



## Power and Energy Measurement for Lasers



Pyroelectric - Thermopile - Powermeter - OEM-Detectors - THz-Detectors

# Introduction

## Laser measurement products - Made in Germany

More than 40 years' experience in development and production of high quality pyroelectric energy detectors and thermal power detectors are the basement our products and services.

We offer an excellent Service!

It doesn't matter if you ask for a customer specific solution, special attachments or a special calibration, we will do our best to make all your wishes become true. Searching for the right product? We would love to give you advise. We are specialized for solving problems other can't.



The management system of SLT Sensor- und Lasertechnik GmbH has been assessed and certified as meeting the requirements of ISO 9001:2015

# Calibration

The calibration of our detectors is traceable to the PTB Braunschweig and Berlin (the National Metrological Institute). For calibration or recalibration of all detectors a reference detector calibrated at the PTB is used. During calibration procedure the output signal of the customer sample is compared with the output signal of the reference detector.

To eliminate inaccuracies due to laser fluctuations, a beam splitter and a monitor detector is used. Normally the third harmonic of a YAG laser (355 nm) is used for the calibration of pyroelectric detectors and a diode laser (880 nm) is used for all thermopile detectors. For special requirements and for detectors having a strong wavelength dependent sensitivity, it is useful to calibrate at customer wavelengths. The following lasers and wavelengths are available.

Additionally to the sensitivity of the detector also the wavelength dependency and the calibration wavelength is stored on the EEPROM or our E-connector.

**Certificate of Calibration**  
Sensor- und Lasertechnik

Sensortyp / Model	PEM 8
Seriennummer / Serial	P8/116
geprüft am / date of calibration	15. January 2013

**Kenndaten / Parameters**

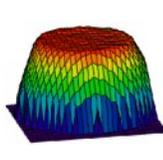
- Empfindlichkeit / Sensitivity	800 V/J an 1 MOhm
- Kalibrierwellenlänge / Calibration wavelength	212 V/J an 100 kOhm
- spektrale Bandbreite / Spectral bandwidth	355 nm
- Kalibriergenauigkeit / Calibration uncertainty	190nm ... 25µm
- thermische Zeitkonstante / Thermal time constant	5%
	20 ms

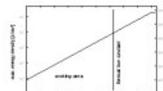
**Grenzwerte / Limiting values**

- Energiedichte / Energy density	0,15 J/cm <sup>2</sup>
- Leistungsdichte / Power density	8 MW/cm <sup>2</sup> (10ns-Pulse)
- mittlere Leistung / Average power	0,15 W/cm <sup>2</sup>
- Temperaturbereich / Operating environment	0° ... 40°C

**Homogenität:**

- Schrittweite / Step width	0,3 mm
- Durchmesser des Teststrahles / Diameter of test beam	1 mm
- Empfindlichkeitsprofil / Profile of homogeneity	





**Equipment used for Calibration**  
Reference Detector PEM 34, Ser.-No. P04018, Certificate-No. PTB-4.54 / 4053330 / 11  
Reference Read-Out: LEM320, Ser.-No. 2023-90 1-1100, Certificate-No. PTB-4.54 / 4053330 / 11  
The accuracy and calibration is traceable to the PTB Germany (national institute of science and technology) through equipment which is calibrated at planned intervals by comparison to the certified standards.

## LASER SAFETY WARNING

These detectors are normally used to measure the output from laser sources. The operator should be familiar with the appropriate laser safety procedures and regulations. In particular it should be noted that a small part of the laser beam incident on the detector head will be reflected. This can be hazardous and both incident and reflected beams should be enclosed if necessary.

# Choosing the Correct Detector

There are a few things you should consider before you buy a detector.

The first one is comparing the laser beam diameter you have with the detector diameter. Think about which area your laser beam will cover. This area should be 80% or less of your active detector area. For example, if your laser beam covers an area of 16 mm, you should choose a detector with an aperture of 20 mm or more. Considering that will help you make sure that you are collecting all of the beam power or energy. It also helps to avoid spatial in-equability, which can occur at the edge of the absorbing layer.

