PDA20L2
Pyroelectric Amplified Detector

User Guide



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Chapter 1 Introduction

1.1 Intended Use

The PDA20L2 pyroelectric amplified detector is used to measure pulsed or modulated laser light signals and is characterized by its high sensitivity to radiation in the UV to far-infrared range.

The PDA20L2 pyroelectric amplified detector is intended for the following applications:

- FTIR (Fourier Transform Infrared Spectroscopy)
- Laser Power Detection in the UV to Far-Infrared Range
- Quality Assurance and Testing

The product may only be used in accordance with the instructions described in this user guide. Any other use will invalidate the warranty.

1.2 Explanation of Safety Warnings

⚠WARNING Warning indicates a hazard with a medium level of risk that, if not avoided, could result in death or serious injury.

⚠CAUTION indicates a hazard with a low level of risk that, if not avoided, could result in minor Caution or moderate injury.

NOTICE Indicates information considered important, but not hazard-related, such as possible damage to the product.

 Shock Warning

 Warning

 ESD Component Caution

 The CE/UKCA markings on the product are the manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation.

 The symbol on the product, the accessories, or the packaging indicates that this device must not be treated as unsorted municipal waste but must be collected separately.

1.3 Description

The PDA20L2 detector is an amplified, switchable-gain, pyroelectric detector designed for detection of light signals ranging from 200 nm to 25 µm. A buffered output drives 50 Ω load impedances up to 5 V. The PDA20L2 detector 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.

1.4 Technical Data

1.4.1 Specifications

All technical data are valid at 23 ± 5 °C and 45 ± 15% relative humidity (non-condensing).

PDA20L2 Pyroelectric Gain Detector	
Detector Specifications	
Type	Pyroelectric Lithium Tantalate ($LiTaO_3$)
Active Area	2 x 2 mm
Window / IR Filter	KBr (0.8 mm Thick)
Field of View (FOV)	85° (Typ.)
Wavelength Range λ	0.2 µm to 25 µm
Responsivity ℜ(λ) (500 K, 100 Hz, 25 °C)[a]	42 kV/W
Detectivity	5×10^8 cm·√Hz/W*@ 10 Hz 2×10^8 cm·√Hz/W @ 1 kHz
NEP (Noise Equivalent Power)	400 pW/√Hz @ 10 Hz 1 nW/√Hz @ >1 kHz
Bandwidth (3dB)	2 Hz - 8 kHz, Detection Possible up to 50 kHz (-20 dB)
TIA Gain	10 GV/A (GBP: 7 x 10^{13} Hz) @ Hi-Z
Measurable Power (Max)	230 µW (1 kHz)
Damage Threshold	60 mW/cm²
Output Impedance	50 Ω
Load Impedance	50 Ω to Hi-Z
Output Voltage (V_{OUT})	±3 V (50 Ω) ±10 V (Hi-Z)
Output Current (I_{OUT}) (Max)	100 mA
General Specifications	
Electrical Outputs	BNC (DC Coupled), 50 Ω Impedance
Package Size	2.79" x 2.10" x 0.89" (70.9 mm x 53.4 mm x 22.5 mm)
Detector Surface Depth[b]	2.2 mm (0.09")
Weight (Detector Only)	0.10 kg (0.22 lbs)
Operating Temperature Range	10 to 40 °C
Storage Temperature Range	-20 to 70 °C

a. The responsivity is the average value measured using a blackbody source calibrated to 423 K and chopped at a frequency of 1 kHz. The measurement is made with the detector in a room with an ambient temperature of 25 °C. This value was measured without the KBr window; therefore, the transmission of the window must be taken into account when calculating the responsivity for a given wavelength.

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

AC/DC Power Supply Specifications (LDS12B)	
DC Output	±12 V @ 250 mA
Input Power[c]	31 W 100 / 120 / 230 VAC, 50 - 60 Hz, Switchable
Output Regulation	±5% Measured at Output Connector
Output Power (Rated)	6 W (Max)
Input Current	0.25 / 0.5 A (Max)

c. Although the power supply is rated for 31 W, the PDA20L2 detector's actual usage is <5 W over the full operating range.

