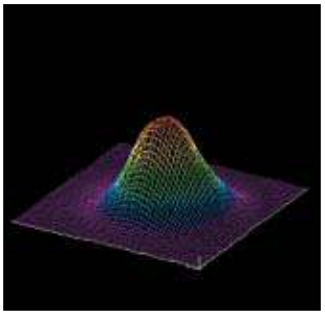
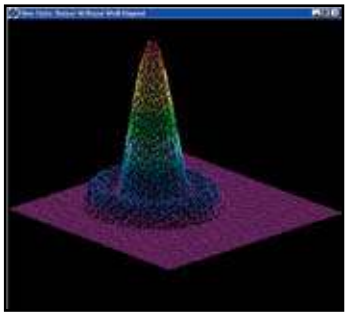


Fig. 6. Spectral response of Pyrocam™ III detector array without window.

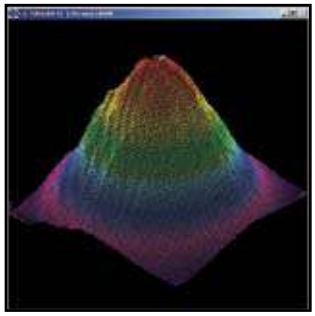
Thus you can use the Pyrocam in the near IR for Nd:YAG lasers at 1.06µm, and for infrared fiber optics at 1.3µm and 1.55µm. Use the Pyrocam for HF/DF lasers near 4µm and for Optical Parametric Oscillators from 1 µm to 10µm. It measures Free Electron Lasers between 193µm and 3000µm.



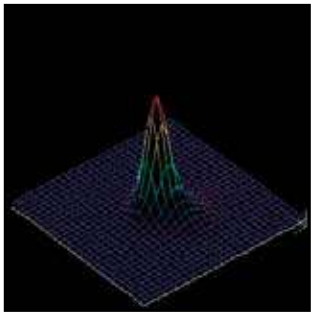
Er:YAG laser at 2.9µm.



Output of infrared fiber optic.



THz laser beam at 1.6THz (184µm).



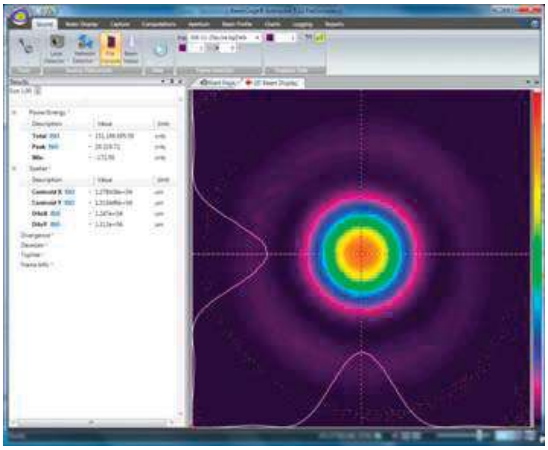
Free Electron laser at 100µm.

The Pyrocam is extremely useful in the UV from 13nm to 355nm for Excimer lasers and for tripled or quadrupled Nd:YAG lasers. The detector is stable under UV illumination, without the deterioration experienced by CCD cameras. (The pyroelectric detector operates in the visible spectrum, and can see the alignment HeNe used with CO_2 lasers. However, spurious response from the underlying silicon multiplexer creates undesirable performance, and the camera is not recommended for quantitative visible measurements).

BeamGage Image Analysis Software

Both Pyrocams come bundled with BeamGage, the state-of-the-art beam profiling system that performs rigorous data acquisition and analysis of laser beam parameters, such as beam size, shape, uniformity, divergence, mode content, and expected power distribution. Once the Pyrocam is connected to the PC and BeamGage is running, the software automatically detects the camera presence and is immediately ready to start taking images and displaying them on the monitor.

BeamGage is the industry's first beam profiling software to be newly designed, from scratch, using the most advanced tools and technologies. BeamGage is based on UltraCal™, Spiricon's patented baseline correction algorithm that helped establish the ISO 11146-3 standard for beam measurement accuracy.
BeamGage provides high accuracy results, guaranteeing the data baseline (zero-point reference) is accurate to 1/8th of a digital count on a pixel-by-pixel basis.

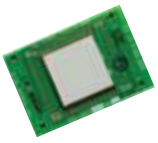


BeamGage recognizes the Pyrocam IIIHR & IV and allows you to quickly start analyzing your laser beam

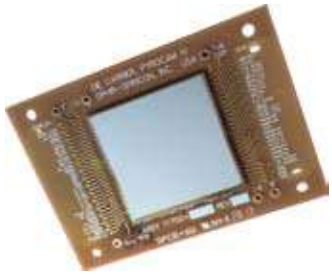
BeamGage permits the user to employ custom calculations for best fit to an individual application. These user-defined computations are treated like the standard calculations. They can be displayed on the monitor, logged with results, and included in hard-copy reports.
The system also allows the user to configure the displayed calculations, set-up the screen layout, and password-protect the configuration. This permits secure product testing, ensures security in production environments where plant floor personnel interface with the system, and assures the validity of the data for Statistical Process Control (SPC).

Hybrid Integrated Circuit Sensor

The Pyrocam consists of a $LiTa0_3$ pyroelectric crystal mounted with indium bumps to a solid-state readout multiplexer. This sensor, developed as the Company's core technology for the Pyrocam I, has proven to be the most rugged, stable, and precise IR detector array available. Light impinging on the pyroelectric crystal is absorbed and converted to heat, which creates charge on the surface. The multiplexer then reads out this charge. For use with short laser pulses, the firmware in the camera creates a very short electronic shutter to accurately capture the thermally generated signal.



Pyrocam™ IIIHR 12.8X12.8mm array



Pyrocam IV 25mm X 25mm array

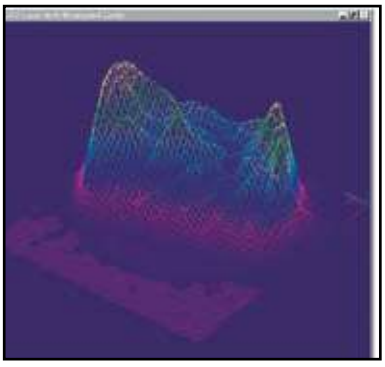
State-Of-The-Art Electronics

The camera features a high resolution A/D converter which digitizes deep into the camera noise. This enables reliable measurement and analysis of both large signals and low level signals in the wings of the laser beam. High resolution digitizing also enables accurate signal summing and averaging to pull weak signals out of noise. This is especially useful with fiber optics at 1.3µm and 1.55µm, and in thermal imaging.

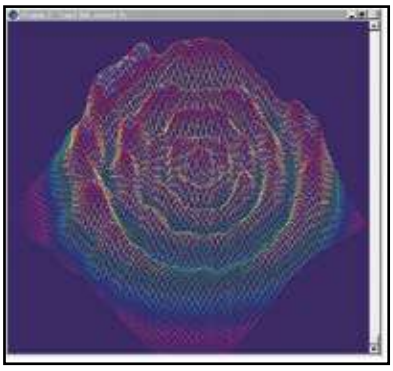
Applications Of The Pyrocam™ IIIHR

The Pyrocam is an ideal camera for use in scientific laboratory investigation of laser beams. This includes physics, chemistry, and electronic system designs. As an example, the photos below show a research CO_2 laser and a research Nd:YAG laser, both with cavity misalignment. The camera is also useful in product engineering of CO_2 and other infrared lasers. The Pyrocam is an integral part of the assembly lines of many CO_2 laser manufacturers. Integrators of systems are using the Pyrocam sensor to make sure that optical systems are aligned and operating properly.

There are many medical applications of the Pyrocam, such as the analysis of excimer lasers used for eye surgery. In many cases these lasers need alignment to ensure that the eye surgery is performed as expected. Other medical IR lasers perform dermatology, for which the uniformity of the beam profile must be assured.



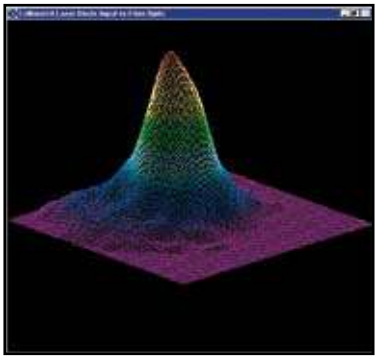
CO_2 laser with cavity misalignment.



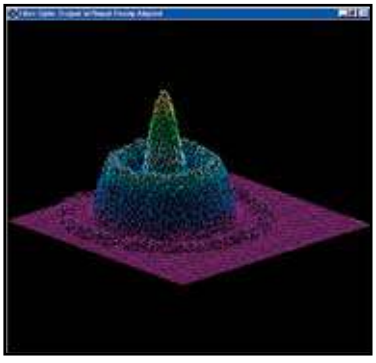
Nd:YAG laser with cavity misalignment.

Fiber optic communications, at 1.3µm and 1.55µm make significant use of the Pyrocam for analyzing the beams being emitted, as well as analyzing properties of the beams before launching them into fibers. The greater stability of the Pyrocam make it a good choice over other cameras operating at telecommunication wavelengths.

The Pyrocam is becoming an essential tool in the maintenance of industrial infrared lasers, especially CO_2. The Pyrocam replaces non-electronic mode burns and acrylic blocks by providing higher definition electronic recording of data, and analysis of short term fluctuations. The Pyrocam is superior to other electronic methods of measuring CO_2 lasers because the entire beam can be measured in a single pulse, and additional measurements made in real-time. This ensures that the beam did not change during the measurement.



CO_2 laser with cavity misalignment.



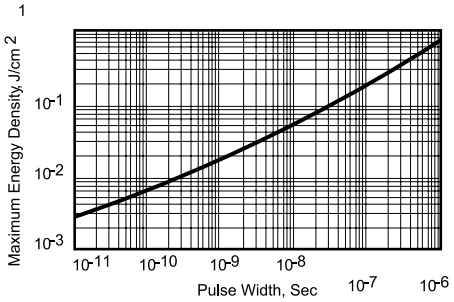
Nd:YAG laser with cavity misalignment.

Detector Damage Threshold

The Pyrocam sensor is capable of operation with intensities about 100 times greater than CCD cameras. This makes the camera ideal for use with high power lasers, as less attenuation is required. Nevertheless, pulsed lasers with fluence too high can evaporate the absorbing front electrode.

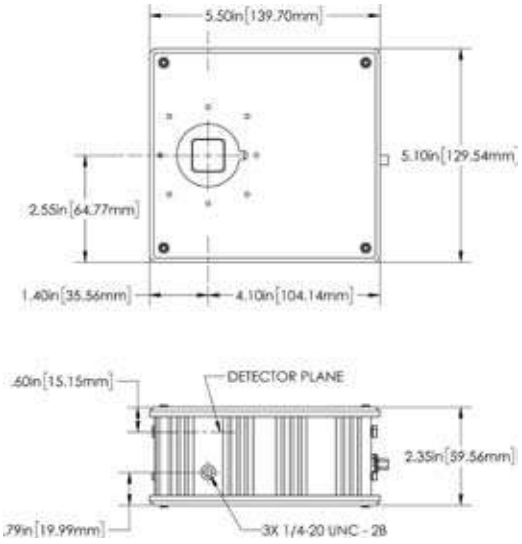
As shown the damage threshold increases with pulse width. With nanosecond and longer pulses, detector saturation occurs before damage.
With shorter pulses it helps to increase the camera amplifier gain so that electronic saturation occurs before damage.

The sensor can be damaged by excessive CW power, which causes crystal cracking. Very few Pyrocam detectors have been damaged by CW power, but some have been ablated by high peak pulse energy.

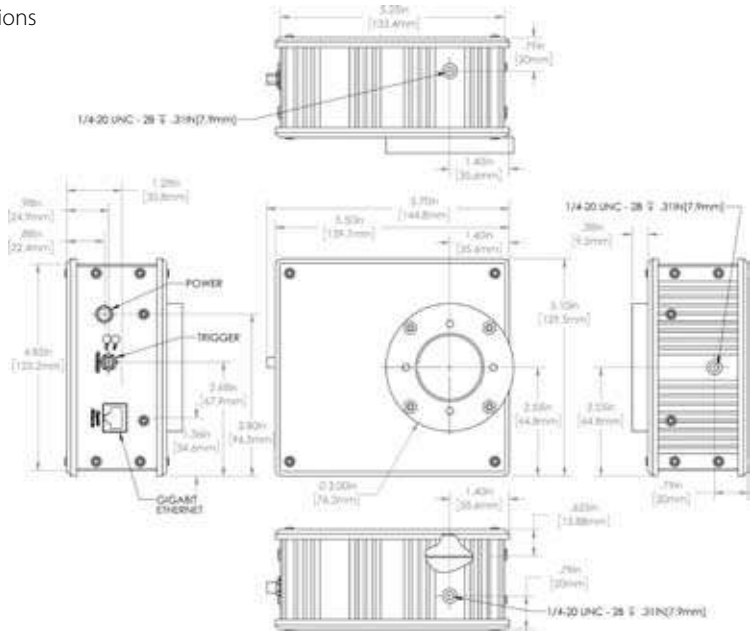


Pulsed damage threshold of pyroelectric detector coating.

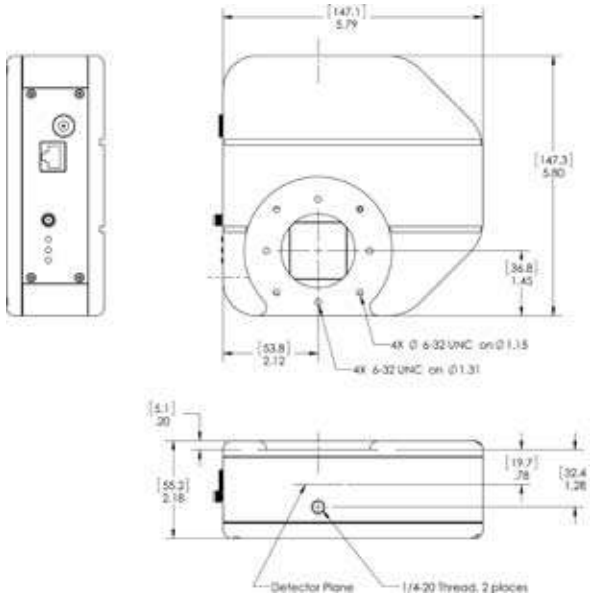
Pyrocam IIIHR Dimensions



Pyrocam IIIHR Plus Dimensions



Pyrocam IV Dimensions



Specifications

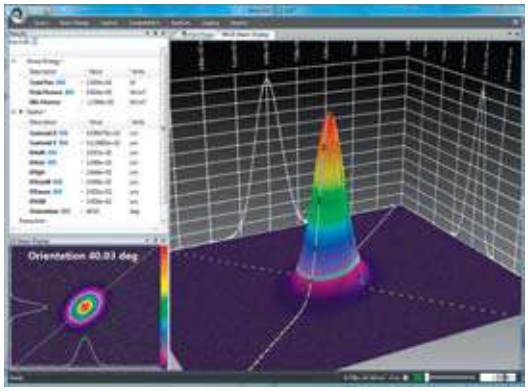
	Pyrocam IIIHR		Pyrocam IIIHR Plus	Pyrocam IV	
Application	UV and IR	MIR [1]	UV and IR	UV and IR	MIR [1]
Spectral response	13 - 355nm	3 - 5µm	13 - 355nm	13 - 355nm	3 - 5µm
	1.06 - 3000µm		1.06 - 3000µm	1.06 - 3000µm	
Interchangeable windows	See selection in Ordering section		See selection in Ordering section	See selection in Ordering section	
Detector array details					
Active area	12.8mm x 12.8mm		12.8mm x 12.8mm	25.6mm x 25.6mm	
Element spacing	80µm x 80µm		80µm x 80µm	80µm x 80µm	
Number of elements	160 x 160		160 x 160	320 x 320	
Pixel size	75µm x 75µm		75µm x 75µm	75µm x 75µm	
CHOPPED CW OPERATION					
Chopping frequencies	25Hz, 50Hz		25Hz, 50Hz	25Hz, 50Hz	
Sensitivity (RMS noise limit)	64nW/pixel (25Hz)		64nW/pixel (25Hz)	64nW/pixel (25Hz)	
	96nW/pixel (50Hz)		96nW/pixel (50Hz)	96nW/pixel (50Hz)	
	1.0mW/cm^2 (25Hz)		1.0mW/cm^2 (25Hz)	1.0mW/cm^2 (25Hz)	
	1.5mW/cm^2 (50Hz)		1.5mW/cm^2 (50Hz)	1.5mW/cm^2 (50Hz)	
Noise equivalent power (NEP)	13nW/Hz$^{1/2}$/pixel (1Hz)		13nW/Hz$^{1/2}$/pixel (1Hz)	13nW/Hz$^{1/2}$/pixel (1Hz)	
Saturation power	3.0W/cm^2(25Hz)		3.0W/cm^2(25Hz)	3.0W/cm^2(25Hz)	
	4.5W/cm^2 (50Hz)		4.5W/cm^2 (50Hz)	4.5W/cm^2 (50Hz)	
Damage threshold power					
Over entire array	2W		2W	2W	
Peak Power Density	8W/CM^2 (Chopped mode)		8W/CM^2 (Chopped mode)	8W/CM^2 (Chopped mode)	
	4W/CM^2 (CW in pulsed mode)		4W/CM^2 (CW in pulsed mode)	4W/CM^2 (CW in pulsed mode)	
PULSED OPERATION					
Laser pulse rate	Single-shot to 1000Hz		Single-shot to 1000Hz	Single-shot to 1000Hz	
Pulse width	1fs - 12.8ms		1fs - 12.8ms	1fs - 12.8ms	
Sensitivity (peak noise limit)	0.5nJ/pixel		0.5nJ/pixel	0.5nJ/pixel	
	8µJ/cm^2		8µJ/cm^2	8µJ/cm^2	
Saturation energy	15mJ/cm^2		15mJ/cm^2	15mJ/cm^2	
Damage threshold	20mJ/cm^2 (1ns pulse)		20mJ/cm^2 (1ns pulse)	20mJ/cm^2 (1ns pulse)	
	600mJ/cm^2 (1 ms pulse)		600mJ/cm^2 (1 ms pulse)	600mJ/cm^2 (1 ms pulse)	
Trigger input					
High logic level	3.5 - 6.0V DC		3.5 - 6.0V DC	3.5 - 6.0V DC	
Low logic level	0 - 0.8V DC		0 - 0.8V DC	0 - 0.8V DC	
Pulse width	4µs min		4µs min	4µs min	
Trigger	Supports both trigger and strobe out		Supports both trigger and strobe out	Supports both trigger and strobe out	
Photodiode trigger	InGaAs response: SP90409		InGaAs response: SP90409	InGaAs response: SP90409	
OPERATING CONNECTIONS AND CONDITIONS					
Power	12VDC		12VDC	12VDC	
Line frequency	60/50Hz External Supply		60/50Hz External Supply	60/50Hz External Supply	
Power consumption	12W		12W	12W	
Operating temperature	5°C to 50°C		5°C to 50°C	5°C to 50°C	
PHYSICAL					
Case Dimensions	140mm H X 130mm W X 60mm D		140mm H X 130mm W X 70mm D	147.3mm H X 147.1mm W X 55.2mm D	
Detector Position	Centered in width 35.6mm from bottom 15.43 ± .75mm behind front cover (without included C-mount attached) Tilt <2°		Centered in width 35.6mm from bottom 15.43 ± .75mm behind front cover (without included telescope attachment) Tilt <2°	53.8mm from bottom left 36.8mm from bottom 19.7 ± .75mm behind front cover Tilt <2°	
Weight	0.85Kg (1.83lbs); not including power supply		0.85Kg (1.83lbs); not including power supply	1.2kg (2.65lbs); not including power supply	
PC interface	Gigabit Ethernet (IEEE 802.3ab), GigE Vision compliant		Gigabit Ethernet (IEEE 802.3ab), GigE Vision compliant	Gigabit Ethernet (IEEE 802.3ab), GigE Vision compliant	
MEASUREMENTS PERFORMED					
Comes with BeamGage PRO	Extensive set of quantitative and image display capabilities. See BeamGage data sheet.		Extensive set of quantitative and image display capabilities. See BeamGage data sheet.	Extensive set of quantitative and image display capabilities. See BeamGage data sheet.	
Array Quality					
	Grade A <50 bad pixels, all correctable No uncorrectable clusters		Grade A <50 bad pixels, all correctable No uncorrectable clusters	Grade A <300 bad pixels, all correctable No uncorrectable clusters	

[1] The MIR (Mid-IR) versions on the Pyrocam IIIHR and IV are designed specifically for Mid-IR lasers in the spectral range 3 to 5µm.
The MIR versions feature specifically designed sensors that maximize the optical signal for high fidelity spatial profile measurements of laser beam in the 3 to 5µm spectral range.

Ordering Information

Item	Description	P/N
13 - 355nm & 1.06 - 3000µm BeamGage **Professional** a windowless bezel comes with the unit, other windows available for purchase		
PY-III-HR-C-A-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional, GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90405
PY-III-HR-C-MIR-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional, GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90415
PY-III-HR-C-A-PLUS	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional, GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included. Comes with telescopic adaptor mounted to front case.	SP90448
Optional windows for Pyrocam IIIHR		
PY-III-HR-W-BK7-1.064	Pyrocam III-HR window assembly, BK7, A/R coated for 1.064µm	SP90365
PY-III-HR-W-SI-1.05-2.5	Pyrocam III-HR window assembly, Si, A/R coated for 1.05 to 2.5µm	SP90366
PY-III-HR-W-SI-2.5-4	Pyrocam III-HR window assembly, Si, A/R coated for 2.5 to 4µm	SP90367
PY-III-HR-W-GE-3-5.5	Pyrocam III-HR window assembly, Ge, A/R coated for 3 to 5.5µm	SP90368
PY-III-HR-W-GE-10.6	Pyrocam III-HR window assembly, Ge, A/R coated for 10.6µm	SP90369
PY-III-HR-W-GE-8-12	Pyrocam III-HR window assembly, Ge, A/R coated for 8 to 12µm	SP90370
PY-III-HR-W-ZNSE-10.6	Pyrocam III-HR window assembly, ZnSe, A/R coated for 10.6µm	SP90371
PY-III-HR-W-ZNSE-10.2µm & 10.6µm	Pyrocam III-HR window assembly, ZnSe, A/R coated for 10.2µm & 10.6µm	SP90412
PY-III-HR-W-ZNSE-2-5	Pyrocam III-HR window assembly, ZnSe, A/R coated for 2 to 5µm	SP90372
PY-III-HR-W-BaF2-Uncoated	Pyrocam III-HR window assembly,BaF2 uncoated for 193 to 10µm	SP90373
PY-III-HR-W-POLY-THZ	Pyrocam III-HR window assembly, LDPE, uncoated for Terahertz wavelengths	SP90374
PY-IV-C-A-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional, GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90404
PY-IV-C-MIR-PRO	Pyroelectric array detector, chopped, Grade A, one Gigabit Ethernet port, BeamGage Professional, GigE to USB3 adaptor, hard shipping case, 3 meter GigE cable, and power supply w/locking connector included.	SP90414
Optional windows for Pyrocam IV		
PY-IV-W-BK7-1.064	Pyrocam IV window assembly, BK7, A/R coated for 1.064µm	SP90301
PY-IV-W-SI-1.05-2.5	Pyrocam IV window assembly, Si, A/R coated for 1.05 to 2.5µm	SP90302
PY-IV-W-SI-2.5-4	Pyrocam IV window assembly, Si, A/R coated for 2.5 to 4µm	SP90303
PY-IV-W-GE-3-5.5	Pyrocam IV window assembly, Ge, A/R coated for 3 to 5.5µm	SP90304
PY-IV-W-GE-10.6	Pyrocam IV window assembly, Ge, A/R coated for 10.6µm	SP90305
PY-IV-W-GE-8-12	Pyrocam IV window assembly, Ge, A/R coated for 8 to 12µm	SP90306
PY-IV-W-ZNSE-10.6	Pyrocam IV window assembly, ZnSe, A/R coated for 10.6µm	SP90307
PY-IV-W -ZNSE-2-5	Pyrocam IV window assembly, ZnSe, A/R coated for 2 to 5µm	SP90308
PY-IV-W-ZNSE-UNCOATED	Pyrocam IV window assembly, ZnSe, uncoated	SP90336
PY-IV-W-POLY-THZ	Pyrocam IV window assembly, LDPE, uncoated for Terahertz wavelengths	SP90309
Options		
BSQ-PY-M	Pyrocam license for Manual BeamSquared	SP90410

3.3.2 BeamMic™ – Basic Laser Beam Analyzer System

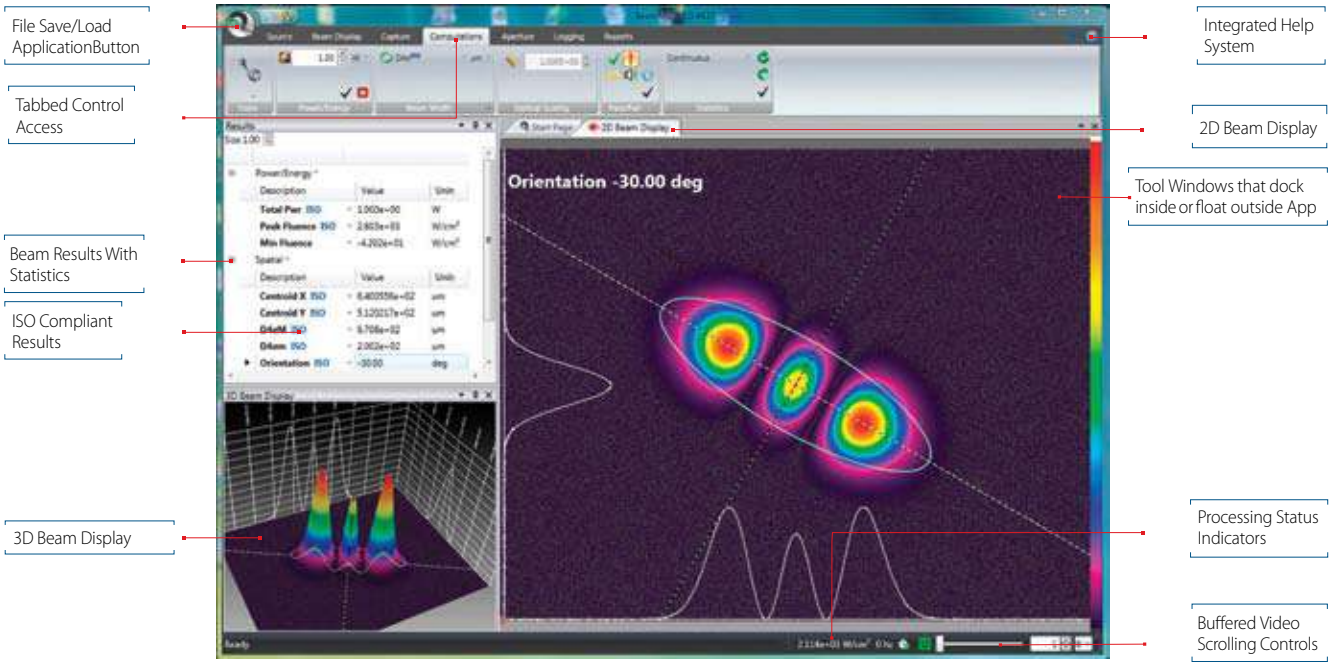


- High-speed false color beam intensity profile displays in both 2D and 3D
- Operates in Windows 7 and Windows 10
- Numerical beam profile analysis employs patented advanced calibration algorithms
- Extensive set of ISO quantitative measurements
- ISO beam width and diameter methods
- Enhanced window layout tools to get the most out of the desktopdisplay area
- Pass/fail testing available on most all measured parameters
- Support for USB SPxxx series cameras
- Supports satellite windows on multiple monitors
- Continuous zoom scaling in both 2D and 3D
- Results logging capabilities exportable to Excel
- Industry std data file formats, HDF5 and CSV
- Configurable Report Generator that allows cut and paste of results, images and settings from .PDF and .XPS file types
- Statistical Analysis of all measured parameters
- Both Drawn and Auto Aperture for isolating beam data
- Integrated automatic Help linked into this .pdf Users Guide
- Automation interface via .NET components

BeamMic is an introductory product for those that do not need all of the features in our award winning beam profiling product, BeamGage. BeamMic includes a simplified set of measurements allowing for basic beam characterization to help improve your system performance without going to a full-featured SPC type system. This is perfect for the operator to do a quick check on the laser system prior to starting their process. BeamMic meets many of our industrial customer's basic needs at a cost effective price.

The beam's size, shape, uniformity or approximation to the expected power distribution, can make or break an application. Accurate knowledge of these parameters is essential to the accuracy of any laser-based application. As laser applications push the boundaries of laser performance it is becoming more critical to understand the operating criteria.

BeamMic Main Display Screen



Camera Compatibility

For lasers between 190-1100nm wavelengths, BeamMic interfaces to silicon CCD USB cameras. For applications between 1440-1605nm, BeamMic supports cost effective phosphor coated CCD cameras.