The second thing you should consider is the power of your laser. Think about the minimum and maximum power you expect. You should choose a detector whose minimum of the detectable range is about 5% of the lowest power you will need to detect. If you want to detect power levels which are really close to the detectors maximum of the detection range, you should make sure that you are cooling it correctly. With that in mind you will get a good signal-to-noise ratio and avoid to damage your detector accidentally.

Last but not least you should think about the maximum average power density. You will need to divide the laser power (W) by your laser beams area (cm<sup>2</sup>) to get the necessary value (W/cm<sup>2</sup>). If you got it we recommend you to apply a multiplier of 2 on your calculated value. That's because most lasers have a Gaussian profile so the power density is not constant over the beam area. If you expect or know that your beam will have spots with an abnormally high power density (so called Hot Spots), it is recommended to take a multiplier of 3 instead of 2. So you can be sure you won't damage your detector with a too high power density.

If you considering all of that you should be able to find the correct power detector.

Still not sure which one you should choose? Feel free to contact us. We will find the detector that fits you and your requirements most.

## Damage Threshold

The damage threshold is defined as the maximum power density which a surface can resist without taking any damage.

For continuous wave (cw) lasers the damage threshold can be calculated from the power and beam diameter. Remember that for laser beams with a Gaussian intensity profile, multiplying the power density by two for safety is required to accommodate the peak power density at the centre of the beam.

Attention! The damage threshold scales with the wavelength, so the damage threshold at 532 nm will be lower than at 1064 nm.

Pulsed lasers typically procreate a different type of damage to the detector than CW lasers. Pulsed lasers often do not heat the detector enough to damage it; instead, pulsed lasers generate strong electric fields capable of procreating dielectric breakdown in the material.

Lets take a look at what damage can be done:

- If the average power is too high, it overheats the detector. This lead to a damage at the thermocouple junctions.
- A too high power density can damage (melting, cracking and/or vaporizing) the absorption layer cause of local heating.
- With a too high peak power density a part of the absorption layer will radically be vaporized so that it exposes the thermopile element underneath the surface. This may affect the sensitivity of the detector really strong.
- The wavelength is also a factor that should not be underrated. Longer wavelengths tends to penetrate deeper into the absorption layer. If the specification got exceeded it can damage the thermopile element. Shorter wavelengths concentrates the energy closer to the absorber surface.
- The simplest way to damage the absorption layer is to scratch it.

However it happens, damage to the absorbers surface doesn't mean a problem for the whole detector but it can change it's sensitivity.

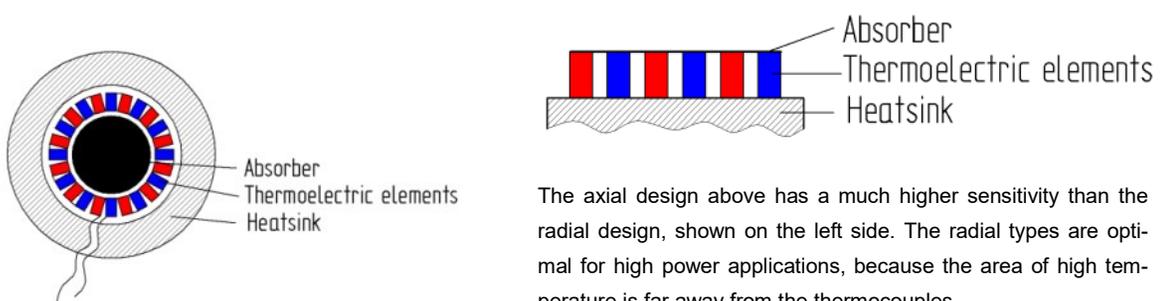
If you got any issues with you detector, please feel free to contact us and we will solve your problem as fast as possible. No matter if you just need a recalibration or any other of our excellent services.

# Thermopile Detectors

Such detectors are used for the determination of the average power of cw or repeatedly pulsed lasers. All types of thermopile detectors use the temperature gradient along the heat flow for the determination of the input power. As shown in the next figures the heat flow can proceed in axial or in radial directions. Independent of the setup, it needs a certain time to reach stationary state. Radial heat flux sensors have a shorter time constant and are able to handle higher power, whereas axial heat flow sensors can have higher sensitivities.