1.4.2 Graphs

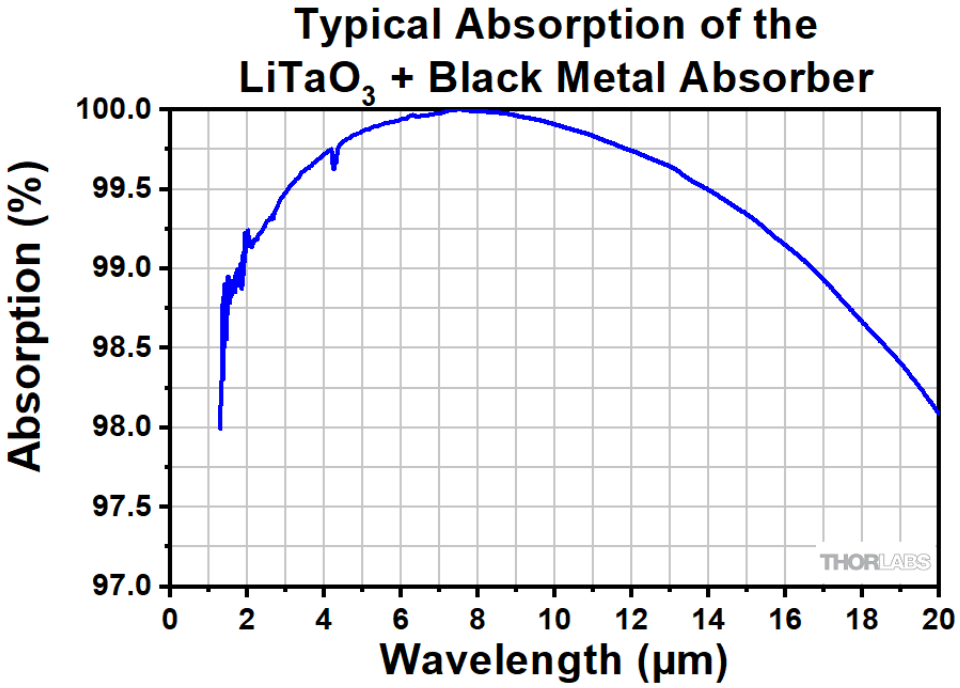


Figure 1 This graph shows the typical absorption of the $LiTaO_3$ sensor and black metal absorber of the PDA20L2 detector. This data is for reference only and actual performance may vary unit to unit.

