PDA13L2
Pyroelectric Switchable Gain Detector

User Guide



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Chapter 1 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly in accordance with this user manual.



Caution
Caution is given when there is a possibility of damage to the product.



ESD Component Caution
The components inside this instrument are ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any electrical connections to the unit.



Caution: Explosive Environments
Do NOT operate this device in explosive environments.



Caution: Electromagnetic Interference
Mobile telephones, cellular phones, or other radio transmitters are not to be used within the range of 3 meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1. This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

Chapter 2 Description

The PDA13L2 is an amplified, switchable-gain, pyroelectric detector designed for detection of light signals ranging from 600 nm to 16 µm. An eight-position rotary switch allows the user to vary the gain in 5 dB steps from 0 dB to 35 dB gain. A buffered output drives 50 Ω load impedances up to 5 V. The PDA13L2 housing includes a removable SM1T1 internally threaded SM1 coupler and an SM1RR retaining ring which is compatible with any of Thorlabs' SM1 threaded accessories. This allows convenient mounting of external optics, light filters, apertures, as well as providing an easy mounting mechanism using Thorlabs' cage assembly accessories.



ESD Component Caution

The components inside this instrument are ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any electrical connections to the unit.

Chapter 3 Setup

3.1 Package Contents

- PDA13L2 Pyroelectric Detector
- LDS12B Power Supply
- SM1RR Retaining Ring
- SM1T1 Internally Threaded SM1 Coupler
- SM1EC2B Dust Cap
- Quick Reference Guide

