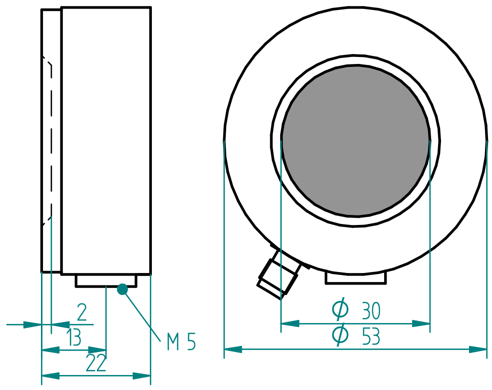
Sensor- und Lasertechnik

Power and Energy Measurement for Lasers

THz-Detectors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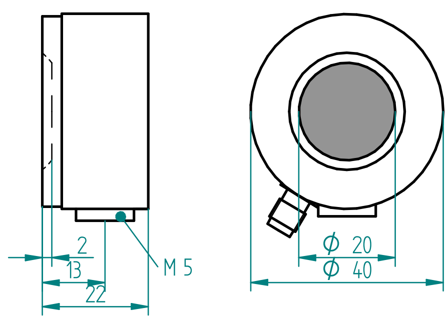
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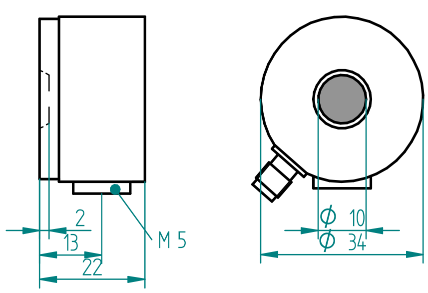
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THz-Detectors

Basics

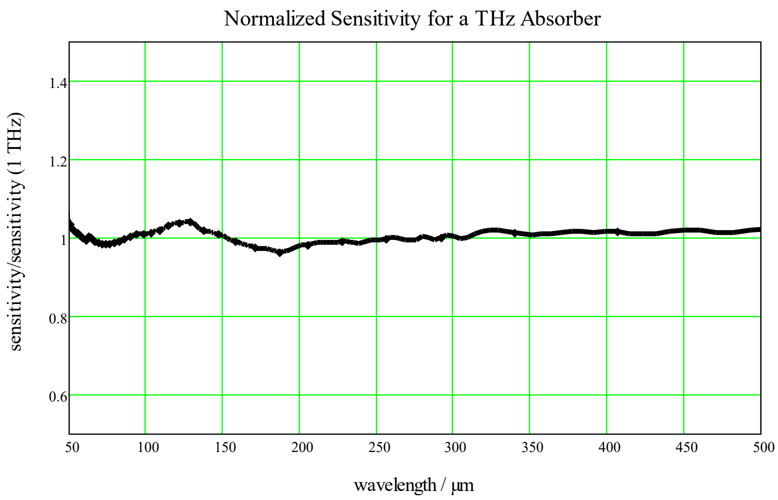
These types of pyroelectric detectors are optimized for application in THz region. The detectors are small, have a large active area and a short response time.

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 will be calibrated at 1.4 THz in combination with a current preamplifier (calibrated in V/W) at the PTB Berlin. According to the physics of absorption the sensitivity should be valid also for longer wavelengths. A nearly wavelength independent absorption behaviour up to 600 µm is confirmed by the PTB. An experimental confirmation for longer wavelengths (up to 3 mm) is available now.

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 Powermeter

This is the typical application for this kind of detectors. 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.