190-1100nm

Model	SP907	SP928
Spectral Response nm	190 - 1100nm*	190 - 1100nm*
Application	1/1.8" format, slim profile, wide dynamic range, CW & pulsed lasers, adjustable ROI	1/1.8" format, high resolution, wide dynamic range, CW & pulsed lasers, adjustable ROI
Number of Elements	964 x 724	1928 x 1448
Interface Style	USB 3.0	USB 3.0
Windows OS Support	Windows 7 and Windows 10	

* May be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to errors of beam width measurement. We would suggest our XC130 InGaAs camera and BeamGage for these wavelengths to give you the best measurements.

1440-1605nm

Model	SP907-1550	SP928-1550
Spectral Response nm	1440 - 1605nm	1440 - 1605nm
Application	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning	NIR wavelengths, 1/1.8" format, low resolution, adjustable ROI and binning
Number of Elements	964 x 724	1928 x 1448
Interface Style	USB 3.0	USB 3.0
Windows OS Support	Windows 7 and Windows 10	

** Despite the small pixel size, the spatial resolution will not exceed 50µm due to diversion of the light by the phosphor coating.

3.3.2.1 Software Specifications

Features	BeamMic - Laser Beam Analyzer Software
Features Overview	Designed for entry level or basic profiling needs
	Supports our patented Ultracal algorithm plus Auto-setup and Auto-exposure capabilities
	Extensive set of ISO quantitative measurements
	Support for high and low resolution USB cameras
	Simultaneous 2D and 3D displays
	Multi-instance, multi-camera use
	Supports Satellite windows on multiple monitors
	Continuous zoom scaling in both 2D and 3D
	Camera ROI support
	Manual and Auto-aperturing to reduce background effects
	Pass/Fail on all results items, w/multiple alarm options
	Results logging capabilities in a reloadable
	Industry standard data file format
	Configurable Report Generator that allows cut and paste of results, images and settings.
	Supports English, German, Japanese and Chinese Windows OS in 64bit . Multilingual GUI in English, Japanese and Chinese.
Quantitative Calculations; Basic Results	(per ISO 11145, 11146-1/-3, and 13694)
Power/Energy Results	Total power or energy
	Peak power/energy density
	Min. Fluence
Spatial Results	Peak and Centroid locations
	Beam width
	▪ Second Moment (D4s)
	▪ Knife Edge 90/10
	▪ Knife Edge (User selectable level)
	▪ Percent of Peak (User selectable)
	▪ Percent of Total Energy (User selectable)
	▪ Encircled power smallest slit @ 95.4
	▪ Moving Slit (User Selectable)
	Beam diameter
	▪ Average diameter (based on x/y widths)
	▪ Second Moment (D4s)
	Elliptical Results
	▪ Elliptical orientation
	▪ Ellipticity
	▪ Eccentricity
2D Features	Continuously zoomable and resizable displays in satellitable window
	Continuous Z axis display magnitude scaling
	Zoomable to subpixel resolution for origin and cursor placements
	Pixel boundaries delinated at higher zoom magnifications
	Adjustable Cursors that can track peak or centroid
	Adjustable manual apertures
	Viewable Auto-aperture placement
	Displayed beam width marker
	Integrated Mouse actuated pan/zoom controls
	Manual or fixed origin placement
3D Features	3D graphics utilize solid surface construction with lighting and shading effects
	Integrated Mouse actuated pan/zoom/tilt/rotate controls
	Selectable Mesh for drawing speed vs resolution control
	Continuously zoomable and resizable displays in satellitable window
	Continuous Z axis display magnitude scaling
	User enabled backplanes with cursor projections
Statistical Analysis	Performed on all measurement functions with on-screen display
	▪ Choices of intervals
	▪ Manual start/stop
	▪ Time from 1 second to 1000 hours
	▪ Frames from 2 to 99,999
	Measurements reported
	▪ Current frame data, Mean, Standard Deviation, Minimum, Maximum of each calculation performed

Features	BeamMic - Laser Beam Analyzer Software
File types	Industry Standard HDF5 data and setup file format which are compatible in third party applications such as MatLab and Mathmatica
	Math program and Excel compatible ASCII-csv results files
	Graphics in jpg file format
	A user defined single file output that can contain settings, beam displays, beam profiles, results in either .pdf or .xps file formats
Printing	Images, reports, results, statistics and setup information
	Option to print many frames in a single operation
	WYSIWYG images
Pass/Fail	Set Maximum/Minimum limits on all calculations and statistics
	Red/Green font color indication on result items
	Multiple choices for indication of failed parameters, including TTL pulse for external alarm
	Master pass/fail which triggers alarm on any failure
	USB signal, beep, stop, and log alarm options
Logging	
	Results in ASCII-csv
	Continuous Logging
	Time Interval Logging
	Frame Count Logging
	Pass/Fail Sampling
Exporting	Convert frame buffer data to third party format
	Export a user specified number of frames from the buffer
	Export Image Data: ASCII-cvs
	Export Results: ASCII-csv
	Export Picture: jpg, gif, tiff, bmp, png file formats supported
	Export Image Data in Aperture
Integrated Help	PDF Operators Manual
	Context Sensitive (Whats this?) Help
	Context Sensitive Hints
Signal Conditioning for Enhanced Accuracy	Spiricon's patented Ultracal enables more accurate beam measurement and display. Ultracal takes a multi- frame average of the baseline offset of each individual pixel to obtain a baseline accurate to approximately 1/8 of a digital count. This baseline offset is subtracted from each frame, pixel by pixel, to obtain a baseline correction accurate to 1/8 digital count. Spiricon's Ultracal method retains numbers less than zero that result from noise when the baseline is subtracted. Retaining fractional and negative numbers in the processed signal can increase the beam width measurement accuracy by up to 10X over conventional baseline subtraction and clip level methods. Spiricon's Ultracal conforms to the best method described in ISO 11146-3:2004
Frame Averaging	Up to 256 frames can be averaged for a signal-to-noise ratio, S/N, improvement of up to 16X (Noise is averaged up to 1/256th [8 fractional bits]). Data is processed and stored in a 32bit format
Frame Summing	Up to 256 frames can be summed to pull very weak signals out of the noise. Due to the precise nature of Ultracal baseline setting, (i.e., a retention of both positive and negative noise components) summing of frames can be performed without generating a large offset in the baseline
Convolution (Adjacent Pixel Averaging)	Choice of 5 convolution algorithms for spatial filtering for both display and calculations. Spatial filtering improves the visual S/N
Camera Features	Camera features are governed by the capabilities of the various cameras that will interface with these software products, and second by which of these camera features are implimented in the software. This section will describe typical camera features supported in the application
	Black Level Control (used by Ultracal and Auto-X and Auto-setup)
	Gain Control (used by Auto-X and Auto-setup)
	Exposure Control (used by Auto-X and Auto-setup)
	Pixel Sampling
	Bits per pixel setting
	External Trigger Input
	Trigger Delay
	Strobe Output
	Strobe Delay
	External Trigger Probe
	Internal Trigger Probe
Camera related features in the applications	These are features related to but not generally dependent upon the camera design
	Gamma Correction
	Gain Correction
	Bad Pixel Correction
	Lens Applied Option
	Pixel scale settings
	Magnification settings
	Frame buffer settings
	Ultracal
	Enable Auto-X (auto exposure control)
	Perform an Auto-Setup
	8 & 12 bits per pixel
	Select Format
	Measure S/N ratio

Features	BeamMic - Laser Beam Analyzer Software
Trigger, Capture and Synchronization Methods	Capture methods are features related to the application while Synchronization methods relate more to the abilities of the specific camera. NOTE: Frame capture rates are determined by many factors and are not guaranteed for any specific operating configuration.
	Trigger modes
	▪ CW - captures continuously, see Capture Options below
	▪ Trigger-In from laser: Trigger pulses supplied to the camera
	▪ Strobe-Out to laser: Strobe pulses output from the camera
	▪ Video Trigger: Frame captured and displayed only when the camera sees a signal greater than a user set level
	Capture options
	▪ Capture options are redefined and are approached in a different manner than older products. The items listed below will allow for all of the previous methods but with more flexibility than ever before
	▪ Results Priority: Results priority will slow the capture rate to be in sync with the computational results and display updates
	▪ Frame Priority: Frame priority will slow results and display updating to insure that frames are collected and stored in the frame buffer as fast as possible (replaces block mode)
	▪ Stop After: Will collect a set number of frames and then stop (replaces Single-Shot mode)
	▪ Periodic: Will collect frame at a programmed periodic rate
	▪ Periodic Burst: Will collect frames in a Burst at programmed periodic rates
	Post processing is still available but is done via a different mechanism and is limited to only data file sources
Automation Interface (.NET)	Automation Interface with examples in LabVIEW, Excel and Net VB
	Automate launch and termination of the application
	Automate start, stop, Ultracal, Auto-X and Auto Setup
	Automate the loading of application setups
	Automate control of most camera settings
	Automate a subset of the application features and controls
	Automate the capture of Binary Video Data
	Automate the acquisition of application results
	Automate the acquisition of application Images
System Requirements	PC computer running Windows 7 and Windows 10 Laptop or Desktop.
	GHz Pentium style processor, dual core recommended
	Minimum 2GB RAM
	Accelerated Graphics Processor Hard drive space suitable to hold the amount of video data you expect to store (50-100 GB recommended)
	Windows 7 (64) and Windows 10

3.3.2.2 Ordering Information

Item	Description	P/N
BeamMic USB2 Beam Analyzer Systems (camera and software)		
BM-USB-SP907-OSI	BeamMic software, software license, 1/1.8" format 964X724 pixel camera with 4.5mm CCD recess. Comes with USB cable and 3 ND filters	SP90425
BM-USB-SP907-1550-OSI	BeamMic software, software license, 1/1.8" format 964X724 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB cable and 3 ND filters	SP90426
BM-USB-SP928-OSI	BeamMic software, software license, 1/1.8" format 1928X1448 pixel camera with 4.5mm CCD recess. Comes with USB and cable and 3 ND filters	SP90427
BM-USB-SP928-1550-OSI	BeamMic software, software license, 1/1.8" format 1928X1448 pixel camera with 4.5mm CCD recess. Phosphor coated to 1550 nm. Comes with USB and cable, 3 ND filters	SP90428
Software Upgrades		
BeamMic to BGS Upgrade	Upgrade BeamMic to BeamGage Standard Edition. Requires a camera key to activate. (SP cameras may require a firmware upgrade to enable ROI features)	SP90219
BeamMic to BGP Upgrade	Upgrade BeamMic to BeamGage Professional Edition. Requires a camera key to activate (SP cameras may require a firmware upgrade to enable ROI features)	SP90229
Optical Synch for Pulsed Lasers		
Photodiode Trigger, Si, 1100	Optical trigger assembly which can be mounted on camera or separately to sense laser pulses and synchronize SP cameras with pulses. See optical trigger data sheet	SP90408
Recommended Optional		
LBS-300s-BB	Dual beam splitters and configurable 9 ND filters for 190-1550nm; screws onto front of camera	SP90467

3.3.3 Focal Spot Analyzer

Measure how focal distance shifts with power

- Image focal spots down to 25µm in size
- For laser powers up to 400W (additional external ND filters required)
- Can measure systems with focal length as short as 73mm (exact path length distance within the assembly will be NIST calibrated and includes a calibration certificate +/-50µm)
- Produces undistorted sample of laser under test
- Adjustable attenuation maximizes system dynamic range
- Up to 1 x 10^{-10} attenuation available (without external filters)
- Analyzer includes camera, attenuation, BeamGage software and calibration certificate

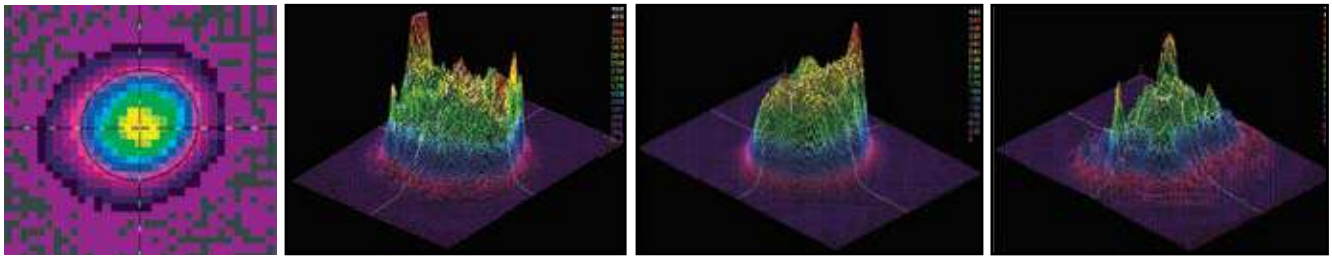
Measure your laser beam power distribution and focal spot size of wavelengths from 266 – 1100nm. The average power can be from <1 to 400 Watts and the focal spot can be as small as 25µm. The FSA can also be used to measure how the focal spot shifts with power during its critical start-up phase.

The FSA includes; choice of high resolution camera, 2 beam splitters, a removable beam block on the 2nd splitter, and user selectable attenuation filters prior to the beam entering the camera.

Operation

The assembly is placed below the final focusing lens of the laser at a distance equal to the expected focal length. The focal spot is found by moving the assembly closer and farther from the beam until the smallest spot size is seen. The distance between the focusing lens and the datum point on the FSA assembly is added to the distance from the datum to the camera array (each FSA assembly will be factory calibrated to within +/- 50 µm). These two measurements will give you the exact distance of your lasers focal spot.

Examples of Usage



65µm diameter focal spot

Focal spot spatial power density changing with laser power level

Specifications

Model	SP928	LT665
Application	1/1.8" format	1" format
Spectral Response	190 - 1100nm (2)	190 - 1100nm (2)
Active Area	7.1mm x 5.3mm	12.5mm x 10mm
Pixel spacing	3.69µm	4.54µm x 4.54µm
Number of effective pixels	1928 x 1448	2752 x 2192
Minimum system dynamic range	56 dB	54 dB
Linearity with Power	±1%	±1%
Accuracy of beam width	±2%	±2%
Frame rates in 12 bit mode (4)	13 fps at full resolution	27 fps at full resolution
Shutter duration	30µs to multiple frames	31µs to multiple frames
Gain control	0 dB to 24 dB	0.8 dB to 56 dB
Trigger	Hardware/Software trigger & strobe out	Hardware/Software trigger & strobe out
Photodiode trigger	N/A	Si response: SP90408
Saturation intensity (1)	0.97µW/cm^2	1.3µW/cm^2
Lowest measurable signal (1)	1.2nW/cm^2	0.3nW/cm^2
Damage threshold	50W/cm^2 / 0.1J/cm^2 with all filters installed for < 100ns pulse width(3)	50W/cm^2 / 0.1J/cm^2 with all filters installed for < 100ns pulse width(3)
Dimensions	48 mm x 44 mm x 20.2 mm	43 mm x 43 mm x 65 mm
CCD recess	4.5 mm	17.5mm
Image quality at 1064nm	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good	Pulsed with trigger sync - excellent Pulsed with video trigger - good CW - good
Operation mode	Interline transfer CCD	Quad Tap interline transfer CCD
Software supported	BeamGage STD or PRO	BeamGage STD and PRO
PC interface	USB 3.0	USB 3.0
OS Supported	Windows 7 (64) and Windows 10	Windows 7 (64) and Windows 10

Notes:

(1) Camera set to full resolution at maximum frame rate and exposure times, running CW at 632.8nm wavelength. Camera set to minimum useful gain for saturation test and maximum useful gain for lowest signal test.
(2) Camera may be useable for wavelengths below 350nm but sensitivity is low and detector deterioration may occur. Therefore UV image converter is recommended. Although our silicon cameras have shown response out to 1320nm it can cause significant blooming which could lead to significant errors of beam width measurement. We would suggest our XC130 InGaAs camera for these wavelengths to give the best measurements.
(3) This is the damage threshold of the filter glass of the filters. Assuming all filters mounted with ND1 (red housing) filter in the front. Distortion of the beam may occur with average power densities as low as 5W/cm^2.
(4) Highly dependent on PC processor and graphics adapter performance.

Ordering Information

Model	LBS-300s-UV	LBS-300s-VIS	LBS-300s-NIR	LBS-300s-BB
Wavelength	266-355nm	400-700nm	1064nm	190-1550nm
Wedge Material	UVFS	UVFS	UVFS	UVFS
Wedge Coating	A/R ≤1%	AR ≤1%	AR ≤1%	No coating, 4% reflection
Clear aperture	17.5mm	17.5mm	17.5mm	17.5mm
Reflection	0.01%	0.01%	0.01%	0.16%
Wedge ND value, each	ND ≥2	ND ≥2	ND ≥2	ND ~1.3
ND Filters	Inconel	Bulk ND	Bulk ND	One each of the UV, VIS & NIR sets
ND Values, nominal	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Blu holders)	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Grn holders)	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Red holders)	See UV, VIS and NIR descriptions
Filter Slides	3	3	3	9
Maximum allowable input to filter (1)	100 W/cm^2 CW 20mJ/cm^2, 10ns pulse	50 W/cm^2 1J/cm^2, 10ns pulse	50 W/cm^2 1J/cm^2, 10ns pulse	See adjacent specifications

Note: (1) ND bulk absorbing filters damage threshold is 50W/cm^2 but should be used at <5W/cm^2 to avoid thermal lensing effects.

Ordering Information

Item	Description	P/N
BGS-LBS-300s-UV-CAL	LBS-300s-UV beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90456
BGS-LBS-300s-UV-CAL-Lt665	LBS-300s-UV beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90477
BGS-LBS-300s-VIS-CAL	LBS-300s-VIS beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90457
BGS-LBS-300s-VIS-CAL-Lt665	LBS-300s-VIS beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90478
BGS-LBS-300s-NIR-CAL	LBS-300s-NIR beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90458
BGS-LBS-300s-NIR-CAL-Lt665	LBS-300s-NIR beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90479
BGS-LBS-300s-BB-CAL	LBS-300s-BB beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90459
BGS-LBS-300s-BB-CAL-Lt665	LBS-300s-BB beam splitter & neutral density filters combo + BeamGage Standard software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90480
BGP-LBS-300s-UV-CAL	LBS-300s-UV beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90460
BGP-LBS-300s-UV-CAL-Lt665	LBS-300s-UV beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1" format 2752X2192 pixel camera pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90481
BGP-LBS-300s-VIS-CAL	LBS-300s-VIS beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90461
BGP-LBS-300s-VIS-CAL-Lt665	LBS-300s-VIS beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90482
BGP-LBS-300s-NIR-CAL	LBS-300s-NIR beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90462
BGP-LBS-300s-NIR-CAL-Lt665	LBS-300s-NIR beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90483
BGP-LBS-300s-BB-CAL	LBS-300s-BB beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1/1.8" format 1928X1448 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90463
BGP-LBS-300s-BB-CAL-Lt665	LBS-300s-BB beam splitter & neutral density filters combo + BeamGage Professional software, software license, 1" format 2752X2192 pixel camera + NIST traceable calibrated path length from top of unit to CCD array. Comes with USB cable and 3 ND filters.	SP90484

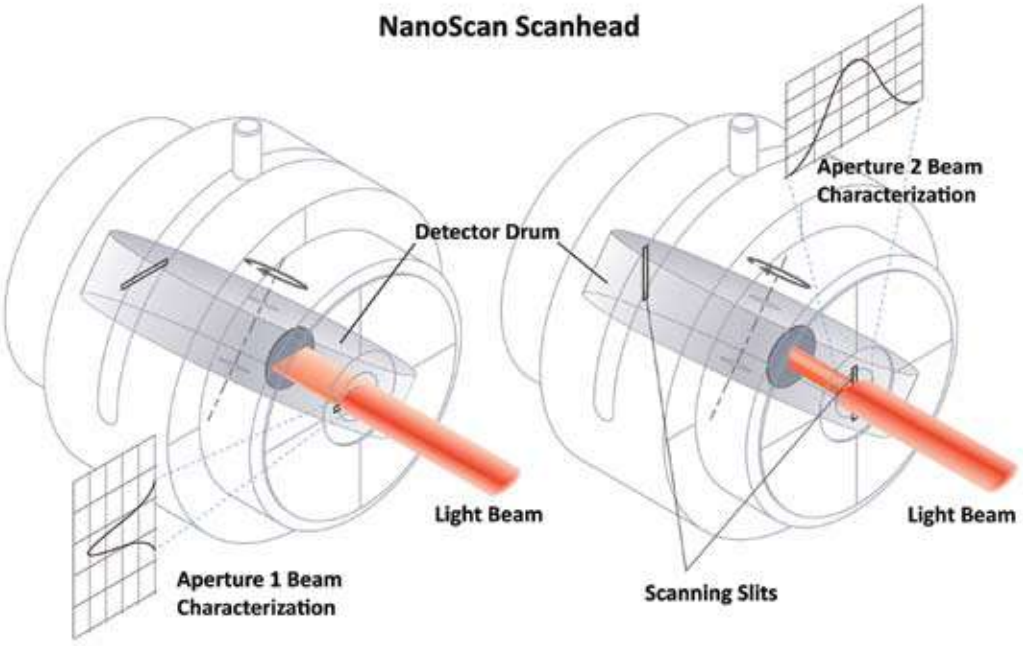
3.4 Introduction to Scanning-Slit Profilers

The scanning slit beam profiler moves two narrow orthogonal slits in front of a linear photo-detector through the beam under analysis. Light passing through the slit induces a current in the detector. Thus, as the slit scans through the beam, the detector signal is linearly proportional to the spatial beam irradiance profile integrated along the slit. A digital encoder provides accurate slit position. The photo-induced current signal is digitized and analyzed to obtain the beam profile in both X and Y from the two orthogonal slits.

The slit apertures act as physical attenuators, preventing detector saturation for most beam applications. High dynamic range amplification allows operation over many orders of magnitude in beam power.

From these profiles, important spatial information such as beam width, beam position, beam quality, and other characteristics are determined. This technique can accommodate a wide variety of test conditions. Because slit scanners measure beams at high powers with little or no attenuation, they are ideal to profile beams used in material processing.

Carbon dioxide (CO_2) lasers are widely used in materials processing, and have a 10.6 micron wavelength that cannot be profiled with most cameras. Slit scanners, therefore, provide an convenient means of measuring high-resolution CO_2 lasers with powers up to and exceeding 1000 watts.



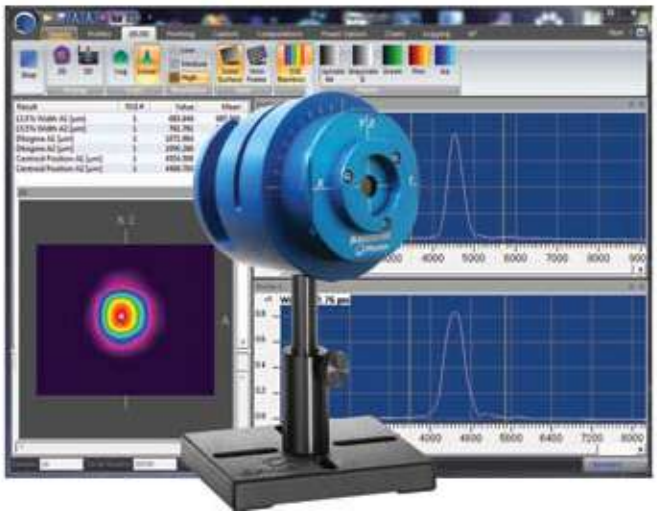
3.4.1 NanoScan 2s

3.4.1.1 NanoScan 2s – Standard Version

Scanning Slit Beam Profiler For High Accuracy Dimensional Measurement

NanoScan 2s combines the convenience and portability of direct USB connectivity with the speed, accuracy, and dynamic range that users have come to expect from the Photon NanoScan slit based profilers. The NanoScan 2s is available with a silicon, germanium or pyroelectric detector, which allows it to profile lasers of any wavelength from UV to far infrared, out to 100µm and beyond. With the new NanoScan 2s software package, the user can configure the display interface however it is desired; displaying those results of most interest on one easy-to-read screen, or on multiple screens.

The NanoScan slit profiler is the most versatile laser beam profiling instrument available today: providing instantaneous feedback of beam parameters for CW and kilohertz pulsed lasers, with measurement update rates to 20Hz. The natural attenuation provided by the slit allows the measurement of many beams with little or no additional attenuation. The high dynamic range makes it possible to measure beams while adjustments to focus are made without having to adjust the profiler. Just aim the laser into the aperture and the system does the rest!



Capabilities

NanoScan 2s is a PC-based instrument for the measurement and analysis of laser beam spatial irradiance profiles in accordance with the ISO standard 11146. The scan heads also measure power in accordance with ISO 13694.

NanoScan uses the scanning slit, one of the ISO Standard scanning aperture techniques. It can measure beam sizes from microns to centimeters at beam powers from microwatts to over kilowatts, often without attenuation. Detector options allow measurement at wavelengths from the ultraviolet to the infrared.

The NanoScan 2s digital controller has 16-bit digitization of the signal for enhanced dynamic range up to 35dB power optical. With the accuracy and stability of the beam profile measurement you can measure beam size and beam pointing with a 3-sigma precision of several hundred nanometers. The software controllable scan speed and a "peak-connect" algorithm allows the measurement of pulsed and pulse width modulated lasers with frequencies of 10kHz and higher*. The NanoScan is also able to measure up to 16 beams, or regions of interest, in the aperture simultaneously.

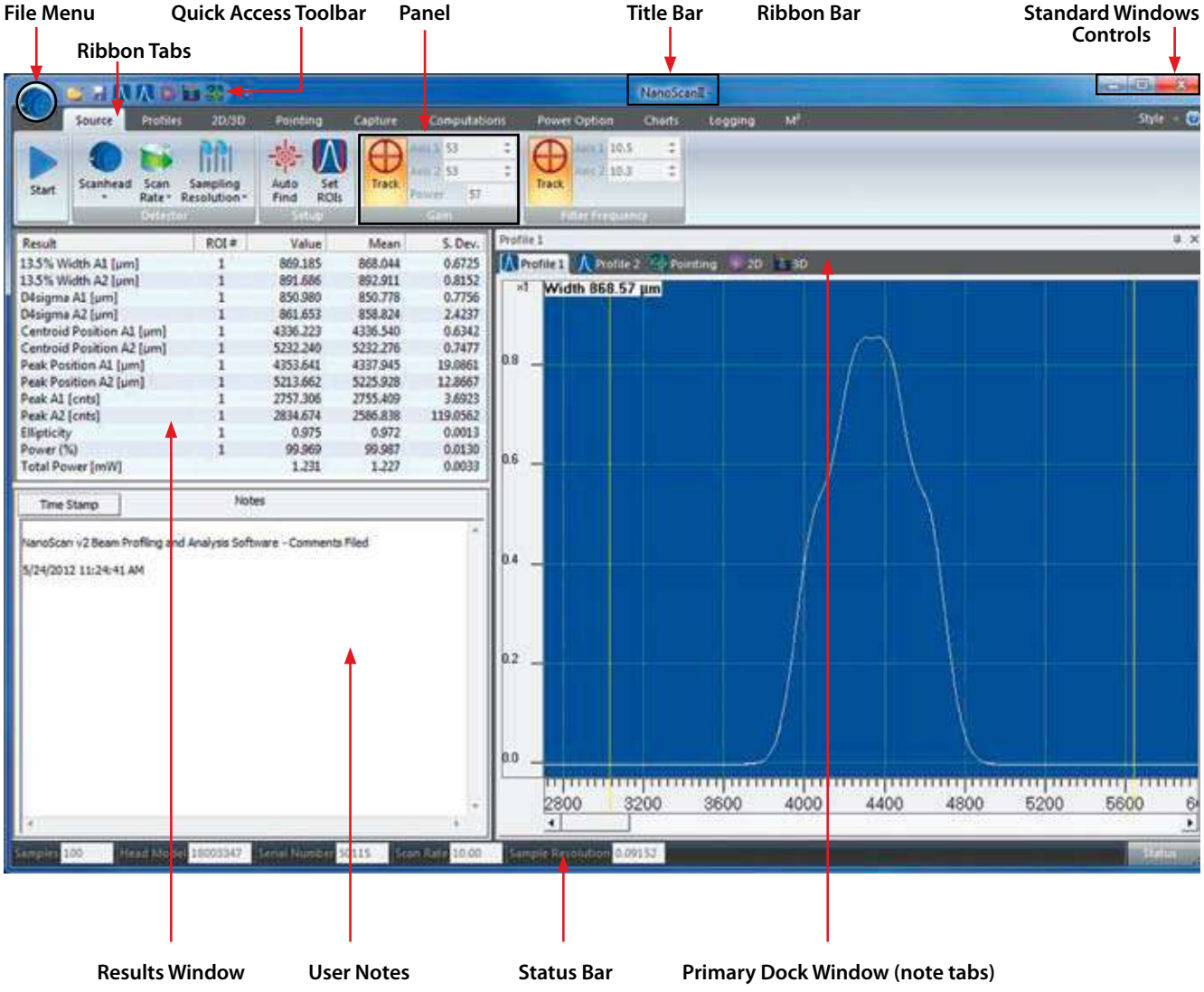
Benefits

- Measure any wavelength from UV to very far infrared (190nm to >100µm)
- Instantaneous real time display of results; beam found in less than 300ms and updated at up to 20Hz
- Waist location can be determined to within ±25µm due to the well-defined Z-axis datum plane of the NanoScan
- Measure pulsed and CW lasers
- For pulsed beams the pulse rate is measured and reported
- From as small as 7µm beams, can be measured directly with guaranteed accuracy and precision
- Additional high signal to noise ratio can be achieved with averaging
- Z-axis caustic measurements are available with built-in mechanical linear stage control
- M2 propagation ratio values available with simple M^2 Wizard included with the software.
- Any beam result can be charted and monitored over time
- Power levels can be monitored along with spatial measurements to determine if losses are introduced by beam adjustments
- Log results to text files for independent analysis
- Automate the system using optional ActiveX Automation commands, available with the PRO version software and scan heads Samples of automation programs included for Excel, VBA, LabView and Visual Basic.net

* The minimum frequency is a function of the beam size and the scan speed. This is a simple arithmetic relationship; there must be a sufficient number of pulses during the time that the slits sweep through the beam to generate a meaningful profile. Please refer to Photon's Application Note, Measuring Pulsed Beams with a Slit-Based Profiler.