In most cases the time constant is larger than 10 seconds. This rise time can be reduced using adequate electronics, but for an evaluation of the fluctuation of pulsed lasers a pyroelectric detector is the better choice.

Similar to joule meters the power meters can have different absorber sheets, optimized for a broadband behaviour and lower power densities or for high peak powers and reduced wavelength independence.



The axial design above has a much higher sensitivity than the radial design, shown on the left side. The radial types are optimal for high power applications, because the area of high temperature is far away from the thermocouples.

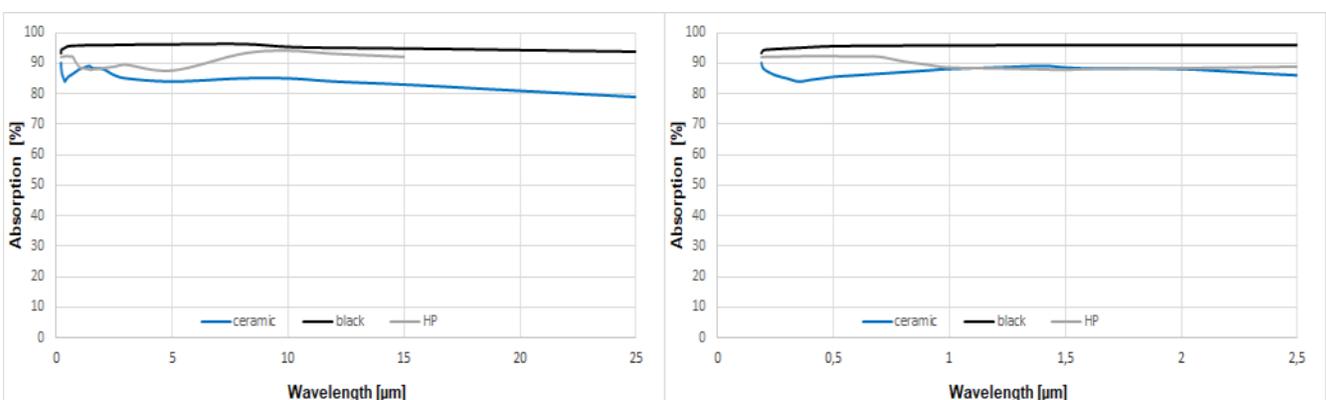
## Coatings for Thermopile Detectors

The absorber coating of the detector has to withstand the intense laser power. Its stability determines the lifetime of the detector. Nearly all absorbers are a compromise between wavelength independent absorption and stability.

We use three different coatings for our detectors:

- Our organic black coating offers a very broadband absorption layer for low energy densities and medium power densities. It works with a nearly wavelength independent absorption of  $97 \pm 1\%$  between 190 nm and 25  $\mu\text{m}$ , which means that no wavelength correction is necessary.
- Our ceramic based coating works with very high energy densities and low power densities. The absorption depends on the wavelength. It works best for all high peak power lasers (Nd:YAG, Excimer,  $\text{CO}_2$ )
- Our HP coating is used for high power densities und medium energy densities. Its absorption depends on the wavelength

For wavelengths larger than 100  $\mu\text{m}$ , the absorption decreases for all known absorbers, caused by an increasing transparency. This can only be compensated for by a larger thickness of the absorber leading to disadvantages for power and energy sensors.



# Power and Energy Meter PEM 710

A large 7" capacitive touch panel and clearly arranged menus make this device very comfortable and easy to handle.

Very low noise amplifiers and for every signal path optimised AD converters, allow to use a wide range of sensor heads. After connecting a detector, the display read all relevant parameters from detector-EEPROM and setting up the device automatically. Manually setup possibilities for wavelength and correction are possible.

