SLT
Sensor- und Lasertechnik

Power and Energy Measurement for Lasers

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

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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 costumer 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.

ISO 9001
EINGETRAGENE FIRMA

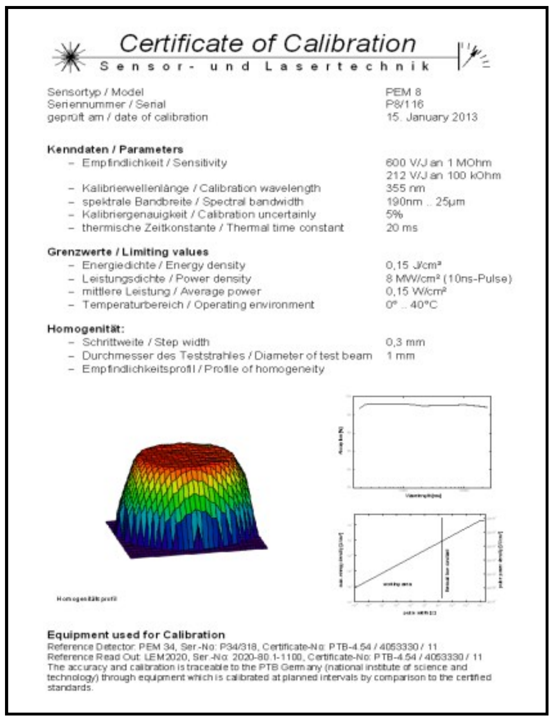
The management system of SLT Sensor- und Lasertechnik GmbH has been assessed and certified as meeting the requirements of *ISO 9001*:2015

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

Grenzwerte / Limiting values

– Energiedichte / Energy density	0,15 J/cm²
– Leistungsdichte / Power density	8 MW/cm² (10ns-Pulse)
– mittlere Leistung / Average power	0,15 W/cm²
– 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	

Homogenitätsprofil

Equipment used for Calibration
Reference Detector: PEM 34, Ser.-No: P34/318, Certificate-No: PTB-4.54 / 4053330 / 11
Reference Read Out: LEM2020, Ser.-No: 2020-80.1-1100, 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 (cm²) to get the necessary value (W/cm²). If you got it we recommend you to applicate 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 that 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:

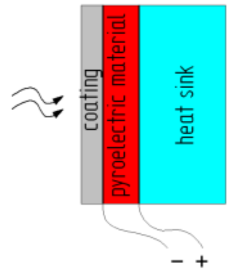
- If the average power is too high, it overheats the detector. This lead to a damage at the thermocouple junctions.
- A too high power density can damage (melting, cracking and/or vaporizing) the absorption layer cause of local heating.
- With a too high peak power density a part of the absorption layer 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.

Pyroelectric Detectors

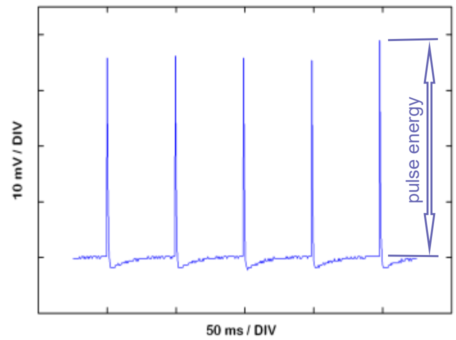
Pyroelectric detectors belong to the class of thermal detectors. Such detectors work independent of wavelength. They consist of an absorber in good thermal contact to the pyroelectric element. Pyroelectric detectors do not need cooling and have the same sensitivity for all wavelengths as long as the absorption process is perfect. The third element in the setup of a pyroelectric detector is the heat sink. It has good thermal contact to the pyroelectric sensor and is responsible for heat transfer to the surroundings.



Pyroelectric sensors are only able to detect modulated or pulsed radiation. Every pyroelectric sensor generates a charge proportional to the temperature change (the laser pulse energy). Dependent on the detection circuit, the charge is detected as a voltage peak, or the deviation of the charge (a current) is detected proportional to the pulse power. For a correct measurement, the pulse duration must be smaller than the thermal time constant so no heat loss occurs during the measurement.

A good pyroelectric material shows linearity between energy and charge for at least 5 orders of magnitude.

Most of the detectors are coaxially arranged and very insensitive against electromagnetic disturbances. A benefit of such detector heads is that they can be directly connected to an oscilloscope and energies from µJ to J can be detected without an amplifier or readout unit.



typical output of an pyroelectric detector

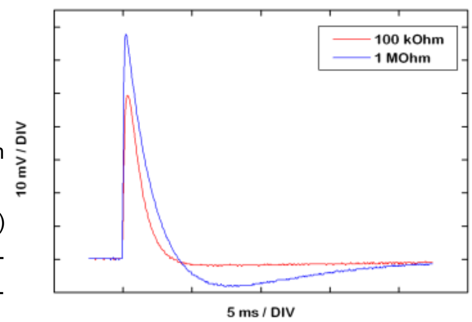
For a measurement of high rep. pulse lasers smaller thermal and electric time constants are desired. Dependent on the construction of the detectors, some types are able to detect pulse energies up to 100 kHz.

Three parameters limit the use of a pyroelectric detector:

Too high peak power destroys or partially evaporates the absorber

Too high average power and

Too high pulse energy is dangerous for the sensor material



output on dependence of load resistor

The limits depend on the wavelength of the radiation and the pulse duration. High threshold coatings are available for most sensor types.

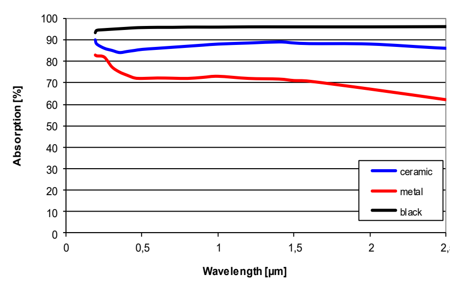
For all detectors the sensitivity (V/J) is specified for a load of 1MΩ (oscilloscope) and for 100kΩ for enabling higher rep. rates. For both loads the sensitivity is determined at 355nm by a comparison with a master detector calibrated at PTB Braunschweig.

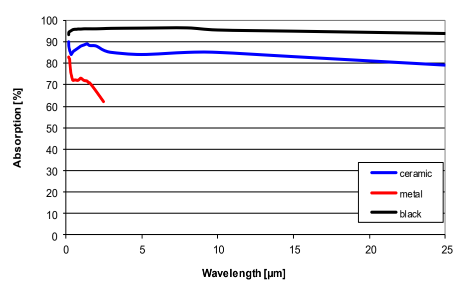
Coatings for Pyroelectric Detectors

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:

- Organic black coating with a high and nearly wavelength independent absorption of 97±1 % between 190 nm and 25 µm
- Ceramic based high power absorber, especially for all high peak power lasers (YAG, Excimer, CO_2)
- Metallic absorber with high thermal conductivity for high rep rates





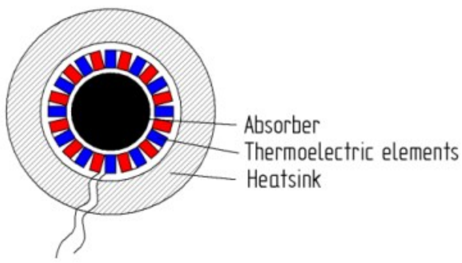
For wavelengths larger than 100 µm, the absorption decreases for all known absorbers , caused by an increasing transparency. This can only be compensated for by a larger thickness of the absorber leading to disadvantages for power and energy sensors.

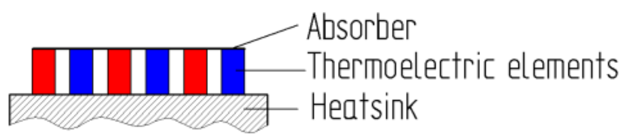
Thermopile Detectors

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.