NanoScan 2s Configurable User Interface

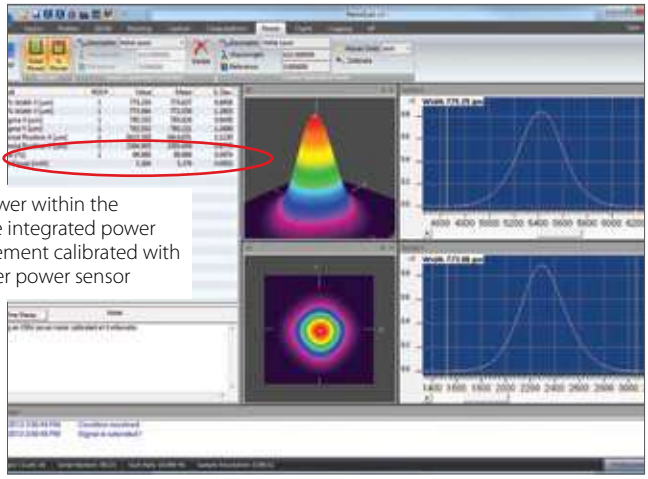
In addition to new hardware, the NanoScan 2s has an updated integrated software package for the Microsoft Windows Platform, which allows the user to display any of the results windows on one screen. The NanoScan 2s software comes in two versions, STD and PRO. The NanoScan 2s Pro version includes ActiveX automation for users who want to integrate the NanoScan into OEM systems or create their own user interface screens with C++, LabView, Excel or other OEM software packages.



Example of display configuration window

Integrated Power Meter

The silicon and germanium detector equipped NanoScan 2s systems include an integrated 200mW power meter. The scanhead comes with a quartz attenuator window that provides a uniform response across a broad wavelength range.
This is a relative power meter that has better than 1.5% correspondence when calibrated with a user-supplied power meter and used in the same configuration as calibrated.
The power meter screen in the software shows both the total power and the individual power in each of the beams being measured.



% of power within the aperture integrated power measurement calibrated with customer power sensor

Available Detectors

The NanoScan 2s is available with silicon, germanium or pyroelectric detectors to cover the light spectrum from UV to very far infrared.

Apertures and Slits

The NanoScan 2s is available with a variety of apertures and slit sizes to allow for the accurate measurement of varying beam sizes. The slit width defines the minimum beam width that can be measured; due to convolution error, the slit should be no larger than ¼ the beam diameter to provide a ±3% accurate measurement. For this reason the minimum beam diameter measureable with the standard 5µm slit is 20µm. To measure beams smaller than 20µm it is necessary to use the small aperture 1.8µm slit instrument, providing a minimum beam diameter of ~8µm. Because these slits are so narrow, the maximum length limits the aperture to 3.5mm. Contrary to many people's beliefs, these smaller slits do not improve the resolution of the measurement, only the minimum size of the beam. Therefore, unless it is necessary to measure beams less than 20µm, one would be advised to stick with the 9mm/5µm configurations.
For very large beams, NanoScan is available with a large 20 or 25mm aperture with 25µm slits. These sensor are larger than the standard scan heads (100mm diameter)

NanoScan 2s Scanhead Model	Si/3.5/1.8µm	Si/9/5µm	Si/9/25µm
Wavelength	190nm - 950nm	190nm - 950nm	190nm - 950nm
Slit Size	1.8µm	5µm	25µm
Aperture Size	3.5mm	9mm	9mm
1/e² Beam Diameter Range	7µm-~2.3mm	20µm-~6mm	100µm-~6mm
Spatial Sampling Resolution	5.3nm-18.3µm		
Profile Digitization	16-bit		
Scan frequency	1.25, 2.5, 5, 10, 20Hz		
Power Reading	User calibrated		
Power Aperture Window	Metalized Quartz (200mW upper limit)		
Laser Type	CW or Pulsed		
Operating Range	See Operating Space Charts		
Damage threshold	See Operating Space Charts		
Rotation Mount	Standard		
Scanhead Dimension	63.4mm diameter x76.8mm long See Mechanical Drawing for details		

NanoScan 2s Scanhead Model	Ge/3.5/1.8µm	Ge/9/5µm	Ge/9/25µm
Wavelength	700nm - 1800nm	700nm - 1800nm	700nm - 1800nm
Slit Size	1.8µm	5µm	25µm
Aperture Size	3.5mm	9mm	9mm
1/e² Beam Diameter Range	7µm-~2.3mm	20µm-~6mm	100µm-~6mm
Spatial Sampling Resolution	5.3nm – 18.3µm		
Profile Digitization	16 bit		
Scan Frequency	1.25, 2.5, 5, 10, 20Hz		
Power Reading	User calibrated		
Power Aperture Window	Metalized Quartz (200mW upper limit)		
Laser Type	CW or Pulsed		
Operating Range	See Operating Space Chart		
Damage Threshold	See Operating Space Chart		
Rotation Mount	Standard		
Scanhead Dimension	63.4mm diameter x 76.8mm long See Mechanical Drawing for details		

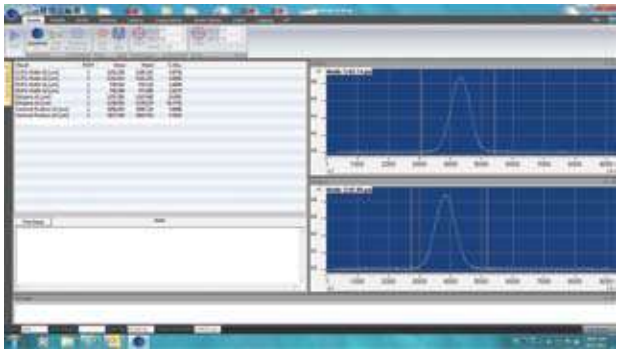
NanoScan 2s Scanhead Model	Pyro/9/5µm	Pyro/9/25µm
Wavelength	190nm->100µm	190nm->100µm
Slit Size	5µm	25µm
Aperture Size	9mm	9mm
1/e² Beam Diameter Range	20µm-~6mm	100µm-~6mm
Spatial Sampling Resolution	5.3nm-18.3 µm	
Profile Digitization	16-bit	
Scan Frequency	1.25, 2.5,5,10,20Hz	
Power Reading	Not available	
Power Aperture Window	N A	
Laser Type	CW or Pulsed	
Operating Range	See Operating Space Chart	
Damage Threshold	See Operating Space Chart	
Rotation Mount	Standard	
Scanhead Dimension	63.4 mm diameter x 76.8mm long See Mechanical Drawing for details	

The Most Versatile and Flexible Beam Profiling System Available

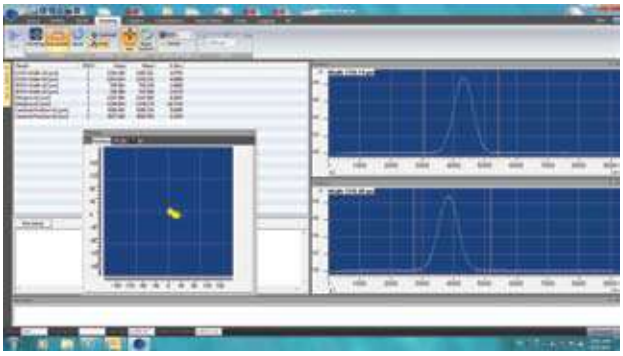
With the available range of detectors, slit sizes and apertures the NanoScan 2s provides the maximum versatility in laser beam profiling. NanoScan 2s adds the convenience and portability of direct USB connectivity: no external controllers or power supplies required to operate the profiler. In addition the rotation mount has been redesigned to provide a stand for vertical operation, if desired. The mount can be positioned in one of two places. If vertical operation is desired the mount is positioned toward the back of the scanhead to expose the stand, which can be affixed to the optical table or stage. If standard horizontal operation is desired, then the rotation mount can be positioned in the forward configuration, maintaining the original length and size of the scanhead.

See Your Beam As Never Before

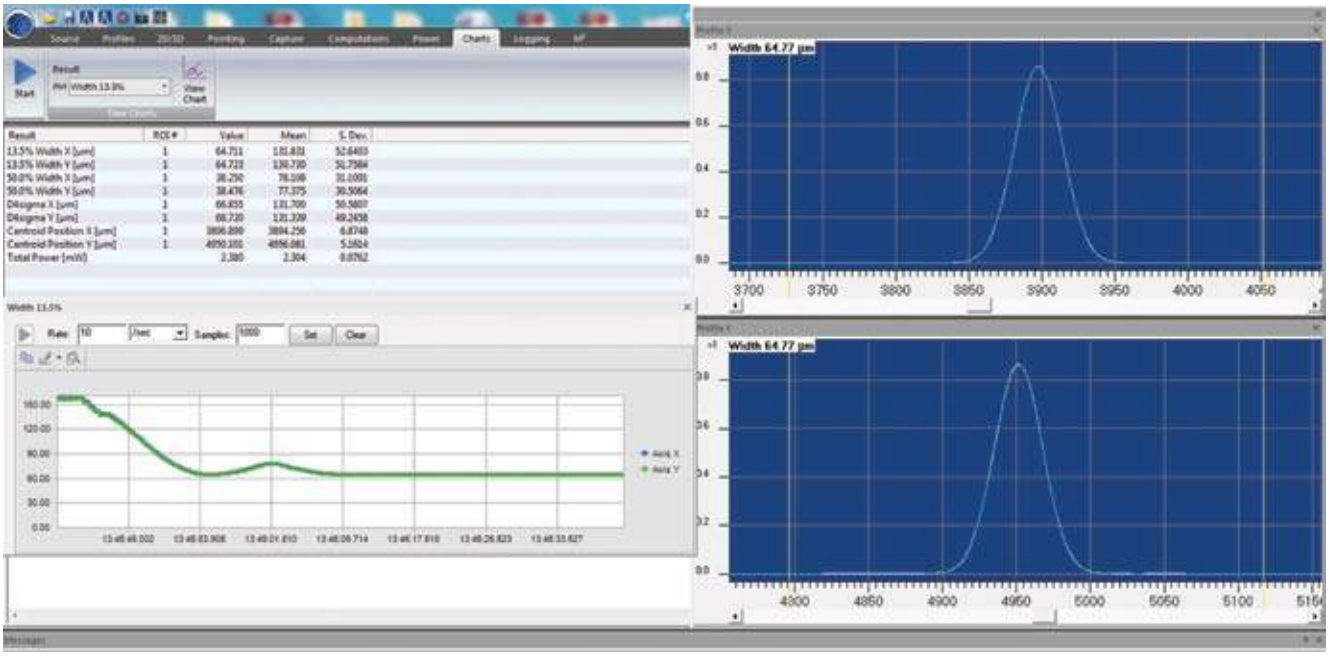
The new NanoScan 2s graphical user interface (GUI) allows the user to set the display screens to any appropriate configuration, displaying those that are of interest and hiding what is not. This means that you can have the information that you want to see, uncluttered by extraneous output, and you can have all the features you need, visible at once. The screens can be docked or floating with ribbon bars for the controls that can be visible or hidden as desired. This allows you to take advantage of a large, multi-monitor desk top or maximize the useful information on a small laptop display.



Simple docked view of profiles and numerical results



Both docked and undocked windows: profiles, results, and pointing



Example of time charts used to monitor focusing process

Measured Beam Results

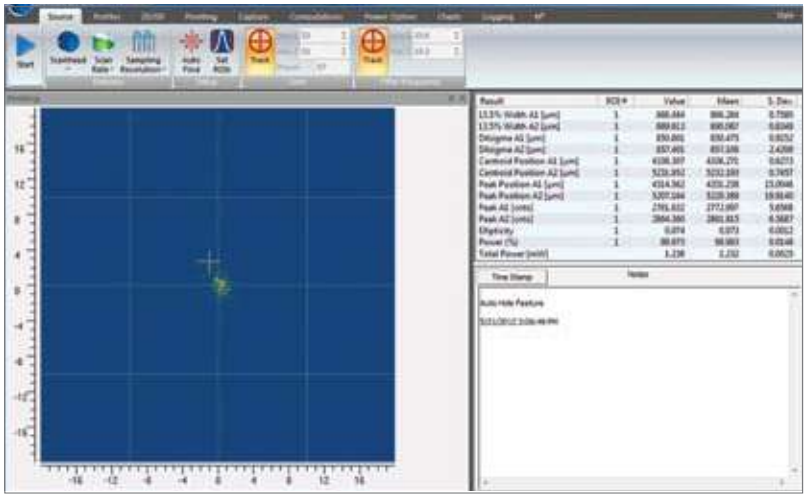
From 1989 through 1996, John Fleischer, founder and past President of Photon Inc., chaired the working laser beam width ISO/DIN committee that resulted in the ISO/DIN 11146 standard. The final approved standard, available in 13 languages. The standard governs profile measurements and analysis using scanning apertures, variable apertures, area sensors and detector arrays. NanoScan 2s measures spatial beam irradiance profiles using scanning slit techniques.

Results measured include:

- Beam Width at standard and user-definable clip levels, including $1/e^2$ and 4σ
- Centroid Position
- Peak Position
- Ellipticity
- Gaussian Fit
- Beam Divergence
- Beam Separation
- Pointing Stability
- ROI Power
- Total Power
- Pulsed Laser Repetition Rate

Result	ROI #	Value	Mean	S. Dev.
13.5% Width A1 [µm]	1	863.328	864.612	0.7082
13.5% Width A2 [µm]	1	876.317	875.622	0.9432
D4sigma A1 [µm]	1	849.062	849.700	1.5084
D4sigma A2 [µm]	1	842.054	840.924	2.3751
Centroid Position A1 [µm]	1	1.111	-0.133	0.5622
Centroid Position A2 [µm]	1	-1.730	0.275	1.2221
Peak Position A1 [µm]	1	-11.521	-19.890	5.6014
Peak Position A2 [µm]	1	4.156	8.732	6.9860
Peak A1 [cnts]	1	2812.438	2810.688	4.0486
Peak A2 [cnts]	1	2687.898	2678.320	5.5879
Ellipticity	1	0.806	0.807	0.0023
Power [%]	1	99.994	99.979	0.0273
Total Power [mW]		1.202	1.203	0.0002

Example of the many measurements that can be made and the precision you can expect



Knowing pointing stability is a critical factor in laser performance

M^2 Wizard

M-squared (M^2) software Wizard is an interactive program for determining the "times diffraction limit" factor M^2 by the Rayleigh Method. The M^2 Wizard prompts and guides the user through a series of manual measurements and data entries required for calculating M^2. Used with a user-provided translation stage focusing lens and the M^2 Wizard in the NanoScan Analysis Software, the user can quickly and easily determine the times-diffraction propagation factor (M^2) of a laser. For automated and automatic M^2 measurements the NanoModeScan option is required.

Pulsed Laser Beam Profiling

In addition to profiling CW laser beams, NanoScan can also profile pulsed laser beams with repetition rate in the 10kHz range and above. To enable the measurement of these pulsed lasers, the NanoScan profiler incorporates a "peak connect" algorithm and software-controlled variable scan speed on all scanheads. The accuracy of the measurement generally depends on the laser beam spot size and the pulse-to-pulse repeatability of the laser. The NanoScan is ideal for measuring Q-switched lasers and lasers operating with pulse width modulation power (PWM) control. In the past few years, lasers with pico- and femtosecond pulse durations have begun to be used in many applications. Although these lasers add some additional complication to the measurement techniques, the NanoScan can also measure this class of laser.

3.4.1.2 NanoScan 2s – Professional Version

Automation Interface

For customer who want to incorporate the NanoScan 2s into an automated procedure or to create a customized user interface, the PRO version scanheads include an ActiveX Automation Server that can be used by an Automation Client written in Visual Basic for Applications (VBA), C/C++ or by an application which supports ActiveX Automation, such as Microsoft Excel, Microsoft Word or National Instruments' LabVIEW. The software package include example of programs written in Excel and LabVIEW in the automation folder.

3.4.1.3 NanoScan 2s Acquisition and Analysis Software

Use the Software specification from the existing NanoScan 2s data sheet

*Feature		NanoScan Standard	NanoScan Professional (all features in Standard plus)
Controls			
Source	ScanHead Select, Gain, Filter, Sampling Resolution, AutoFind, Rotation Frequency, Record Mode	●	
Capture	Averaging, Rotation, Magnification, CW or Pulse Modes, Divergence, Gaussian Fit, Reference Position, Recompute	●	
Regions of Interest (ROI)	Single or Multiple, Automatic or Manual, Colors	●	
Profiles	Vertical Scale (1´, 10´, 100´), Logarithmic Scale, Z & PAN (Automatic or Manual)	●	
Computation: ISO 13694, ISO 11146	D_{slit}, (13.5%, 50% 2 User Selectable Clip Levels), $D_{4\sigma}$, Width ratios, Centroid Position, Peak Position, Centroid Separation, Peak Separation, Irradiance, Gaussian Fit, Ellipticity, Divergence, Total Power, Pulse Frequency, % power	●	
	Continuous, Rolling, Finite	●	
Pointing	Centroid or Peak, Accumulate Mode, Beam Indicator, Graph Center, Colors	●	
2D/3D	2D or 3D Mode, Linear or Logarithmic Scale, Resolution, Fill Contours, Solid Surface, or Wireframe, Clip Level Colors	●	
Charts	Chart Select, Parameter Select, Aperture Select, Update Rate, Start and Clear	●	
Logging	File Path/Name, Delimiter, Update Rate	●	
M^2	Rail Setup: Com Port and Length, Connect/Disconnect, Rail Control	●	
Views			
Profiles	Displays Beam Profiles for each axis, with optional Gaussian Overlays	●	
Results	Displays Values and Statistics for Selected results	●	
Pointing	Displays the XY position of the Centroid or Peak for each ROI , with optional overlays and Accumulate Mode	●	
Charts	Displays Time Charts for User-selected results	●	
2D/3D	Displays pseudo 2D/3D Beam Profile	●	
M^2 Wizard	An interactive procedure for measuring M^2 by the Rayleigh Method	●	
File Saving			
NanoScan Data Files		●	
Text Files		●	
Data Logging			
Log to File		●	
Reports			
NanoScan Report		●	
Automation Interface			
ActiveX Automation Server			●
Minimum System Requirements			
PC computer running windows 7 (32/64) Laptop or Desktop[1]			
A dual core processor CPU, 2GHz or better			
2GB of RAM[2]			
1-USB 2.0 port available			
At least 250MB of free HDD space			
1400 x 900 display resolution or better			
Graphics card w/hardware accelerator			
DVD-ROM drive			
Microsoft compatible pointing devices(e.g., mouse, trackball, etc)			

*Download the NanoScan Acquisition and Analysis Software Manual for a complete description of all Software Features

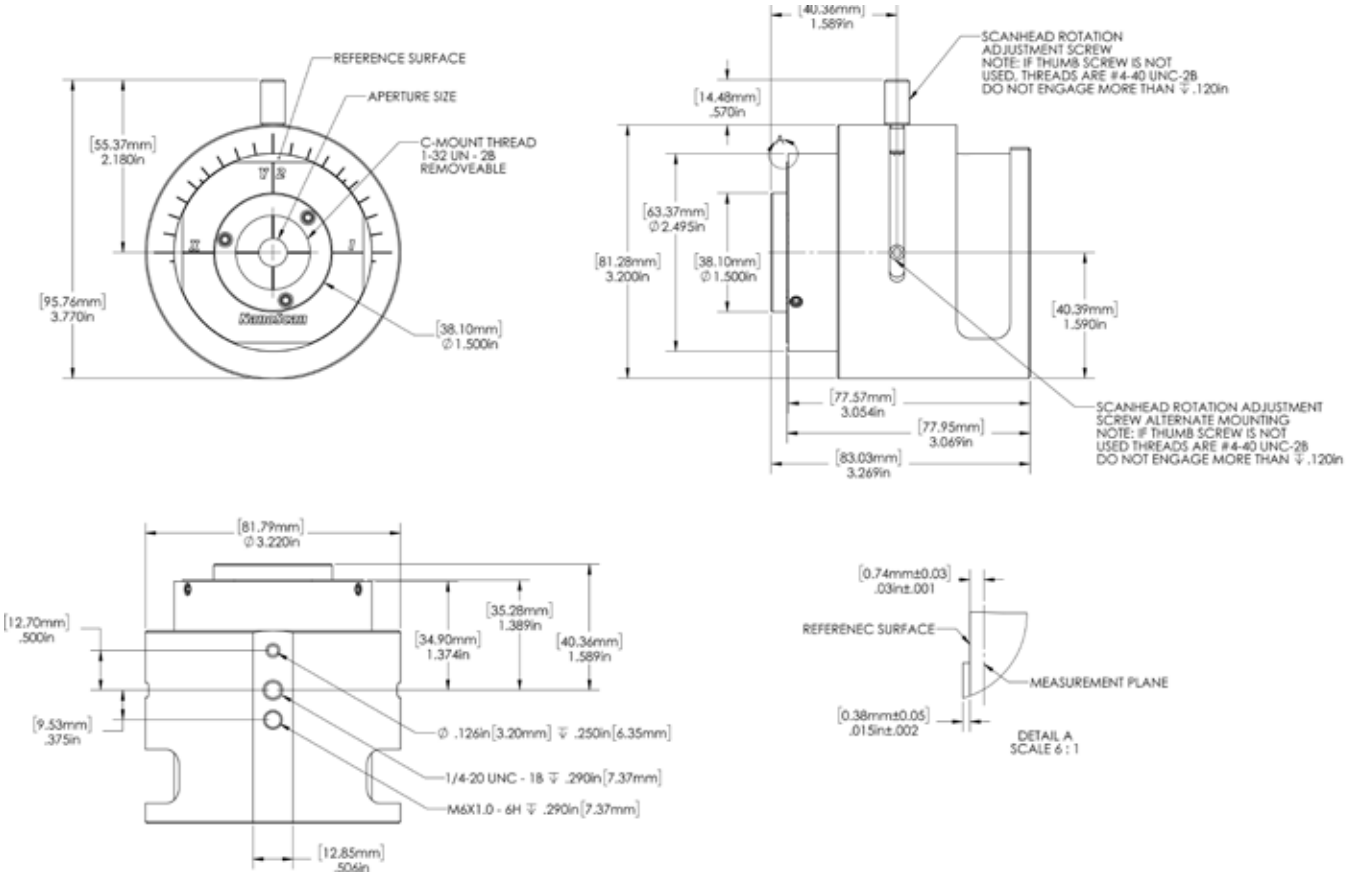
1. A business/professional version of windows is recommended. The NanoScan v2 software has not been tested with home versions of Windows. Both 64-bit and 32-bit versions of Windows 7 are supported. NanoScan v2 is no longer tested on Windows XP 32-bit operating systems.
2. The computer memory (RAM) will affect the performance of the software in the Data Recorder.

3.4.1.4 Specifications

Model	General Specification
Bus interface	USB 2.0
Signal digitization	16bit
Maximum digitization clock	21.4MHz
Maximum update rate	20Hz
Data transfer	Bulk Transfer Mode
On-board memory	64MB mDDR SDRAM
Weight	434g (15.3 ounces)
Operating temperature	0-50°C
Humidity	90%, non-condensing
Scanhead Dimensions	3.03"(7.68cm) L X 2.5"(6.35cm) Ø
Power	USB 2.0 Bus Powered
CPU Clock	300MHz
Memory Clock	264MHz
Scanning Motor	Brushed DC, 4W max

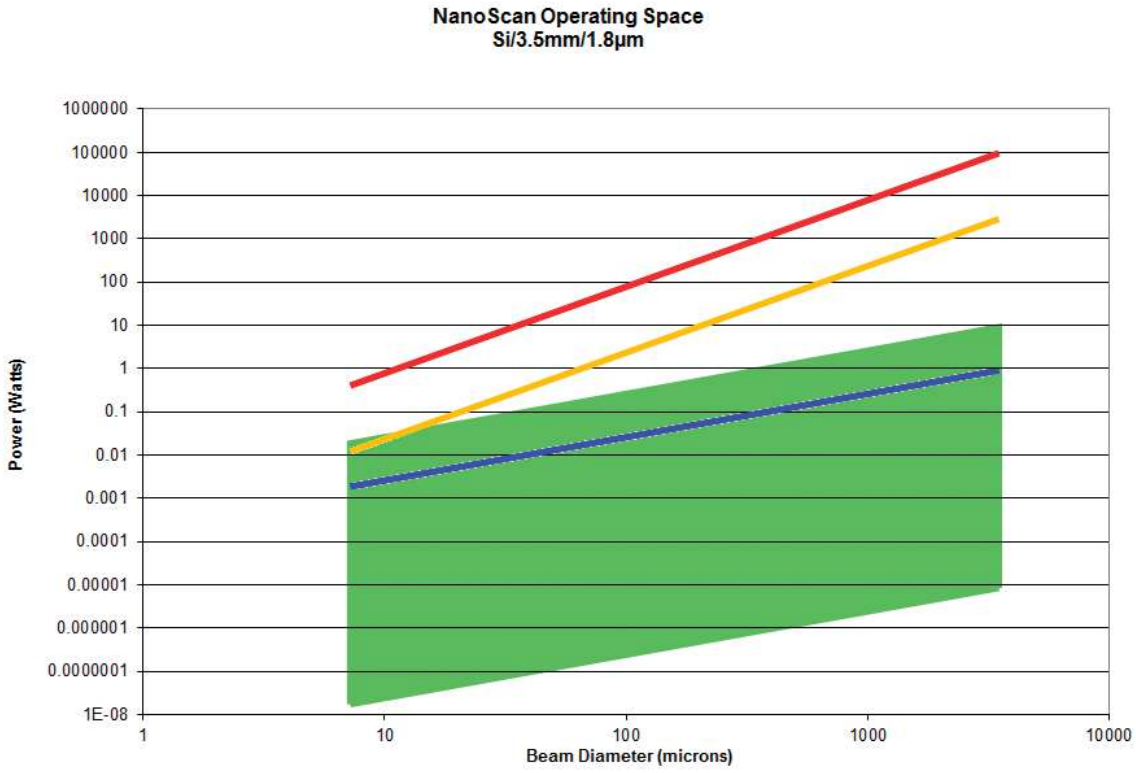
Mechanical Dimensions

NanoScan 2s Standard Scanhead: NS2s-Si, NS2s-Ge and NS2s-Pyro



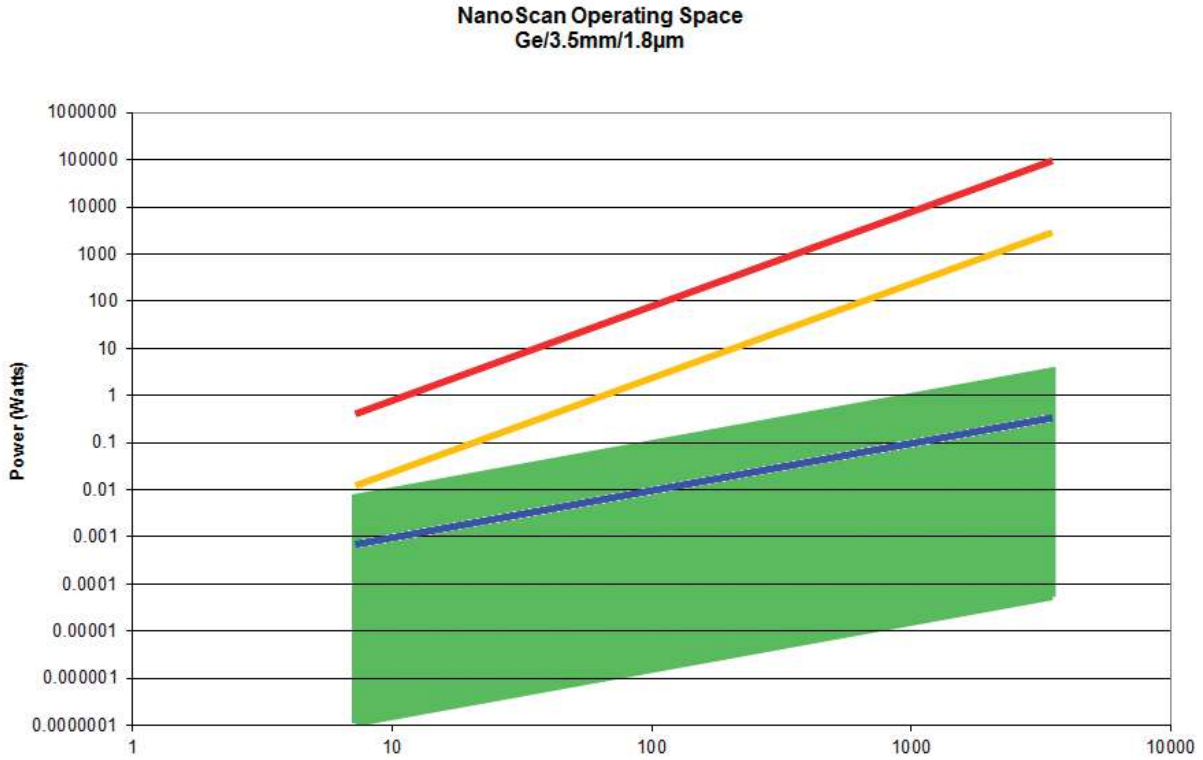
Typical NanoScan Operating Space Charts

Operating range is at peak sensitivity of detector. Operating space is NOT absolute.
THESE CHARTS TO BE USED AS A GUIDE ONLY.