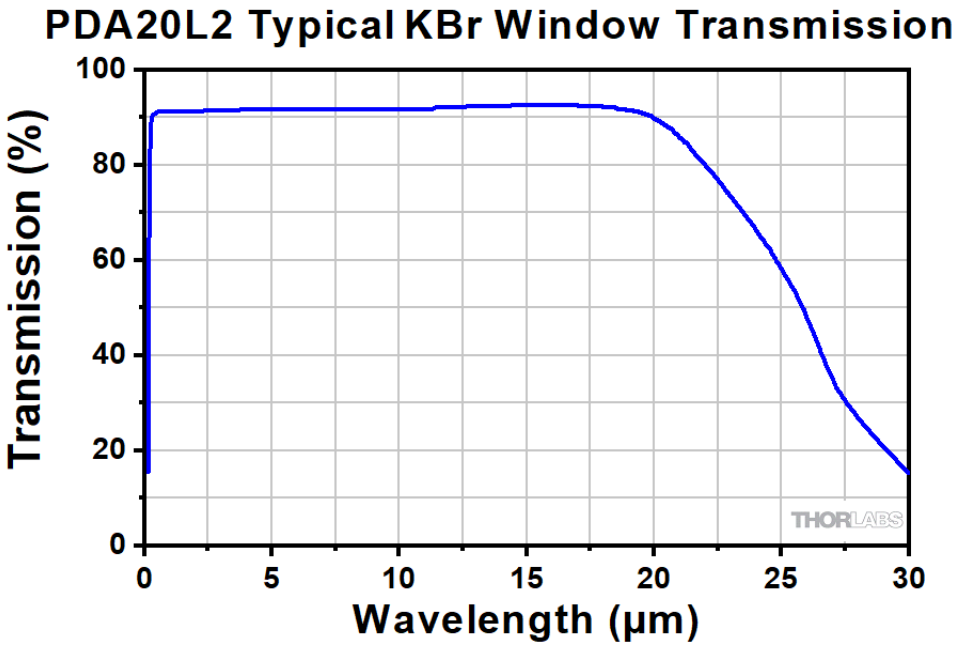


Figure 2 Typical KBr Window Transmission Graph of the PDA20L2 Detector

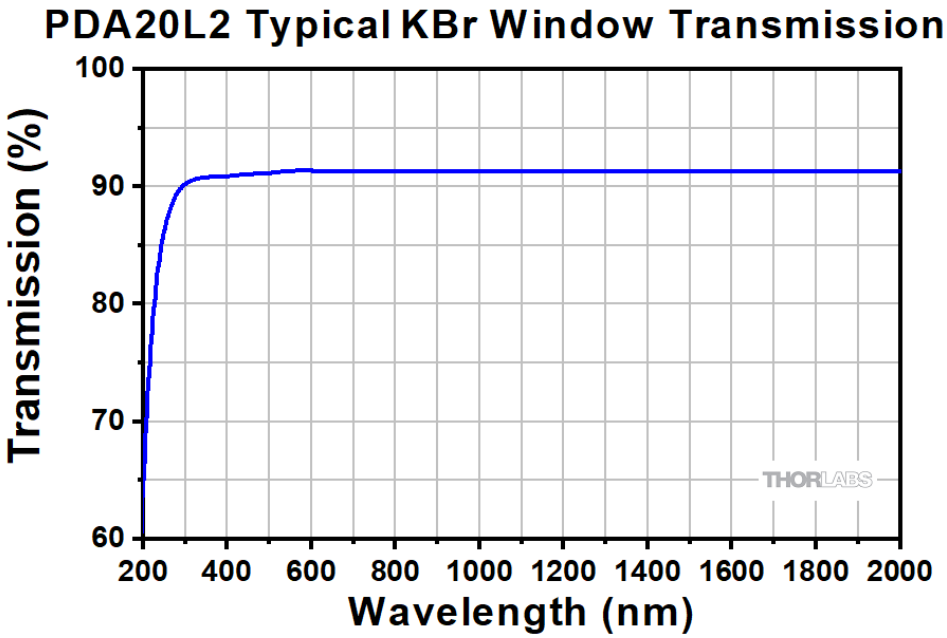


Figure 3 This graph shows the typical transmission for the KBr window of the PDA20L2 detector across the visible to near-infrared regime. This data is for reference only and actual performance may vary unit to unit.