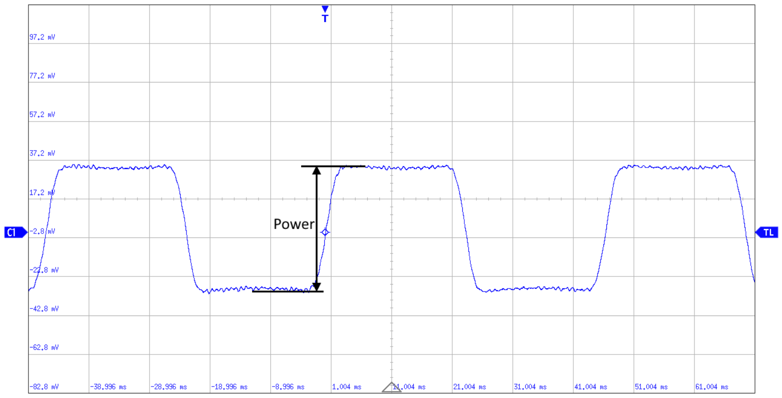
	THz 10	THz 20	THz 30	THz 10 HS	THz 20 HS
Diam. of active area [mm]	10	20	30	10	20
Thermal time constant [ms]	50	50	50	20	20
Max. power density [mW/cm²]	15	15	15	5	5
Typical current sensitivity [µA/W]	0.5 .. 0.6	0.5 .. 0.6	0.5 .. 0.6	1.5 .. 1.8	1.5 .. 1.8
Rise time * [µs]	100	700	2000	<100	350
Max. chopper 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 repetition rates 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

THz - Detectors



Typical oscillogram of a THz20 in combination with a current amplifier CPA and a chopper as a power meter

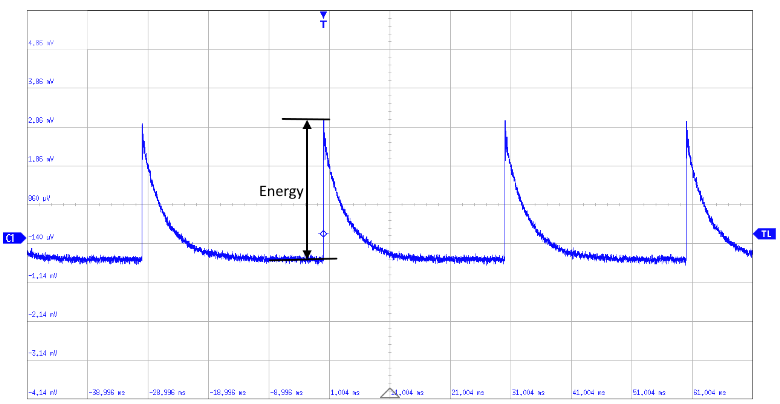
THz - Detector as Joulemeters

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.

The use of the HS types is not recommended for energy measurement, as the sensitivity is significantly reduced due to the significantly higher sensor capacity.

	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



Typical oscillogram of a THz20 in combination with a voltage amplifier VPA as an energy meter

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.

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.

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

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.