Silicon Detector

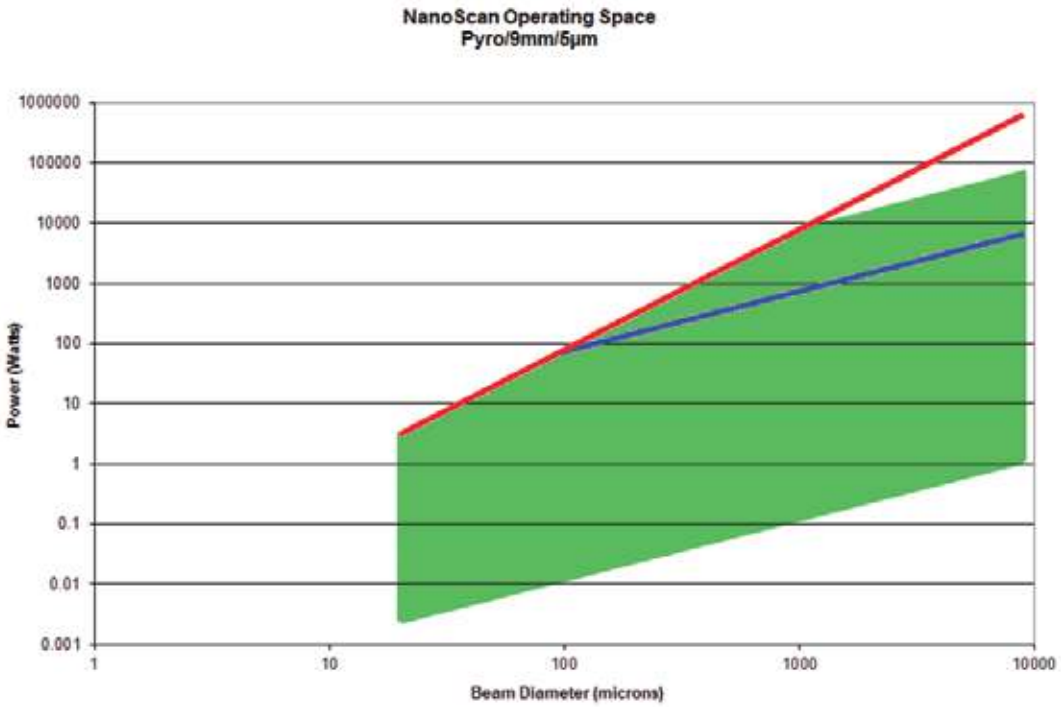
Silicon Detector: Responsivity varies with wavelength. Detects between 400-1100nm. Peak responsivity is 0.7 amps/watt at 980nm. Detector to detector responsivity variation can be as great as ±20%.
Power: Average power in the laser beam.
Beam Diameter: Assumes a round beam. The operating point for an elliptic beam can be approximated by using the average diameter. For extremely elliptic beams (ratio >4:1), contact Spiricon.
Pulsed Operation (**):** Upper limit of the operating space for pulsed laser measurements.
Black Coating Removed (**):** Slits are blackened to reduce back reflections; blackening begins to vaporize near this line. Slits in pyro detectors are not blackened.
Slit Damage (**):** Power density (watts/cm^2) where one can begin to ablate and cut the slits.
Refer to Spiricon's *Damage Threshold with High Power Laser Measurements* document.
Left Boundary: The left boundary is 4 times the slit width, where slit convolution error becomes significant to the 5% level for reported 1/e^2 diameter of a TEM$_{00}$ Gaussian beam.
Right Boundary: The right boundary is the instrument entrance aperture diameter, which determines the largest beam profile and diameter that can be measured. For a TEM$_{00}$ Gaussian beam the 1/e^2 diameter needs to be ≤1/2 the aperture diameter to measure and see the entire profile out to the tails. Similarly for a Flat-top distribution the 1/e^2 diameter needs to be ≤~95% of the aperture diameter.
To obtain any given clip level diameter for any beam (but not the full profile) ~95% of the aperture is useable.



Germanium Detector

Responsivity: Detector converts constant, incident photons to a current.

Germanium Detector: Responsivity varies with wavelength. Detects between 800-1800nm. Peak responsivity is 1.05 amps/watt at 1550nm. Detector to detector responsivity variation can be as great as ±20%.
Power: Average power in the laser beam.
Beam Diameter: Assumes a round beam. The operating point for an elliptic beam can be approximated by using the average diameter. For extremely elliptic beams (ratio >4:1), contact Spiricon.
Pulsed Operation (——— **):** Upper limit of the operating space for pulsed laser measurements.
Black Coating Removed (——— **):** Slits are blackened to reduce back reflections; blackening begins to vaporize near this line. Slits in pyro detectors are not blackened.
Slit Damage (——— **):** Power density (watts/cm^2) where one can begin to ablate and cut the slits. Refer to Spiricon's *Damage Threshold with High Power Laser Measurements* document.
Left Boundary: The left boundary is 4 times the slit width, where slit convolution error becomes significant to the 5% level for reported 1/e^2 diameter of a TEM$_{00}$ Gaussian beam.
Right Boundary: The right boundary is the instrument entrance aperture diameter, which determines the largest beam profile and diameter that can be measured. For a TEM$_{00}$ Gaussian beam the 1/e^2 diameter needs to be ≤1/2 the aperture diameter to measure and see the entire profile out to the tails. Similarly for a Flat-top distribution the 1/e^2 diameter needs to be ≤~95% of the aperture diameter. To obtain any given clip level diameter for any beam (but not the full profile) ~95% of the aperture is useable.



Pyroelectric Detector

Pyroelectric Detector: Uniform in response between 0.2 and 20 microns wavelength.
Power: Average power in the laser beam.
Beam Diameter: Assumes a round beam. The operating point for an elliptic beam can be approximated by using the average diameter. For extremely elliptic beams (ratio >4:1), contact Spiricon.
Pulsed Operation (———): Upper limit of the operating space for pulsed laser measurements.
Slit Damage (———): Power density (watts/cm^2) where one can begin to ablate and cut the slits. Refer to Spiricon's *Damage Threshold with High Power Laser Measurements* document.
Left Boundary: The left boundary is 4 times the slit width, where slit convolution error becomes significant to the 5% level for reported 1/e^2 diameter of a TEM_{00} Gaussian beam.
Right Boundary: The right boundary is the instrument entrance aperture diameter, which determines the largest beam profile and diameter that can be measured. For a TEM_{00} Gaussian beam the1/e^2 diameter needs to be ≤1/2 the aperture diameter to measure and see the entire profile out to the tails. Similarly for a Flat-top distribution the 1/e^2 diameter needs to be ≤~95% of the aperture diameter. To obtain any given clip level diameter for any beam (but not the full profile) ~95% of the aperture is useable.

3.4.1.5 Ordering Information

Item	Description	P/N
NS2s-SI/3.5/1.8-STD	NanoScan 2s Silicon Detector 3.5mm aperture 1.8µm slits. High-resolution head featuring Silicon detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength	PH00456
NS2s-SI/9/5-STD	NanoScan 2s Si Detector 9mm aperture 5µm slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength	PH00457
NS2s-SI/9/25-STD	NanoScan 2s Si Detector 9mm aperture 25µm slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength	PH00458
NS2s-Ge/3.5/1.8-STD	NanoScan 2s Ge Detector 3.5mm aperture 1.8µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8µm wide slits. Use from 700nm to 1.8µm wavelength	PH00459
NS2s-Ge/9/5-STD	NanoScan 2s Ge Detector 9mm Aperture 5µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 700nm to 1.8µm wavelength	PH00460
NS2s-Ge/9/25-STD	NanoScan 2s Ge Detector 9mm Aperture 25µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use from 700nm to 1.8µm wavelength	PH00461
NS2s-PYRO/9/5-STD	NanoScan 2s Pyro Detector 9mm Aperture 5.0µm slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 190nm to >100µm wavelength	PH00462
NS2s-PYRO/9/25-STD	NanoScan 2s Pyro Detector 9mm Aperture 25.0µm slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 190nm to >100µm wavelength	PH00463
NS2s-Si/3.5/1.8-PRO	NanoScan 2s Silicon Detector 3.5mm aperture 1.8µm slits. High-resolution head featuring Silicon detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength Software includes ActiveX automation feature	PH00464
NS2s-Si/9/5-PRO	NanoScan 2s Si Detector 9mm aperture 5µm slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5 µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength Software includes ActiveX automation feature	PH00465
NS2s-Si/9/25-PRO	NanoScan 2s Si Detector 9mm aperture 25µm slits. High-resolution head featuring Si detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use from 190nm to wavelengths <1µm. Not for 1.06µm wavelength Software includes ActiveX automation feature	PH00466
NS2s-Ge/3.5/1.8-PRO	NanoScan 2s Ge Detector 3.5mm aperture 1.8µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 3.5mm entrance aperture, and matched pair of 1.8µm wide slits. Use from 700nm to 1.8µm wavelength Software includes ActiveX automation feature	PH00467
NS2s-Ge/9/5-PRO	NanoScan 2s Ge Detector 9mm Aperture 5µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 700nm to 1.8µm wavelength Software includes ActiveX automation feature	PH00468
NS2s-Ge/9/25-PRO	NanoScan 2s Ge Detector 9mm Aperture 25µm slits. High-resolution head featuring Germanium detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 25µm wide slits. Use from 700nm to 1.8µm wavelength Software includes ActiveX automation feature	PH00469
NS2s-Pyro/9/5-PRO	NanoScan 2s Pyro Detector 9mm Aperture 5.0µm slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 190nm to >100µm wavelength Software includes ActiveX automation feature	PH00470
NS2s-Pyro/9/25-PRO	NanoScan 2s Pyro Detector 9mm Aperture 25.0µm slits. High-resolution head featuring pyroelectric detector, 63.5mm diameter head with rotation mount, 9mm entrance aperture, and matched pair of 5µm wide slits. Use from 190nm to >100µm wavelength Software includes ActiveX automation feature	PH00471
Software Upgrades		
NSv2 STD to NSv2 PRO Upgrade	Upgrade NanoScan v2 Standard version software to the PRO version. This upgrade opens the NanoScan automation feature for those users wanting to integrate or develop their own interface using Visual Basic for Applications to embed into such applications as LabView. Return scanhead to factory	PH00417

3.5 Accessories for Beam Profiling

Introduction

Spiricon has the most extensive array of accessories for beam profiling existing. There are components for attenuating, filtering, beam splitting, magnifying, reducing and wavelength conversion. There are components for wavelengths from the deep UV to CO_2 wavelengths. Most of the components are modular so they can be mixed and matched with each other to solve almost any beam profiling requirement needed.

3.5.1 Neutral Density Attenuators/Filters

For almost all applications, the laser beam intensity is too high for the operating range of the CCD. Therefore ND glass attenuator filters are available to reduce the intensity to the proper level at the CCD. These filters are carefully designed not to affect beam quality or cause interference effects. One stackable ND1 filter and 2 ND2 filters are supplied standard with each c-mount camera.

Model	Stackable ND Filters ND1 / ND2 / ND3	ATP-K Variable Attenuator	UV ND Filters	Specialty Filter for 355nm
Nominal ND value	1, 2, 3	ND=1.7-4.6 Max. ND: 7.4 (with fixed 2.8 gray-glass attenuator)	0.3, 0.7, 1.0, 1.3, 1.7, 2.0, 2.3, 2.7, 3.0, 3.3, 3.7, 4.0, 4.3, 4.7, 5.0, 6.0	Pass 355nm, blocks 532nm & 1064nm
Clear aperture	Ø19mm	Ø15mm	Ø20mm	Ø19mm
Damage threshold	5W/cm² no distortion	100mW/mm no thermal lensing	100W/cm² CW, 10ns pulses, no distortion	5W/cm² no distortion
Mounting	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads

Stackable ND filters

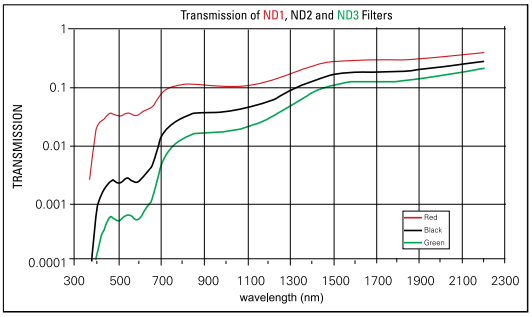
The individual filters come in three versions, the ND1 filter in the red housing with ~10% transmission in the visible, the ND2 filter in the black housing with ~1% transmission and the ND3 filter in the green housing with ~0.1% transmission. The individual filters can be screwed on top of each other and thus stacked.
They are set at a small wedge angle in the housing so as not to cause interference effects.

ND1, ND2 and ND3 stackable filters

Stackable filter showing wedge

Transmission vs. Wavelength

These bulk-absorbing "neutral density" or ND filters do not have a flat response in attenuation vs. wavelength. See the graph for typical transmission vs. wavelength characteristics.



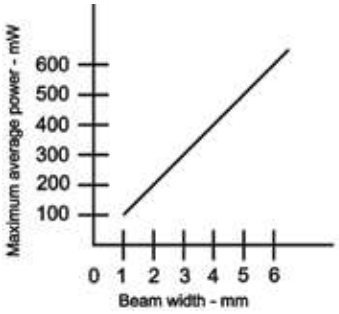
Specifications	
Item	**ND1 / ND2 / ND3**
Nominal ND (vis)	1, 2, 3
Clear Aperture	Ø19mm
Damage threshold	5W/cm², 1J/cm² for ns pulses

ATP-K Variable Attenuator

This option makes beam profiling easy. The ATP-K attenuates your laser without ghost reflections or fringes and has a knob-operated variable wedge attenuator of ND 1.7–4.6, and comes with a fixed gray-glass attenuator with ND 2.8.
The ATP-K is also designed to be used with the HP-XXX high power attenuators and beam splitters. Both types of attenuators attach directly to the ATP-K via C-mount. The ATP-K has simple reproducible attenuation settings, and has a wavelength range of 360 to 2500+ nm.

Figure 1 below shows the safe average power for negligible beam distortion from thermal lensing. Absorptive filters, such as used in the ATP-K have an upper power limit of approximately 100mW per mm beam diameter. For pulsed beams, Figure 2 shows the damage threshold for energy where breakage of the glass wedge may occur. This is approximately 5J per mm beam diameter. For lasers with power or energy levels above this the first stage of attenuation will need to come from our line of high power reflective attenuators.

Figure 1 – Safe average power for negligible beam distortion



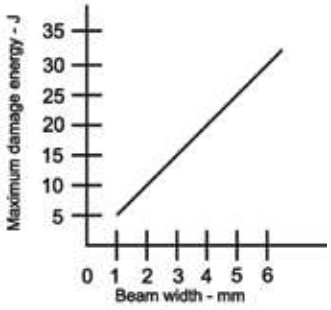


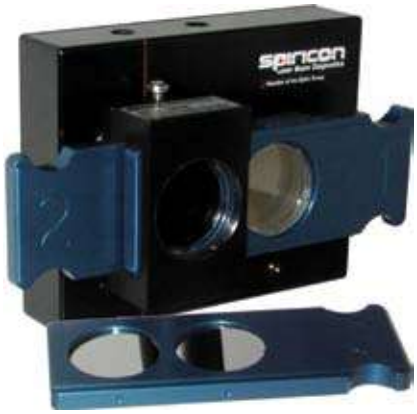
Figure 2 – Point at which damage will occur with pulsed energy

ATP-K Specifications	
Maximum Power/Energy Handling	100 mW/mm beam diameter 100 mJ total avg. energy Damage threshold: 5J
Note: Powerful laser sources may require additional attenuation prior to the beam's exposure to Model ATP-K. Additional attenuation usually is achieved by use of high-power laser mirror attenuators or clean, high-quality quartz plates (recommended with slight wedge angles).	
Wavelength Range	360-2500+ nm Near flat response out to 1500nm
Attenuation Range	Variable filters: ND = 1.7 to 4.6 Maximum ND 7.4 (with fixed 2.8 gray-glass attenuator)
Note: ND (optical density) = log (1/T) or T=10^(-ND) where T is the fraction of light transmitted. For example, an ND of 5 transmits 0.00001 or 0.001%.	
Clear Aperture	15mm diameter
Dimensions	94 (W) x 28 (H) x 43 (D) mm
Thickness Tolerance	±0.25mm
Mounting	C-mount
Base Mount	¼-20

UV ND Filters

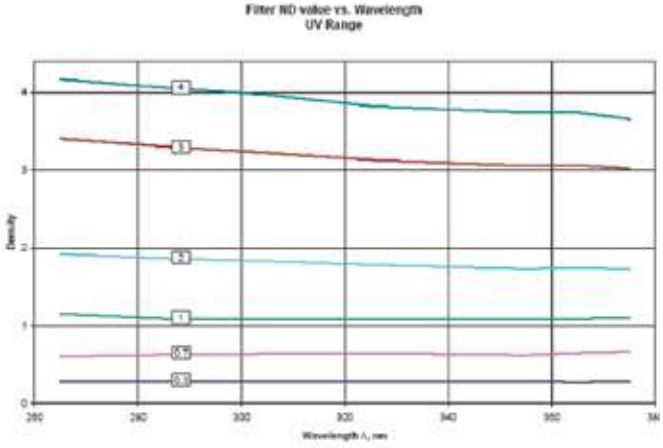
This accessory can be used with any camera fitted with C- mount threads. Simply thread the attenuator assembly into the front of the camera and then slide the ND filter arrays to get the desired amount of attenuation. This device can be used with laser outputs from microwatts to Watts. Three filter holders are provided with two filters in each holder. Each filter in the holder provides for a different value of attenuation. To use, slide the desired holder into the housing slot. A click is felt when the filter is properly aligned with the beam. The holders provided will allow for attenuation of up to ND 6.

C-mount interface for universal application to our CCD and Pyroelectric cameras 190-380nm
attenuation covers Excimer, Helium Cadmium, and the Nd:YAG UV harmonic laser wavelengths.
Attenuation with these ND filters permits the best use of the dynamic range of a beam profiling camera.
Attenuation range of 0.3 to 6.0 optical densities (ND).
Set consists of three slides with two filters in each slide.
The Six Filters include 0.3, 0.7, 1.0, 2.0, 3.0 and 4.0 optical densities.
Two filters can be employed at one time for 0.3 – 6.0 optical attenuation in 0.3 or 0.4 ND steps.
20mm clear aperture will not vignette any of our applicable camera sensors.
Damage threshold = 100W/cm^2 for CW lasers and 20mJ/cm^2 for nano-second pulse width lasers.
Additional Beam Splitters can be added for attenuation of high power UV lasers.
UV attenuation system uses high quality optics from the leader in laser beam diagnostics.



Specifications

Item	UV ND Filters
Nominal ND (UV)	0.3, 0.7, 1.0, 1.3 ,1.7, 2.0, 2.3, 2.7, 3.0, 3.3, 3.7, 4.0, 4.3, 4.7, 5.0, 6.0
Aperture	Ø20mm
Damage threshold	100W/cm^2 CW, 10ns pulses, no distortion



Specialized Filters

There are also specialized filters available to eliminate extraneous wavelengths when measuring very short or very long wavelengths where the CCD cameras are not sensitive and the desired signal can get swamped by extraneous light of other wavelengths.
These filters are as follows:

1. The 355nm filter for monitoring the 3rd harmonic of YAG. This filter transmits 355nm but blocks 532nm and 1064nm.

Transmission	~ 60 at 355mn, zero at 532nm, and 5E-6 at 1064nm
Filter Thickness	4mm
Filter Spacing	8mm
Flatness	2 waves in the visible
Laser damage Threshold	0.6J/cm^2 and 50W/cm^2

This filter has the same standard thread so it can be mixed with all the other components.
See ordering information for more details.

Ordering Information

Item	Description	P/N
ND1 stackable filter (red housing)	4mm spacing screw on filter for camera with transmission of between 20% and 5% depending on spectral range. Can be stacked and combined with other filters and beam splitters.. One filter is included with Spiricon cameras	SPZ08234
ND2 stackable filter (black housing)	4mm spacing screw on filter for camera with transmission of between 7% and 0.5% depending on spectral range. Can be stacked and combined with other filters and beam splitters. Two filters are included with Spiricon cameras	SPZ08235
ND3 stackable filter (green housing)	4mm spacing screw on filter for camera with transmission of between 2% and 0.05% depending on spectral range. Can be stacked and combined with other filters and beam splitters	SPZ08253
ATP-K	Variable Attenuator Package provides smooth knob operated variable wedges with attenuation of optical density (ND) 1.7–4.6 for a total attenuation capability of ND 7.4. Specially designed to eliminate ghost reflections, fringes, and light leaks. Small compact module including C-mount adapter to attach to camera, and C-mount receptacle to easily attach additional HP-series attenuators	PH00128
UV ND Filters	3 Filters holders each with 2 inconel UV ND. Filters for attenuation up to ND 6	SP90228
Filter for 355nm-V2; give an undistorted image of the 355nm light	Silicon cameras can see the 355nm 3rd harmonic radiation of YAG. The YAG however usually emits some light at 532nm and 1064nm as well. This filter filters out the other 2 wavelengths to give undistorted image of the 355nm light	SPZ08246

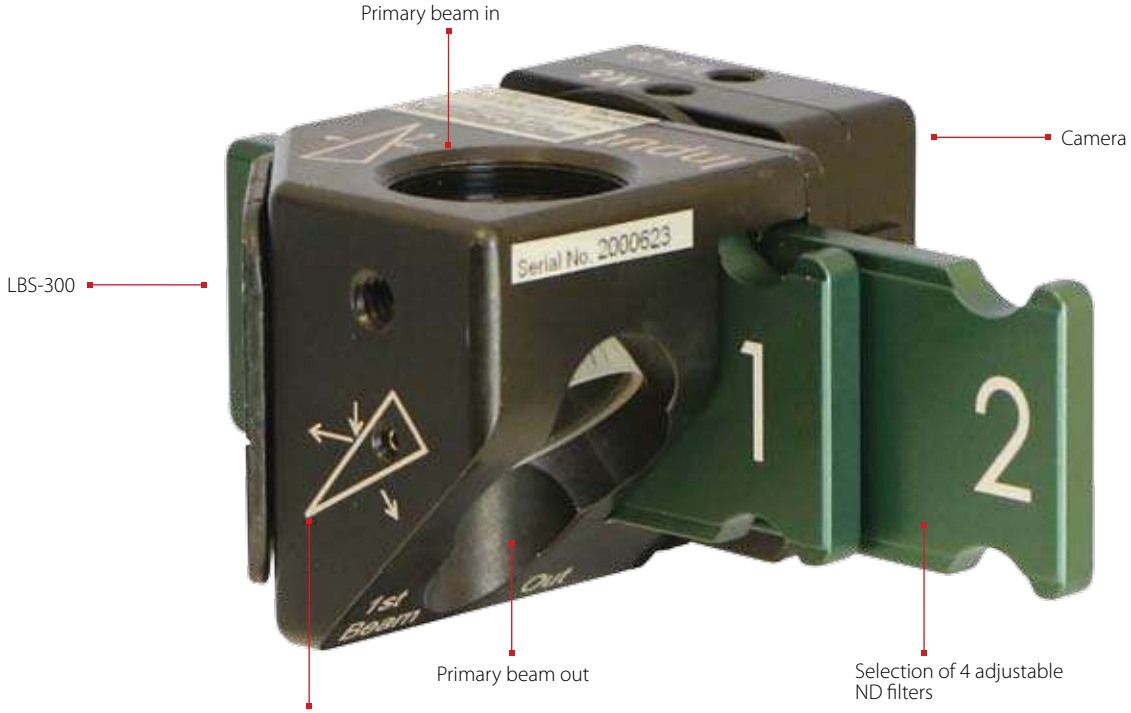
3.5.2 Beam Splitter + Neutral Density Filters Combo

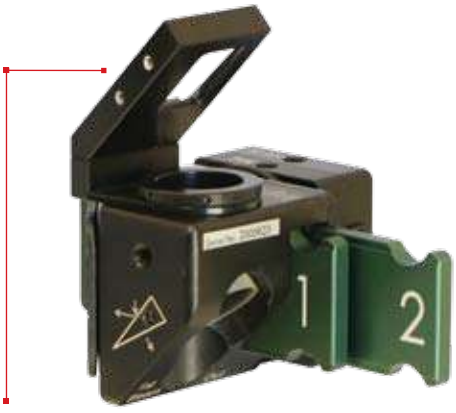
The attenuators described before can provide a high degree of attenuation however, these neutral density attenuators cannot dissipate more than 5W or so. Therefore we often place beam splitters in front of the attenuators to reduce the intensity before the ND filters. These beam splitters are made of UV grade fused silica for use from 190 to 2000nm. Since they do not absorb light, they have a much higher power handling capacity than the ND attenuator/filters.

Model	LBS-300s	LBS -400	LBS-100
Wavelength	multiple versions from 190 to 1550nm	UV or 10.6µm	multiple versions; 400-700nm, 1064nm, 10.6µm
Reflection	0.01% of incident beam	0.01%	4% @ 400-900nm, 1% @1064nm, 0.5% or 5% @10.6µm
Nominal ND value (vis)	0.3, 0.7, 1, 2, 3, 4	0.5, 1.0 in both filters	0.3, 0.7, 1, 2, 3, 4 for 300-700nm & 1064nm 30% & 60% for 10.6µm
Clear Aperture	Ø17.5mm	Ø31.75mm	Ø19mm
Damage threshold	see spec sheet	See spec sheet	5W/cm^2 no distortion
Mounting	CS-mount or Ophir mount	Custom thread	C-Mount and Lab post mounted

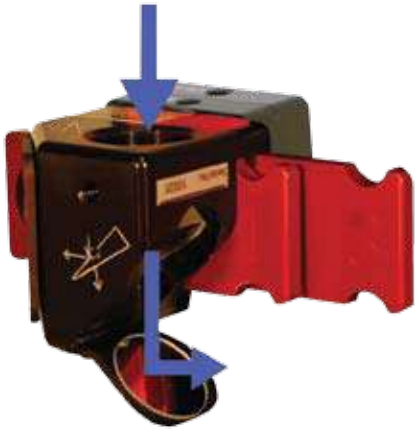
LBS-300s Beam Splitters

The LBS-300s beam splitter attachment for C-mount, CS-mount, or Ophir mount cameras allow you to measure laser beams with diameters up to 15mm and powers ranging from 10 mWatts to ~400 Watts. The beam sampler is designed so that the preferential polarization selection effect of a single wedge is cancelled out and the resulting beam image is polarization corrected to restore the polarization components of the original beam. The beam sampler operates by reflecting the incoming beam from the front surfaces of a pair of wedges through 90 degrees into the camera. Approximately 99% of the beam is transmitted through the beam sampler with 0.01% passed on to the camera. A set of adjustable ND filters are provided to make final intensity adjustments to the beam before it reaches the camera imager. If additional attenuation is needed, an external wedge may be mounted at the input port, however this 3rd wedge will cause polarization selectivity when the beam is significantly polarized different in the S and P planes. A 1.035-40 thread is provided behind each wedge along the axis of the output beam that can be used to directly mount accessories with 1" lens tubes such as beam dumps or even power and energy sensors to the LBS-300s.

