PDA10X2
Black Silicon Amplified Fixed Gain Detector

User Guide



Table of Contents

Chapter 1 Introduction 1
1.1 Intended Use 1
1.2 Explanation of Safety Warnings 1
1.3 Description 1
1.4 Technical Data 1
1.4.1 Specifications 2
1.4.2 Graphs 3
1.4.3 Mechanical Drawings 4
1.5 Components 4
1.6 Simplified Declaration of Conformity 5
1.7 FCC Designation 5
Chapter 2 Safety 6
Chapter 3 Installation 6
3.1 Warranty Information 6
3.2 Packing List 7
3.3 Installation Instructions 7
Chapter 4 Operation 8
4.1 Theory of Operation 8
4.2 Responsivity and Dark Current 8
4.3 Transimpedance and Conversion Gain 9
Chapter 5 Maintenance and Cleaning 10
Chapter 6 Troubleshooting and Repair 10
Chapter 7 Disposal 11
Chapter 8 Thorlabs Worldwide Contacts 12

Chapter 1 Introduction

1.1 Intended Use

This product is intended to be used to monitor light signals ranging from 240 nm to 1170 nm and create an appropriate electrical signal in a laboratory environment. The housed detector is intended to be used with the Thorlabs 30 mm cage systems and post mounting systems. The sensor is flush with the front face of the detector. These mounting holes can be used for mounting into custom housings and devices. A BNC connector is used to output a signal from the device. Power is supplied through a 3-pin connector applying ±12V.

1.2 Explanation of Safety Warnings

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

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


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

1.3 Description

The PDA10X2 is a high-speed amplified silicon photodetector designed for detection of optical signals over the 240 to 1170 nm wavelength range. It has a frequency response from DC to 21 MHz, a 20 ns rise time, and a maximum transimpedance gain of 60 kV/A. A buffered output drives 50 Ω loads up to 5 V with an NEP of 21.1 pW/√Hz.

1.4 Technical Data

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

1.4.1 Specifications

Electrical Specifications		
Detector	-	b-Si
Active Area	-	1 x 1 mm (1 mm^2)
Wavelength Range	λ	240 to 1170 nm
Peak Wavelength (Typical)	λ_p	1010 nm
Peak Responsivity (Typical)	$\Re(\lambda_p)$	0.73 A/W
Small Signal Bandwidth[a]	-	21 MHz
Rise Time	-	20 ns
NEP (λ_p)[b,c]	-	2.11 x 10^{-11} W/√Hz
Noise (RMS)[c]	-	350 μV_{RMS}
Max Output Current	I_{OUT}	100 mA
Offset	-	±10 mV
Load Impedance	-	50 Ω to Hi-Z
Transimpedance Gain	-	30 x 10^3 ± 2% V/A (50 Ω) 60 x 10^3 ± 2% V/A (Hi-Z)
Output Voltage	V_{OUT}	0 to 5 V (50 Ω) 0 to 10 V (Hi-Z)

a. Tested at 650 nm wavelength. For NIR wavelengths, the rise time of the photodiode element will become slower, which may limit the effective bandwidth of the amplified detector.

b. NEP is specified at the peak responsivity wavelength.

c. Measured with a 50 Ω Load

General Specifications	
On/Off Switch	Slide
Output	BNC (DC Coupled) 50 Ω Impedance
Package Size[a]	2.79" x 1.96" x 0.89" (70.9 mm x 49.8 mm x 22.5 mm)
PD Surface Depth[b]	0.14" (3.5 mm)
Weight, Detector Only	0.10 kg
Accessories	SM1T1 Coupler SM1RR Retaining Ring
Operating Temp	10 to 40 °C
Storage Temp	-20 to 70 °C
AC/DC Power Supply (LDS12B)	
DC Output	+ 12.0 V @ 0.25 A, - 12.0 V @ 0.25 A
Input Voltage	100 / 120 / 230 VAC, Switch Selectable
Output Regulation	± 5% Measured at Output Connector
Output Power (Rated)	6 W (Max)
Input Current	0.25 / 0.5 A (Max)
Input Frequency	60 / 50 Hz

a. Not Including SM1T1 Adapter

b. The Distance from the front Edge of the External SM1 Threading to the Active Surface of the Photodiode