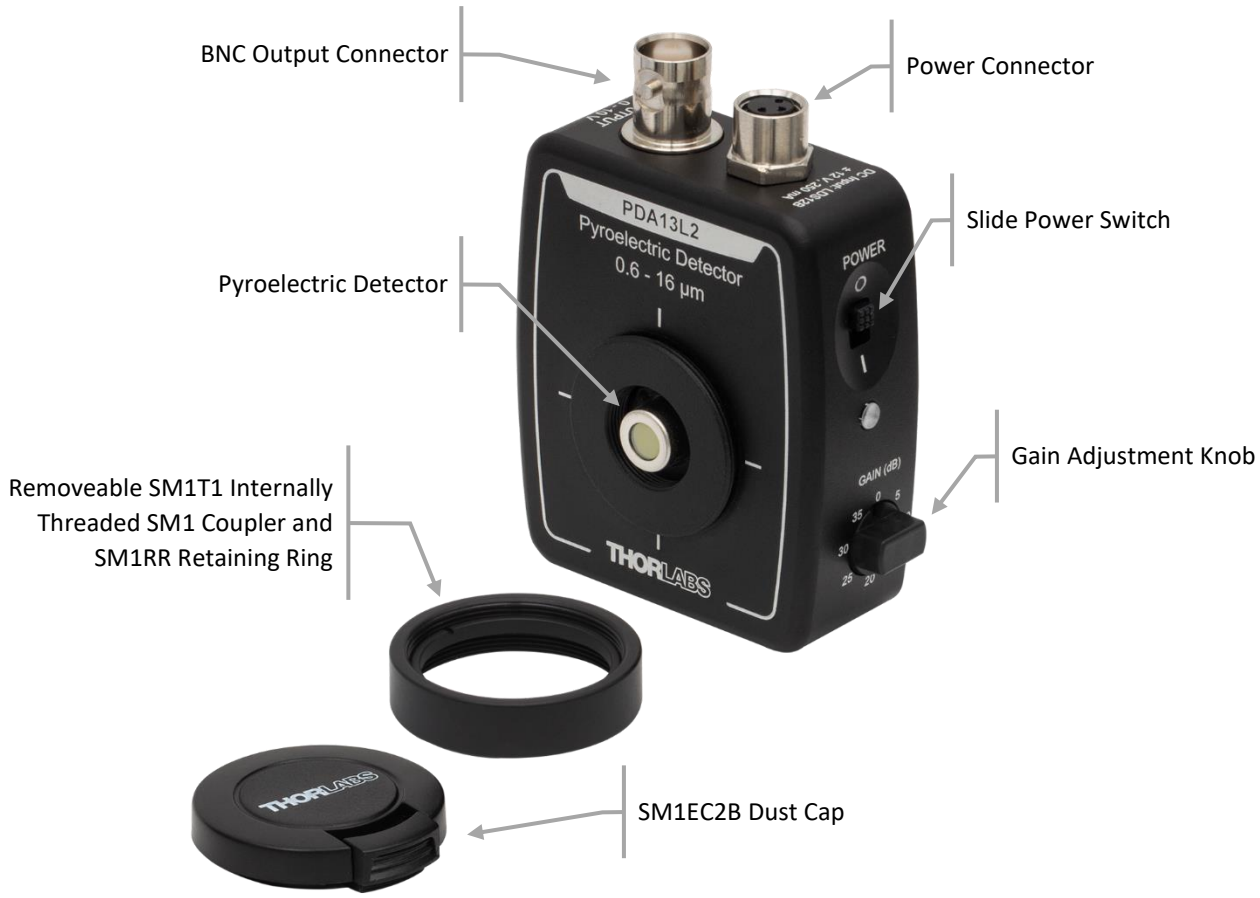


Figure 1 Location of Features

3.2 Device Setup

The PDA13L2 detector can be set up in many ways using our extensive line of adapters. However, the detector should always be mounted and secured for best operation, discussed below.

1. Unpack the optical head, install a Thorlabs TR-series Ø1/2" or Ø25 mm post into one of the mounting holes, located on the bottom and side of the sensor, and mount using a PH-series post holder. Note that these detectors feature tapped holes that accept both 8-32 and M4 x 0.7 threads, so using either imperial or metric TR posts is possible.

2. Connect the 3-pin plug of the LDS12B power supply into the power receptacle on the PDA13L2 detector.
3. Plug the power supply into a 50 to 60Hz, 100 V / 120 V / 230 V power outlet.
4. Attach a 50 Ω coax cable with a BNC connector (i.e. RG-58U) to the output of the PDA. When running cable lengths longer than 12" we recommend terminating the opposite end of the coax with a 50 Ω resistor (Item # T4119) for maximum performance. Connect the remaining end to a measurement device such as an oscilloscope or high speed DAQ card. Caution: Many high-speed oscilloscopes have input impedances of 50 Ω. In this case, do not install a 50 Ω terminator. The combined loads will equal 25 Ω which could allow ~135 mA of output current. This will cause the PDA13L2 to enter a short circuit protection state and impair operation.
5. Power the PDA13L2 detector on using the power switch located on the side of the unit.



Caution!
The PDA13L2 detector was designed to allow maximum accessibility to the photodetector by having the active area surface of the diode flush with the outside of the PDA housing. When using fiber adapters, make sure that the fiber ferrule does not crash into the detector. Failure to do so may cause damage to the diode and or the fiber.

6. Install any desired filters, optics, adapters, or fiber adapters to the input aperture using the SM1T1 adapter or the external SM1 threads on the PDA13L2 detector.
7. During alignment, take appropriate precautions, such as using reduced radiation power, or other precautions, and use proper eye and/or skin protection as recommended by the radiation source manufacturer.
8. Apply a light source to the detector. Adjust the gain to the setting that achieves the desired signal level.

Chapter 4 Operation

4.1 Theory of Operation

Pyroelectric materials produce a voltage difference in response to a change in temperature. Pyroelectric detectors take advantage of this by using an optically absorbing layer to convert incoming light into heat. This leads to a temperature change which is converted into a voltage by a pyroelectric material. This approach allows a wide range of optical wavelengths to be detected with the same device by appropriate selection of the absorber.

The operating principle requires a change in temperature to produce a signal, so the detector still functions at a range of ambient temperatures. However, this also means an unmodulated CW source will not produce a measurable signal once the detector reaches thermal equilibrium. The use of an optical chopper or other form of modulation is suggested in such cases. The rate of heat transfer within the detector can also lead to a reduced upper bandwidth limit compared to some photodiodes.

The PDA13L2 detector includes an amplified lithium tantalate ($LiTaO_3$) pyroelectric detector element with switchable gain. The amplifier is optimized for a more consistent response as a function of modulation frequency across its bandwidth in comparison to the detector element alone. The detector is packaged behind an uncoated ZnSe window with a transmission band from 0.6 to 16 µm.