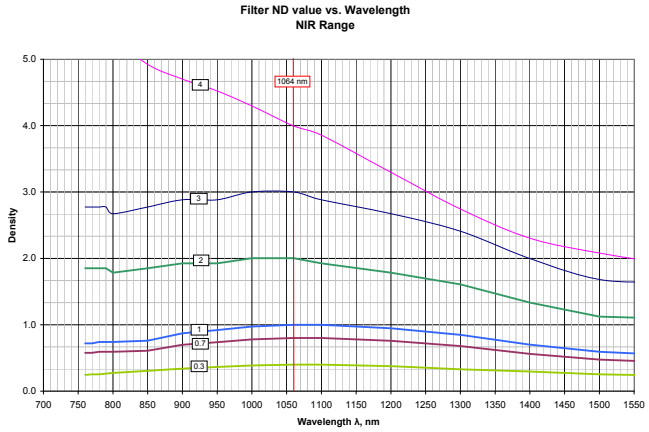




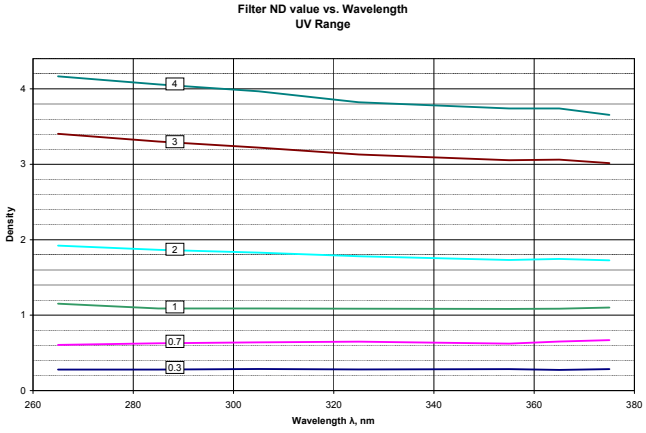
Optional SP90273 Large C-mount Wedge Splitter



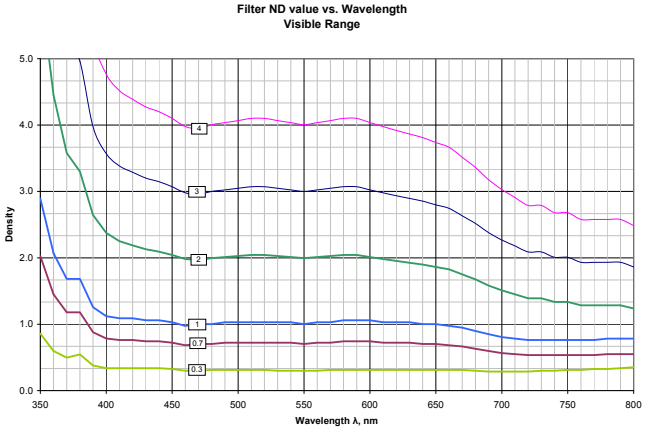
Optional SP90263 Beam Deflector



NIR filter set (Red Holders) – SP90185



UV filter set (Blue Holders) – SP90183



VIS filter set (Green Holder) – SP90184

Ordering Information

Model	LBS-300s-UV	LBS-300s-VIS	LBS-300s-NIR	LBS-300s-BB
Part No.	**SP90464**	**SP90465**	**SP90466**	**SP90467**
Wavelength	266-355nm	400-700nm	1064nm	190-1550nm
Wedge Material	UVFS	UVFS	UVFS	UVFS
Wedge Coating	A/R ≤1%	AR ≤1%	AR ≤1%	No coating, 4% reflection
Clear aperture	17.5mm	17.5mm	17.5mm	17.5mm
Reflection	0.01%	0.01%	0.01%	0.16%
Wedge ND value, each	ND ≥2	ND ≥2	ND ≥2	ND ~1.3
ND Filters	Inconel	Bulk ND	Bulk ND	One each of the UV, VIS & NIR sets
ND Values, nominal	0.3, 0.7, 1.0, 1.5, 2.0, 3.0 (Blu holders)	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 (Grn holders)	0.4, 0.8, 1.0, 2.0, 3.0, 4.0 (Red holders)	See UV, VIS and NIR descriptions
Filter Slides	3	3	3	9
Maximum allowable input to filter (1)	100 W/cm² CW 20mJ/cm², 10ns pulse	50 W/cm² 1J/cm², 10ns pulse	50 W/cm² 1J/cm², 10ns pulse	See adjacent specifications
Accessories				
Beam Dumps	BD-040-A, 40 Watts Max Power, Air Cooled			SP90192
	BD-500-W, 500 Watts Max Power, Water Cooled			SP90193
Large C-mount Wedge Splitter	For additional attenuation add this to the front end of the LBS-300. Good for 350-2000nm			SP90273
Beam Deflector Assembly	for 350-1200 nm only			SP90263
Beam Deflector Assembly	For 266 nm, high damage threshold			SP90287
Beam Deflector Assembly	For 355 nm, high damage threshold			SP90286
Beam Deflector Assembly	For 532 nm, high damage threshold			SP90285
Beam Deflector Assembly	For 1064 nm, high damage threshold			SP90284
Note: (1)	ND bulk absorbing filters damage threshold is 50W/cm² but should be used at <5W/cm² to avoid thermal lensing effects.			

LBS-400 Beam Splitters

The LBS-400 beam sampler attachment for Pyrocam cameras allow you to measure UV, NIR or IR wavelength laser beams with diameters up to 1 inch (25.4mm) and powers ranging from 10mW to ~500W. The beam sampler is designed so that the preferential polarization selection effect of a single wedge is cancelled out and the resulting beam image is polarization corrected to restore the polarization components of the original beam.

The beam sampler operates by reflecting the incoming beam from the front surfaces of a pair of wedges through 90 degrees into the camera. Approximately 99% of the beam is transmitted through each beam sampler with 0.01% passed on to the camera. A set of adjustable filters are provided to make final intensity adjustments to the beam before it reaches the camera imager.

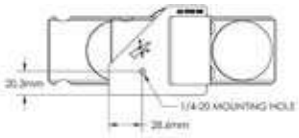
Model	**LBS-400-UV**	**LBS-400-NIR**	**LBS-400-IR**
Part No.	**SP90351**	**SP90354**	**SP90349**
Wavelength	193-355nm	1064nm	10.6µm
Wedge Material	UVFS	BK7	ZnSe
Wedge Coating	A/R ≤1.5%	A/R ≤1%	A/R ≤1%
Clear Aperture	1.25 inch (31.75mm)	1.25 inch (31.75mm)	1.25 inch (31.75mm)
Reflection	0.01%	0.01%	0.01%
Wedge ND value (each)	ND ≥2	ND ≥2	ND ≥2
Filter Material	Inconel	Bulk ND	CaF2
Filter ND Values nominal	0.5, 1.0 in both filters	0.5, 1.0 in both filters	0.5, 1.0 in both filters
Adjustable Filter Slides	2	2	2
Filter Damage [1]	100 W/cm^2 20mJ/cm^2, 10ns pulse	50 W/cm^2 1J/cm^2, 10ns pulse	5W/cm^2 300 J/cm^2, 1ms pulse

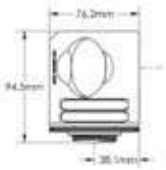
[1] ND bulk absorbing filters damage threshold is 50W/cm^2 but should be used at <5W/cm^2 to avoid thermal lensing effects.

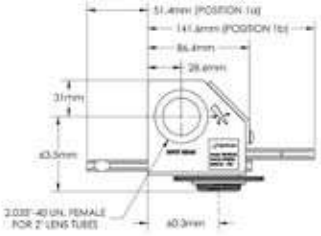
Accessories

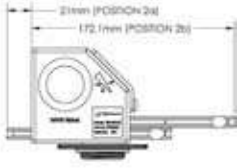
LBS-400 to L11059 adapter	SP90439	Adapter plate to mount L11059 to LBS-400
Beam Dumps	BD-040-A, SP90192 BD-500-W, SP90193	40 Watts Max Power, Air Cooled 500 Watts Max Power, Water Cooled

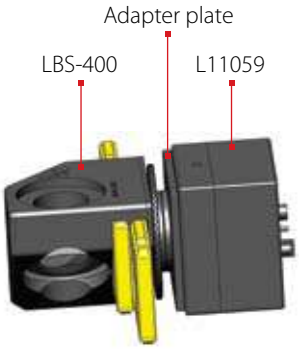
LBS- 400



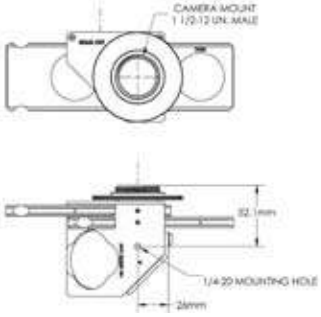








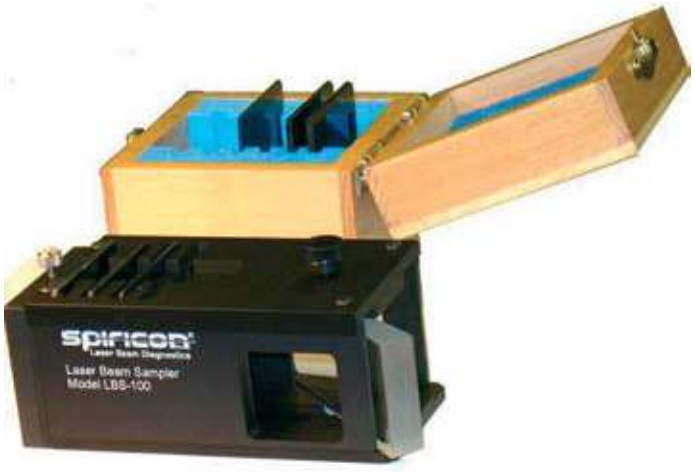
Accessory adapter plate

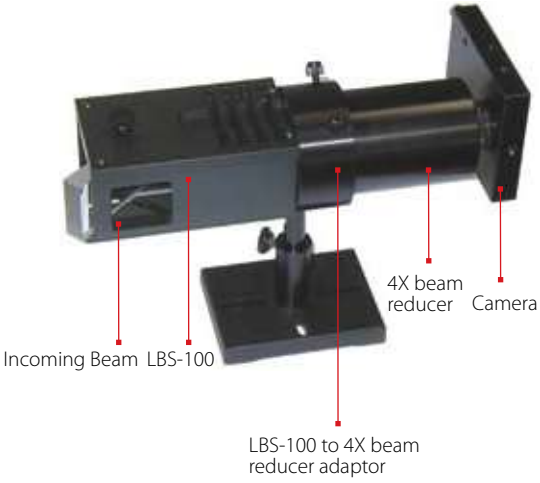


LBS-100 Attenuator

The LBS-100 system that is not as compact as the LBS-300 above but has larger aperture, and has versions for longer wavelengths. The system contains the mounting frame, 1 wedge beam splitter and several attenuators. The exit end of the LBS-100 is standard C mount thread so all our cameras can be mounted to the frame. The wedge angle is 6.5 degrees to insure that the reflection from the rear side will not enter the camera. The optical elements are flat to 1/4 wave in the visible to ensure no distortion of the beam.

LBS-100 System





The LBS beam splitter/attenuator system can be combined with the 4X beam reducer, as shown above, to attenuate and view large beams.

Ordering Information

Item	Wavelength range	Absorber material	Neutral Densities or transmission	Wedge material and reflection	Max power density on ND filters	Clear aperture	Dimensions	P/N
LBS-100	400 - 700nm recommended, functional to 2600nm	Neutral density glass	0.3, 0.7, 1.0, 2.0, 3.0, 4.0 ND at 632nm	Fused Silica 4% in wavelength range 400 - 900nm	5W/cm² for no distortion, 50W/cm² damage	19mm	65mm W x 55mm H x 140mm D	SP90061
LBS-100 YAG	1064nm	Same	Same	1% at 1064nm	Same	Same	Same	SP90057
LBS-100 IR 0.5	10.6µm	CaF2 flats,3 -3mm and 1-1mm	30% T for 3mm flat, 60% T for 1mm flat at 10.6µm	ZnSe 0.5% at 10.6µm	Same	Same	Same	SP90058
LBS-100 IR 5.0	10.6µm	Same	Same	ZnSe 5% at 10.6µm	Same	Same	Same	SP90059
Accessories								
LBS-100 filter set	Replacement filter set							SP90141
LBS-100 -YAG filter set	Replacement filter set							SP90142
LBS-100 to L11058/L11059 adaptor	Mount L11058/L11059 camera to LBS-100 attenuator							SP90196
LBS-100 to 4X beam reducer adapter	This adapter enables mounting of the LBS-100 beam splitter/attenuator assembly in front of the 4X beam reducer. The combined assembly can image large high power beams in one unit.							SPZ17029

3.5.3 Beam Splitter




Model	Beam Tap I & II	Beam Tap I & II YAG	Stackable Beam Splitter	Single & Dual Front-Surface Beam Samplers
Wavelength	400-700nm	1064nm	190-2000nm	200nm-2.5µm
Reflection	4% & 0.16% of incident beam	0.5% & 0.0025% of incident beam	5% & 0.25% of incident beam	0.057% @ 532nm
Clear aperture	Ø17.5mm	Ø17.5mm	Ø15mm	14mm x 14mm
Damage threshold	1MW/cm^2 CW, or 1MJ/cm^2 pulsed	1MW/cm^2 CW, or 1MJ/cm^2 pulsed	>5J/cm^2	100MW/cm^2
Mounting	C-Mount Threads	C-Mount Threads	C-Mount Threads	C-Mount Threads

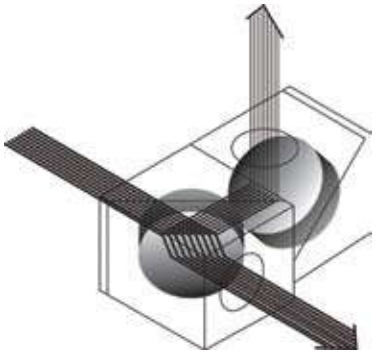
Beam Tap I & II

- Dual surface reflector for equalizing S & P polarization
- The two planes of reflection are orthogonal

Single Surface Polarization Problems

A single surface reflection at 45° is often used to sample a laser beam for profile measurements or for monitoring power or energy. However, as shown on page 191, at 45° a single surface reflects the S polarization component at more than 10 times the reflection of the P component. Depending on the laser polarization content, or stability, this sampling can provide very misleading and unreliable measurements. (The BT-I-YAG has both surfaces A/R coated for 1064nm so the reflection for both polarizations is equal at 0.5%. At other wavelengths far from 1064nm the above discussion applies).

Equalizing S & P reflected polarization

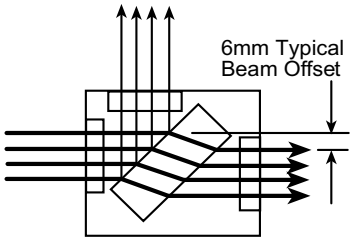


Any arbitrary polarization component can be broken into equivalent S & P components. With complimentary sampling surfaces any given component gets reflected once as the S polarization, and the second time as the P polarization. Thus using 2 surfaces, the total reflected energy for all polarization components is the sum of the **S** reflectance and the **P** reflectance. This causes the sampled beam to have **S & P** components that are identical to the original beam.

Beam path through beam tap

The Beam Tap II uses two reflecting surfaces such that the two planes of reflection are orthogonal. The standard Beam Tap I rear surface is AR coated from 400-700nm.

This diagram shows the 6mm offset of the through beam that is created by the reflecting optic. The deflection angle of the output beam is less than 0.007 degrees. The rear surface of the flat is AR coated to maximize the throughput of the main beam. The standard Beam Tap II rear surface is AR coated for 400nm-700nm. The YAG version is AR coated for 1064nm on both surfaces.



Beam tap reflection vs wavelength

Shown is the Beam Tap II final sampled reflection vs. wavelength.
As shown both the S & P reflection are nearly constant at 0.05% from the UV to the infrared.
(See figure 7 in the Beam Tap manual in our website)

Ordering Information

Model	Surface	Wavelength range	Optical Material	Reflection	P/N
BT-I	Single surface, 1 cube	400-700nm	UVFS	4% Ravg	SP90135
BT-II	Dual surface, 2 cubes	400-700nm	UVFS	0.16% Ravg	SP90133
BT-I-YAG	Single surface, 1 cube	1064nm	BK7	0.5% Ravg	SP90173
BT-II-YAG	Dual surface, 2 cubes	1064nm	BK7	0.0025% Ravg	SP90172

Stackable Beam Splitters

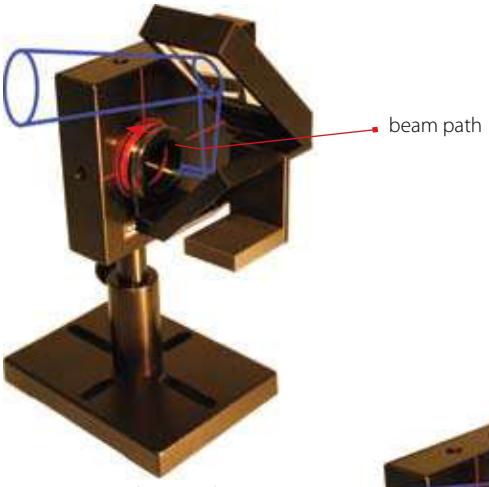
The stackable beam splitters are designed for maximum modularity and shortest beam path. They are compatible with almost all of our cameras having the standard C mount thread and can mount either to other attenuators or to the camera itself. Each beam splitter reflects ≤6% of the incoming beam and allows approximately ≥94% of the beam to pass directly through. By stacking 2 splitters ≤6% of ≤6% or 0.36% of the original beam intensity is directed into the camera. The beam splitters are mounted over the fixed or variable attenuators with a simple fastening ring and can be oriented in any direction with the beam coming from right, left, up, down, or front. The Beam Splitters will operate for wavelengths from 193nm - 2500nm. Damage threshold is >5J/cm2 for 10ns pulses.

An optional Ø30mm clear aperture splitter allows for larger diameter incoming beams. Caution: Beam convergence and power density must be known at the imager so you don't overflow the imager size and maximum power density at the imager.

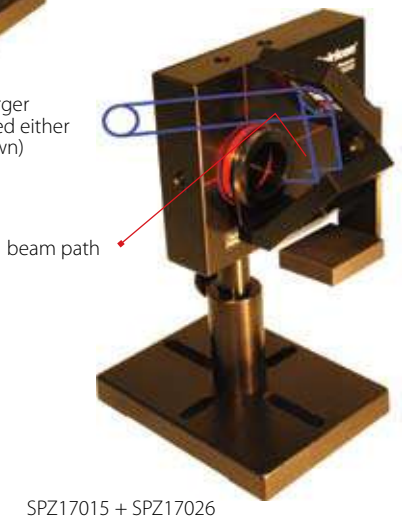
A different set of stackable beam splitters are specifically coated for optimization at 1064nm. Each beam splitter reduces the intensity to 1% of the input Beam. 2 stacked splitters will produce a sampling Beam with 0.01% intensity of the original beam.

The wedge angle of 10 degrees insures that only the reflection from the front surface will appear on the camera with no double images. The user must insure that there are beam stops for the transmitted and reflected beams.

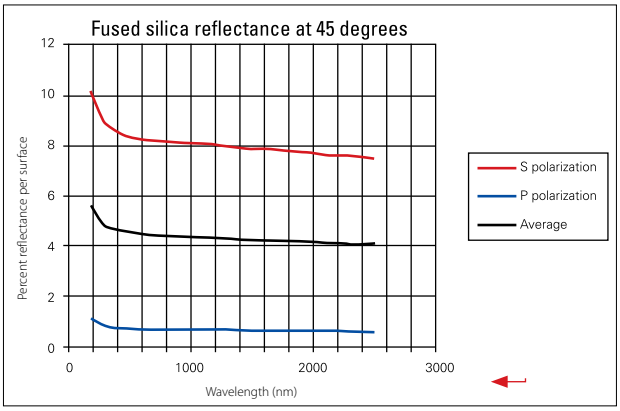
Note that if possible, the user should use an even number of beam splitters so as to cancel any possible polarization effects.



For converging beams a larger aperture splitter can be used either by itself or stacked (as shown)



SPZ17015 + SPZ17026
(used either singularly or stacked)



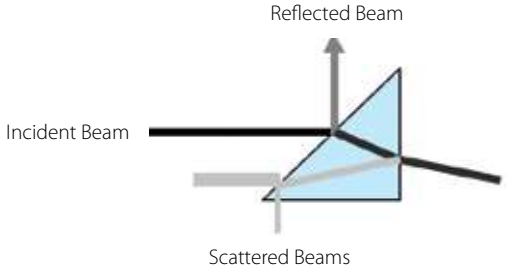
Ordering Information

Item	Description	Clear Aperture	Material	Wavelength	Reflectance	Path length to CCD with 3 screw-on ND filters	P/N
1st Wedge Beam Splitter	45 degree wedged beam splitter	Ø15mm	UVFS	193-2500nm	≤6%	60mm	SPZ17015
2nd Wedge Beam Splitter	Additional 45 degree wedged beam splitter to mount to 1st wedge beam splitter		UVFS	193-2500nm	≤6%	93mm	SPZ17026
Large Aperture Wedge Beam Splitter	For converging beams a larger aperture wedge beam splitter	Ø30mm	UVFS	193-2500nm	≤6%	60mm	SPZ17025
1st Wedge Beam Splitter	45 degree wedged beam splitter	Ø15mm	UVFS coated 1064nm	1064nm	≤1%	60mm	SPZ17031
2nd Wedge Beam Splitter	Additional 45 degree wedged beam splitter to mount to 1st wedge beam splitter		UVFS coated 1064nm	1064nm	≤1%	93mm	SPZ17032

Single and Dual Prism Front-Surface Beam Samplers

The Prism Front-Surface Beam Sampler (PFSA) is a C-mount fixture housing a UV-Grade Fused Silica right angle prism, used for sampling the front surface reflection for high power/energy beam-profiling applications. Reflection at nominal incidence of 45°is polarization and wavelength dependent, with 532nm s-polarization reflected at 8.27%, and p-polarization at 0.68%.

The system is available as either a single prism (PFSA) or dual orthogonal prism (DPFSA) unit. The dual orthogonal prism configuration results in polarization independent reflection of 0.057% at 532nm. Other filters and attenuators can be attached using the C-mount female threads at the input end. The use of a right-angle prism to sample the incident beam guarantees that any scattered secondary beams do not interfere with measurement, as shown in the sketch.



Dual Prism Front Surface Sampler

Prism Front Surface Attenuator Specifications

Wavelength of use	200nm to ~2.5um	
Optical Material	UV-Grade Fused Silica	
Surface Quality	20-10	
Surface Accuracy	λ/10	
Angle of Incidence	45°	
Clear Aperture	14mm x 14mm	
Reflection	Polarization	
λ (nm)	P	S
248.3	0.88%	9.40%
351.1	0.75%	8.65%
532	0.68%	8.27%
1064	0.64%	8.01%
Laser Damage Threshold	CW> 100MW/cm^2	
Dimensions(PFSA)	38.1mm x 32.3mm x 29.5mm	
Dimensions (DPFSA)	44.5mm x 40mm x 32.5mm	
Output Mounting with Brass Lock Ring	C-Mount Male (1"-32 Thread Male)	
Input Mounting	C-Mount Female (1"-32 Thread Female)	

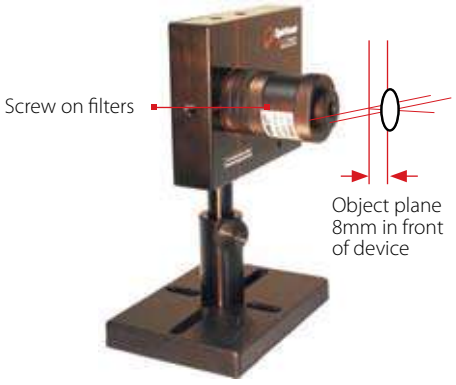
Two Single Prism Front Surface Samplers mounted on a ATP-K Attenuator

Ordering Information

Model	Surface	P/N
PFSA	Single Prism Front Surface Sampler	PH00052
DPFSA	Dual Prism Front Surface Sampler	PH00053

3.5.4 Beam Expanders Microscope Objectives

Model	Beam Expander	4X Beam Expander with UV Converter
Wavelength	400-1800nm	193nm-360nm
Beam Size Change	4X, 6X, 12X, 22X	4X Expansion
Clear aperture	1/4 the size of the CCD imager	
Mounting	C or CS Mount Threads	



Camera with 4X beam Expander (SPZ12022)

Beam expanders are designed to work with C-mount threaded cameras that have 4.5mm imager back focal spacing or with CS (12.5mm) back focal spacing. The 4X beam expander is an expanding telescope that images the beam as it looks at 8mm from the end of the expander onto the CCD while enlarging the image 4X. In addition to the 4X beam expander, other microscope objectives are available for expanding the beam even more. There are objectives for 6X, 12X, and 22X expansion. The various expanders allow the use of our 2% and 10% filters as well as the variable attenuator so as to accommodate the camera to a wide range of source intensities.

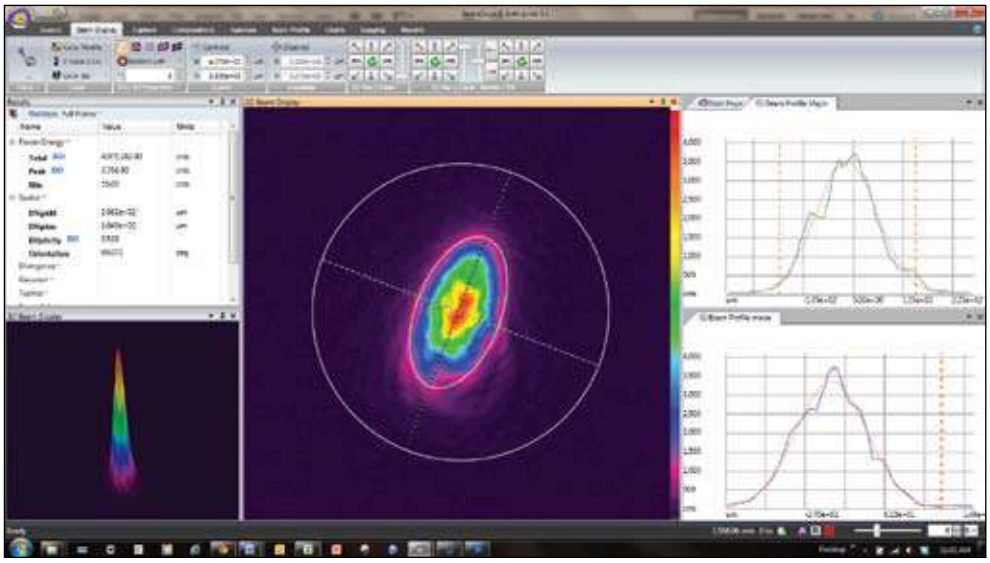
With a camera having 4.4µm pixel spacing using the beam expander, the effective resolution can be as good as 0.5µm. The object plane that is imaged onto the CCD is located several mm in front of the assembly so even hard to get to focal spots and other small images are easy to image. The beam expanders are designed to accommodate up to 3 screw on filters or a variable attenuator behind them so a wide range of intensities can be accommodated.

For intensities too large to be accommodated by just filters, beam splitters are available to reduce the intensity before the beam expander. The beam expander is primarily intended for nonparallel beams such as focal spots and fiber tips. If small parallel beams are imaged, interference effects may occur.

The 4X Beam expander can also be fitted with a UV converter plate at its object plane so that you can look at small beams in the spectral range 193-360nm and expand them 4X.
See ordering information for further details.

Camera with 12X Expanding Microscope Objective (SPZ08259)

Camera with 4X Beam Expander (SPZ17022) and SPZ17027 Beam Splitter



Shown is an image of the tip of a single mode fiber measuring 16µm by 30µm in the two axes. The beam width as measured on the profiles shows 4X the actual size so we can measure to a resolution of ~2µm.

Approximate expansion ratio	Spectral range	Distance from lens barrel to focus	Distance from focus to 1st beam splitter	Distance of closest approach to focus with 1 beam splitter	Total length of assembly
4X	400 - 1800nm	8mm	18mm	32mm	50mm
6X	600 - 1064nm	16mm	10mm past 1st surface	4.5mm	107mm
12X	600 - 1064nm	6mm	6mm	20mm	101mm
22X	600 - 1064nm	2.4mm	8mm	22mm	102mm

The UV converter is a UV sensitive plate that can be mounted over the 4X Beam Expander.
The UV sensitive plate is positioned at the object plane of the 4X beam expander, 8 mm in front of the unit. When UV radiation hits the fluorescent plate, it absorbs the UV radiation and re-emits visible light proportionate to the incident UV light. This light pattern is then expanded 4 times and imaged onto the imager of a C-mount camera.