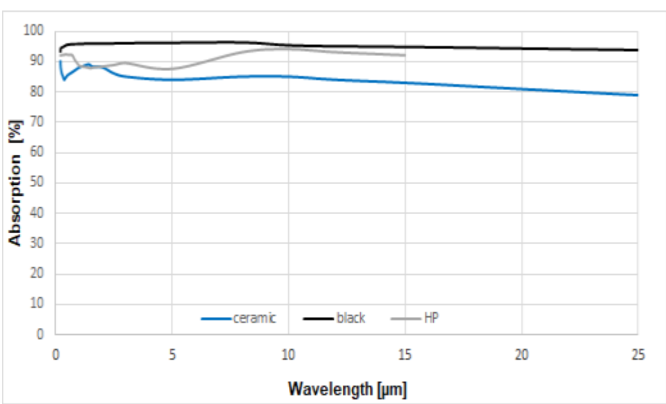
Coatings for Thermopile Detectors

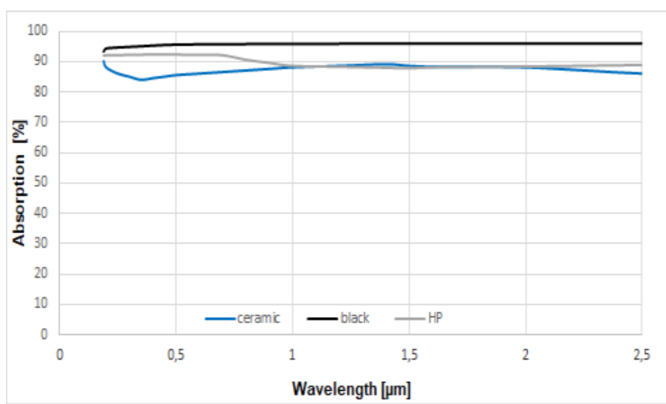
The absorber coating of the detector has to withstand the intense laser power. Its stability determines the lifetime of the detector. Nearly all absorbers are a compromise between wavelength independent absorption and stability.

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±1 % between 190 nm and 25 µm, 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, 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 µm, 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 the PM280 and PEM710 Consoles, 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 PM100USB 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

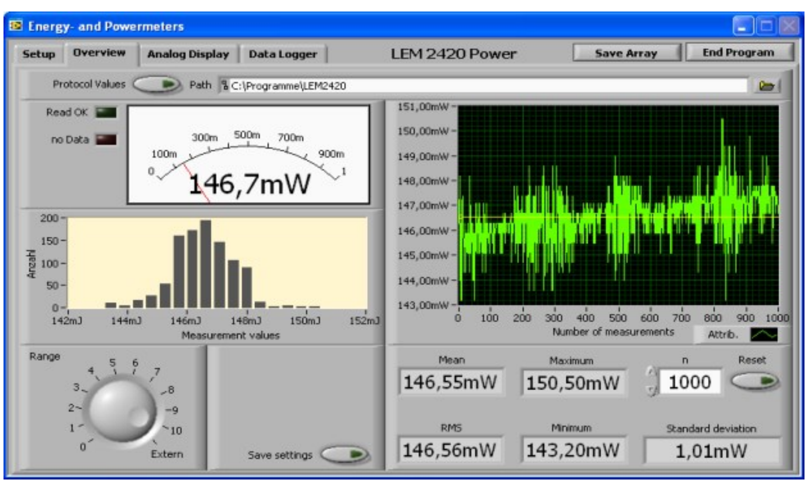
Software

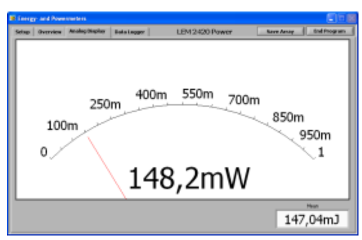
A LabVIEW based software for Windows PC's which displaying all via USB transferred data is available for PEM710, PEM280, Powerbox and Pyrobox. This software is inclusive with every unit.

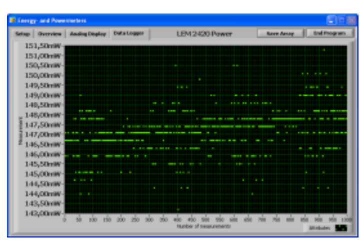
An overview window shows a small analogue instrument, Histogram, data logger and also some statistical results. Additionally it is possible to save the displayed data into a file.

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.





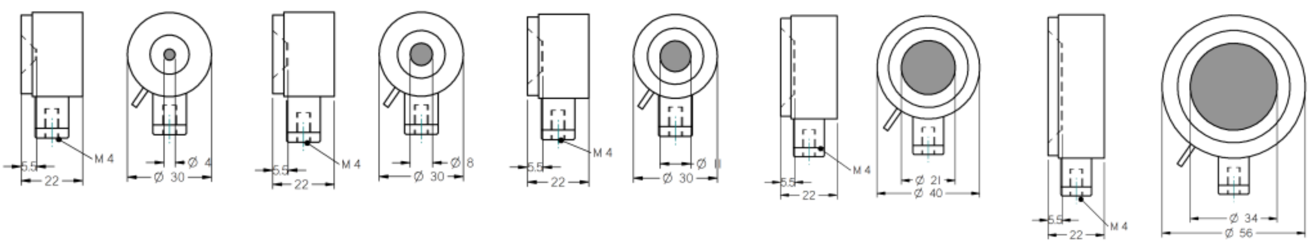


Pyroelectric Energy Detectors
PEM Standard

The detectors are coated with a black absorption layer which possesses an almost constant absorption in the wavelength range from 185 nm to 25 µm. Particularly beneficial is the comparatively high sensitivity of the detectors which permits laser pulse measurements in the µJ range without an additional amplifier and due to the insensitivity to interferences.

The maximum pulse repetition rate depends on the internal capacitance of the detector as well as the load resistor. All detectors can be directly connected using the BNC connector to the 1 MOhm-Input of an oscilloscope. A small load resistor can be used to obtain the highest pulse repetition rate. Repetition rates of up to 100 Hz are then possible. Load resistors of 100 kOhm are part of the deliverable assortment. The corresponding sensitivity of the sensors is also specified.

A much more comfortable way is to use our PEM710 or Pyrobox to display the measured energies.



PEM 4 PEM 8 PEM 11 PEM21 PEM 34

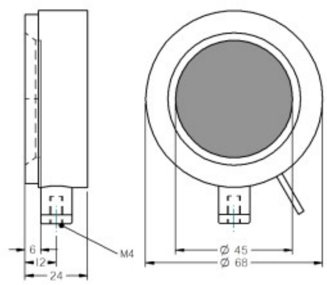
Type	PEM 4	PEM 8	PEM 11	PEM 21	PEM 34
Active diameter	4 mm	8 mm	11 mm	21 mm	34 mm
Working range with scope	1 µJ .. 10 mJ	2 µJ .. 30 mJ	3 µJ .. 70 mJ	5 µJ .. 200 mJ	15 µJ .. 500 mJ
Sensitivity in V/J	500..1000 at 1 MΩ 130..250 at 100 kΩ	200..500 at 1 MΩ 50..200 at 100 kΩ	100..400 at 1 MΩ 50..150 at 100 kΩ	50..150 at 1 MΩ 30..80 at 100 kΩ	20.. 70 at 1 MΩ 10..40 at 100 kΩ
Repetition rates with oscilloscope	80 Hz at 1 MΩ 120 Hz at 100 kΩ	40 Hz at 1 MΩ 100 Hz at 100 kΩ	40 Hz at 1 MΩ 80 Hz at 100 kΩ	25 Hz at 1 MΩ 50 Hz at 100 kΩ	25 Hz at 1 MΩ 80 Hz at 100 kΩ
Working range with display*	**0.1 µJ .. 10 mJ**	**0.2 µJ .. 30 mJ**	**0.3 µJ .. 70 mJ**	**0.5 µJ .. 200 mJ**	**1.5 µJ .. 500 mJ**
Repetition rates with display*	**500 Hz**	**250 Hz**		**100 Hz**	**75 Hz**
max. pulse duration	2 ms				
spectral range	0,19 .. >25 µm				
power density	8 MW/cm²				
energy density	80 mJ/cm² (10 ns - pulse); 160 mJ/cm² (20 ns - pulse)				
average power	0,15 W/cm²				
accuracy	2 %				
dimension (diameter · length)	30 mm x 22 mm			40 mm x 22 mm	56 mm x 22 mm
connector	BNC cable length 1.5m, E-connector with EEPROM				

* PEM710, Pyrobox

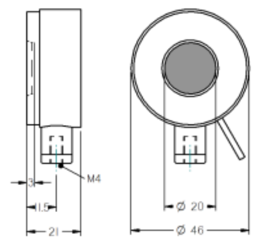
Pyroelectric Energy Detectors
PEM HP

In opposition to our detectors of series PEM Standard these detectors are made for higher average power densities and a higher average power. As absorption coating we use our proven black coating with an very high and flat absorption over a wide wavelength range for these detectors.