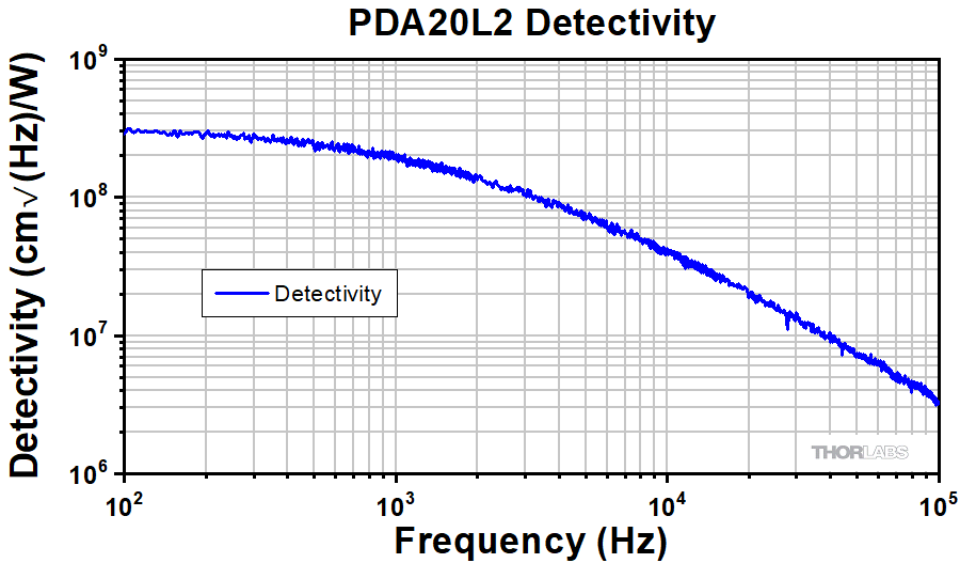


Figure 4 Detectivity Graph of the PDA20L2 Detector

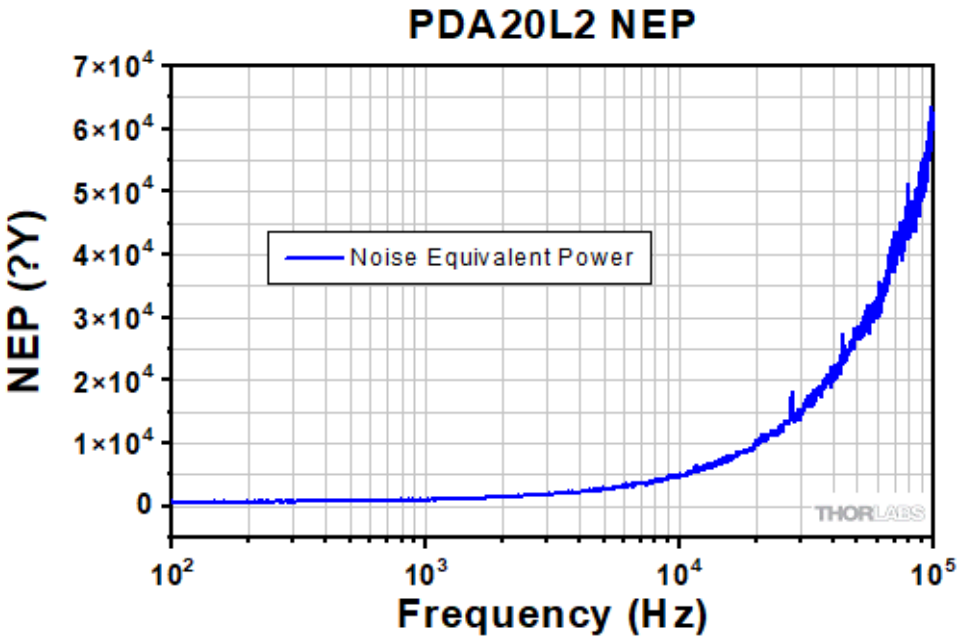


Figure 5 NEP Graph of the PDA20L2 Detector

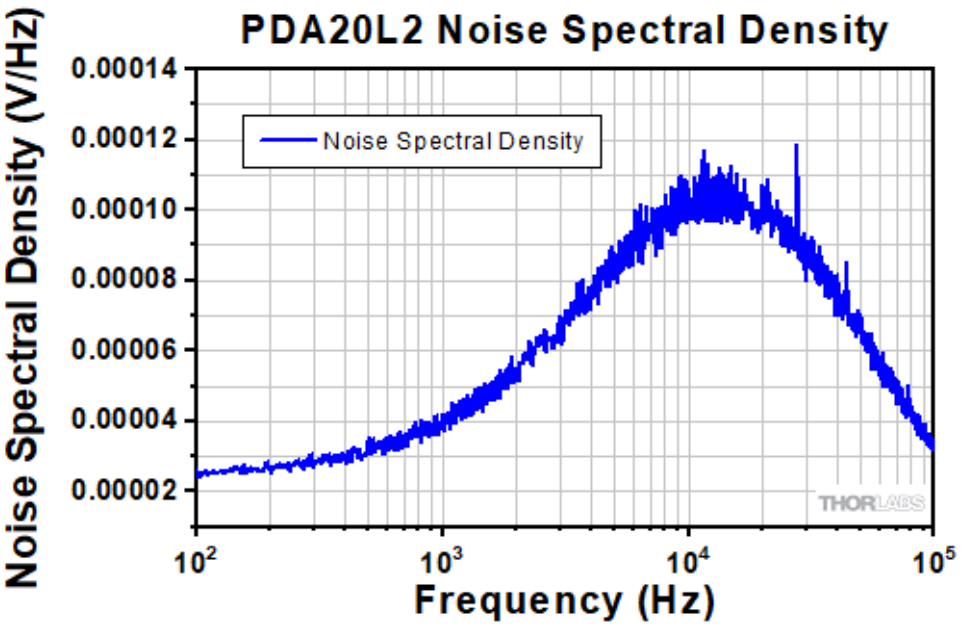


Figure 6 Noise Spectral Density Graph of the PDA20L2 Detector

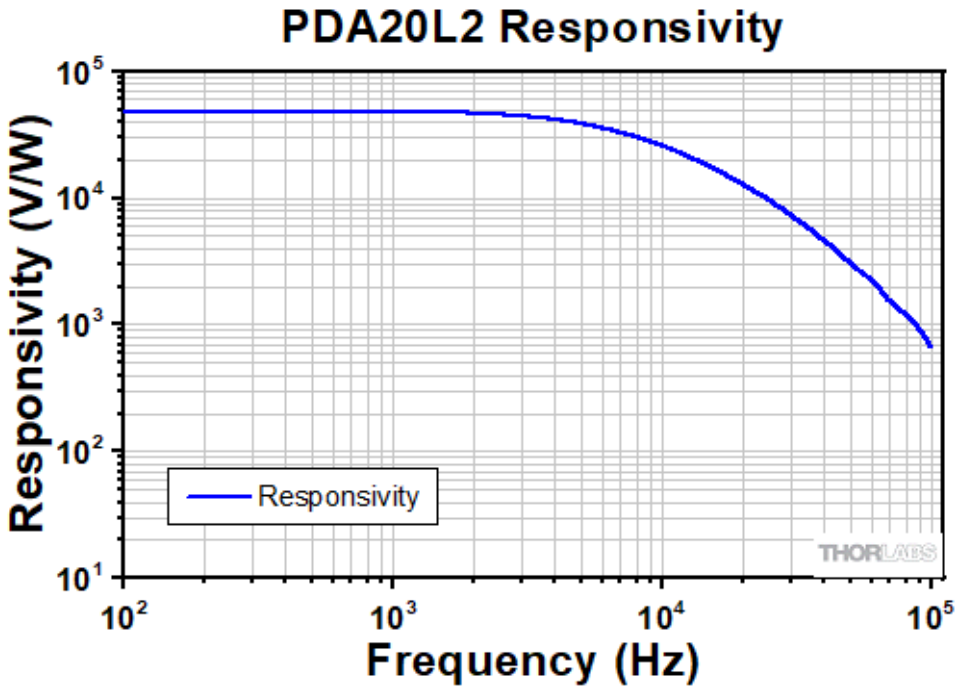


Figure 7 Responsivity Graph of the PDA20L2 Detector

1.4.3 Mechanical Drawing

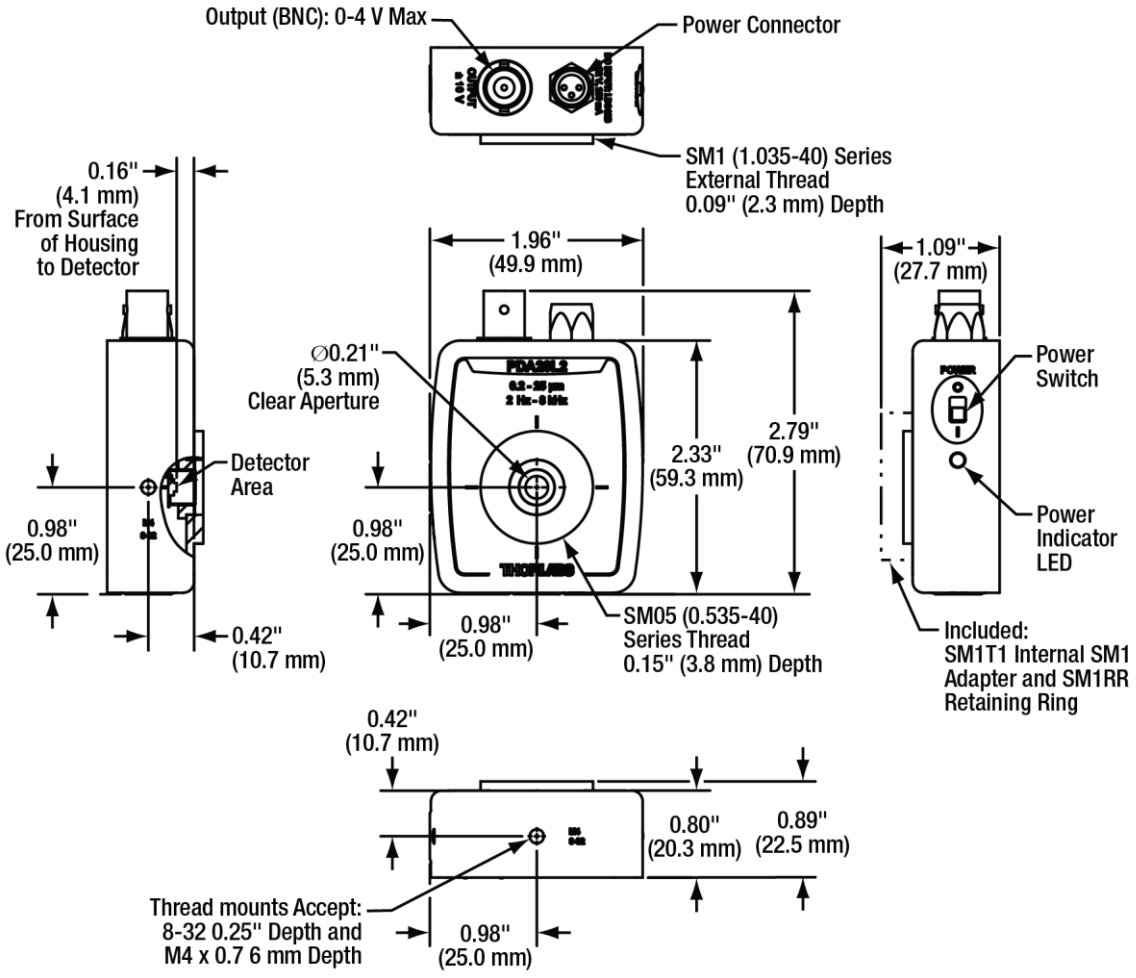


Figure 8 Mechanical Drawing of the PDA20L2 Pyroelectric Gain Detector

1.5 Components



Figure 9 Components of the PDA20L2 Detector

Callout	Feature	Description
1	Power Connector	Power Supply Connector for Connecting LDS12B Power Supply (Included)
2	Power Switch	Slide Switch for Power On/Off
3	Threaded Coupler	Removable SM1T1 9 SM1 (1.035"-40) Coupler, Internal Thread
4	Dust Cap	SM1EC2B Snap-On Plastic Dust Cap for SM1 Lens Tubes
5	SM05 Threaded Aperture	SM05 Internal Thread
6	Detector	Pyroelectric Detector
7	BNC Connector	BNC Output 0 - 4 V (Max)

Table 1 Components of the PDA20L2 Detector

1.6 Simplified Declaration of Conformity

The full text of the EU declaration of conformity is available at the following internet address:
https://www.thorlabs.com/f302443

Chapter 2 Safety



WARNING: Risk of Serious Injury and Even Death Due to Electrical Shock
Improper grounding and connecting the power supply to the mains can cause electric shock.
Electric shock results in damage to your health or even death.
Observe the following instructions when applying power to the power supply:

- Make sure that the protective conductor for the three conductor mains power cord is correctly connected to the protective earth ground contact of the socket outlet.
- Before connecting the power supply to the mains make sure that the line voltage range marked on the power supply agrees with your local supply.