The large graphic display offers space for a variety of display and analysis choices. The digital display can be used for determining the energy, frequency and average power. The analogue part with its bar graph display is useful for e.g. laser adjustments. Laser stability can be monitored using the data logger and statistics window. Also a data logging window and a statistic window with histogram in selectable

The PEM 710 is equipped with USB interfaces. These ports allow remote control and transferring of all data to a PC or USB memory stick. An analogue output offers a lot of possibilities to integrate the display into own measurement arrangements.



- For pyroelectric energy sensor heads and thermopile power sensor heads
- Digital display, analogue display, graphic data logger, statistics and histogram
- HiRes 7" Graphic display with background illumination
- Wide dynamic range
- Input of correction factors e.g. for mirrors or beam splitters
- Wavelength correction
- Adjustable trigger level
- Analogue output
- Capacitive touch panel
- USB 2.0 interface for remote operation
- compatible to all heads of PEM, HP, LP and BB series
- In energy mode rep rates 2000 pps
- Data storage on USB memory stick
- Compatible with E-connector with integrated EEPROM with all detector parameters
- Dimension 220 mm x 190 mm x 57 mm

## Pyrobox and Powerbox

Use this interfaces to connect your thermopile detector or pyroelectric detector directly to your PC. The interfaces contains many of the same features as PEM710, except it does not have a display screen or built-in console controls. Instead, the console and sensor are completely controlled via a USB connection and the supplied software. The Interfaces converts the signal from the attached sensor and transfers it to the PC. Each interface uses an analogue signal path which is optimised for the specified detectors.

This two interfaces are simple to program and drivers for the most operating systems are available.

- USB 2.0 connection
- LabVIEW based software for different applications available (Analogue and digital display, data logger, statistics)
- Data transfer as ASCII code
- Compatible with E-connector
- Powerbox: 4 ranges
- Pyrobox: 8 ranges
- Power supply from USB
- Dimensions 110 mm x 62 mm x 30 mm



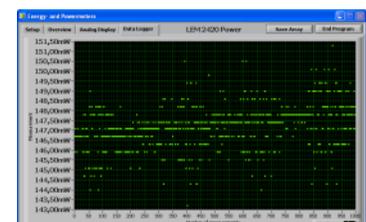
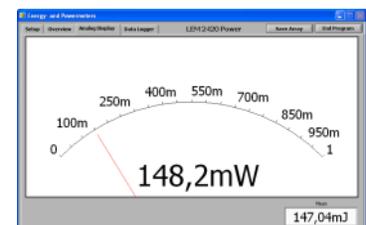
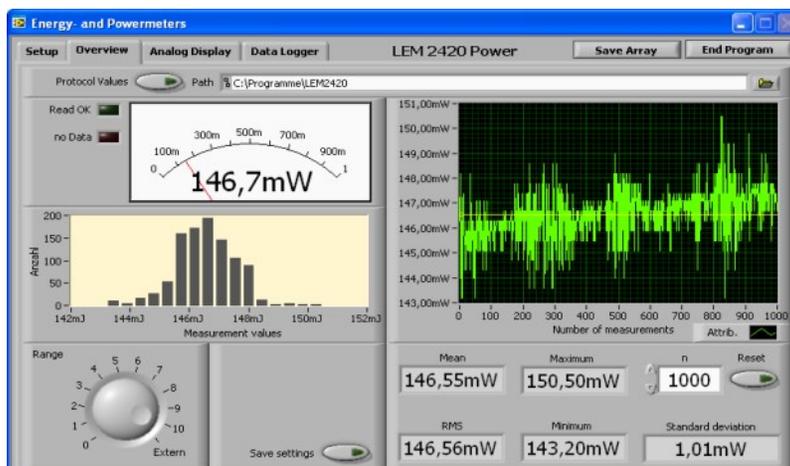
## Software

A LabVIEW based software for Windows PC's which displaying all via USB transferred data is available for PEM710, PEM280, Powerbox and Pyrobox. This software is inclusive with every unit.