The detectors PEM 20 HF and PEM 45 HPF have a reduced electrical time constant to allow higher repetition rates by a little reduced sensitivity.



PEM 45 HP



PEM 20 HP

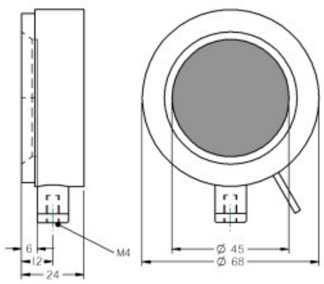
Optional diffusors
for PEM45 and PEM20 to allow a 4 to 5 times higher energy density. The wavelength depending absorption is stored in the EEPROM too and will be corrected automatically by PEM710 and Pyrobox. Threads for additional optics or fibre adaptors are integrated.

	PEM 20 HP	PEM 20 HPF	PEM 45 HP	PEM 45 HPF
Diameter of active area	20 mm	20 mm	45 mm	45 mm
Sensitivity / Scope	30 .. 50 V/J at 1 MOhm	20 .. 40 V/J at 1 MOhm	8 .. 15 V/J at 1 MOhm	5 .. 12 V/J at 1 MOhm
Max. repetition rate / Scope	50 Hz at 1 MOhm	150 Hz at 1 MOhm	25 Hz at 1 MOhm	100 Hz at 1 MOhm
Working range with display*	**2 µJ .. 500 mJ**	**3 µJ .. 600 mJ**	**12 µJ .. 2 J**	**18 µJ .. 2 J**
Max. repetition rate with display*	**200 Hz**	**300 Hz**	**70 Hz**	**200 Hz**
Max. average power	3 W	3 W	5 W	5 W
Max. average power density	0.5 W/cm²			
Detection threshold	2 µJ	3 µJ	12 µJ	15 µJ
Accuracy	±3 %			
Connector	BNC, E-connector with EEPROM			
Dimensions (Ø x Length)	46 mm x 21 mm		68 mm x 24 mm	

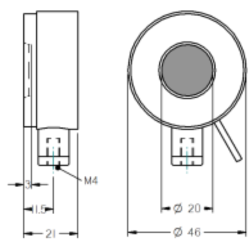
* PEM710, Pyrobox

Pyroelectric Energy Detectors
PEM K

Main applications for this detector are pulse lasers with high power density (Excimer-, CO_2-TEA-, Nd-YAG-Laser). With this device we offer a sensor that can be used in a wide range of applications due to a high damage threshold, a short time constant, relatively high sensitivity and large aperture.
In opposite to other coatings these coating is very resistant. So it is possible to clean the surface with most solvents or disinfectants. This fact and the high damage threshold for Excimer lasers make these types ideal for medical applications.



PEM 45 K



PEM 20 K

permissible power- and energy densities at selected wavelengths:

	Peak power density	Energy density
Excimer, 308 nm, t = 20 ns	50 MW /cm²	1 J/cm²
Nd:YAG, THG, 355 nm, t = 7 ns	65 MW /cm²	450 mJ/cm²
Nd:YAG, SHG, 532 nm, t = 8 ns	70 MW /cm²	560 mJ/cm²
Nd:YAG, 1064 nm, t = 8 ns	120 MW /cm²	970 mJ/cm²
CO_2-TEA, 10,6 µm, t = 0,5 µs	10 MW /cm²	5 J/cm²

Optional diffusors

In combination with the optional diffusors from page 11 it is possible to allow a 4 to 5 times higher energy density. The wavelength depending absorption is stored in the EEPROM too and will be corrected automatically by PEM710 and Pyrobox. Threads for additional optics or fibre adaptors are integrated.

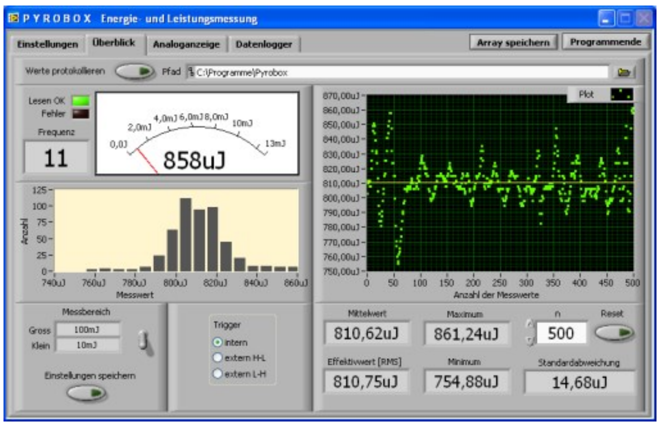
	PEM 45 K	PEM 20 K
Diameter of active area	45 mm	20 mm
Sensitivity / Scope	1.5 .. 3.5 V/J at 1 MOhm	10 .. 15 V/J at 1 MOhm
Max. repetition rate / Scope	30 Hz at 1 MOhm	
Working range with display*	**50 µJ .. 3 J**	**20 µJ .. 2 J**
Max. repetition rate with display*	**40 Hz**	**80 Hz**
Max. average power	5 W	3 W
Max. average power density	1 W/cm²	
Detection threshold	50 µJ	20 µJ
Accuracy	±3 %	
Connector	BNC, E-connector with EEPROM	
Dimensions (Ø x Length)	68 mm x 24 mm	46 mm x 21 mm

* PEM710, Pyrobox

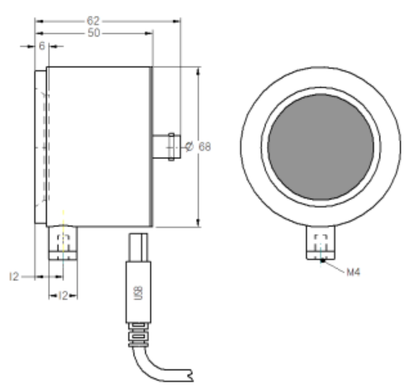
Pyroelectric Energy Detectors
PEM USB

This pyroelectric detectors PEM45KUSB respectively PEM45USB are a combination of a robust pyroelectric sensor with a read out electronic with USB-port. It can be connected to an oscilloscope using the BNC-connector or to a PC using the USB port. In USB mode the BNC connector is an external trigger input.

The output signal is transferred to a connected PC via USB. The device is powered from an USB-port. A user friendly software to display the measured values is available.



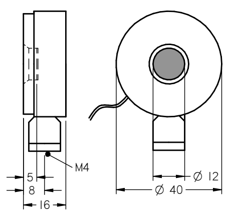
A comfortable user interface allows a comfortable operation with a lot of display and analysis possibilities. For initial operation no driver installation is necessary. For own applications a DLL and a LabView library is available.



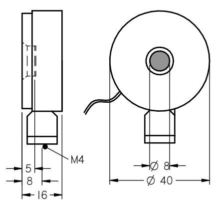
	PEM 45 USB	PEM 45 K USB
active diameter	45 mm	45 mm
sensitivity with oscilloscope	8 .. 15 V/J	1,5 .. 3,5 V/J
working range with USB	100µJ – 200 mJ	1 mJ – 1 J
repetition rate	30 Hz	
max. average power	5 W	
max. energy density	80 mJ/cm²	1 J/cm²
max. pulse density	8 MW/cm²	120 MW/cm²
accuracy	±3 %	
connector	BNC, USB	
dimension	diameter 68 mm, length 53 mm	

Pyroelectric Energy Detectors
PEM HiRep

These sensors have a thin metallic (MC) or black absorption (BC) layer leading to a faster heat transfer to the sensor element. Repetition rates up to more than 5000 pps. are possible. The spectral behaviour of the MC types is flat in the VIS and NIR but for longer wavelengths the absorption properties have to be taken into account. The absorption of the BC type detectors is very flat from UV up to IR. Main application is the use at one wavelength. The metallic coating of the two MC types is more stable in the ultraviolet region than the organic black coating.