The PDA13L2 detector operates by the same principles as the ESxxxC line of pyroelectric energy sensors but has a smaller element size and is intended for use with continuous modulation rather than pulses.

4.2 Piezoelectric Properties

It is important to note that pyroelectric materials are also piezoelectric, meaning their physical deformation also leads to a voltage difference. Consequently, pyroelectric detectors may also produce signals when exposed to mechanical vibrations. This should be kept in mind when designing and working with systems using these devices. One approach to evaluate whether this is occurring is to block variable incoming light while measuring the detector output in the intended environment.

4.3 Responsivity

The responsivity of a pyroelectric detector can be defined as a ratio of generated voltage (V) to the incident optical power (P) at a given wavelength (λ):

$$\Re(\lambda) = \frac{V}{P}$$

The responsivity is generally flat over the full operating wavelength range and, as such, is given as a single value of 120 V/W. This value; however, does not account for the window transmission or $LiTaO_3$ sensor absorption. Therefore, to calculate the responsivity at a given wavelength, the transmission of the ZnSe window and absorption of the $LiTaO_3$ sensor at a particular wavelength must be included in the voltage output equation in **Section 4.5** below. Multiplying the responsivity of 120 V/W by the transmission and absorption from the graphs in **Section 6.1** will provide a representation of the actual responsivity for the pyroelectric detector package.

4.4 Bandwidth and Response

Pyroelectric sensors act as an integrator of heat over the modulation cycle. Therefore, they do not have a DC response and need to operate with a modulated input source. To counteract this integrating effect, a differentiator is used to flatten the output vs frequency response. Since this sensor relies on a heating effect, bandwidth is relatively limited as compared to a semiconductor material such as Si or InGaAs. For the PDA13L2 detector, the optimal operating modulation frequency range is between 10 Hz and 10 kHz. This is ideally suited to operation with an optical chopper such as Thorlabs' MC2000B optical chopper system.

A low pass filter of 10 kHz rolls off bandwidth across all gain stages to maintain gain flatness over the full operating frequency range.

4.5 Terminating Resistance

The maximum output of the PDA13L2 detector is 10 V for high impedance loads (i.e. R_{Load} > 5 kΩ) and 5 V for 50 Ω loads. Adjust the gain so that the measured signal level out of the PDA13L2 detector is below 10 V (5 V with a 50 Ω load) to avoid saturation.

For low terminating resistors, <5 kΩ or 1% error, the detector output has a 50 Ω series resistor (R_s) which needs to be considered. The output load creates a voltage divider with the 50 Ω series resistor as follows:

$$Scale\ Factor = \frac{R_{Load}}{R_{Load} + R_s}$$

The Scale Factor is used to calculate the output voltage on the detector given by:

$$V_{OUT} = \Re(\lambda) \times Gain \times Scale\ Factor \times Input\ Power\ (W)\ \times T(\lambda)$$

Where $\Re(\lambda)$ is the responsivity, Gain is the selected gain setting of the detector, Input Power is the optical power incident on the sensor, and $T(\lambda)$ is the transmission of the ZnSe window. A plot of the window transmission versus wavelength for the ZnSe window and absorption vs wavelength for the $LiTaO_3$ sensor material are provided in **Section 6.1**.

4.6 Gain Adjustment

The PDA13L2 detector includes a low noise, low offset, variable gain amplifier that allows gain adjustment over a 35 dB range with 8 gain settings incremented in 5 dB steps. The gain is adjusted by rotating the gain control knob located on the side of the unit below the power switch.

Chapter 5 Troubleshooting

Problem	Suggested Solutions
There is no signal response.	Verify that the power is switched on and all connections are secure.
	Verify the proper terminating resistor is installed if using a voltage measurement device.
	Verify that the optical signal wavelength is within the operating wavelength range of the PDA13L2 detector.
	Verify that the optical signal is illuminating the detector active area.
	Verify that the optical signal is modulated either using an optical chopper or modulating the signal source directly. A high pass filter stage will remove all CW signal sources.
Output Voltage will not increase. **Detector Output is skewed.**	Check to make sure the detector is not saturated. Refer to the Output Voltage in the Specifications in **Chapter 6**. Install a 1" Lens Tube (SM1L10) to the included SM1T1 thread coupler to baffle any external light sources to see if this improves the response.
Signal exhibits 0 V flat response that breaks up sinusoidal signal	This is due to phase shifting from the integration of the sensor and differentiator output stage. This is especially predominant at the lower end of the frequency range where the integrator is dominant to the differentiator response. The gain stage may have the signal clipping by saturating on the supply rails. The differentiator then counteracts, and phase shifts the signal resulting in the clipping showing at the midpoint of the signal. To eliminate this, try one of the following: • Lower the Incident Light Level • Lower the Gain Step Selected • Increase the Modulation Frequency