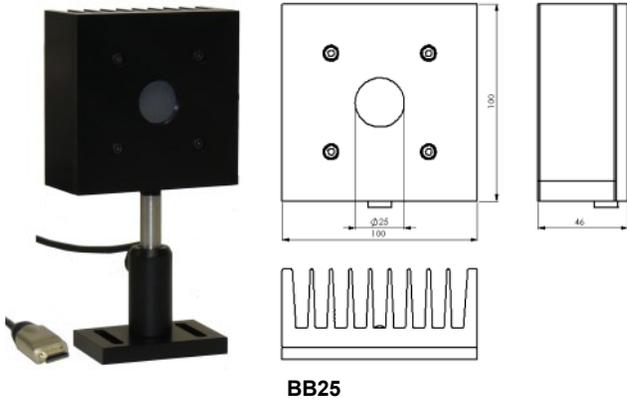
An overview window shows a small analogue instrument, Histogram, data logger and also some statistical results. Additionally it is possible to save the displayed data into a file.

For adjustment work it is possible to switch to the analogue instrument or the data logger.

Some basic LabVIEW VIs for own projects are available. Because of the simple data structure and the simulated COM-port it is very easy to implement the device in other programming languages or other operating systems.



# Thermopile Power Detectors LP / BB Series



BB25

The heads of the **Series BB and LP** family have a black, broadband absorbing coating. The main characteristic of the **Series LP** sensor family is the very high sensitivity. This enables the sensor to measure small laser power with high precision and resolution over the high dynamic range of 5 orders of magnitude. For stabilisation of the sensor one can use a thermal isolation of the sensor housing. Additionally, the housing can adapt with a protection tube to protect the surface against stray light and air moving. You can also replace the tube by special adapters for using optical fibres.