Specifications	4X Beam Expander with UV converter
Beam Reduction	4X expansion ±2% with included correction factor
Spectral range	193 - 360nm
Resolution	15µm x 15µm;
Minimum signal	~50µJ/cm^2
Saturation intensity	~30mJ/ cm^2 at 193nm, ~15mJ/cm^2 at 248nm 20 times greater with optional beam splitter
Effective Aperture	1/4 the size of the CCD dimensions
Damage threshold	0.1J/cm^2 w/o beam splitter, 2J/cm^2 w/ beam splitter
Dimensions	Ø31mm dia x 120mm length

Camera with 4X Beam Expander and UV Image Converter

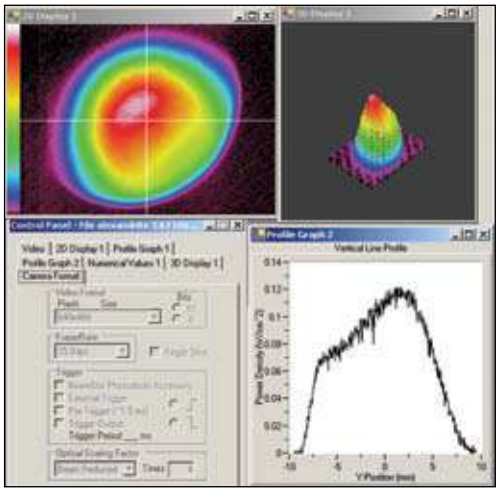
Ordering Information

Item	Description	P/N
4X reimaging beam expander	Screw optical assembly that images the plane 8 mm in front of the expander onto the CCD while enlarging it 4X. Fits 4.5mm recess and CS mount cameras	SPZ17022
UV converter assembly for 4X beam expander	Screw on assembly which has UV plate that converts 193 - 360nm radiation to visible. This plate is at the object plane of the 4X expander so it produces a 4X enlarged image on the CCD	SPZ17019
6X expanding microscope objective	Screw optical assembly that images the plane 16mm in front of the lens onto the CCD while enlarging it ~6X. Fits 4.5mm recess and CS mount cameras. Needs spacer assembly SPZ08261	SPZ08257
12X expanding microscope objective	Screw optical assembly that images the plane 6mm in front of the lens onto the CCD while enlarging it ~12X. Fits 4.5mm recess and CS mount cameras. Needs spacer assembly SPZ08261	SPZ08259
22X expanding microscope objective	Screw optical assembly that images the plane 2.6mm in front of the lens onto the CCD while enlarging it ~22X. Fits 4.5mm recess and CS mount cameras. Needs spacer assembly SPZ08261	SPZ08260
Spacer assembly for objectives	Spacer assembly for above. One only needed for all expanders above	SPZ08261
Beam splitter for expanders above	45 degree angle wedge beam splitter which mounts onto beam expander. Reduces beam intensity by ~20 times. For spectral range 190 – 2500nm. Introduces 35mm extra beam path to object plane	SPZ17027
Additional beam splitter for above	Additional beam splitter to mount to 1st beam splitter	SPZ17026

3.5.5 Beam Reducers

4X Reimaging Beam Reducer

The 4X Beam Reducer is an imaging system that images the plane 30cm in front of the reducer onto the camera CCD sensor while reducing the size 4 times and inverting it. The beam reducer uses the 3 screw on attenuators provided with the camera. Since the intensity of a beam after reduction will be increased by 4x4=16 times, it is advisable to attenuate the beam more than you would without beam reduction. This can be done with additional external beam splitters and attenuators which are available (see ordering information).
Note that the custom designed beam reducer gives better image quality than tapered fibers since it does not introduce graininess or uneven pixel response. Also the image distortion of ~1% is considerably lower than with most tapered fibers. The beam reducer is not compatible with CS mount cameras.



Shown is an image of an Alexandrite laser with beam diameter of 18mm. As can be seen, it is easily seen with the SP 620 camera with the 4X beam reducer.

4X beam reducer (SPZ17017)

Optional large wedge beam splitter (SPZ17018)

LBS-100 (SPZ17029) + LBS-100 combined with 4X beam reducer (SP90061+SPZ17017)

The 4X beam reducer can be combined with the LBS-100 beam splitter/attenuator system to attenuate higher power beams before reducing them in size

Specifications of 4X beam reducer

Spectral Range	360nm to 1100nm
Antireflection Coating	Antireflection coating optimized for 1064nm and 532nm
Beam reduction Accuracy	± 3%
Size	Ø60 mm dia x 94mm length
Aperture	50mm
Maximum Beam Size	SP 503: 25x19mm, SP 620 or GRAS20: 28x21.2mm
Distortion of Beam	Less than 1% over 80% of diameter
Damage Threshold	30mJ per pulse for nanosecond pulses

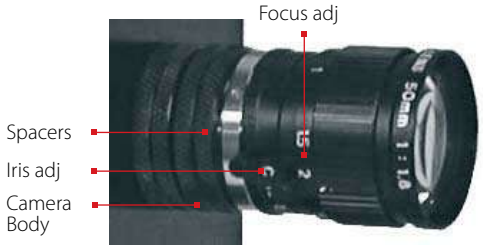
Ordering Information

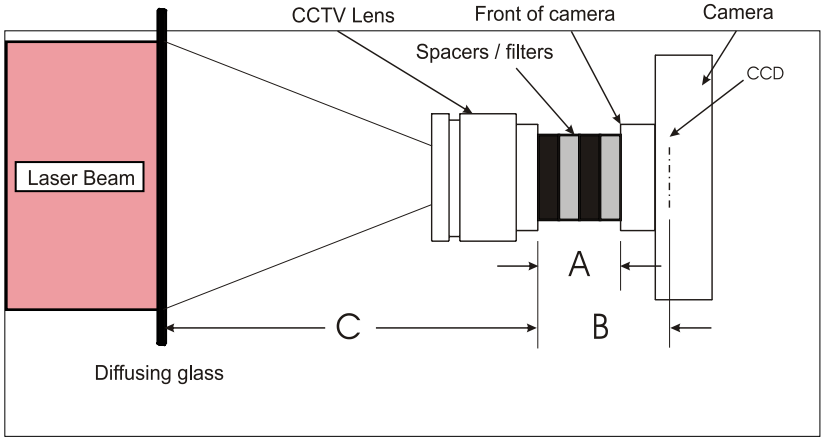
4X Imaging Beam Reducer

Item	Description	P/N
4X reimaging beam reducer	Screw on beam reducer for beams in the wavelength region 360 – 1100nm that reimages the beam 30cm in front of the unit onto the CCD while reducing the beam size 4X. Entrance aperture is 50mm. Fits 4.5mm recess cameras only	SPZ17017
Accessories		
LBS-100 to 4X beam reducer adapter	This adapter enables mounting of the LBS-100 beam splitter / attenuator assembly in front of the 4X beam reducer. The combined assembly can image large high power beams in one unit	SPZ17029
Beam splitter large wedge	Wedge, UVFS, 44X32 mm, uncoated wedge housing mounts to 1/4" thread, 1/2" diameter laboratory rod (not included)	SPZ17018

3.5.6 CCTV lens for front imaging through glass or reflected surface

When direct imaging in front of the camera, for example, an image projected onto a diffusing surface, such as a ground glass plate, it is necessary to reduce the image so that it completely fits onto the CCD chip surface. The 25mm and 50mm CCTV lenses image an object from a given plane in front of the lens onto the CCD while reducing the size. The lens can image such objects at distances from about 10cm in front of the lens (20cm for the 50mm lens) to 1 meter or more depending on the distance from the lens to the camera. The distance from lens to camera depends on the camera type and spacers placed between the lens and the camera.

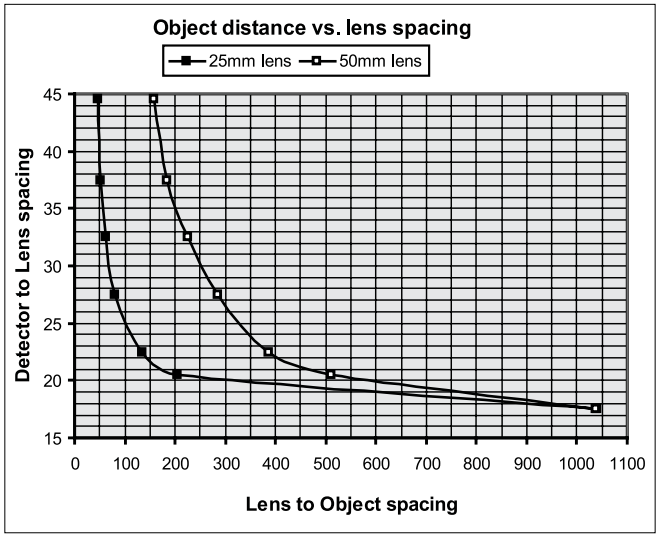


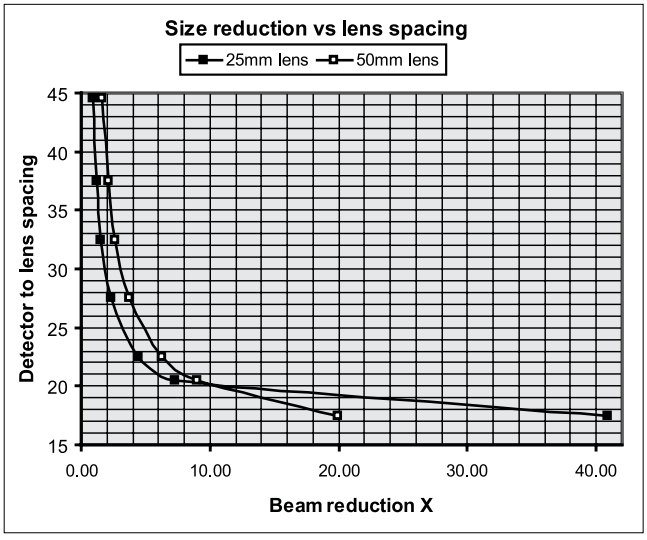


A. - Total length of spacers added to system
B. - Detector to Lens spacing. Distance 'A' plus the CCD inset for the camera type
C. - Lens to Object spacing

CCD inset for Camera Types

C mount (Camera front to CCD = 17.5mm) for nominal lens magnification, use without spacers.
CS mount (Camera front to CCD = 12.5mm) for nominal lens magnification, use 5mm spacer.
SP mount (SP cameras. Camera front to CCD = 4.5mm) for nominal lens magnification, use with 13mm spacers.





Ordering Information

Item	Description	P/N
25mm focal length CCTV lens kit	25mm focal length lens assembly with locking iris and focus adjustment. Includes 1 ea - 8mm spacer and 2 ea - 5mm spacers	SP90085
50mm focal length CCTV lens kit	Same as above except 50mm focal length lens	SP90038
4mm spacer	Screw on spacer to add 4mm spacing to optical system	SPG01698
5mm spacer	Screw on spacer to add 5mm spacing to optical system	SPG02106
8mm spacer	Screw on spacer to add 8mm spacing to optical system	SPG02067

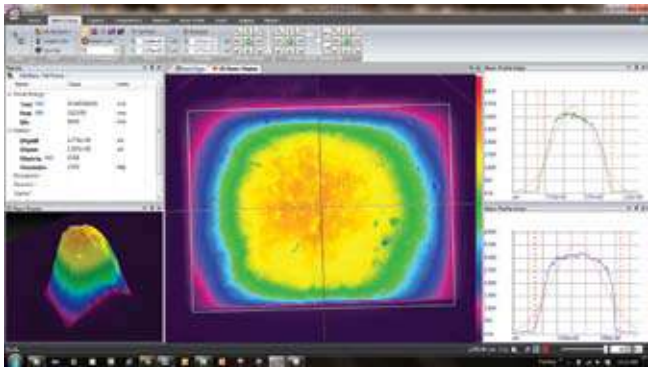
3.5.7 Imaging UV lasers

Integral Reimaging UV Image Converters

The UV image converters are fluorescent plates that convert UV radiation that is poorly imaged by silicon cameras into visible light that is then imaged onto the CCD of the camera. These fluorescent plates are specially designed for UV conversion and have a high light output, wide linear dynamic range and high damage threshold. There are 3 versions available:

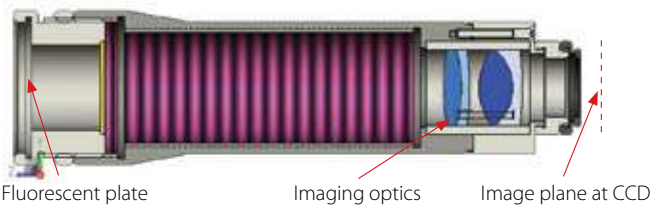
1. The 4X UV image converter for large beams converts to visible and then images onto the CCD while reducing the beam size 4X.
2. The 1:1 UV image converter converts to visible and images the beam onto the CCD without changing the size.
3. The 4X expander with UV converter converts to visible and images a beam enlarged 4X onto the CCD.

All of the above imagers allow a beam splitter to be mounted at 45 deg angle in front of the imager so as to allow imaging of higher power/energy beams.



Shown here is a profile of a 355nm UV laser. The beam is converted to a visible wavelength, reduced in size and imaged by the beam profiling camera

Cross section of 4X reducing UV image Converter



4X beam reducing UV Image Converter as mounted on camera (SPZ17024)

1X UV Image Converter with Optional Beam Splitter (SPZ17023 + SPZ17015)

4X beam expander with UV converter (SPZ17019+SPZ17022)

Specifications	4X UV Image Reducing Converter	1X UV Image Converter	4X Beam Expander with UV converter
Beam Reduction	4X reduction ±2% with included correction factor	1:1 imaging ±2% with included correction factor	4X expansion ±2% with included correction factor
Resolution	50µm x 50µm	35µm x 35µm	15µm x 15µm
Spectral range	193 to 360nm		
Minimum signal	~1µJ/cm² with blank filter		
Saturation intensity	~30mJ/cm² at 193nm, ~15mJ/cm² at 248nm with included filter 20 times above values with optional beam splitter	~15mJ/cm² at 193nm, ~20mJ/cm² at 248nm with included filter, 20 times greater with optional beam splitter	~30mJ/cm² at 193nm, ~15mJ/cm² at 248nm 20 times above values with optional beam splitter
Effective Aperture	Ø30mm but effective beam size is limited to 4X CCD dimensions	Ø18mm but effective beam size is limited to CCD dimensions	1/4 the size of the CCD dimensions
Damage threshold	100W/cm² or 2J/cm² with beam splitter		
Dimensions	Ø50mm dia x 185mm length	Ø31mm dia x 120mm length	Ø29mm dia x 69mm length

Ordering Information

Item	Description	P/N
1X UV image converter	Screw on imaging telescope that converts UV image to visible and images same size on CCD. For beam intensities from 50µJ/cm² to 15mJ/cm². Fits 4.5mm recess and CS mount cameras.	SPZ17023
Beam splitter for above	45 degree wedged beam splitter to reduce intensities on image converter by ~20X. For beam intensities of up to 300mJ/cm² at 193nm.	SPZ17015
4X reducing UV image converter	Screw on imaging telescope that converts UV image to visible reduces the size 4X and images on CCD. For beam intensities from 1µJ/cm² to 15mJ/cm².	SPZ17024
Beam splitter for above	45 degree wedged beam splitter to reduce intensities by ~20X. For beam intensities of up to 300mJ/cm² at 193nm.	SPZ17007
UV converter assembly for 4X beam expander	Screw on assembly which has UV plate to convert 193 - 360nm radiation to visible. The plate is at the object plane of the 4X expander (P/N SPZ17022) and produces a 4X enlarged image on the CCD. Requires separate purchase of 4X reimaging beam expander SPZ17022	SPZ17019
20mm diameter UV imaging plate	Ø20mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 50µJ/cm² to 10mJ/cm².	SPF01177
30mm diameter UV imaging plate	Ø30mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 50µJ/cm² to 10mJ/cm².	SPF01150
50mm X 50mm UV imaging plate	50X50mm diameter UV image conversion plate only. For customers that have own imaging system. Converts UV image to visible. For beam intensities 1mJ/cm² to 20mJ/cm². Not suitable for 193nm.	SP90082

Optical Camera Trigger

The Optical Camera Trigger is an optical sensor that detects pulsed light sources and generates outputs to trigger a camera. The front aperture of the Optical Trigger must be directed at a light source that provides the necessary properties for trigger activation. (e.g. a laser flash lamp, a pick-off source from the main laser beam, or similar). The light source may be a direct or indirect pulsed waveform.

The Optical Trigger system is supplied with a C-Mount adapter, a ¼-20 adapter, M6-1.0 adapter, Through-Hole adapter, or Velcro Strap options which allows attachment of the Optical Triger in a multitude of mounting configurations. One trigger cable and one mount option comes with the photodiode trigger. Specify one of each at time of order. See user guide for camera specific mounting options.

Specifications

Model	1100	1800
Detector	Si	Si/InGaAs
Mininum pulse width	1µs	1µs
Optical Threshold Wavelength		
200nm	10.0 1µJ	N/A
633nm	3.5 1µJ	4 1µJ
1064nm	5 1µJ	10.0 1µJ
1550nm	N/A	4 1µJ

Mounting Options

SP90437 C-Mount Mounting Plate & Locking Ring

SP90436 Through Hole Mounting Plate

SP90434 ¼-20 Hole Mounting Plate

SP90435 M6 X 1.0 Hole Mounting Plate

SP90438 Velcro Mounting System

Example of mounting options

Ordering Information

Item	Description	P/N
1100	Photodiode Trigger, Si	SP90408
1800	Photodiode Trigger, InGaAs	SP90409
	With either trigger above you must specify 1 cable and 1 mount at time of order	
Cable	Photodiode Trigger Cable for GRAS3, GRAS20, SP300, 6ft	SP90430
Cable	Photodiode Trigger Cable for SP907, SP928, 6ft	SP90431
Cable	Photodiode Trigger Cable to SMA for LT665, Pyrocam IIIHR & IV, 6ft	SP90432
Cable	Photodiode Trigger Cable to BNC for Gevicam, L11059, Xeva, Pyrocam III, 6ft	SP90433
Mount	1/4-20 Mount, Photodiode Trigger	SP90434
Mount	M6 X 1.0 Mount, Photodiode Trigger	SP90435
Mount	Thru Hole Mount, Photodiode Trigger	SP90436
Mount	C-Mount, Photodiode Trigger	SP90437
Mount	Velcro Strap Mount, Photodiode Trigger	SP90438

3.6 Near Field Profilers

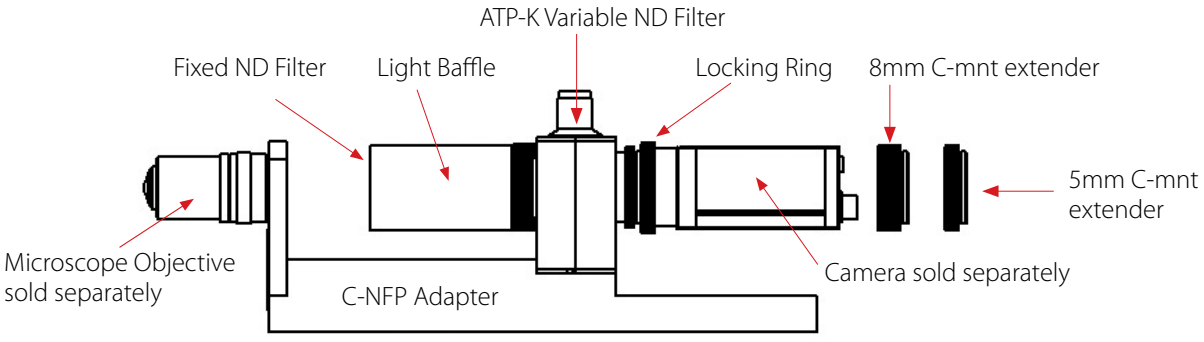
3.6.1 Camera Based Near-Field Profiler

- Allows measurement of beams normally too small for camera profiler
- Expands beam to reduce power/energy density
- Provides near-field profile of fibers, LD junctions, and other small sources
- Can be used to measure tightly focused beam with camera and attenuation
- Nominal 10X, 20X, 40X, 60X Beam expansion available
- Easily calibrated to provide absolute measurement values
- Built-in continuously variable attenuation
- C-mount for attachment to any silicon CCD camera profiler
- Camera and BeamGage software purchased separately

Near field profiling can also be used with camera profilers to analyze small beams, and involves a microscope objective lens to image the beam onto a camera detector array. This technique expands the measurement range of the camera to include smaller beams, which could not be ordinarily measured due to the pixel size of the detector array. Near field profiling is performed in fiber and waveguide analysis, lens characterization, and other applications where beams 50 microns or smaller are analyzed. While there are more accurate techniques to measure these beam sizes, the camera provides two-dimensional information that cannot always be obtained through knife-edge or scanning slit methods. This camera accessory includes base plate for mounting camera and Microscope Objective, ATP-K variable attenuator, 50mm C-Mount and an 8mm and 5mm spacer. User selectable magnification lenses, camera and BeamGage must be purchased separately.

The near field of the test beam or sample is imaged with the microscope objective lens and relayed to the camera. The bracket mounting fixture holds both the lens and camera, which itself can be mounting on a positioner or optical rail. This complete system provides everything necessary to perform near-field measurements right out of the box.

C-mount NFP Adapter Assembly



Ordering Information

Item	Description	P/N
C-NFP Assy	Includes base plate for mounting camera and Microscope Objective, ATP-K variable attenuator, 50mm C-Mount and an 8mm and 5mm spacer	SP90291
60X	60X, Microscope objective	SP90292
40X	40X, Microscope objective	SP90293
20X	20X, Microscope objective	SP90294
10x	10X, Microscope objective	SP90295

3.7 What is M^2 ?

M^2 or Beam Propagation Ratio, is a value that indicates how close a laser is to being a single mode TEM_{00} beam, which in turn determines how small a beam waist can be focused. For the perfect Gaussian TEM_{00} condition the M^2 equals 1.

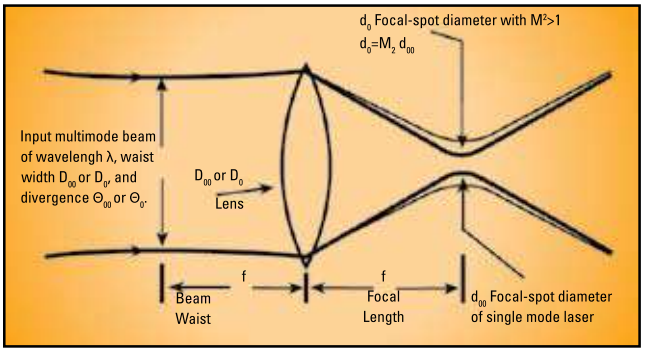
For a laser beam propagating through space, the equation for the divergence, θ, of an unfocused beam is given by:

$$\theta_0 = M^2 4\lambda/\pi D_0$$

For a pure Gaussian TEM_{00} beam M^2 equals 1, and thus has no impact on the calculation. The calculation of the minimal beam spot is then:

$$d_0 = 4\lambda/\pi\theta$$

Again with M^2 equal to 1, the focused spot is diffraction limited. For real beams, M^2 will be greater than 1, and thus the minimum beam waist will be larger by the M^2 factor.



Characteristics of a laser beam as it passes through a focusing lens.

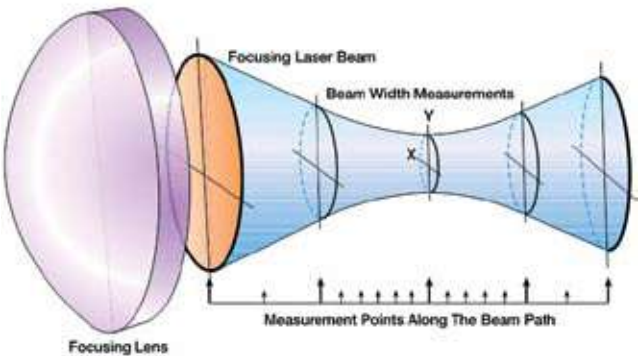
How is M^2 measured?

M^2 cannot be determined from a single beam profile measurement. The ISO/DIS 11146 requires that M^2 be calculated from a series of measurements as shown in the figure above. M^2 is measured on real beams by focusing the beam with a fixed position lens of known focal length, and then measuring the characteristics of the artificially created beam waist and divergence.

To provide an accurate calculation of M^2, it is essential to make at least 5 measurements in the focused beam waist region, and at least 5 measurements in the far field, two Rayleigh ranges away from the waist area. The multiple measurements ensure that the minimum beam width is found. In addition, the multiple measurements enable a "curve fit" that improves the accuracy of the calculation by minimizing measurement error at any single point. An accurate calculation of M^2 is made by using the data from the multiple beam width measurements at known distances from a lens, coupled with the known characteristics of the focusing lens.

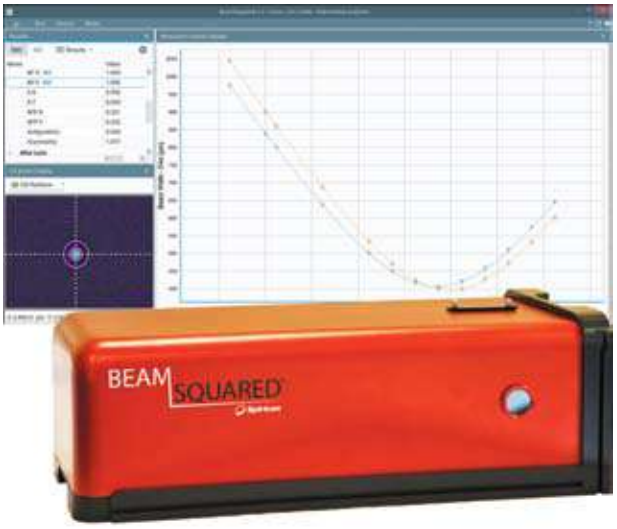
M^2 Measurement Solutions

Ophir-Spiricon and Photon have a number of solutions for the measurement of M^2 ranging from simple manual processes to fully automated dedicated instruments, depending on the frequency of the need to measure M^2 of lasers and laser systems. We have a system that will meet most needs, whether for research and development of new laser systems, manufacturing quality assurance, or maintenance and service of existing systems.



3.7.1 Camera Based Beam Propagation Analyzer: M^2

3.7.1.1 BEAM SQUARED

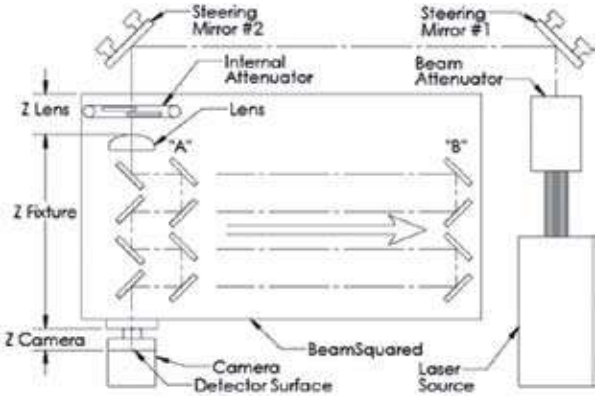


- ISO compliant
- Automatically measure your beam quality in under 1 minutes
- Tune your laser for best operation
- Specifically developed for continuous usage
- Unequaled accuracy using patented Ultracal™ Calibration
- Long optical train & automatic attenuation adjustment
- Flexible mounting configurations, install horizontal or vertically
- Pulsed and CW for most beam diameters and powers
- Compact and portable
- Detectors from 266nm to 10.6µm

The BeamSquared system is a compact and fully automated tool for measuring the propagation characteristics of CW and pulsed laser systems from the UV to NIR to Telecom wavelengths. Users can also measure wavelengths above 1.8 microns, including CO2 and terahertz in manual mode (a bench set-up; without the automated optical train) with a Pyrocam IV or IIIHR. Our longer optical train and patented UltracalTM Calibration makes BeamSquared the most accurate product on the market and is ISO 11146 compliant. Its operational robustness and reliability ensures continuous use applications in industry, science, research and development.

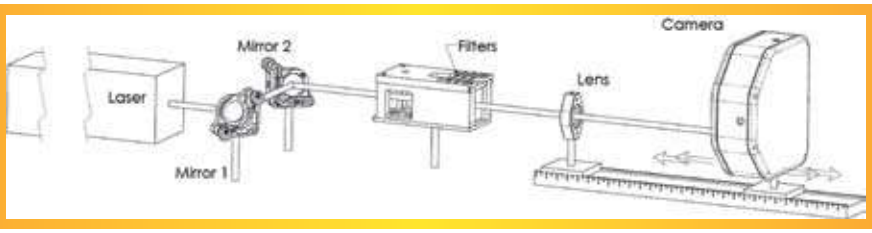
Automatic M^2 - at Production Speeds

The Beam Squared optical train uses a fixed position lens with movable mirrors and camera. The mirrors that direct the focused beam into the camera are moved to precise locations, translating the beam through the near field, the waist, and the far field regions. All these measurements and translations, as well as incremental beam attenuation, are automatically controlled by the BeamSquared software. Design improvements in the BeamSquared system have decreased the measurement reporting time by 2-3 times, making it possible to report M^2 in under a minute.



Manual M^2

Manual mode is available for wavelengths greater than NIR, particularly Terahertz and above, and for beams that are too large or too small for the BeamSquared optical system. Users are required to provide a manual translation/attenuation apparatus.



Features

Supports both automated and manual runs	
New Hardware	
	Camera Options include: SP920, Xeva, Pyrocam III HR or IV
	RF Lens Reader
	▪ Lens must be present for operation
	▪ Lens configuration data stored with lens (Focal length, calibration wavelength, material, etc.)
	Shutter only open when in live mode
	Table and attenuator calibration at startup (homing before each run)
Supports hardware Trigger	
Faster run times than M2-200s	
New Interface	
	Selectable theme colors
	Splash screen with progress bar
2D display	
	Selectable Color Palette
	Manual Cursor when not running (Cursor at centroid otherwise)
Caustic Display	
	Selecting individual frames
	Auto Aperture
	Exclude points from run
Run Info Display	
	Displays Caution Notice when beams are non-conforming: (too dark, too bright, misaligned, too large or too small)
	Option to ignore misaligned beams
Editable Settings (Wavelength, Laser to box distance, Laser to lens and focal length in manual mode)	
Calculations	
	Frame Results (Total, Min, Peak, % in Aperture, Avg Pwr Density, Beam Width, Centroid, Peak, Cross Sectional Area)
	Laser Results (Waist Width, Divergence, Waist Location Rayleigh Length, M2, K, BPP, Astigmatism, Asymmetry)
	After Lens Results (Waist Width, Divergence, Waist Location Rayleigh Length, Astigmatism, Asymmetry)
	Effective Focal Length of lens
	Fitted/Measured Divergence
	Supported Beam Width calculations
	▪ D4 Sigma
	▪ Knife Edge 10/90 and Programmable
	▪ EPSA - Encircled Power Smallest Aperture (power in a bucket)
Multiple Runs	
	Result statistics
	Progress Indicator
Single Page Report	
	Setup information
	Results
	Statistics
	Caustic chart
Logging/Export data	
	.CVS File

Accuracy by Design

Spiricon products are known for accuracy. Using our patented Ultracal calibration method, auto aperturing to exclude noise beyond the wings of the laser beam, and long optical path, assures the user of the most accurate measurements in the industry.