Chapter 6 Specifications

All performance specifications are typical, performed at 25 °C ambient temperature, and assume 50 Ω load, unless stated otherwise.

Performance Specifications[a]			
0 dB Setting		**20 dB Setting**	
Gain (Hi-Z)[b]	3.00 V/V ±2 %	**Gain (Hi-Z)**[b]	29.7 V/V ± 2%
Gain (50 Ω)[b]	1.50 V/V ± 2%	**Gain (50 Ω)**[b]	14.9 V/V ± 2%
Bandwidth	10 Hz - 10 kHz	**Bandwidth**	10 Hz - 10 kHz
Noise (RMS)	185 µV	**Noise (RMS)**	1.45 mV
NEP	32.5 nW/√Hz	**NEP**	32.1 nW/√Hz
Offset	±10 mV (Max)	**Offset**	±10 mV (Max)
5 dB Setting		**25 dB Setting**	
Gain (Hi-Z)[b]	5.32 V/V ± 2%	**Gain (Hi-Z)**[b]	53.3 V/V ± 2%
Gain (50 Ω)[b]	2.66 V/V ± 2%	**Gain (50 Ω)**[b]	26.7 V/V ± 2%
Bandwidth	10 Hz - 10 kHz	**Bandwidth**	10 Hz - 10 kHz
Noise (RMS)	320 µV	**Noise (RMS)**	2.20 mV
NEP	33.9 nW/√Hz	**NEP**	28.3 nW/√Hz
Offset	±10 mV (Max)	**Offset**	±10 mV (Max)
10 dB Setting		**30 dB Setting**	
Gain (Hi-Z)[b]	9.45 V/V ± 2%	**Gain (Hi-Z)**[b]	94.1 V/V ± 5%
Gain (50 Ω)[b]	4.73 V/V ± 2%	**Gain (50 Ω)**[b]	47.1 V/V ± 5%
Bandwidth	10 Hz - 10 kHz	**Bandwidth**	10 Hz - 10 kHz
Noise (RMS)	550 µV	**Noise (RMS)**	2.95 mV
NEP	31.4 nW/√Hz	**NEP**	26.4 nW/√Hz
Offset	±10 mV (Max)	**Offset**	±10 mV (Max)
15 dB Setting		**35 dB Setting**	
Gain (Hi-Z)[b]	16.8 V/V ± 2%	**Gain (Hi-Z)**[b]	170 V/V ± 5%
Gain (50 Ω)[b]	8.4 V/V ± 2%	**Gain (50 Ω)**[b]	85.0 V/V ± 5%
Bandwidth	10 Hz - 10 kHz	**Bandwidth**	10 Hz - 10 kHz
Noise (RMS)	920 µV	**Noise (RMS)**	3.75 mV
NEP	31.8 nW/√Hz	**NEP**	22.6 nW/√Hz
Offset	±10 mV (Max)	**Offset**	±10 mV (Max)

a. The PDA13L2 has a 50 Ω series terminator resistor (i.e. in series with amplifier output). This forms a voltage divider with any load impedance (e.g. 50 Ω load divides signal in half).

b. This represents the electronic gain in V/V. To calculate the detector output, multiply the electronic gain times the window transmission at the desired wavelength and the responsivity.