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

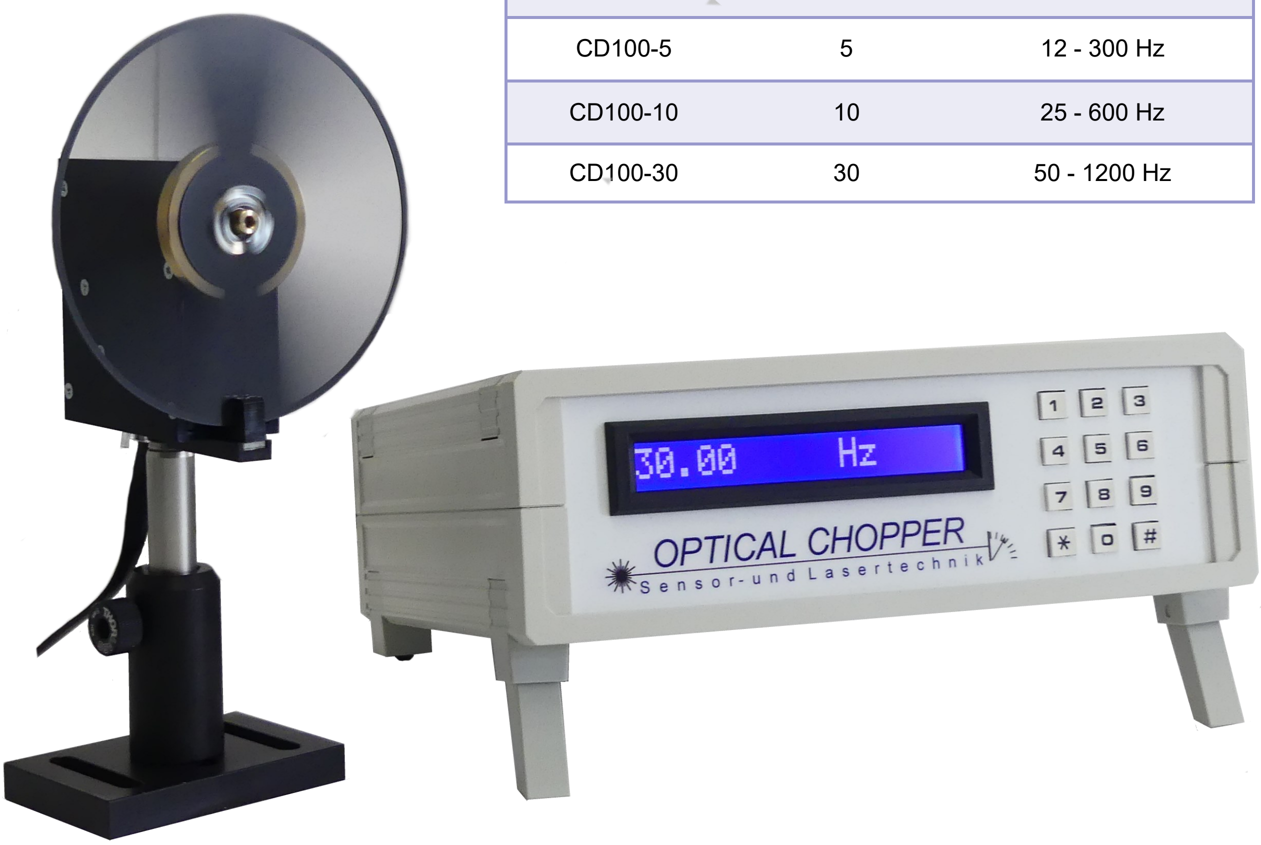
Optical Chopper

The 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
CD100-30	30	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

Digital LockIn Amplifier SLT-THz100

This DSP lock-in amplifier is optimized for evaluating signals from the THz10, THz20, and THz30 THz sensors and their high-sensitivity variants.

The amplifier input is a current amplifier designed for the large sensor capacitances of the THz sensors. However, it is also possible to evaluate other sensors, such as photodiodes. However, the maximum possible repetition rate is limited to the parameters of the THz sensors, and the potential of a much smaller and lower-noise photodiode cannot be fully exploited.

Operation is carried out exclusively via the PC software and the USB interface. Power is also supplied via USB. This device is a dual-phase lock-in amplifier and determines the output signal for two different phase shifts that differ by 90°. By Pythagorean addition of the two resulting output signals, the final measurement result becomes phase-independent, enabling both simpler and more precise measurements. Furthermore, complex phase measurements and phase shifts are no longer necessary to determine the result. It is also possible to display the first three harmonics and add individual components if necessary. The resultant of the fundamental frequency is always available at the BNC output.

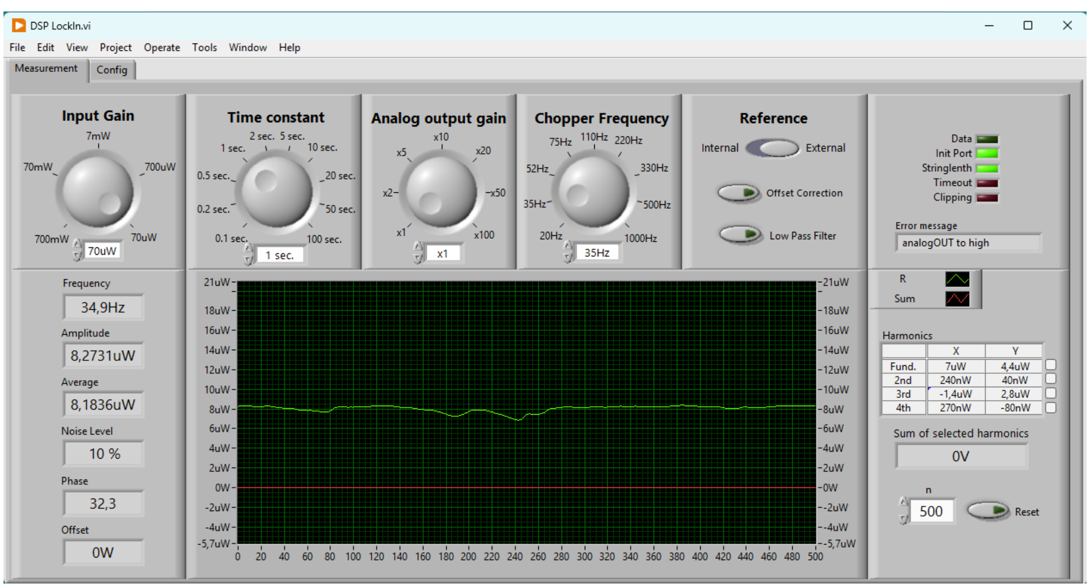
The reference inputs and outputs are TTL compatible and electrically isolated.