Designed by Our Customers

Guided by customer input from our widely deployed previous generation M2-200s system, Spiricon redesigned the BeamSquared to meet the challenging demands of the laser industry. The new BeamSquared system has significantly higher durability and operational robustness for continuous use in a three shifts a day, seven days a week environment. The rigid baseplate and internal optics greatly simplifies and reduces the time for initial set-up and alignment. The lens configuration data is now stored using an RF ID chip embedded in the lens holder which is uploaded automatically by the BeamSquared system when the lens cartridge is inserted in the system, eliminating the need for our customers to keep track of configuration file. Both novice and seasoned users will appreciate these new features along with the time-tested excellence that Spiricon has provided over the years.

Measurements

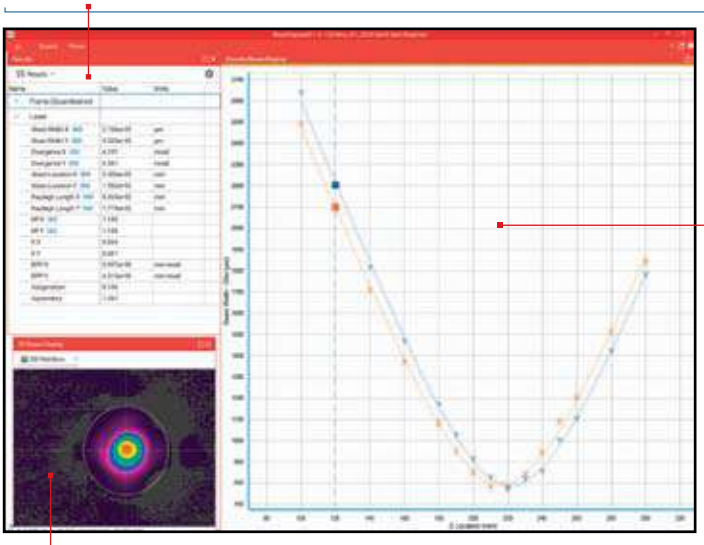
BeamSquared measures propagation characteristics in both the X and Y axes and displays the following parameters:

- Waist diameters
- Full angle Divergences
- Waist locations
- Rayleigh lengths
- M^2 or K and BPP factors
- Astigmatism
- Asymmetry

To optimize bench space, BeamSquared can be mounted either horizontally or vertically. Laser beam input port is the same dimension with either mounting method, X = Y, and the same as the M^2-200s that it is replacing.

Main Screen Functions

This window displays quantitative measurements of the laser parameters. These include the X and Y beam widths, M^2 or K, the divergence angles, the Rayleigh range, and other parameters shown.



This window presents measurements of beam width vs. position for a given run. After measuring a few points, the software extrapolates a curve fit. The Xs and Ys represent individual measurement points. The solid lines present the best fit hyperbola of the beam propagation equation to the measured points. The M^2 and other laser parameters are computed from the best fit hyperbola since it provides a smoothing of the data points.

This window displays the 2D or 3D beam profile of the currently measured point in the beam propagation curve. This image enables visual intuitive verification of the beam profile behavior through focus. After each run the user can click any individual measured point and observe the beam profile. Outlying or anomalous points can be automatically or manually excluded from the curve fit calculations for more accurate results.

3.7.1.1.1 Specifications

Measurements			
	M2x, M2y, Kx, Ky, BPPx, BPPy		
	Width at waist Wx, Wy		
	Divergence angle Qx, Qy		
	Waist location Zx, Zy		
	Rayleigh X, Y		
	Astigmatism		
	Asymmetry ratio		
	Statistical results are available on all measurements		
General			
Accuracy	±5% typical, ±10% waist location and Rayleigh length typical		
Measurement Cycle Time	<1 minute typical, depending on setup conditions and operating mode		
Camera Attachment	Standard C-mount, 90° camera on axis rotation		
Translation System	Step-motor driven ball screw		
Resolution	0.05mm		
Standard Optics			
	Different lenses are required for different wavelength regions, spot sizes and divergences. Four lenses are included with the SP920 systems and two lenses with the XC-130 system. See below, for nominal focal lengths. Additional lenses must be ordered separately.		
Lenses	BSQ-SP920 266-440nm UV 500mm FL (included) 430-700nm VIS 500 FL (included) 430-700nm VIS 400 FL (included) 650-1000nm NIR 400 FL (included) 1000-1700nm Extended NIR 400 FL (included)	BSQ-XC-130-A 1000-1700nm Extended NIR 400 FL (included)	BSQ-A Lens kits – optional
Attenuation Range			
	Nominally from ND 1.0 to ND 4.8. Actual values vary with wavelength.		
Damage Limits [1]			
For the SP920	.15 mW/cm2 CW mode 1.0 µJ/cm² pulse mode for a 10mm Both of the above for an M²=1 @ 1064nm		
[1] **CCD cameras can be damaged by power in excess of 0.1 mW/cm² or energy in excess of 1 mJ/cm². BeamSquared employs a focusing optic. While it may be that the laser input power or energy measures well below this damage threshold, it can easily exceed these levels when focused onto the camera sensor. Use caution and error on the side of safety. CCD cameras can be costly to repair or replace.**			
For the XC-130 and Pyrocam IIHR and Pyrocam IV	See individual camera data sheets		
Optical Limits			
Wavelength Range	266 -1700nm limited by Camera The CCD camera is operational from 266 to 1100nm. InGaAs camera operates from 900 to 1700nm. Pyrocam from 1.06 to 3000µm		
Beam Size	BeamSquared Auto Mode 1mm – 10mm BeamSquared Manual Mode 0.8mm – 10mm maximum for Pyrocam IIIHR and 0.8mm – 20mm maximum for Pyrocam IV Varies with wavelength, waist size, location, and M²		
Minimum Beam Width	SP920 XC-130 Pyrocam IIIHR or IV (manual & w/o optical train only)	36.9µm 300µm 800µm	
Environmental			
Storage Temperature	-30° C to 65° C		
Storage Humidity	95% maximum (non-condensing)		
Operating Temperature	10° C to 40° C		
Operating Humidity	95% maximum (non-condensing)		
Power Requirements[2]			
Input Voltage	90 – 264 V AC		
AC Line Current	1.6 A		
Line Frequency	47Hz to 63Hz		
[2] For the optical train only. The PC computer supplies the power for the system components, such as the CCD camera.			
Physical			
Weight	26 lbs. w/o camera		
Dimensions	See manual or web site		

3.7.1.1.2 Ordering Information

Item	Description	P/N
BSQ-SP920	BeamSquared software, software license, SP300 USB 3.0 camera, optical train, automatic and manual operation, recommended for 266nm - 1100nm wavelengths.	SP90502
BSQ-XC-130-A	BeamSquared software, software license, XC-130 USB 2.0 camera, optical train, automatic and manual operation, recommended for 900nm - 1700nm wavelengths.	SP90444
BSQ-A	BeamSquared software, software license, and optical train no camera included. For use with compatible cameras purchased. Compatible camera must be return to factory for upgrade at no additional charge. If, upon inspection the camera does not meet specifications, a repair change will be applicable.	SP90445
BSQ-PY-M	BeamSquared software and software license for manual M^2 measurement using a Pyrocam camera (optical train and Pyrocam camera not included).	SP90410
Options		
BSQ-Lens Kit 266-1000		SP90449
BSQ-Lens Kit 650-1700		SP90450
BSQ-Lens Kit UV 500mm		SP90451
BSQ-Lens Kit VIS 500mm		SP90452
BSQ-Lens Kit VIS 400mm		SP90453
BSQ-Lens Kit NIR 400mm		SP90454
BSQ-Lens Kit Extended NIR 400mm		SP90455

3.7.2 Slit - Based Beam Propagation Analyzer: M^2

3.7.2.1 NanoModeScan

The NanoModeScan combines the flexibility and speed of the NanoScan with dedicated M^2 measurement hardware and software. The NanoModeScan provides an automated measurement of M^2 using either the ISO 11146 or the Rayleigh method.

The ISO Method software and hardware report the ISO 11146 parameters:

- Times diffraction limit: M^2
- Beam propagation factor: K
- Beam waist size: d_0
- Beam waist location: Z_0
- Divergence: θ
- Rayleigh range: Z_r

NanoModeScan

By adding the capabilities of the NanoScan to the ModeScan, the range of possible measurable lasers is greatly expanded and the speed of the measurements dramatically improved. The NanoScan's software controlled variable scan speed allows the measurement of both CW and kHz pulsed lasers with any NanoScan scan head, covering the entire wavelength range from UV to FIR.
The NanoScan's rapid beam finding and autoranging speed up the total M^2 measurement to ~20 seconds for CW lasers. NanoModeScan comes with two user selectable lenses to generate the proper artificial waist for the laser source under test. For ease of alignment, there is an entrance iris on the optical axis of the NanoModeScan and a precision alignment stage for horizontal and vertical positioning.

The ISO 11146 Method

The ISO 11146 method for measuring the propagation of a laser source calls for the measurement of the beam diameter for at least 10 positions through the waist created by a test lens inserted in the beam path. Five locations should be within ±1 Rayleigh range of the artificial waist and at least five more points beyond two Rayleigh ranges from this waist. These measurements are then used to compute the laser propagation parameters. Once points are selected properly, the ISO Method is the fastest measurement method and best for volume testing of lasers.

The Rayleigh Method

The ISO method requires the user to manually select the measurement points, and changing one or two of the selected points can yield different M^2 values. The Rayleigh method is completely automated, selecting its own measurement points based on mapping the Rayleigh range of the beam waist. This method is fully discussed in the user manual. In addition, the Rayleigh method can yield more consistent results for M^2 values for lasers that are not exactly like those for which the ISO standard was written, such as fiber lasers, lensed diode lasers, and VCSELs.

The NanoScan Difference

With the NanoScan-equipped NanoModeScan, all scan heads can measure pulsed beams with repetition frequencies down to 10kHz. The silicon and germanium detectors will measure less than a milliwatt of power. The pyroelectric detector-equipped NanoScan head can analyze higher power lasers at all wavelengths. The increased dynamic range of the NanoScan enhances the signal to noise ratio of the system and allows a much broader range of laser powers to be analyzed with one instrument setup.

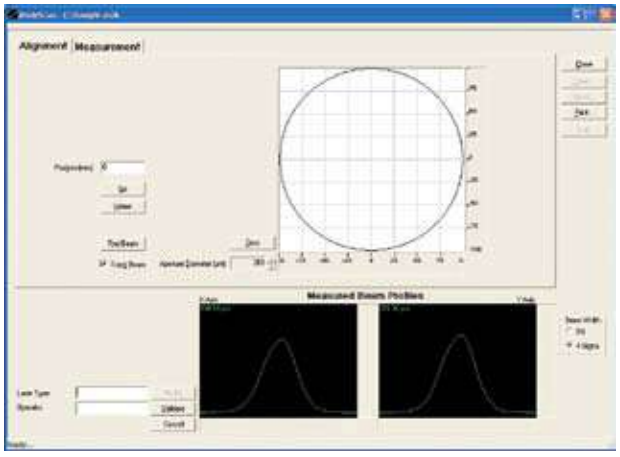
Real-Time Divergence Measurement

By monitoring the divergence angle θ, it is possible to make a measurement that will be directly proportional to M^2. This enables the adjustment of the laser performance in real time at the NanoScan's rapid update rate (up to 20Hz). To use this feature, the scan head is moved to a position one geometric focal length from the test lens. Divergence is the beam diameter divided by the focal length, and the measured divergence is equal to M times the embedded divergence.

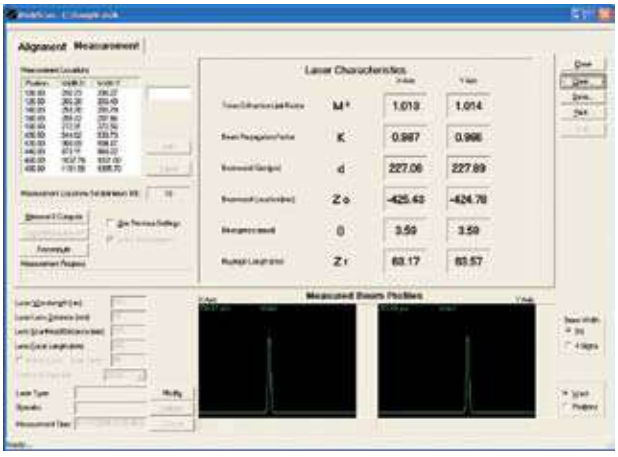
Therefore when the beam diameter at this location is minimized, the divergence is at its minimum and the M^2 of the laser should then be optimized. After this real-time adjustment, the full M^2 measurement can be done to generate the required parameter values. This method makes the NanoModeScan an even more valuable tool for the final setup of lasers on the manufacturing floor by decreasing the time it takes both to adjust the laser system and to make the measurements required for quality control documentation.

3.7.2.1.1 NanoModeScan Specifications

Sensor/Detector	
Scan head Travel	500mm
Optical Axis Height	140-170mm
Lens	See ordering chart
Minimum Spot Size	See scan head specifications
Computer/Electrical	
Source Power	See scan head specifications
File Saving and Data Logging	Data files, ASCII Files
AC Power	110V, 60Hz standard 220V, 50Hz optional
Communication	RS-232 Interface or USB to RS-232 adapter provided
Mechanical (Dimensions in mm)	
NanoModeScan Linear Stage	812 × 102 × 78
Photon Motion Controller	273 × 89 × 57
Weight	
NanoModeScan Linear Stage	8.4kg
Photon Motion Controller	1.5kg



Alignment screen in ModeScan software



Measurement results screen in ModeScan software

3.7.2.1.2 Ordering Information - NanoModeScan M^2 Systems

All NanoModeScan Systems include (unless otherwise noted):

- High-resolution scanhead with rotation mount
- Two user selectable lenses come with the NanoModeScan
  - 200 mm focal length VIS coated for 430–700nm (not for use with Germanium detector)
  - 400 mm focal length VIS coated for 430–700nm (not for use with Germanium detector)
  - NIR Near IR: 650–1000nm
  - LIR Long IR: 1000–1550nm (not for use with Silicon detector)
  - VLIR: Very long infrared >1550nm. (for use with NMS-NS2s-Pyro/9/5 only)
  - UV: 200 mm focal length lens coated for UV wavelength

Item	Description	P/N
NanoModeScan M^2 Systems		
NMS-NS2s-Si/9/5	Model 1740 ModeScan with NanoScan 2s Silicon (Si) Detector 9mm aperture 5µm slits Si detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 190 to 1000nm wavelengths.	PH00477
NMS-NS2s-GE/9/5	Model 1740 ModeScan with NanoScan 2s Germanium (GE) Detector 9mm aperture 5.0µm slits. Germanium detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 700nm to 1.8µm wavelength.	PH00478
NMS-NS2s-Pyro/9/5	Model 1740 ModeScan with NanoScan 2s Pyroelectric Detector 9.0mm aperture 5µm slits. Pyroelectric detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5µm wide slits.	PH00479
NanoModeScan Accessories		
NanoModeScan comes with two user selectable, must specify at time of order		
LENS 200mm VIS	200mm focal length lens for use 400-700nm wavelength	PH00237
LENS 400mm VIS	400mm focal length lens for use 400-700nm wavelength	PH00238
LENS 100 VIS	100 mm focal length lens for use 400–700nm wavelength	PH00093
LENS 100 NIR	100 mm focal length lens for use 650–1000 nm wavelength	PH00094
LENS 200mm NIR	200mm focal length lens for use 650-1000nm wavelength	PH00239
LENS 400mm NIR	400mm focal length lens for use at 650-1000nm wavelength	PH00240
LENS 100 LIR	100 mm focal length lens for use 1000–1550nm wavelength	PH00095
LENS 200mm LIR	200mm focal length lens for use at 1000-1550nm wavelength	PH00241
LENS 400mm LIR	400mm focal length lens for use at 1000-1550nm wavelength	PH00242
LENS 400 2um	400mm focal length lens for use at @2µm wavelength	PH00224
LENS 190 10.6	7.5-inch focal length lens for use at 10.6µm wavelength	PH00092
LENS 200 UV-XXX	200mm quartz lens for use between 190–400nm wavelengths. Specify use wavelenght in the XXX item description.	PH00090
LENS 400 UV-XXX	Optional 400mm quartz lens for use between 190–400nm wavelengths. Specify use wavelenght in the XXX item description.	PH00091
1740 LENS MNT	Lens mount for users wanting to use their own 25mm diameter lens	PH00075
Model 1740 ModeScan	Rail w/o scan head, small scan head	PH00447
1740 LENS PREP	ModeScan custom lens	PH00076

BEAMWATCH®
U.S. PATENT 8,988,673

3.8 BeamWatch® Non-contact, Focus Spot Size and Position monitor for high power YAG, Diode and Fiber lasers

- Instantly measure focus spot size
- Dynamically measure focal plane location during start-up
- From 400W and up – no upper limit (So far we have measured up to 100kW)
- Non-contact, laser beam is completely pass-through
- Automation Control Interface for System Integration
- GigE camera interface for local network installation
- Patented

BeamWatch utilizes disruptive technology to measure laser beam characteristics of very high power lasers. By not intercepting the beam and yet providing instantaneous measurements, you can now monitor the beam at frequent intervals without having to shut down the process or remove tooling and fixtures to get access. In addition, you can now measure focal spot location at several times per second and know if there is any focal spot shift during those critical start-up moments.

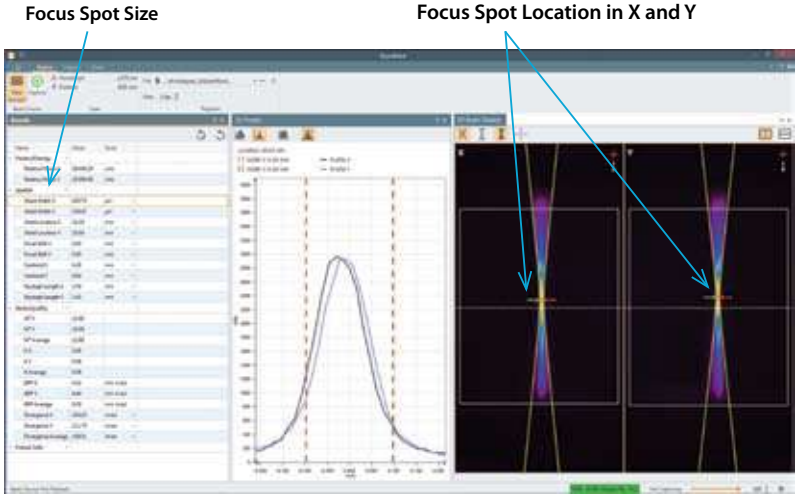
Disruptive Technology

BeamWatch is the first device to measure a laser without coming in contact with its beam which allows it to be the first laser quality measurement product in history to have no upper limit on the lasers which it can measure. BeamWatch provides high-power industrial laser users with data never before seen such as the dynamic measurement of focus shift caused by thermal effects on the laser system. BeamWatch also provides the industrial laser user with measurement of other key laser operating parameters in real-time.

The system measures the signal generated from Rayleigh scattering around the laser's beam waist, where the power density is the highest. Rayleigh scattering is a physical property of light caused by light scattering off of air molecules. Unlike traditional beam measurement systems, the beam passes directly through BeamWatch and is not disrupted, mechanically or optically. In addition, BeamWatch has no moving parts so there is no need for cooling of any components. Specialized system software dynamically measures the signal multiple times per second, allowing the laser user to key in on critical operational laser attributes, such as beam waist size and position with respect to the material being processed.

BeamWatch User Interface

The user has access to those tools needed for start-up and advanced beam diagnostics.



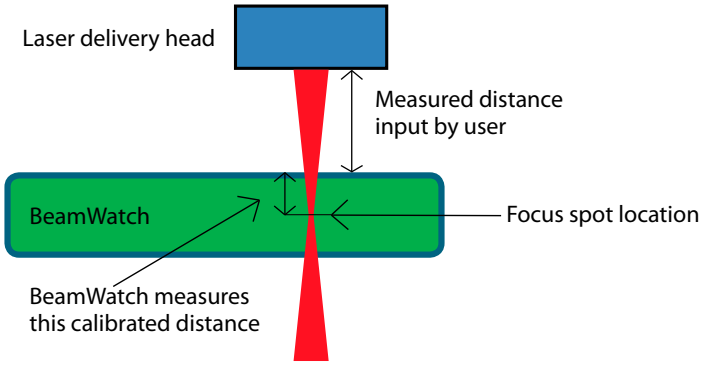
User interface for dual axis set-up and beam diagnostics

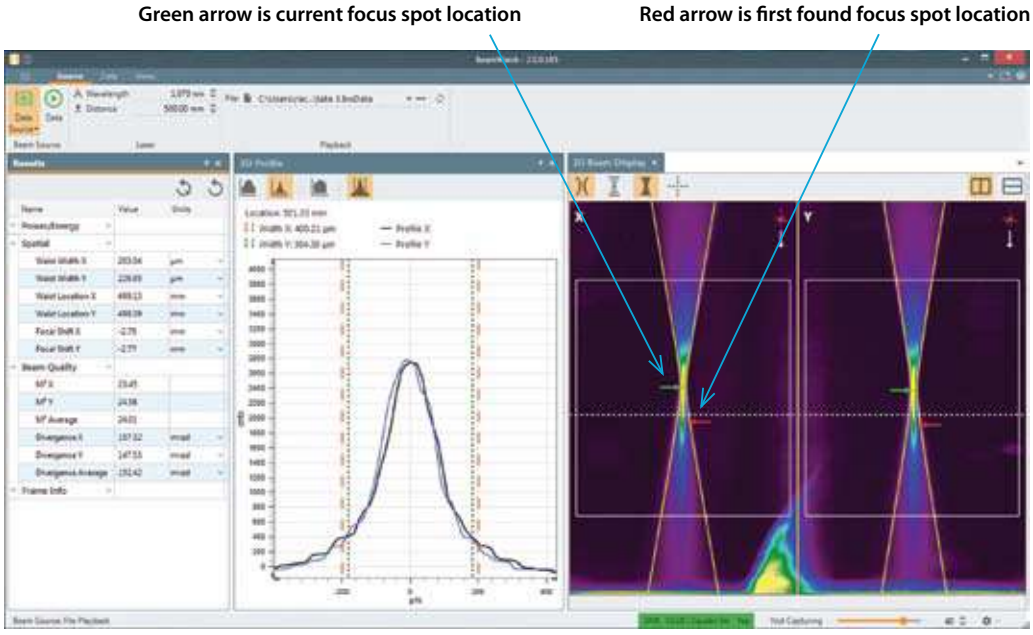
Focus Spot Size (Waist Width)

BeamWatch images the full beam caustic measuring the waist at its smallest point, many times per second.

Focus Spot Location

Now you can precisely know the dynamic behavior of focal spot shift throughout the laser duty cycle. By inputting the known distance from the laser delivery head to a precise datum on BeamWatch the focal spot distance is constantly measured and tracked with millisecond updates.





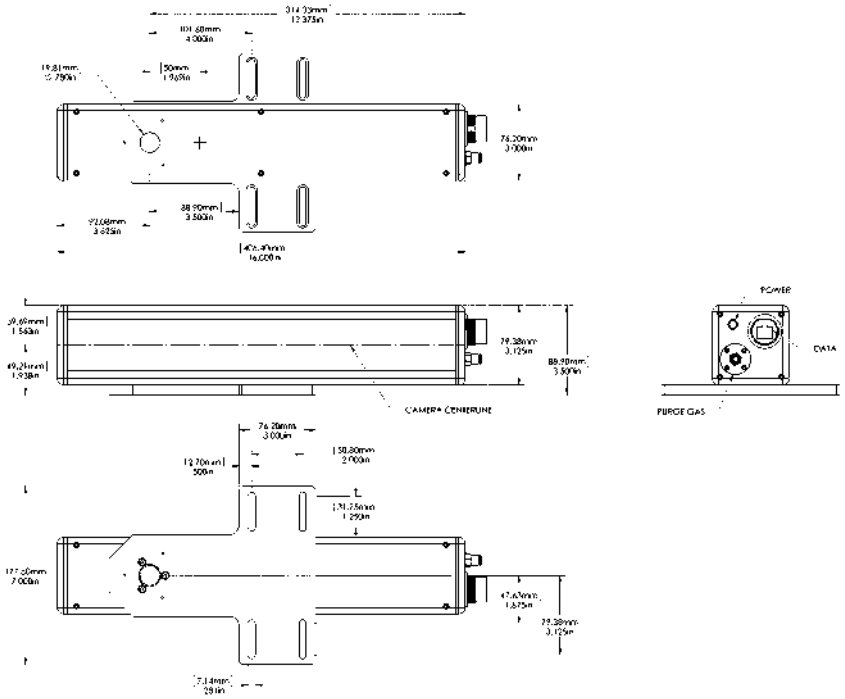
Assured Process Consistency

Measure as often as needed to assure repeatable and consistent process uniformity. Mount BeamWatch into the process or manually insert BeamWatch and make periodic measurements.
You can also automatically compare to initial process validation measurements and utilize automated pass/fail.

Automation Interface

BeamWatch includes the tools to support Automation Clients written in Visual Basic for Applications (VBA), C++ CLI, or any .Net compliant environment, such as Microsoft Excel or National Instruments' LabVIEW.

Periodically measure and compare



3.8.1 Product Specifications

Model	BeamWatch
Wavelength	980-1080nm
Minimum Power density	2 Megawatts/cm^2
Minimum Spot Size	
SP90390 Dual axis	155 microns
SP90391 Dual axis	55 microns
Maximum Beam diameter at entrance/exit	12.5mm
Communication to PC	GigE Ethernet
Power	110 – 220 Volts AC
Particulate Purge	Clean Dry Gas, approximately 10 LPM
Accuracy	
Waist Width (Spot Size)	±5%
Waist Location	±125 micrometers within the BeamWatch window
Focal Shift	±50 microns
Beam Parameter Product	±3.5% RMS
Divergence	±3.5% RMS
M^2	±3.5% RMS

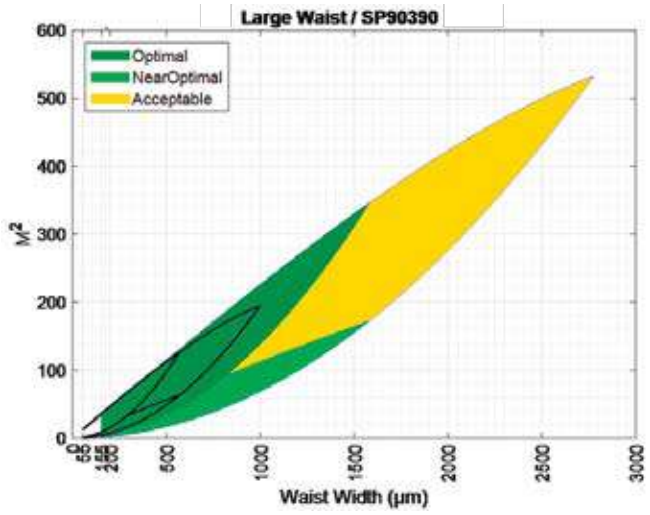
Specification subject to change

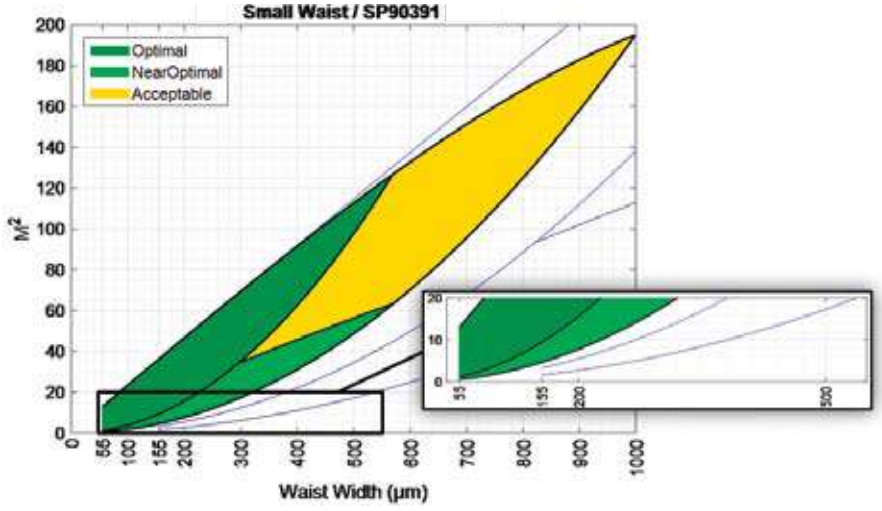
Operating Space Charts

The plots are intended to give a visual indication of the recommended operating space for BeamWatch. If BeamWatch is operated outside of this space, it may be more difficult to see the curvature of the caustic or the beam may be large enough at the edges of the image that it is out of focus.
The maximum waist is dependent on the power density and M^2 of the beam. Specified is a minimum power density of 2 megawatts/cm^2 and the M^2 vs waist width is shown in the corn-looking graphs. Following these charts also covers the 12.5mm max beam size as it enters and exits the unit.