Electrical Specifications		
Detector	-	Pyroelectric Lithium Tantalate ($LiTaO_3$)
Active Area	-	Ø1.3 mm
Window / IR Filter	-	ZnSe (0.8 mm Thick)
Wavelength Range	λ	0.6 µm to 16 µm
Field of View	FOV	85° (Typ.)
Responsivity (500 K, 100 Hz, 25 °C)[a]	$\Re(\lambda)$	120 V/W
Output Impedance	-	50 Ω
Max Output Current	I_{OUT}	100 mA
Load Impedance	-	50 Ω to Hi-Z
Gain Adjustment Range	-	0 dB to 35 dB
Gain Steps	-	8 Steps (5 dB Increments)
Output Voltage	V_{OUT}	0 to 5 V (50 Ω) 0 to 10 V (Hi-Z)

a. The responsivity is the average value measured using a blackbody source calibrated to 500 K and chopped at a frequency of 100 Hz. The measurement is made with the detector in a room with an ambient temperature of 25 °C. This value was measured without the ZnSe window; therefore, the transmission of the window must be taken into account when calculating the responsivity for a given wavelength.

General	
On/Off Switch	Slide
Gain Switch	8 Position Rotary
Output	BNC (DC Coupled)
Package Size	2.79" x 1.96" x 0.89" (70.9 mm x 49.9 mm x 22.5 mm)
Detector Surface Depth[a]	0.09" (2.2 mm)
Weight, Detector Only	0.10 kg
Accessories	SM1T1 Coupler SM1RR Retaining Ring SM1EC2B Dust Cap LDS12B Power Supply
Operating Temperature	10 to 40 °C
Storage Temperature	-20 to 70 °C
AC Power Supply	AC - DC Converter
Input Power[b]	31 W 100 V / 120 V / 230 V, 50 - 60 Hz

a. Measured from top of threaded surface. Detector active area surface is flush with front housing body.

b. *Although the power supply is rated for 31 W, the PDA13L2 detector's actual usage is <5 W over the full operating range.*

6.1 Graphs

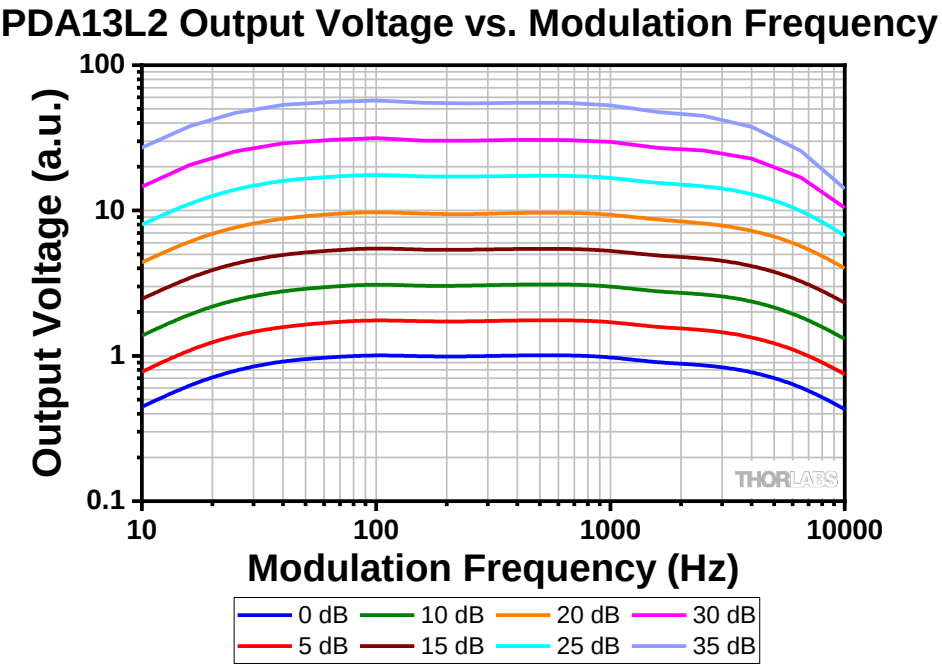


Figure 2 ***The graph above shows the output voltage versus the modulation frequency of light incident on the detector from an M660L4 LED for the eight different gain steps.***