PEM 12 HiRep BC
PEM 12 HiRep MC

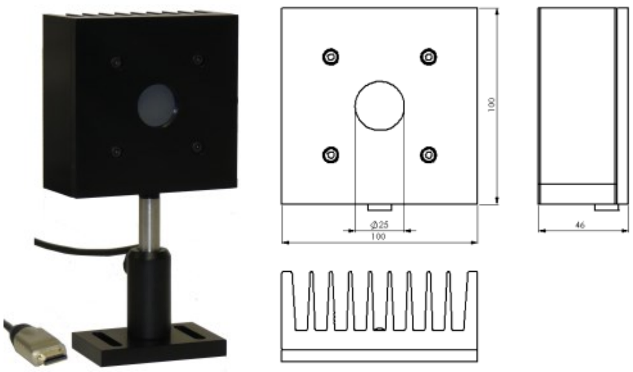


PEM 8 HiRep BC
PEM 8 HiRep MC

	PEM 8 HiRep BC	PEM 12 HiRep BC	PEM 8HiRep MC	PEM 12 HiRep MC
Diameter of active area	8 mm	12 mm	8 mm	12 mm
Sensitivity / Scope	10 .. 20 V/J	10..20 V/J	30 .. 50 V/J	30..50 V/J
max. repetition rates / Scope	1.5 kHz		5 kHz	
working range / Scope	50 µJ - 5 mJ		20 µJ - 5 mJ	
Working range with display*	**10 µJ - 2 mJ**	**10 µJ - 5 mJ**	**2 µJ - 2 mJ**	**2 µJ - 5 mJ**
Max. repetition rate with display*	**1.5 kHz**	**1.5 kHz**	**5 kHz**	**5 kHz**
max. energy density (10 ns pulse)	80 mJ/cm²		100 mJ/cm²	
max. peak power density	8 MW/cm²		10 MW/cm²	
max. average power	1 W	2 W	1 W	2 W
Wavelength	190 nm .. 25 µm		190 nm .. 2.5 µm	
accuracy	±3%			
dimension (diameter x length)	40 mm x 16 mm			

* PEM710, Pyrobox

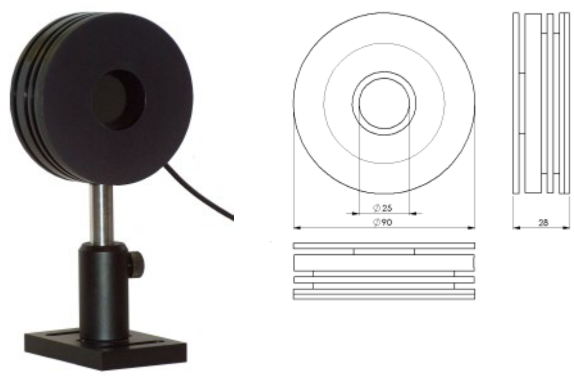
Thermopile Power Detectors
LP / BB Series



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

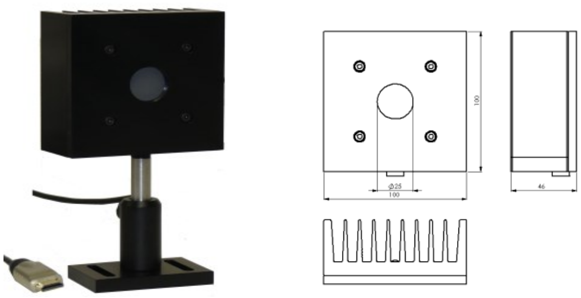


BB25 S

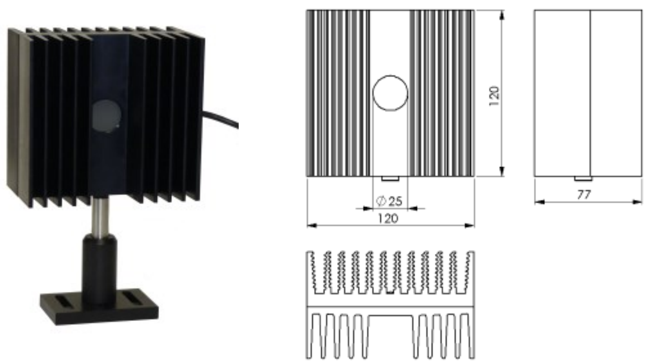
	LP10	BB10	BB25	BB25S
Active diameter	10 mm		25 mm	
Max. power	3 W		20 W	5 W
Min power	50 µW	100 µW	1 mW	
Response time	< 2 seconds (with display)			
max. power density	20 W/cm²			
Max. energy density	150 mJ/cm² (at 10 ns) | 500 mJ/cm² (at 10 µs)			
Sensitivity	≈400 mV/W		≈100 mV/W	
Linearity	±1%			
Calibration 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

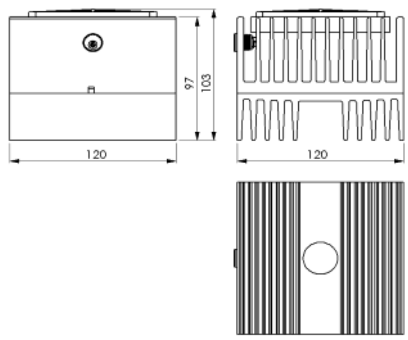
The measuring heads from **Series HP** are provided with a inorganic absorbing layer which allows high energy and power densities also in a UV wavelength range.



HP25/30



HP25/50



HP25/150

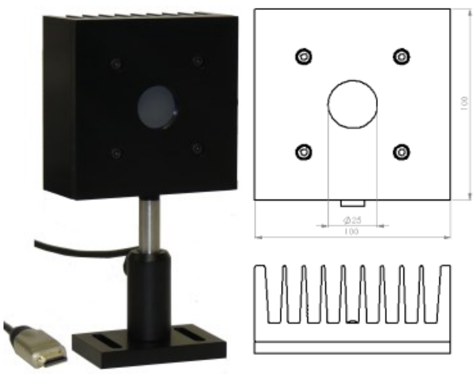
	HP 25/30	HP 25/50	HP 25/150
Active diameter	25 mm		
Max. power	30 W 50 W for 2 minutes	50 W 75 W for 2 minutes	150 W 200 W for 2 minutes
Min power	10 mW		100 mW
Response time	< 2 seconds (with display)		
Max. power density	10 kW/cm²		
Max. energy density	300 mJ/cm² (at 10 ns) | 1,2 J/cm² (at 10 µs)		
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

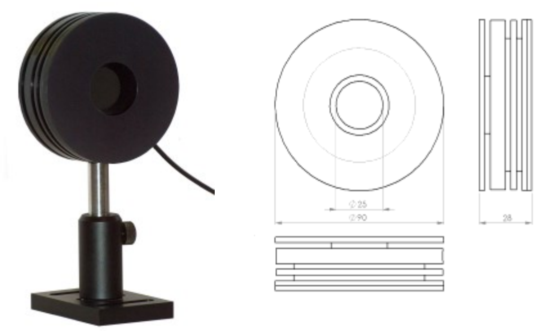
Main applications for this detector are pulse lasers with high power density (Excimer-, CO_2-,TEA-, Nd-YAG-Laser). With this device we offer a sensor that serves in a wide range of applications due to a high damage threshold, a short time constant, relatively high sensitivity and high aperture. The head **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, τ = 20 ns	50 MW /cm²	1 J/cm²
Nd:YAG, THG, 355 nm, τ = 7 ns	65 MW /cm²	450 mJ/cm²
Nd:YAG, SHG, 532 nm, τ = 8 ns	70 MW /cm²	560 mJ/cm²
Nd:YAG, 1064 nm, τ = 8 ns	120 MW /cm²	970 mJ/cm²
CO_2-TEA, 10,6 µm, τ = 0,5 µs	10 MW /cm²	5 J/cm²