WARNING: Risk of Serious Injury and Even Death Due to Explosion
The device must not be operated in explosion endangered environments.



CAUTION: Risk of Serious Injuries of Incorrect Use
Pay attention to the following aspects during use:

- Do not remove covers or open the device.
- Refer servicing to qualified personnel.
- No changes may be made to the device or components used that were not supplied by Thorlabs without written authorization from Thorlabs.



CAUTION: Sensitive ESD Components
The components inside the PDA20L2 detector are ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any electrical connections to the unit.



NOTICE: Electrically Sensitive Product
Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.
The device has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 m (9.8 ft).

- The instrument must only be operated with a duly shielded and low resistance USB cable delivered by Thorlabs.
- All modules must only be operated by duly shielded BNC connection cables.

Chapter 3 Installation

3.1 Warranty

The precision devices are 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.

General Terms and Conditions of Sale can be found at https://www.thorlabs.com/legal.

3.2 Packing List

The following items are included in the PDA20L2 detector package:

- PDA20L2 Pyroelectric Detector
- LDS12B Power Supply
- SM1RR Retaining Ring
- SM1T1 Internally Threaded SM1 Coupler
- SM1EC2B Dust Cap
- Printed User Guide

3.3 Installation Instructions

The PDA20L2 detector can be set up in many ways using our extensive line of adapters. However, the PDA20L2 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 PDA20L2 detector.
3. Plug the power supply into a 50 to 60 Hz, 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 PDA20L2 detector. 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 PDA20L2 detector to enter a short circuit protection state and impair operation.
5. Power the PDA20L2 detector on using the power switch located on the side of the unit.
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 PDA20L2 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 PDA20L2 detector.

Chapter 4 Operation

4.1 Theory

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 PDA20L2 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 KBr window with a transmission band from 0.2 to 25 µm.

The PDA20L2 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 ($\Re$) 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 42 kV/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 KBr window and absorption of the $LiTaO_3$ sensor at a particular wavelength must be included in the voltage output equation in **Section 4.5**. Multiplying the responsivity of 42 kV/W by the transmission and absorption from the graphs in **Section 1.4.2** 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 semiconductor material such as Si or InGaAs. For the PDA20L2 detector, the optimal operating modulation frequency range is between 2 Hz and 8 kHz. This is ideally suited to operation with an optical chopper such as Thorlabs' MC2000B optical chopper system.

4.5 Terminating Resistance

The maximum output of the PDA20L2 detector is 10 V for high impedance loads (i.e. R_{Load} > 5 kΩ) and 3 V for 50 Ω loads. Adjust the gain so that the measured signal level out of the PDA20L2 detector is below 10 V (3 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:

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

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

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

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 KBr window. A plot of the window transmission versus wavelength for the KBr window and absorption vs wavelength for the $LiTaO_3$ sensor material are provided in **Section 1.4.2**.

Chapter 5 Maintenance and Cleaning

NOTICE

NOTICE: Risk of Damaging the PDA20L2 Detector

The PDA20L2 detector is not water resistant. If the PDA20L2 detector gets into contact with fluids, the PDA20L2 detector can be damaged.

To avoid damaging, do not expose the PDA20L2 detector to:

- Sprays
- Liquids
- Solvents
- Adverse Weather Conditions

To clean the PDA20L2 detector housing, use mild detergent and damp cloth. Do not soak the unit in water or use solvent based cleaners.

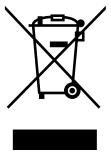
When cleaning the windows of the photo detectors, please remember that it is a sensitive optical device. Gently blow off any dust using compressed air.

The unit does not need regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please see **Section 3.1** for return instructions.

Chapter 6 Troubleshooting and Repair

Problem	Suggested Solutions
No Signal	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 PDA20L2 detector.
	Verify that the optical signal illuminates 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.
No Voltage Increase	Check to make sure the detector is not saturated. Refer to the Output Voltage in **Section 1.4.1**.
Skewed Output	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.
0 V Flat Signal **Distorted Sine 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 7 Disposal



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.

Chapter 8 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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