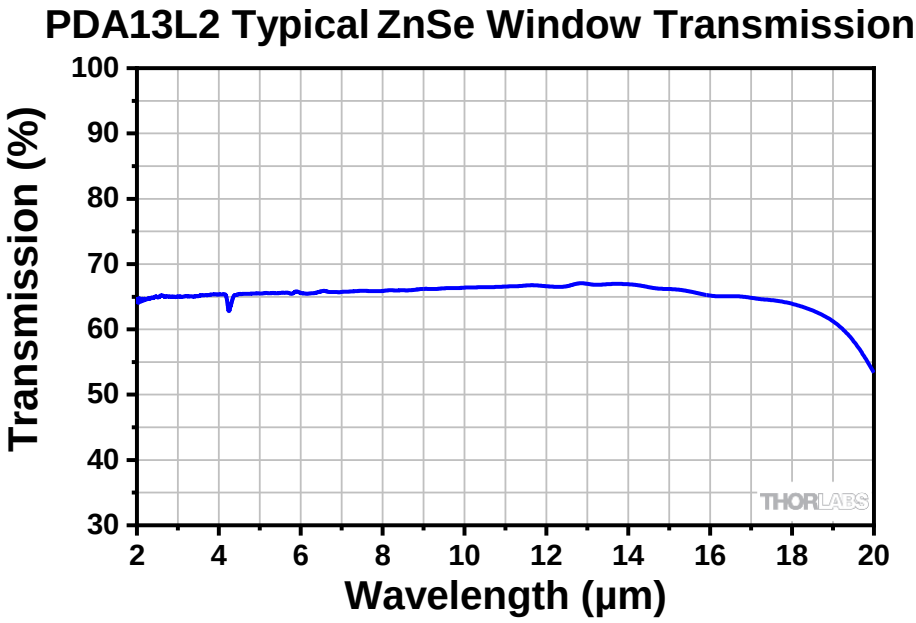


Figure 3 ***This plot shows the typical transmission for the ZnSe window of the PDA13L2 detector. This data is for reference only and actual performance may vary unit to unit.***