CP25



CP25 S

	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/cm²	
Max. energy density	1 J/cm² (at 10 ns) | 5J/cm² (at 10 µs)	
sensitivity	≈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]	100 x 100 x 46	Ø 90, L: 28

THz-Detectors

Basics

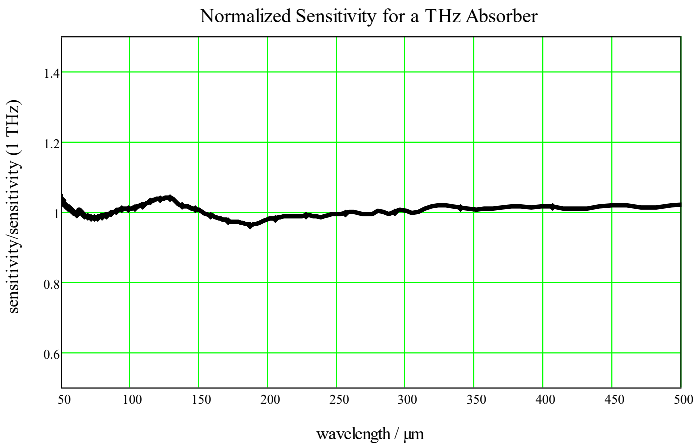
These types of pyroelectric detectors are optimized for application in THz region. The detectors are small, have a large active area and a short response time.

The basic principle of pyroelectric detection is that the radiation pulse coming from a pulsed laser or a chopped cw-laser is absorbed in an absorber sheet. From there the heat energy is transferred to the pyroelectric sensor material by heat conduction. For all types of THz detectors a broadband metallic absorber is used. For realizing broadband absorption a partial absorption of nearly 50 % is realized, whereas 25% are reflected and the 25% transmitted radiation is absorbed in a dump. A temperature change of the sensor material leads to a generation of a free charge at two opposite surfaces of the sensor.

There are two possibilities to detect this signal:

- Using a **voltage detection** with a high load resistor for energy measurement
- Using a **current detection** with transimpedance amplifier for power measurement

Absorption



The figure to shows the sensitivity of the pyroelectric detectors normalized with the sensitivity at 1 THz. Between 200 and 500 µm the sensitivity changes within 2 %. Additional measurements and comparisons at wavelengths up to the cm-range are done with same excellent absorption behaviour.

Calibration

All detectors are calibrated from PTB Berlin, the national institute of standards in Germany, at a wavelength of 2.4 THz in combination with a preamplifier. Other conditions on request.

The calibration of the detector is done without any window. Under these conditions any movement of air must be avoided. We deliver the detector with a protection cap having a THz transparent insert. This cap can be used for avoiding any type of disturbance from moving air or fans.

THz - Detector as Joulemeters

For many application the pyroelectric sensors can be used directly in combination with an oscilloscope (R_i= 1 MΩ) or the voltage preamplifier VPA (see page 20). For these conditions the parameters (min. detectable energy and the max. rep. rate) are limited. In combination with a preamplifier these parameters can be extended. Some typical parameters for detectors without preamplifier are summarized in the following list:

In dependence on sensor diameter and rep.- rate sensitivities up to 10^6 V/J can be realized. Max. rep. rates as high as 1000 pps and min. detectable energies in the order of 50 nJ are possible. Please ask for more information.

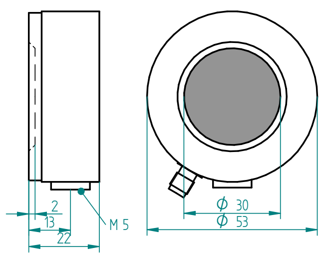
	Sensitivity /V/J	Min. detect. energy /µJ	Max. rep. rate
THz 10	>500	0.5	30
THz 20	>200	1	25
THz 30	>20	2	20

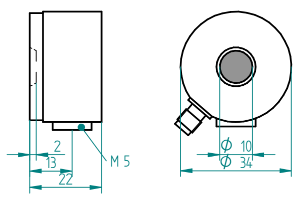
THz - Detector as Powermeters

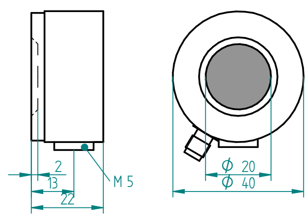
This is the typical application. The THz detection system consists of a detector and a current preamplifier CPA (see page 20). It is optimized for application in connection with cw- lasers and a chopper.

The response of a pyroelectric detector can be very fast, but for a reduction of noise the bandwidth of the preamplifier is limited. A further reduction of noise is possible by using detectors with smaller active area. The actual bandwidth depends on the frequency limit and is given in the preamplifier datasheet. Two possibilities for a Signal/Noise improvement for continuously repeated signals are often used:

-Averaging
-Lock in amplification.







	THz 10	THz 20	THz 30	THz 10 HS	THz 20 HS
Diam. of active area [mm]	10	20	30	10	20
thermal time constant [ms]	50	50	50	20	20
Max. power density [mW/cm²]	15	15	15	5	5
Typical current sensitivity [µA/W]	0.5 .. 0.6	0.5 .. 0.6	0.5 .. 0.6	1.5 .. 1.8	1.5 .. 1.8
Rise time * [µs]	100	700	2000		
Max. chopper rate* [Hz]	>500	200	80	1 kHz	500 Hz
Working range*	8µW .. 10mW	10µW .. 10mW	20µW .. 100mW	1µW .. 1mW	1µW .. 5mW

*Rise time, max. chopper rate and working range strongly depending on the bandwidth of the amplifier. For typical applications. As lower the bandwidth, as lower the noise and lowest measurable power, but maximum chopper frequency sinks. Amplifiers for high rep. rate or low power application are available on request.

Examples for detection limits for preamplifier CPA with different bandwidths

Detector	Preamplifier f_{lfl} =17 Hz	Preamplifier f_{lfl} =70 Hz	Preamplifier f_{lfl} =200 Hz	Preamplifier f_{lfl} =4 kHz
THz 10	8 µW	20 µW	25 µW	100 µW
THz 20	10 µW	25 µW	35 µW	130 µW
THz 30	20 µW	35 µW	140 µW	180 µW

Current Preamplifiers CPA

The current preamplifier is necessary to realize a power measurement of the incoming radiation. The amplifier consists of an IC as transimpedance amplifier at the input side and two further voltage amplifier stages. There are some additional components for a noise reduction and offset regulation. In praxis the maximum amplification is limited by the cut off-frequency. Highest amplification can only be realized for small frequency intervals. For THz detectors in combination with a chopper often the upper frequency is limited to values less than 50 Hz. For such amplifiers conversion factors between 10^{7} V/W and 10^{10} V/W can be realized.

The sensitivity of the combination detector and preamplifier is determined by multiplication of the current sensitivity of the detector and the amplification of the current amplifier (e.g. detector 10^{-6} A/W and CPA 10^{9} V/A leads to a total sensitivity : 10^{-6}A/W*10^{9} V/A=1000 V/W). The amplification can be set by a switch.

Specifications:	
Connectors:	BNC
Amplification:	10^{7}, 10^{8}, 10^{9}, 10^{10} V/A
Bandwidth:	50 Hz - 250 Hz, switchable
Power supply:	5 V, Micro-USB

The amplification can be set by a 4-step switch: e.g. 10^{7}... 10^{10} V/A ; the bandwidth is fixed* to e.g. 50Hz or 250 Hz. The detection limit depends on the amplification, the bandwidth and detector diameter.

Amplification and bandwidth can be adapt on your requests.

Voltage Preamplifiers VPA

For many application the pyroelectric sensors can be used directly in combination with an oscilloscope (Ri= 1 MΩ). For these conditions the parameters (min. detectable energy and the max. rep. rate) are limited. In combination with a preamplifier these parameters can be extended. In combination with a preamplifier sensitivities up to 10^{6} V/J can be reached and the minimum detectable energy is in the order of 50 nJ.

Due to the modular assembly the whole dynamic range will be greatly increased. Additionally, losses of sensitivity by using a smaller load resistor (to increase the possible repetition rate) can be compensated.