LP10/BB10



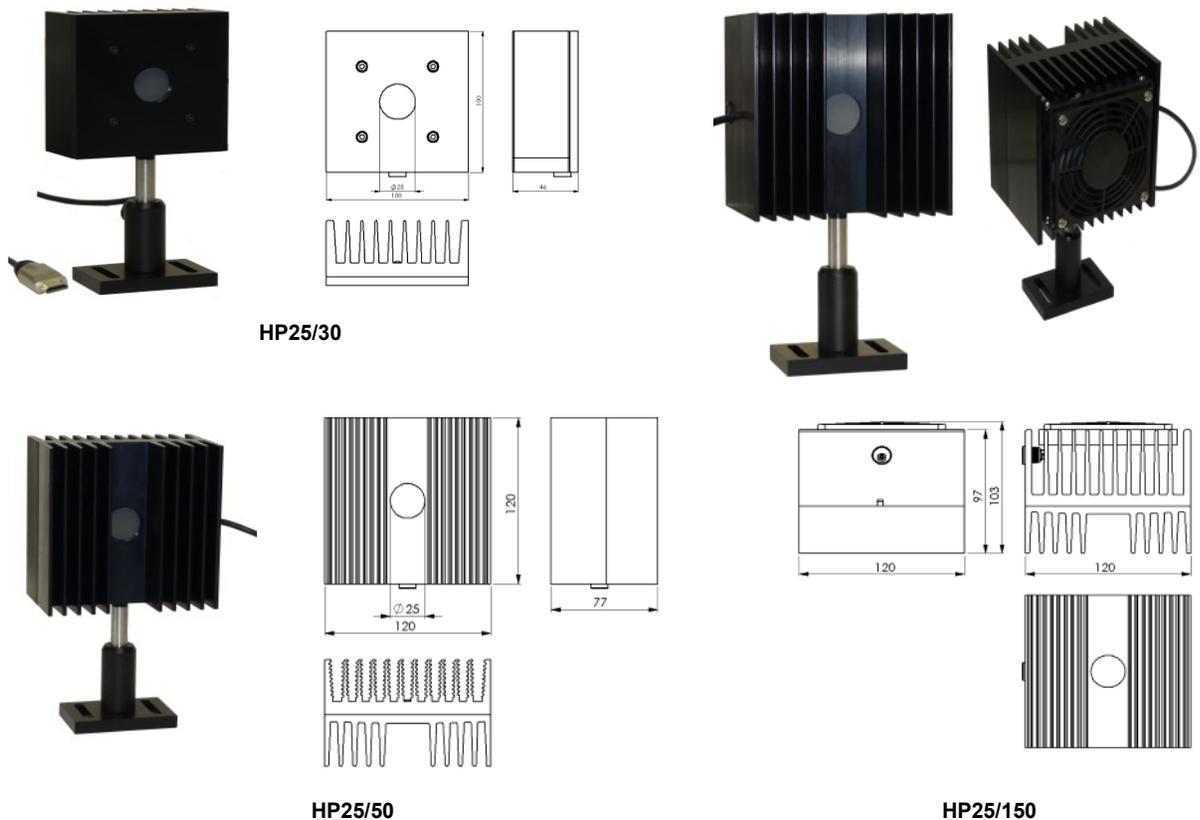
BB25 S

	LP10	BB10	BB25	BB25S
Active diameter	10 mm		25 mm	
Max. power	3 W		20 W	5 W
Min power	50 µW	100 µW	1 mW	
Response time	< 2 seconds (with display)			
max. power density	20 W/cm <sup>2</sup>			
Max. energy density	150 mJ/cm <sup>2</sup> (at 10 ns)   500 mJ/cm <sup>2</sup> (at 10 µs)			
Sensitivity	≈400 mV/W		≈100 mV/W	
Linearity	±1%			
Calibration uncertainty	±3%			
Cooling	convection			
Spectral range	190 nm - 25 µm			
Connector	E-connector with EEPROM, Cable length 1.5m			
Dimensions [mm]	Ø 60, L: 20	100 x 100 x 46		Ø 90, L: 28

# Thermopile Power Detectors

## HP Series

The measuring heads from **Series HP** are provided with a inorganic absorbing layer which allows high energy and power densities also in a UV wavelength range.



HP25/30

HP25/50

HP25/150

	HP 25/30	HP 25/50	HP 25/150
Active diameter	25 mm		
Max. power	30 W 50 W for 2 minutes	50 W 75 W for 2 minutes	150 W 200 W for 2 minutes
Min power	10 mW		100 mW
Response time	< 2 seconds (with display)		
Max. power density	10 kW/cm <sup>2</sup>		
Max. energy density	300 mJ/cm <sup>2</sup> (at 10 ns)   1,2 J/cm <sup>2</sup> (at 10 μs)		
Sensitivity	≈1 mV/W		≈0.1 mV/W
Linearity	±1%		
Calibration uncertainty	±3%		
Cooling	convection		fan power supply 12V
Spectral range	190 nm - 15 μm		
Connector	E-connector with EEPROM, Cable length 1.5m		
Dimensions [mm]	100 x 100 x 46	120 x 120 x 77	120 x 120 x 103

# Thermopile Power Detectors CP Series

Main applications for this detector are pulse lasers with high power density (Excimer, CO<sub>2</sub>-,TEA-, Nd-YAG-Laser). With this device we offer a sensor that serves in a wide range of applications due to a high damage threshold, a short time constant, relatively high sensitivity and high aperture. The head **CP25S** is specially made for service application. The compact dimensions enable easier transport. Due to the smaller heat sink, high powers are only possible for a short time.

**permissible power- and energy densities at selected wavelengths:**

Laser	Peak power density	Energy density
Excimer, 308 nm, $\tau = 20$ ns	50 MW /cm <sup>2</sup>	1 J/cm <sup>2</sup>
Nd:YAG, THG, 355 nm, $\tau = 7$ ns	65 MW /cm <sup>2</sup>	450 mJ/cm <sup>2</sup>
Nd:YAG, SHG, 532 nm, $\tau = 8$ ns	70 MW /cm <sup>2</sup>	560 mJ/cm <sup>2</sup>
Nd:YAG, 1064 nm, $\tau = 8$ ns	120 MW /cm <sup>2</sup>	970 mJ/cm <sup>2</sup>
CO <sub>2</sub> -TEA, 10,6 $\mu$ m, $\tau = 0,5$ $\mu$ s	10 MW /cm <sup>2</sup>	5 J/cm <sup>2</sup>