The 12.5mm maximum beam size at entrance and exit is the physical clear aperture of unit, and is the same for all models.

- Optimal has at least 3 Rayleigh lengths on both sides of the waist, with the waist at the center of the image
- Near Optimal has at least 3 Rayleigh lengths on 1 side of the waist, with the waist at the end of the image
- Acceptable has at least 1.5 Rayleigh lengths on both sides of the waist, with the waist at the center of the image



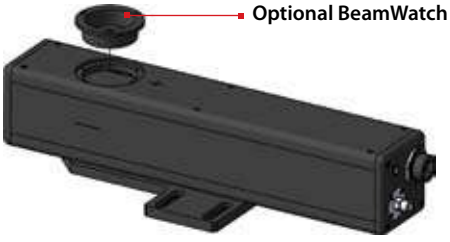


3.8.1.1 Software Features

Software Features	Dual Axis
Results - Power/Energy	Relative Power
Results - Spatial	Waist Width X & Y
	Waist Location X & Y
	Focal Shift X & Y
	Centroid X & Y
	Width at Cursor X & Y
	Ellipticity at Cursor
	Rayleigh Length X & Y
	Waist to Cursor X & Y
Results - Beam Quality	M^2 X & Y
	M^2 Average
	K X & Y
	K Average
	BPP X & Y
	BPP Average
	Divergence X & Y
	Divergence Average
Results	All results can be shown/hidden.
Frame Info	Frame ID
	Timestamp
1D Profile	Logarithmic or Linear
	Control to enable/disable the beam width markers
	Profiles are drawn at the cursor location. Cursor is controlled in the 2D display
	Display shows current cursor location and width at cursor results
	The X and Y profiles are overlapped in a single display
2D Beam Display	Overlays that can be enabled/disabled
	Fitted caustic and drawn beam area
	Raw data points
	Beam Image
	Alignment Crosshair – Marks the center of the display for each axis
	Beam can be displayed vertically or horizontally on the screen
	Labels indicate X and Y axis and the direction of beam propagation
	Cursor can be moved to any point along the beam
	Focal point indicators – one shows current waist position, another shows first found waist position
Statistics	Mean, Std Dev, Max, Min, and Sample Size
System Requirements	PC computer running Windows 7 (64) and Windows 10 Laptop or Desktop:
	GHz Pentium style processor, dual core recommended
	Minimum 2GB RAM
	Accelerated Graphics Processor
	Hard drive space suitable to hold the amount of video data you expect to store (50-100 GB recommended)

Option

For those applications where the laser delivery nozzle cannot be positioned close enough to the measurement centerline, the cup aperture replaces the flat aperture.



3.8.1.2 Ordering

Item	Description	P/N
BW-NIR-2-155	Dual axis - BeamWatch non-contact, focus spot size and position monitor for focus spots from 155µm and larger (see operating space charts)	SP90390
BW-NIR-2-55	Dual axis - BeamWatch non-contact, focus spot size and position monitor for focus spots from 55µm and larger (see operating space charts)	SP90391
Options		
Cup aperture	For those applications where the standard flat aperture does not position the delivery head close enough to the measurement centerline. Includes alignment tool SP90475	SP90476
Suggested Add-Ons		
Rotation Mount	Add-on 180° manual rotation mount to bottom of BeamWatch	SP90346
Locking Ethernet Cable	Replace standard Ethernet cable with one that locks into place, IP67 rated	SP90394
5000W-BB-50	5kW water cooled power sensor	7Z02754
10K-W-BB-43	10kW water cooled power sensor	7Z02756
30K-W-BB-74	30kW water cooled power sensor	7Z02757
120K-W	100kW water circulated power sensor for laser with an approximately Gaussian beam and fiber output	7702691
Juno	Compact module to operate one Ophir sensor from your PC USB port	7Z01250
Vega	Hand held color universal power meter	7Z01560

3.8.2 BeamCheck™ - Beam profiling system for Additive Manufacturing

- Beam check measures:
  - Focal spot size at the build plane
  - Laser power at the build plane
  - Laser power density at the build plane
  - Changes in spot size & power density over time
- 0.1 to 600 Watt integrated power sensor
- For fiber lasers; 1060 to 1080nm Wavelength
- Power densities to >3MW/cm^2
- Spot sizes – 37um to 3.5mm
- Frame rate – multiple frames per second
- Additive manufacturing system focal length 200mm – >400mm

Additive manufacturing has restructured how prototype, developmental and advanced design mechanical components are made. Direct Laser Melting, Selective Laser Sintering or 3D metal Printing is quickly becoming the standard for designs that could not be fabricated with traditional metal removing techniques.

To create consistent, strong structures using laser-based additive manufacturing processes that meet flyable DOD standards or FDA requirements, the metallurgy must be consistent, and a laser beam of known dimension, power density and focal spot location is required.

Quality 3D laser printed processes require a laser delivering the correct amount of power, distributed correctly and focused at the correct location. To insure consistent and structurally sound parts these parameters should be directly measured before and after any critical part is made.

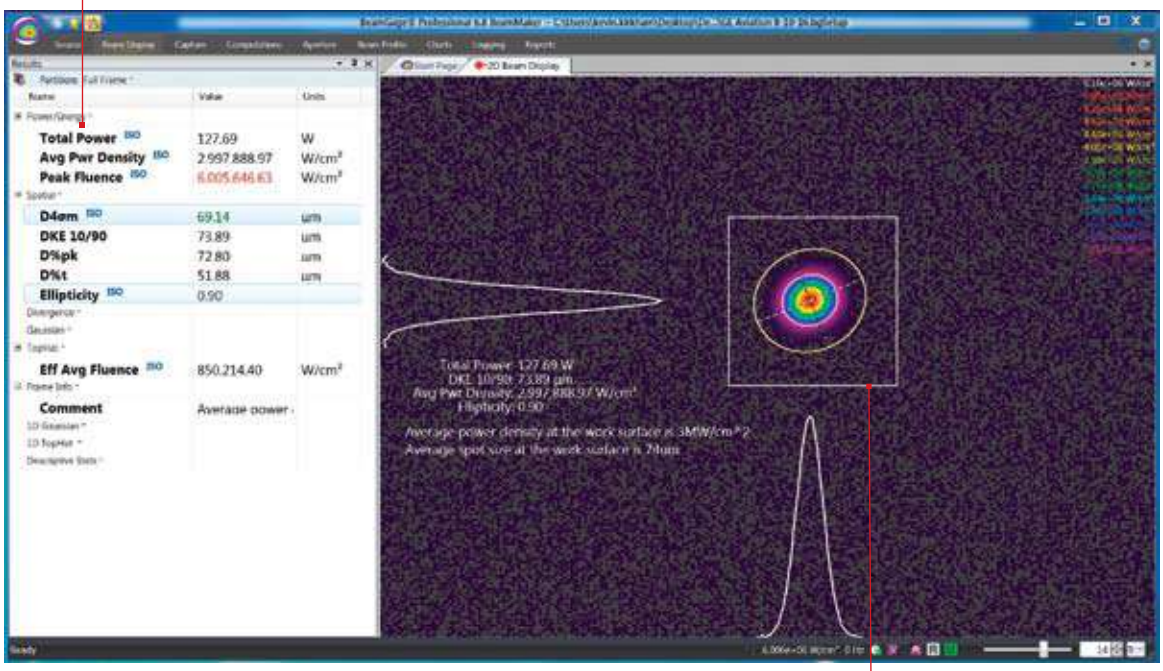
BeamCheck is an integrated laser measurement system designed to measure critical laser beam parameters for laser-based additive manufacturing systems BeamCheck includes a CCD camera for spatial measurements and a NIST-traceable power sensor that will provide a complete analysis of the laser power density profile.

The camera is precisely located at the build plane so that an accurate power density model of the working laser beam can be made. A beam splitter directs a small percentage of the beam to the camera, while the majority of the beam is directed to the integrated power sensor. From these measurements an accurate beam spot size and power density can be derived.

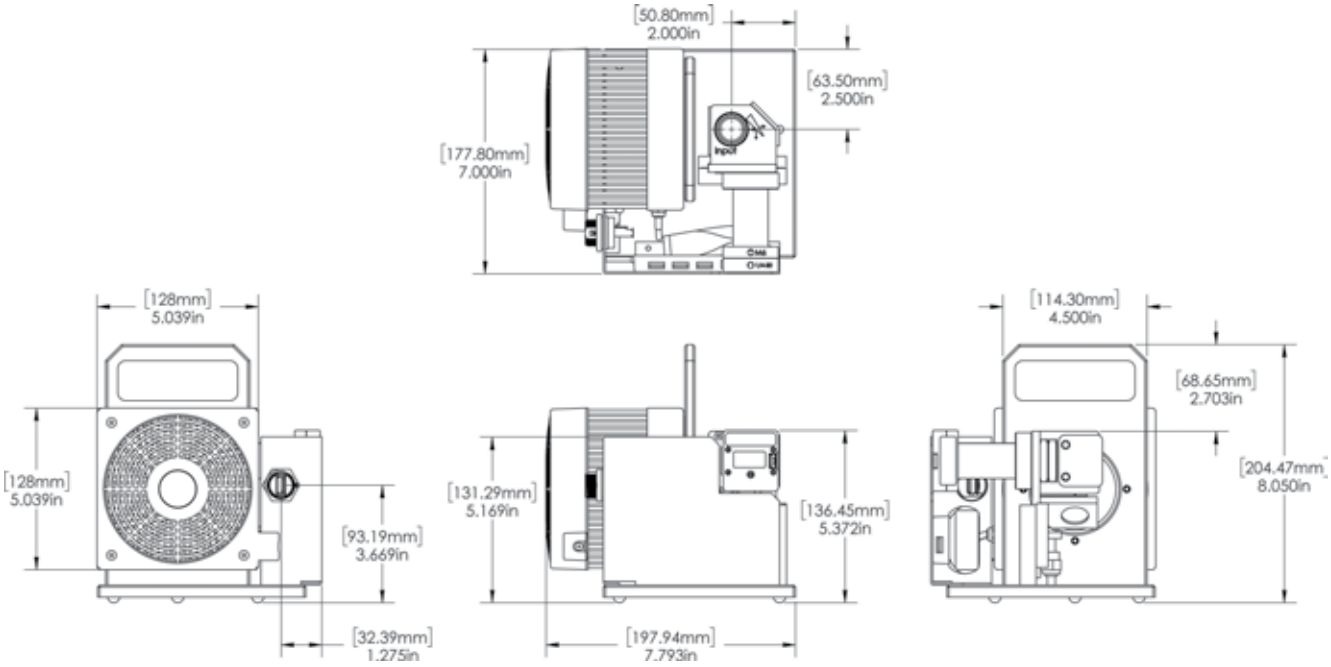
BeamCheck Includes

Beam Profiling	
	SP928 high resolution CCD camera
	▪ 3.69um square pixel, USB 3.0, multiple frames per second
	CCD is positioned within +/- 50µm of the same distance as the work surface
	LBS-300-NIR laser beam splitter / attenuator
	▪ Directs the beam to both the camera and power sensor
Power Measurement	
	FL600-LP1-65 laser power sensor
	▪ NIST traceable, 600 Watts, fan cooled
	JUNO Smart Sensor to USB Adapter
Software	
	BeamGage Professional Software to run on user supplied PC
	StarLab software to interface power sensor to BeamGage
Data is saved in ASCII and HDF5 formats	
Custom print-out includes;	
	2D False Color Power Density Map
	Total Power
	▪ NIST Traceable certificate
	Beam Diameter (D4sigma, 90/10 Knife Edge, Power-in-a-Bucket)
	Peak Power Density
Calibration Certificates for;	
	FL600-LP1-65 Power Sensor
	JUNO USB Converter
	SP928 CCD Camera
	Calibration of build plate distance to camera array location

Industry standard ISO measurements



1D and 2D representation of spatial distribution of the power within the beam



Ordering Information

Item	Description	P/N
BeamCheck	Beam profiling system for Additive Manufacturing Systems	SP90411

3.8.3 BeamWatch® AM - Beam profiling system for Additive Manufacturing Systems

BeamWatch AM provides simultaneous measurements of multiple profiles along the beam caustic in the camera field-of-view (FOV). Real-time measurements are performed at video rates. They include:

- Waist (focus spot) width and location
- Focal shift
- Centroid
- M2 or K
- Divergence
- Beam Parameter Product
- Rayleigh length
- Absolute power
- Tilt angle

Real-time performance also allows for measurement of dynamic focal shift during laser startup.

Additive manufacturing has restructured how prototype, developmental and advanced design mechanical components are made. Direct Laser Melting, Selective Laser Sintering or 3D Metal Printing is quickly becoming the standard for designs that could not be fabricated with traditional metal removing techniques.

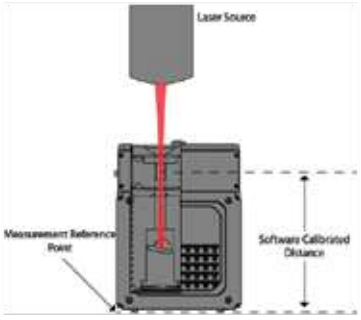
To create consistent, strong structures using laser-based additive manufacturing processes that meet flyable DOD standards or medical device FDA requirements, the metallurgy must be consistent, and a laser beam of known dimension, power density and focal spot location is required.

Quality 3D laser printed processes require a laser delivering the correct amount of power, distributed correctly and focused at the correct location. To insure consistent and structurally sound parts these parameters should be directly measured before and after any critical part is made.

BeamWatch AM measurement technique is based on Rayleigh scattering of laser light by oxygen and nitrogen molecules in the air as the beam propagates through the medium. Measurement of this scattered light provides an equivalent slit-scan of the laser beam in the direction of the observed view. The scattered light is measured using a conventional camera and image capture systems. BeamWatch AM includes a camera for spatial measurements and a NIST-traceable power sensor that will provide a complete analysis of the laser power density profile.

The camera is simultaneously, and real-time, viewing the beam caustic including the near/focus/and far field of the beam. This measurement technique includes Propagation and M2 measurements adhering to the ISO 11146 standards. In addition, and because all measurements are made in real-time, any focal shift occurring during the critical start up seconds is measured and reported.

BeamWatch AM has USB connectivity to Windows personal computers for data acquisition, analysis, and display.

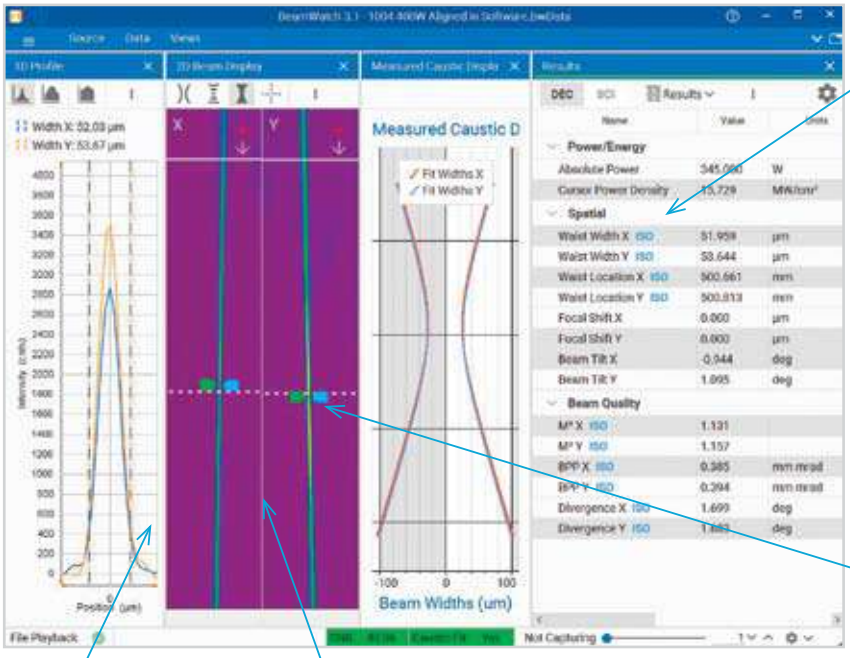


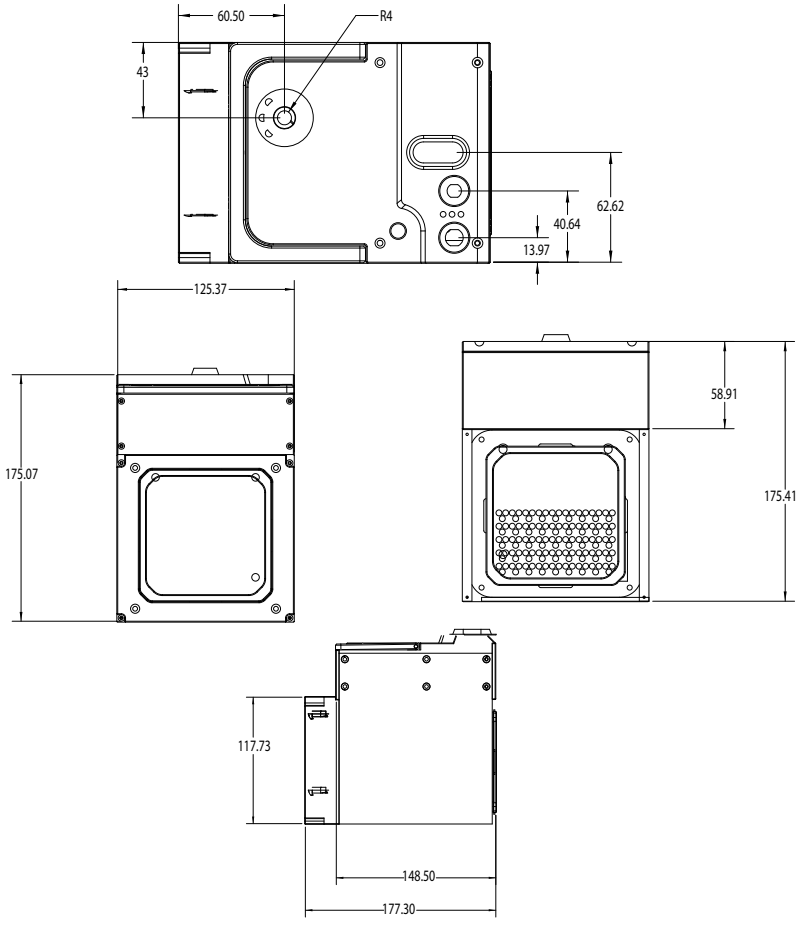
Calibrated beam path for precise focus spot location

Specifications

Beam Profiling	
Wavelength	1060-1080 nm
Minimum Power density	1.5 Megawatts/cm2 (50µm spot at 30 W)
Minimum Focus Spot	50 microns
Maximum Beam diameter at entrance/exit	6 mm (4.5 mm using the Halo Aperture)
ISO 11146 measurements	Self monitoring; will display ISO next to the measurement
Power Meter/Beam Dump	
Measured Power	30 W to 1000 W
Maximum Power Exposure	1000 W for 2 minutes
Precision	NIST traceable calibration, ±3%
Cool-down Time	20 minutes with fan cooling if used to maximum exposure
Software	
BeamWatch AM software	To run on user supplied PC
	Data is saved in ASCII and HDF5 formats
	Print-out of critical measurements and graphics

Calibration Certificates	
Power Sensor	NIST traceable
JUNO USB Converter	NIST traceable
Camera	Certification
Distance from bottom of unit to focus location	NIST traceable
General	
Communication to PC	USB 2.0 & USB 3.0
Power	110 - 220 Volts AC 50/60Hz
Particulate Purge	Clean dry gas
Weight	17 lbs
Dimensions	7.03in x 4.96in x 7.16in
	178.57mm x 126mm x 181.92mm





Ordering Information

Item	Description	P/N
BW-NIR-2-50-AM	Beam profiling system for Additive Manufacturing Systems	SP90470

3.9 A New Method to Assure the Performance of High Power CO_2 Lasers

3.9.1 ModeCheck®

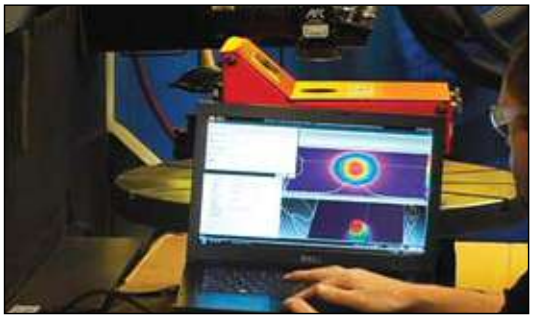
- Beam Profiler for collimated CO_2, 10.6um wavelength, beam width up to 30mm
- Quality Cutting, Marking, Drilling & Ablating Require More Than Consistent Laser Power
- Instantaneously "see" and measure the beam - reduce set-up time between jobs
- Real-time "mode burns" - eliminate hazardous acrylic vapors
- Optimize laser efficiency - reduce cost per part
- Predict laser preventative maintenance - increase manufacturing efficiency

ModeCheck is designed for the industrial parts manufacturer to reduce the time it takes to change over between different jobs. The user can quickly place the ModeCheck in front of the laser and see and measure, in real-time, the laser beam profile to confirm optimal laser performance. In addition, and when used periodically, the user can compare measurement changes from the same set-up and make necessary laser adjustments, keeping the laser output constant for the same job from day-to-day. Over time the user will be able to see and measure laser degradation to predict and advance schedule down-time needed for periodic maintenance.

ModeCheck eliminates operator exposure to acrylic mode burn hazards while improving product quality and manufacturing efficiency.

Measurements:
In addition to both 2D and 3D graphical image display and save, the following measurements are made from each image:

- Beam Widths and Diameters
- Beam Position Stability
- Power Density Peak
- Beam Centroid Location
- Elliptical Analysis with Major Axis Orientation



It's just this easy.

1. Remove Focusing optic or attach the optional MLA
2. Locate the beam center with pointing beam or similar device
3. Place ModeCheck in beam center
4. Turn on Laser
5. Instantly see, measure and electronically store the beam characteristics

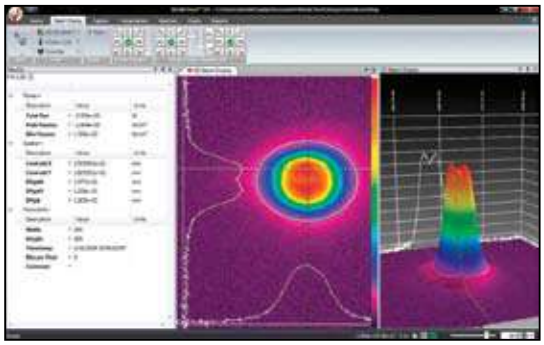
Optional Accessories

One must manage the pass-through laser beam by collecting the beam using either a power meter or beam dump. We recommend using a power meter as the additional measurement information will assist in managing laser optimization. Note that any beam dump or power meter large enough to handle 5-10kW will require water cooling. There are holes on the bottom of ModeCheck for mounting the Power Meter Head or Beam Dump.

A ruggedized storage/carrying case is highly recommended for safe and efficient handling.

The ModeCheck Lens Adapter (MLA) is an option that will enable a ModeCheck to recollimate a focused CO2 laser beam. The advantage of using this adapter is that the focusing head of the machine does not have to be removed, which is the normal case for a ModeCheck without this adapter. The disadvantage is that the ModeCheck must be positioned further from the output head in order to properly recreate the collimated beam profile. The re-collimating lens must be supplied by the user and must be the same lens that is used on the lasers cutting head. (See application note: SP90329).

A PC is required to run the ModeCheck imaging software. The camera is powered over the USB cable that connects the computer to ModeCheck.



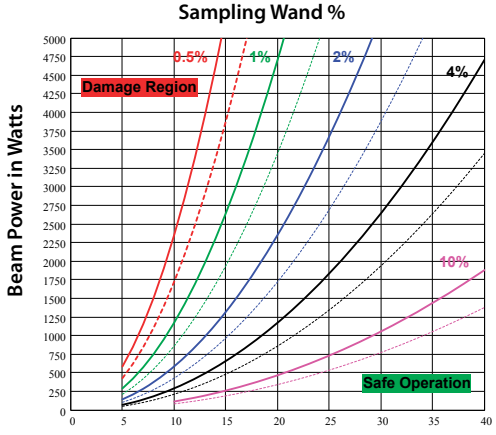
ModeCheck makes instantaneous beam measurements along with graphically displaying both the 2D and 3D power density distribution

ModeCheck with optional MLA, profiling a CO_2 cutting laser with its processing head installed

3.9.1.1 Specifications Model

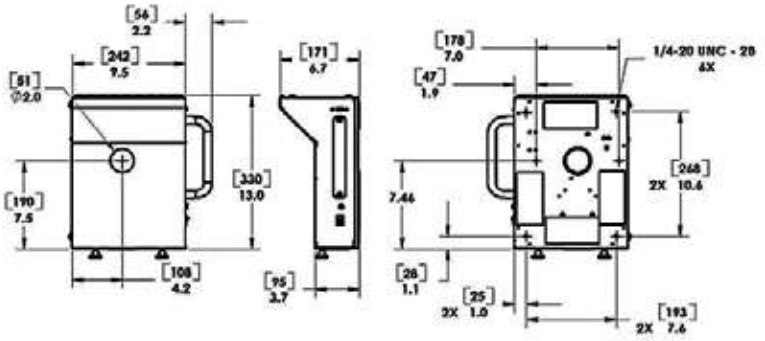
Specifications Model	ModeCheck
Laser Input Power	100-5000 Watts (or more depending on Beam size)
Input Clear Aperture	50mm (~2")
Laser Type	CW, Pulsed >100 KHz
Beam Width	5mm - 30mm
Pick-off Percent	0.5%, 1%, 2%, 4%, 10% sampling wands; user replaceable
Damage Threshold	27 - 36 W/cm^2; See graph
Camera	1/3" format CMOS, 480x480, 6µm pixel, 8bit, CS-mount, USB2
Lens	12mm C-mount
Cooling	Built in Fan (water required for the optional beam dump or optional power meter sensor)
UV Light Source	LED array
Software	ModeCheck
Power Requirements	Input: 100-240 Vac, 50-60Hz, 1.5A Output: 12Vdc, 5.0A, w/power jack, UL listed and CE compliant universal power supply included Camera is powered over the USB port
Dimensions	9.5"x 13"x 6.7" 242mm x 330mm x 171mm Not including handle and cabling or any options
Weight	~8 lbs 3.6kg
Beam Dump (optional)	Water cooled and rated for 5kW total power
Power Meter (optional)	5000W-SH; up to 5kW total power 10kW-SH-V2; up to 10kW total power
Laptop Computer	Provided by user; Windows 7 (32/64)
Compliance	Unit meets CE and RoHS requirements

The optional rugged case is recommended for safe storage in an industrial facility



Damage and Saturation Power vs Beam Dia

Safe Operation is to the Right of the Solid line. Image Saturation is approximately the Dashed line. Chose a sampling Wand that contains your beams maximum power and minimum diameter to be near but below the dashed line for safe and best beam viewing.



MODECHECK DIMENSIONS W/O BEAM DUMP

3.9.1.2 Ordering Information

Item	Description	P/N
MODECHECK CO_2-5kW	ModeCheck, CO_2 sampler for 10.6µm beams up to 5kW, beam width up to 30mm; includes 2 user selectable wands from selection below	SP90211
0.5% wand	0.5% beam wand sampler, see damage and saturation chart	SP90324
1% wand	1% beam wand sampler, see damage and saturation chart	SP90325
2% wand	2% beam wand sampler, see damage and saturation chart	SP90326
4% wand	4% beam wand sampler, see damage and saturation chart	SP90327
10% wand	10% beam wand sampler, see damage and saturation chart	SP90283
Beam Dump; 5kW	Beam dump for up to 5kW continuous, includes mounting bracket, requires continuous water flow.	SP90224
5000W-BB-50	Power sensor, measure CO_2 power up to 5000W; water cooling needed	7Z02754
Mounting Hardware, 5000W detector	Mounting hardware for 5kW power sensor. Required when ordering the 5000W-SH sensor	SP90212
10kW-BB-45	Power sensor, measure CO_2 power up to 10,000W; water cooling needed	7Z02756
Mounting Hardware, 10,000W detector	Mounting hardware for 10KW power sensor. Required when ordering the 10kW-SH-V2 sensor	SP90213
ModeCheck storage/carrying case	Ruggedized ModeCheck storage/carrying case	SP90227
Collimating 2" Lens Adapter	ModeCheck Lens Adapter (MLA) enables a ModeCheck to recollimate a focused CO2 laser beam. MLA should be ordered with the ModeCheck so that it can be factory installed.	SP90329