Also for the measurement of THz pulses with repetition rates below 1 kHz and short pulses below 100µs this detector is very useful.

Specifications:	
Connectors:	BNC
Amplification:	10, 100, 1000, 10000
Input Impedance:	1 MΩ
Power supply:	5 V, Micro-USB

Detector	Detection threshold
PEM 8	30 nJ
PEM 11	50 nJ
PEM 21	100 nJ
PEM 34	200 nJ

Optical Chopper

This chopper is needful to modulate continuous radiation to measure the power in combination with a pyroelectric detector and especially for THz detectors. We use a microprocessor controlled PID controller to offer an easy handling and stable frequency. The frequency can set with a keypad. To repeat measurements at different chopper rates is very easy. Additionally it is possible to control and read out the frequency via USB port.

In standard configuration replaceable chopper discs have a diameter of 100mm. For alternatively operation, for instance in combination with a Lock In amplifier a sync out signal is generated.
One chopper disc with two slots, the most useful for our THz detectors, is included.

Chopper disc	No. of slots	Chopper frequency
CD100-2	2	5 - 120 Hz
CD100-5	5	12 - 300 Hz
CD100-10	10	25 - 600 Hz
CD100-20	20	50 - 1200 Hz

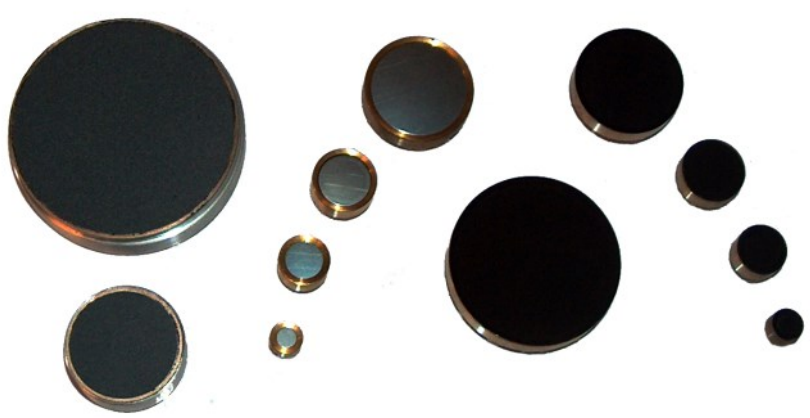
Parameters	
Diameter of chopping discs	100 mm
Frequency drift and jitter	< 1%
Sync Out compatibility	TTL/CMOS
Supply	85 VAC - 240 VAC; 50 - 60 Hz

OEM PES

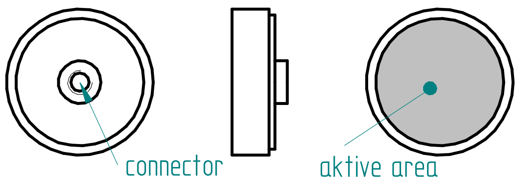
The main application for this type of sensor is energy monitoring of high repetition rate lasers. The co-axially built sensors have a high sensitivity and can be applied in a wide spectral range. Because of the very low noise design and high sensitivity it is possible to monitor low energies, for instance behind beam splitters or semi-transparent mirrors.
Detector diameters between 4 mm and 45 mm are available. The maximum repetition rate depends on the sensor diameter and the load resistor; values up to 3000 pps. are possible. For these sensors 3 absorber coatings are available:

- organic black, flat spectral behaviour
- Metallic coating for high repetition rates
- Ceramic coating for highest peak powers

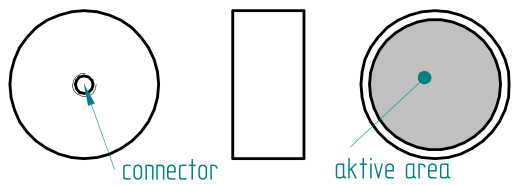
The sensors can easily be combined with own electronics. Additionally we offer our OEM-Pyrobox with RS232 or USB-output.



	PES	PES HR	PES K
Max. energy density:	150 mJ/cm²	100 mJ/cm²	up to 1 J/cm²
Max. power density:	150 mW/cm²	150 mW/cm²	500 mW/cm²
Max. peak power density: (10 ns—pulse)	8 MW/cm²	8 MW/cm²	70 MW/cm²
Temperature range:	0 .. 40°C	0 .. 40°C	0 .. 70°C
Spectral range	190 nm .. 25 µm		
Max. pulse duration	2 ms		
Accuracy	±3%		

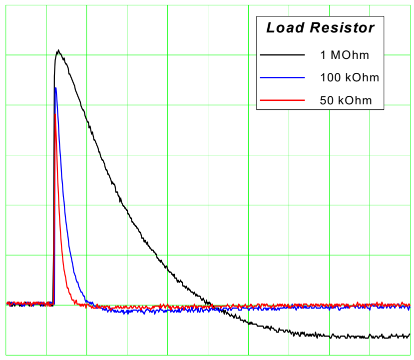


Type PES and PES HR

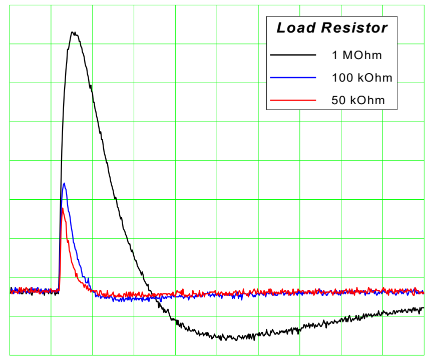


Type PES K and HP

	Aperture	Sensitivity	Rep Rate	Dimension (Dia x length Connector)
PES 4	4 mm	500..1000 V/J at 1 MΩ 130..250 V/J at 100 kΩ	80 Hz at 1 MΩ 120 Hz at 100 kΩ	7 x 9,5 mm² M 3
PES 8	8 mm	200..500 V/J at 1 MΩ 50..200 V/J at 100 kΩ	40 Hz at 1 MΩ 100 Hz at 100 kΩ	11 x 9,5 mm² M 3
PES 11	11 mm	100..400 V/J at 1 MΩ 50..150 V/J at 100 kΩ	40 Hz at 1 MΩ 80 Hz at 100 kΩ	14 x 9,5 mm² M 3
PES 21	21 mm	50..150 V/J at 1 MΩ 30..80 V/J at 100 kΩ	25 Hz at 1 MΩ 50 Hz at 100 kΩ	24 x 9,5 mm² M 4
PES 34	34 mm	40.. 70 V/J at 1 MΩ 10..40 V/J at 100 kΩ	25 Hz at 1 MΩ 80 Hz at 100 kΩ	37 x 10 mm² M 4
PES 20 HP	20 mm	30.. 50 V/J at 1 MΩ 8..20 V/J at 100 kΩ	50 Hz at 1 MΩ 150 Hz at 100 kΩ	25 x 12 mm² M 3
PES 45 HP	45 mm	8.. 15 V/J at 1 MΩ 4..8 V/J at 100 kΩ	25 Hz at 1 MΩ 100 Hz at 100 kΩ	50 x 13 mm² M 4
HR 4	4 mm	1000..1500 V/J at 1 MΩ 900..1200 V/J at 100 kΩ 900..1100 V/J at 50 kΩ	250 Hz at 1 MΩ 2,5 kHz at 100 kΩ 3,3 kHz at 50 kΩ	7 x 9,5 mm² M 3
HR 8	8 mm	700..900 V/J at 1 MΩ 400..500 V/J at 100 kΩ 300..400 V/J at 50 kΩ	150 Hz at 1 MΩ 2 kHz at 100 kΩ 2,5 kHz at 50 kΩ	11 x 9,5 mm² M 3
HR 11	11 mm	400..600 V/J at 1 MΩ 400..500 V/J at 100 kΩ 300..400 V/J at 50 kΩ	250 Hz at 1 MΩ 1,5 kHz at 100 kΩ 2 kHz at 50 kΩ	14 x 9,5 mm² M 3
HR 21	21 mm	150..250 V/J at 1 MΩ 100..250 V/J at 100 kΩ 100..200 V/J at 50 kΩ	50 Hz at 1 MΩ 200 Hz at 100 kΩ 1,4 kHz at 50 kΩ	24 x 9,5 mm² M 4
PES 20 k	20 mm	7..15 V/J at 1 MΩ 1..8 V/J at 100 kΩ	50 Hz at 1 MΩ 50 Hz at 100 kΩ	25 x 12 mm² M 3
PES 45K	45 mm	1.5..4.5 V/J at 1 MΩ 0.4..1.5 V/J at 100 kΩ	20 Hz at 1 MΩ 50 Hz at 100 kΩ	50 x 13 mm² M 4