	CP25	CP25 S
Active diameter	25 mm	
Max. power	25 W 30 W for 2 minutes	8 W 10 W for 2 minutes
Min power	1 mW	
Response time	< 2 seconds (with display)	
max. power density	40 W/cm <sup>2</sup>	
Max. energy density	1 J/cm <sup>2</sup> (at 10 ns)   5J/cm <sup>2</sup> (at 10 $\mu$ s)	
sensitivity	≈100 mV/W	
linearity	±1%	
Calibration uncertainty	±3%	
Cooling	convection	
Spectral range	190 nm - 25 $\mu$ m	
Connector	E-connector with EEPROM, Cable length 1.5m	
Dimensions [mm]	100 x 100 x 46	Ø 90, L: 28

## OEM Powermeter

OEM detectors and accessories are typically used within laser systems for online power monitoring or power regulation. Because they are fixed within the laser on baseplates or the laser housing they have only small or no cooling fins. They use the laser as a heatsink.

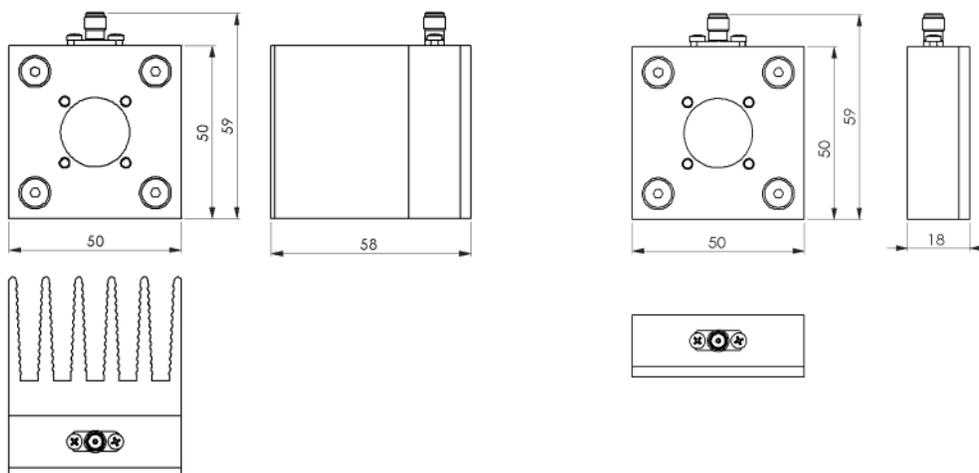
The sensor elements are available in different sizes for different power ranges. The housings have a lot of holes for mounting the detector and for combination with additional optical components like beam splitters, diffuser discs or optical fibre adaptors. Please ask for a solution.

Additionally a preamplifier module with analogue output is available to read the power directly into own applications. For digital interface the OEM Powerbox is available.

### PM505020

Main feature of this family is the high average power density. That's make them ideally for solutions, where it is necessary to measure the whole power of the laser for a short time.

	PM505020-5	PM505020-10
Active diameter	20 mm	
Max. power	5 W	10 W 15 W for 2 minutes
Min power	10 mW	
Response time	< 2 seconds (with electronic)	
Max. power density	10 kW/cm <sup>2</sup>	
Max. energy density	300 mJ/cm <sup>2</sup> (at 10 ns)   1,2 J/cm <sup>2</sup> (at 10 μs)	
Sensitivity	≈1 mV/W	
Linearity	±1%	
Calibration uncertainty	±3%	
Cooling	convection or additional heatsink	
Spectral range	190 nm - 15 μm	
Connector	SMA	
Dimensions [mm]	50 x 50 x 18	50 x 50 x 58



PM505020-10

PM505020-5

# PM404010

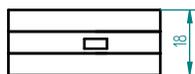
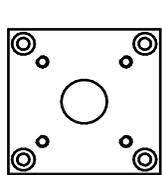
These family of high sensitive thermopile sensors and electronics are ideally for online power monitoring.

For applications at high repetition rate lasers with high peak power we recommend to order these detectors with our ceramic coating.

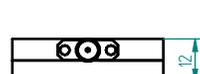
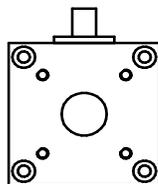
For easy integration within the laser, the housings feature numerous threads on various surfaces. Mounting on solid housing parts or base plates allows for high temperature stability and thus stable measurement results.