A monitor output is available for monitoring the sensor signal. The measurement result is displayed on the program interface and provided via an analog voltage. Both analog outputs are decoupled via isolation amplifiers to further prevent interference.

Readiness, selected reference source, and signal path overload are indicated via LEDs on the front panel.

Communication via the USB interface is fully documented and uses simple ASCII commands. This enables quick and easy integration into your own measurement systems or alternative operating systems. A LabVIEW-based user interface for Windows is included.

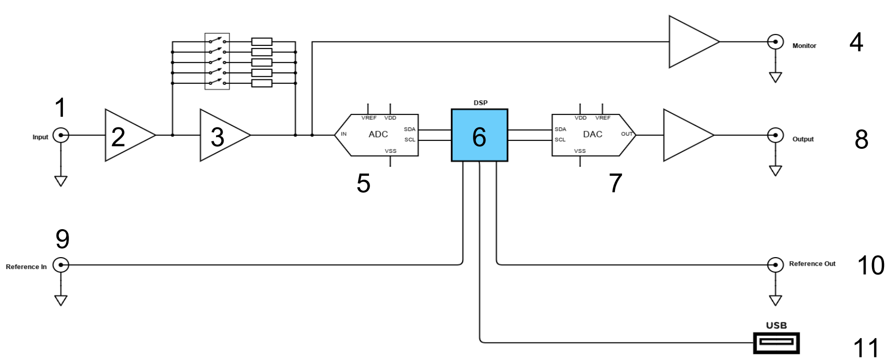
A special feature is the possibility to control the frequency of the reference source via the program interface, provided that it can be addressed via a serial interface.



SPECIFICATION SUMMARY

General	
Power Supply	+5V DC from USB
Mechanical	250mm x 240mm x 50mm (Connectors and feets Included)
Warranty	On year
Signal Channel	
Full Scale Sensitivity:	100 fA to 0.5 A
Max. Current:	10 mA damage threshold
Gain Accuracy:	1% (10 Hz to 200 Hz)
Gain Stability:	200 ppm/°C
Low pass filter:	100 Hz/3dB
Dynamic Reserve:	20 dB LOW (1 μV to 500 mV sensitivity)
	40 dB NORM (100 nV to 50 mV sensitivity)
	60 dB HIGH (100 nV to 5 mV sensitivity)
	Low pass filter adds 20 dB to dynamic reserve
Reference Channel	
Frequency	0.5 Hz to 1 kHz
Input Impedance	1.6kΩ, dc coupled. Galvanic isolated
Input current to drive optocoupler	>1mA at 5V
Trigger	minimum 1 Volt
Outputs & Interfaces	
Analog Output: Amplitude (R), ±5V	
Monitor Output:	PGA Output, galvanic isolated,
	not calibrated, ±10V full scale
Reference Output:	TTL compatble, 5V, 50% duty cycle
USB Interface	controls all functions,
	Baud rate 2M,
	supplies device

BLOCK DIAGRAM



1. Sensor Input
2. Current Amplifier
3. Programmable Gain Amplifier
4. Monitor output (Isolated)
5. HighRes ADC
6. Microcontroller
7. DAC for Analog Output
8. Analog Output (isolated)
9. Reference Input for external Reference Source
10. Referenc Output for Controlling THz Source or Chopper
11. USB-port for Control and Power Supply

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