HR 11, 500 µs/div; 5 mV/div; 100 µJ



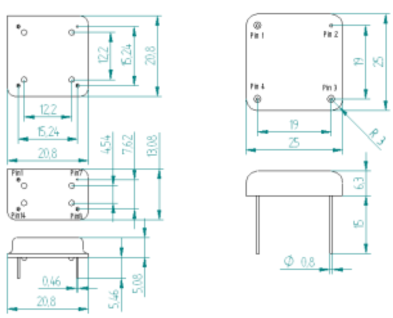
PEM 11, 1 ms/div; 5 mV/div; 100 µJ

Samples of the output signal of different sensors

Pyroelectric OEM detectors series PEO

These sensors are characterised by a high sensitivity and a high repetition rate. Cause of the windowless design and the used metallic absorption coating an usage in the UV-range is also possible. If needed, for example when using the sensor at different wavelengths, we will also supply these sensors with our reliable, broadband black coating. The modular construction set EMK100 can be combined with PEO sensors.
In combination with good adapted amplifiers repetition rates of 30kHz are possible.

max. energy density	50 mJ/cm²
max. average power	1 W
Calibration uncertainly	±3 %
Temperature environment	10°C .. 50°C
Temperature coefficient	+0,1%/K



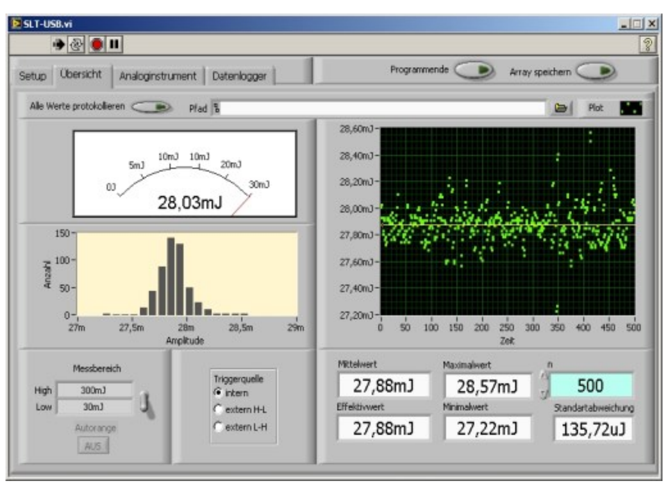
	Aperture	Sensitivity [V/J]	Rep Rate [Hz]
PEO 8	Ø 8 mm	400..500 V/J at 1 MOhm 200..300 V/J at 100 kOhm	1 kHz at 1 MOhm 10 kHz at 100 kOhm
PEO 8 B	Ø 8 mm	300..400 V/J at 1 MOhm 200..300 V/J at 100 kOhm	750 Hz at 1 MOhm 1 kHz at 100 kOhm
PEO 12	Ø 12 mm	300..400 V/J at 1 MOhm 200..300 V/J at 100 kOhm	700 Hz at 1 MOhm 6 kHz at 100 kOhm
PEO 12 B	Ø 12 mm	20..40 V/J at 1 MOhm 10..20 V/J at 100 kOhm	500 Hz at 1 MOhm 750 Hz at 100 kOhm
PEO 20	Ø 20 mm	100..160 V/J at 1 MOhm 70..120 V/J at 100 kOhm	250 Hz at 1 MOhm 2 kHz at 100 kOhm

Pyrobox OEM

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

- For all PEM detectors
- Two different sensitivities
- USB 2.0 connection or RS232
- Power supply from USB
- Max. rep. rate 100 pps
- Additional external trigger input
- Software for different applications available (Analogue and digital display, data logger, statistics,...)
- Data transfer as ASCII code
- Dimensions 90 mm x 62 mm x 30 mm

In addition, we offer the Pyrobox with an integrated sensor. The sensor PES20 or PES20K is used as standard. If necessary, other sensors of the PES series are also possible with adjustments. The compact design and the lack of cables between the sensor and electronics reduce noise and improve accuracy.



Basics
Calibration
Displays
Energy Detectors
Power Detectors
THZ Detectors
OEM

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.

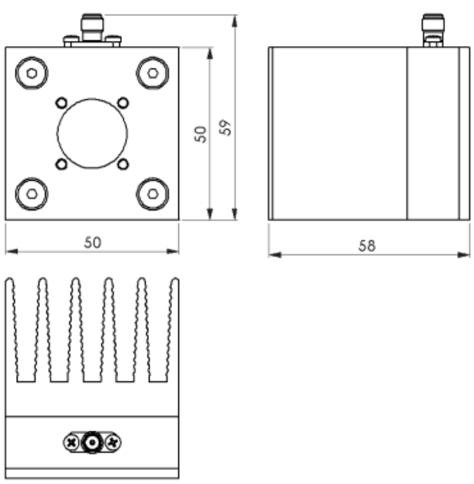
The sensor elements are available in different sizes for different power ranges. The housings have a lot of holes for mounting the detector and for combination with additional optical components like beam splitters, diffuser discs or optical fibre adaptors. Please ask for a solution.

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.

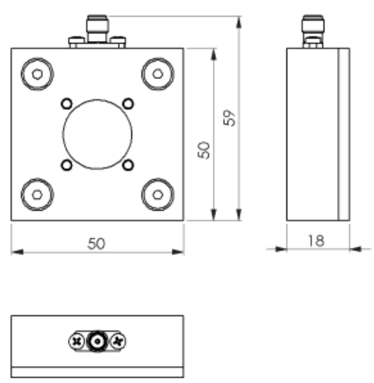
PM505020

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/cm²	
Max. energy density	300 mJ/cm² (at 10 ns) | 1,2 J/cm² (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

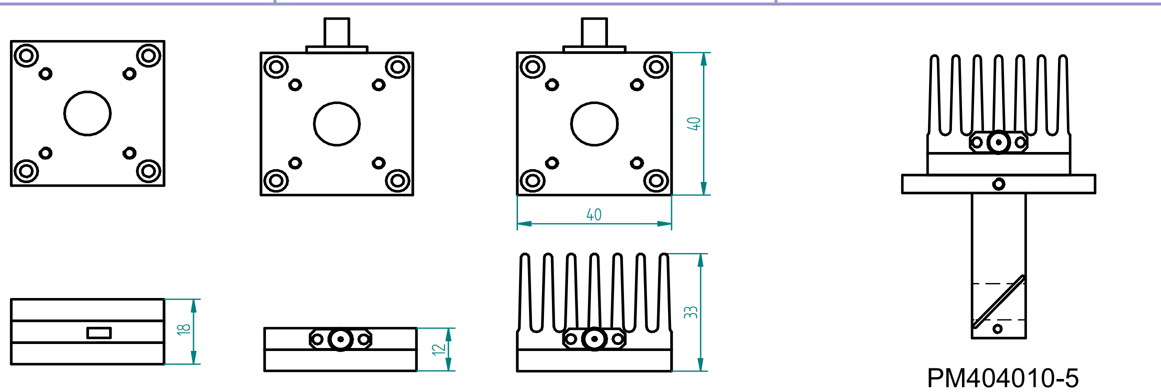


PM505020-5

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.

	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/cm²			
Sensitivity	250 mV/W .. 450 mV/W		1 V/W	
linearity	±1%			
Spectral range	190 nm - 25 µm			
Cooling	Convection or additional heatsink			
Connector	SMA		Molex Microblade	



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

OEM-Module EMK

The OEM modules of the EMK series offer laser manufacturers a simple and inexpensive integration of the PEO series sensors into their own laser systems without a great deal of development effort.