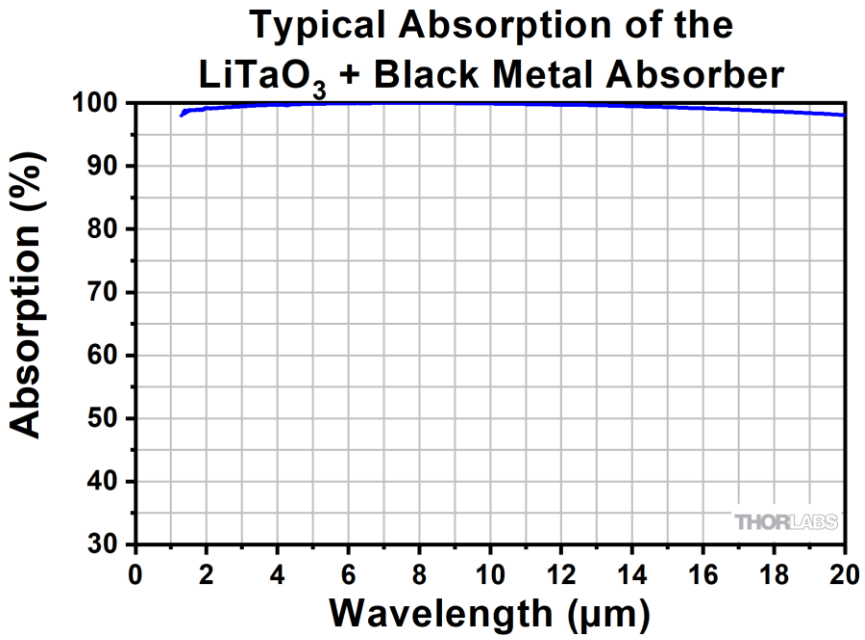
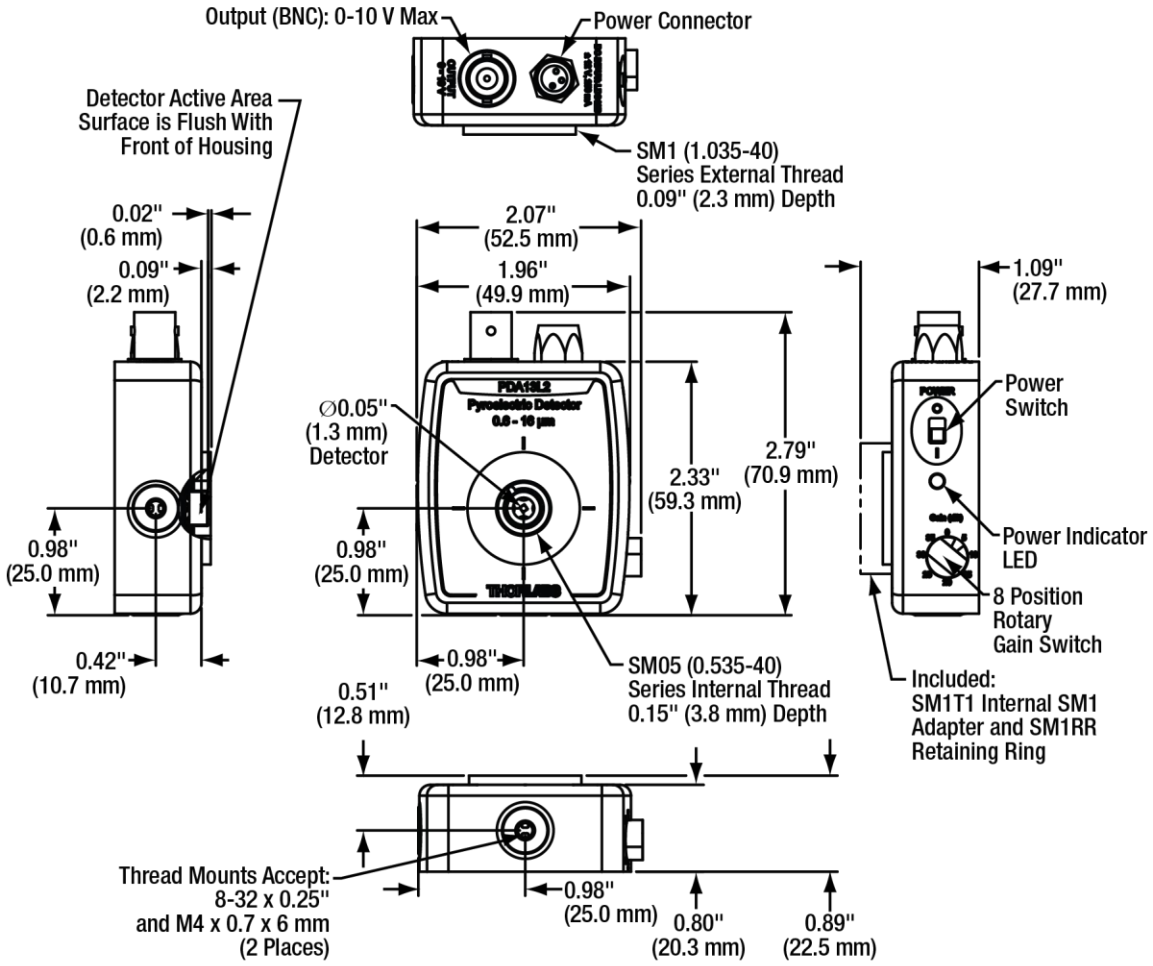
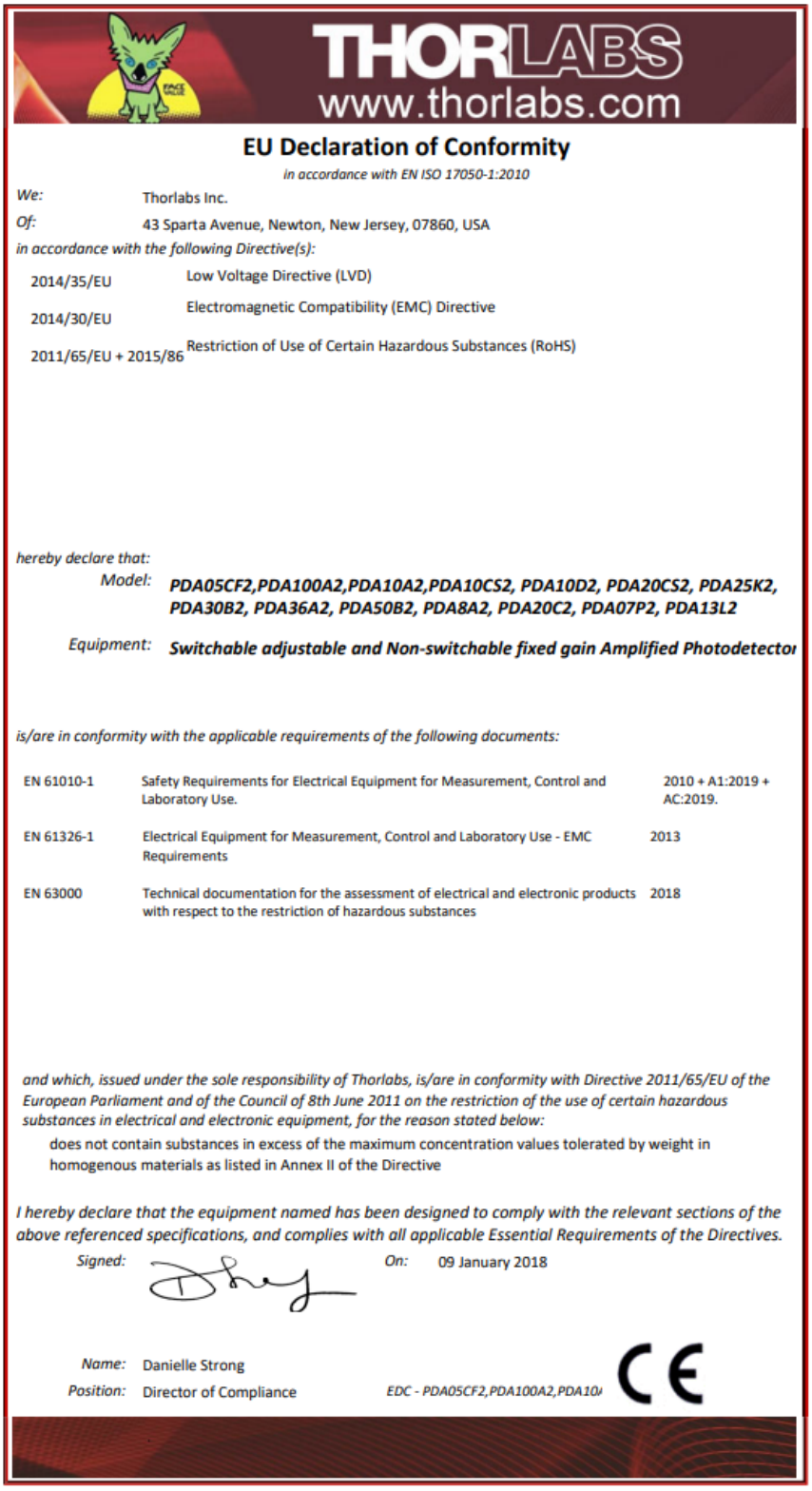