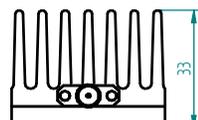
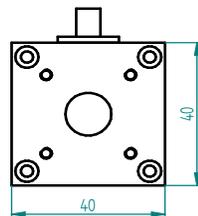
	PM404010-3	PM404010-5	PM404010-3-A	PM404010-5-A
Active diameter	10 mm			
Power range	0.5 mW - 3 W	0.5 mW - 5 W	0.5 mW - 3 W	0.5 mW - 5 W
Max. power density	40 W/cm <sup>2</sup>			
Max. energy density	80mJ/cm <sup>2</sup>			
Sensitivity	250 mV/W .. 450 mV/W			
Linearity	±1%			
Calibration uncertainty	±3%			
Spectral range	190 nm - 25 µm		190 nm - 25 µm	
Cooling	Convection or additional heatsink		Convection or additional heatsink	
Connector	SMA		Molex Microblade	
Dimensions [mm]	0.5 mW - 3 W	0.5 mW - 5 W	40 x 40 x 18	40 x 40 x 39



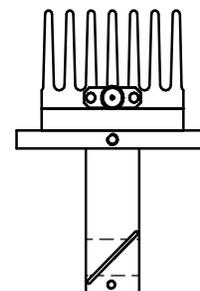
PM404010-3-A



PM404010-3



PM404010-5

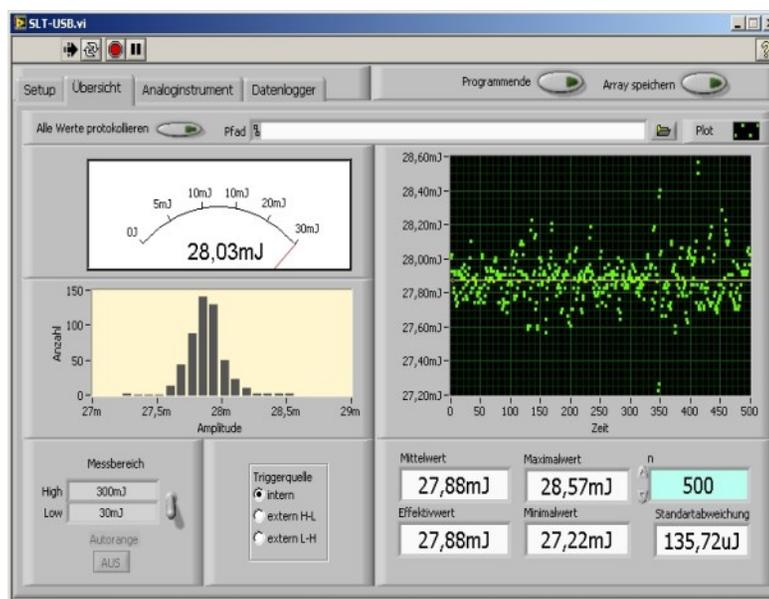


PM404010-5 with additional beam splitter

## Powerbox OEM

This „Powerbox“ processes the signals of all thermopile power detectors. The output signal will be transferred to a connected PC via USB. The device is powered from the USB-port. The Powerbox communicates with the computer using ASCII code and is very easy to integrate into your own existing software program or systems.

- USB 2.0 connection or RS232
- For all thermopile detectors
- Four ranges
- Power supply from USB
- LabVIEW based software for different applications available (Analogue and digital display, data logger, statistics)
- Data transfer as ASCII code
- Dimensions 100 mm x 41 mm x 24 mm



# Powerbox OEM 4-Ch

Based on the Powerbox OEM, we now offer a 4-channel version. A USB and an RS232 version are also available. The range of functions and operation are largely the same as the Powerbox OEM.

- USB 2.0 connection or RS232
- For all thermopile detectors
- Four ranges per channel
- Power supply from USB or external power supply for RS232 version
- LabVIEW based software for different applications available
- Data transfer as ASCII code
- Dimensions 105 mm x 34 mm x 130 mm