The basic model EMK100 delivers a corresponding analog voltage for each laser pulse, which can be easily read in via the laser control unit. Additional header contacts for power supply, measurement and trigger signals offer the option of plugging the circuit board onto your own circuit board and thus reducing the amount of cabling.

Significantly higher repetition rates are possible with the EMK200. The power supply has also been simplified and the output signal has been made available at an SMA socket to reduce interference. Power and trigger signals can be contacted either via a 9-pin D-Sub connection or a simple wire-to-board connector. The trigger signals are decoupled via optocouplers.

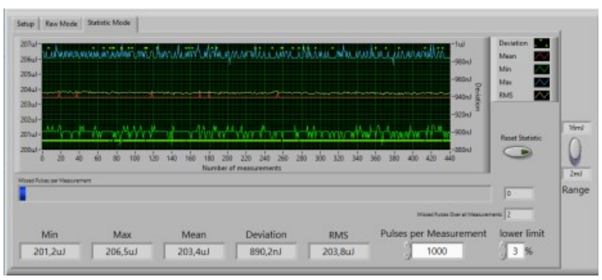
With the EMK200, the measured values reach the laser control via USB without having to take a detour via an analogue signal. Power is also supplied via USB. The communication protocol is kept very simple to facilitate integration into your own software. Labview examples can be supplied. The firmware supports two modes. In "Stream" mode, each recorded energy value is transmitted via the interface. In "Statistics" mode, all relevant statistical values are recorded via an adjustable number of pulses and only these are sent.

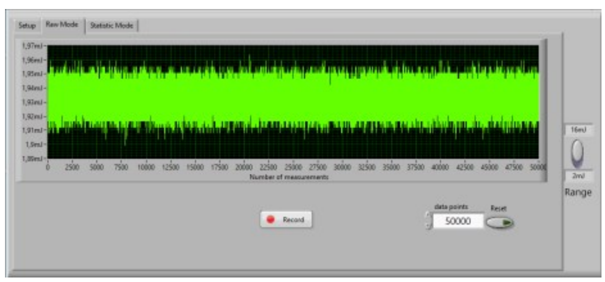
All variants have 2 measuring ranges. With the analogue versions, the switching is done via a 5V signal, with the USB version via software.

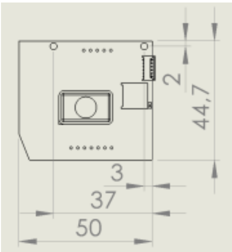
Optional housings are available for all variants. Required mounting holes can be discussed.

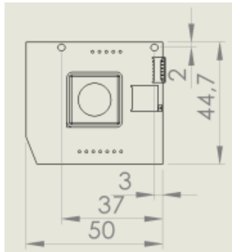
	EMK100	EMK200	EMK200 USB
Dimension PCB	45 mm x 50 mm	44 mm x 77 mm	44 mm x 100 mm
Dimension housing	55 mm x 52 mm x 16 mm	55 mm x 100 mm x 16 mm	50 mm x 100 mm x 16 mm
Ranges *	15µJ - 1mJ 150µJ - 5mJ	5µJ - 100µJ 50µJ - 1mJ	5µJ - 100µJ 50µJ - 1mJ
Rep. rate	up to 5kHz	up to 25kHz	up to 25kHz
Trigger	Internal	External/Internal Selectable by jumper	External/Internal Selectable by jumper
Power supply	±12V .. ±15V	+5V	from USB
In- Output	6-pol. Molex, pitch 1.27	SMA coaxial connector for analog output 6-pol. Molex, pitch 2.54mm or alternatively DSUB for trigger and supply	SMA coaxial connector for trigger input

* Adjustable, alsa depends on the sensor

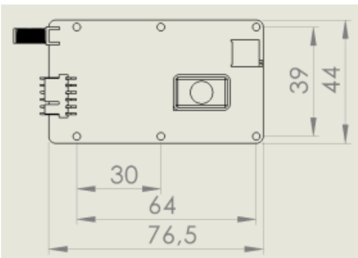


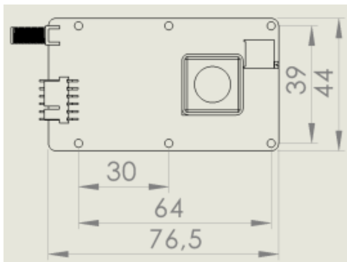




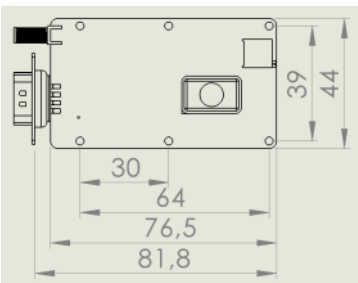


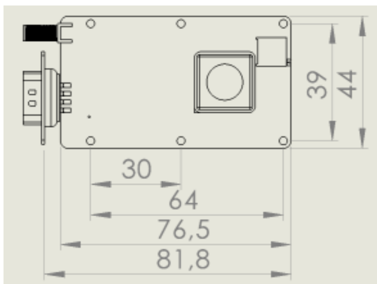
EMK100 with PEO8 sensor

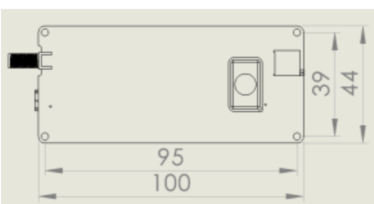


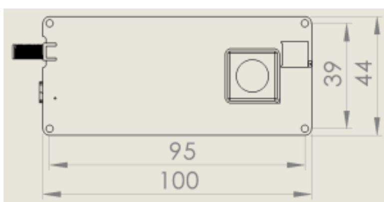


EMK200 with PEO12 sensor,
DSUB9 connector









EMK200USB with PEO12 sensor

EMK100 with PEO12 sensor

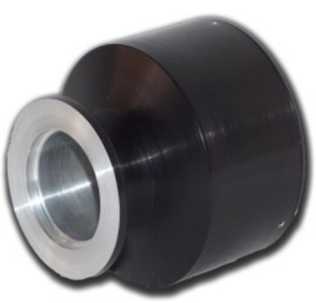
EMK200USB with PEO12 sensor

Power and Energy Detectors for VUV

Special design with vacuum flange for 157nm and all other wavelengths where stirring gas or encapsulated beam guiding are used. The detectors are leak tested.

Unfortunately up to now no calibration standard is available for 157nm. The difference in absorption between these wavelengths should be not very high.

	Energy Detector PEM 24 VUV	Energy Detector PEM 30 K VUV	Power Detector HP 30 VUV
Aperture	24 mm	30 mm	30 mm
Sensitivity	200 V/J at 1 MΩ	1.5 .. 2.5V/J at 1 MΩ	80 .. 120 mV/W
Repetition Rate	300 Hz at 1 MΩ	50 Hz at 1 MΩ	
Max. average power	5 W	30 W	30 W
Accuracy	±5 %	±5 %	±5 %
Max. energy density (t=10ns)	100 mJ/cm²	300 mJ/cm²	300 mJ/cm²
Max. peak power density	5 MW/cm²	30 MW/cm²	30 MW/cm²
Max. average power density	1 W/cm²	1 W/cm²	20 W/cm²
Detection threshold		5 µJ	
Connector		BNC	
Vacuum connector	KF 25 ND	KF 40 ND	KF 40 ND
Dimension (incl. connectors)	Ø55 mm, length 65 mm	Ø100 mm, length 96 mm	Ø100 mm, length 108 mm
Read out unit		PEM 710 or Scope	



permissible pulse power- and energy densities for PEM30 K VUV and HP 30 VUV:

laser	power density	energy density
Excimer, 157 nm, τ = 10 ns	30 MW /cm²	300 mJ/cm²
Excimer, 157 nm, τ = 20 ns	22 MW /cm²	440 mJ/cm²

Notes

Customer Solutions

Several decades of experience in development and fabrication of pyroelectrical energy measuring heads und thermal power measuing heads make it easy for us to solve your problems fast and reliable, no matter if you only need our available products adapted to your wishes or you want something very special.

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