Figure 4 This plot shows the typical absorption of the $LiTaO_3$ sensor and the black metal absorber of the PDA13L2 detector. This data is for reference only and actual performance may vary unit to unit.

6.2 Mechanical Drawing



Chapter 7 Certificate of Conformance



THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Inc.

Of: 43 Sparta Avenue, Newton, New Jersey, 07860, USA

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU + 2015/86	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***PDA05CF2,PDA100A2,PDA10A2,PDA10CS2, PDA10D2, PDA20CS2, PDA25K2, PDA30B2, PDA36A2, PDA50B2, PDA8A2, PDA20C2, PDA07P2, PDA13L2***

Equipment: ***Switchable adjustable and Non-switchable fixed gain Amplified Photodetector***

is/are in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010 + A1:2019 + AC:2019.
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018

and which, issued under the sole responsibility of Thorlabs, is/are in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed: *On:* 09 January 2018

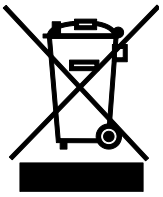
Name: Danielle Strong

Position: Director of Compliance

EDC - PDA05CF2,PDA100A2,PDA10

CE

Chapter 8 Warranty and RMA Information



Annex I

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user's responsibility to delete all private data stored on the device prior to disposal.

8.1 Return of Devices

This precision device is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

Chapter 9 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at **www.thorlabs.com/contact** for our most up-to-date contact information.



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