1.4.2 Graphs

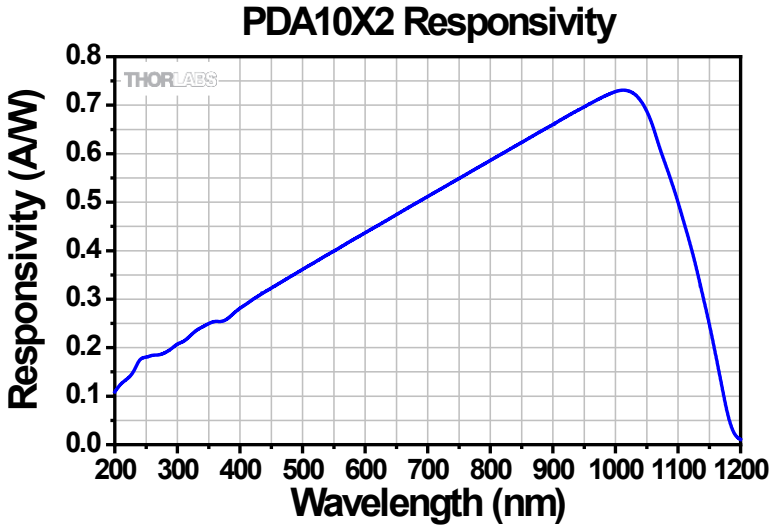


Figure 1 Typical Responsivity of the PDA10X2 Detector

1.4.3 Mechanical Drawings

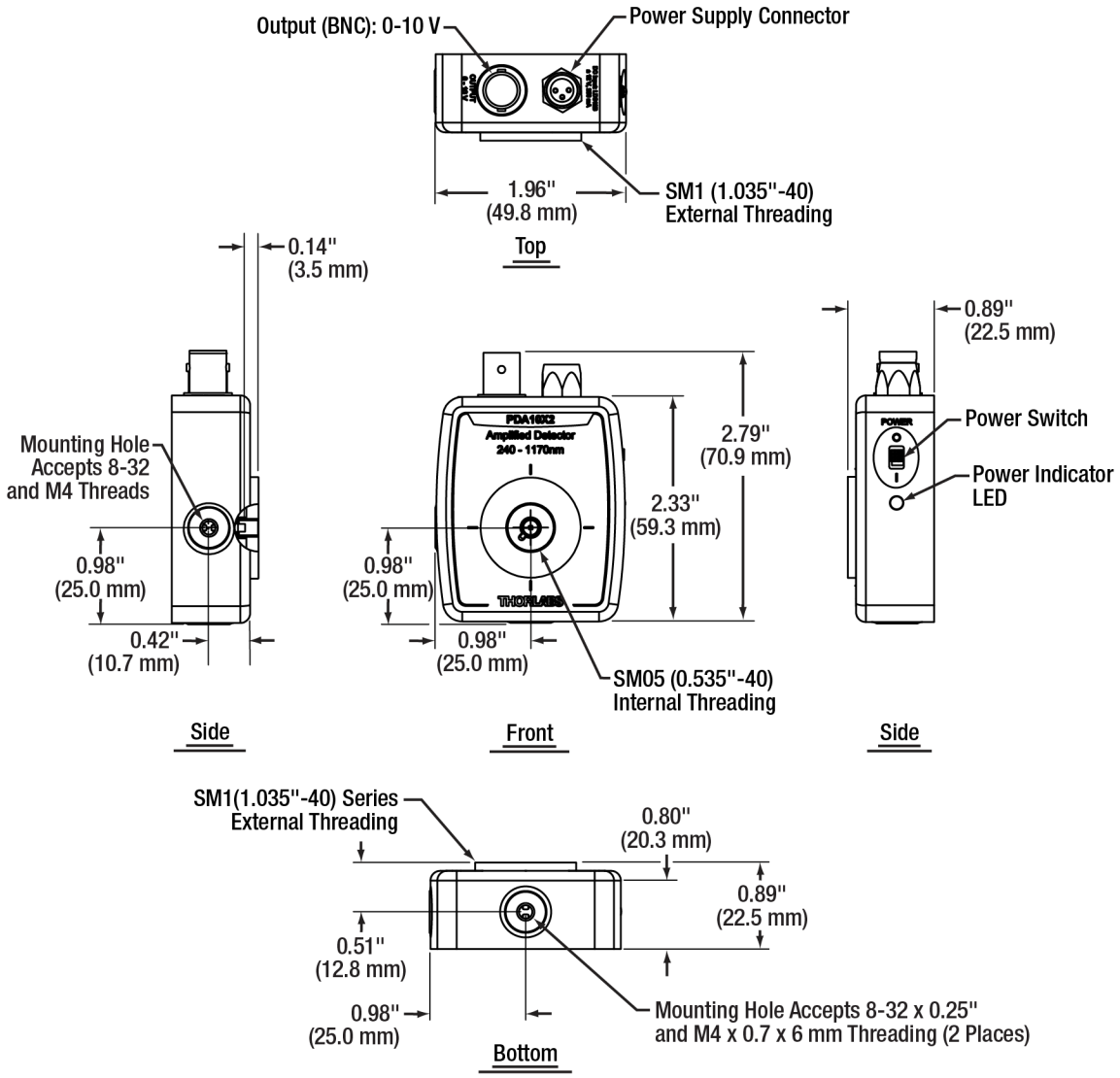


Figure 2 Mechanical Drawing

1.5 Components

The ±12 VDC (**LDS12B**) power supply is included with each amplified photodetector, and a switch on the power supply can be toggled to select the appropriate input voltage (100, 120 or 230 VAC). The PDA10X2 housing includes a removable threaded coupler (**SM1T1**) and retaining ring (**SM1RR**) that are compatible with any of Thorlabs' SM1-threaded (1.035"-40) accessories. The housing also accommodates Thorlabs' SM05-threaded (0.535"-40) series of adapters and accessories. This allows convenient mounting of external optics, **light filters**, and **apertures**, as well as providing an easy mounting mechanism using Thorlabs' **cage assembly accessories**.

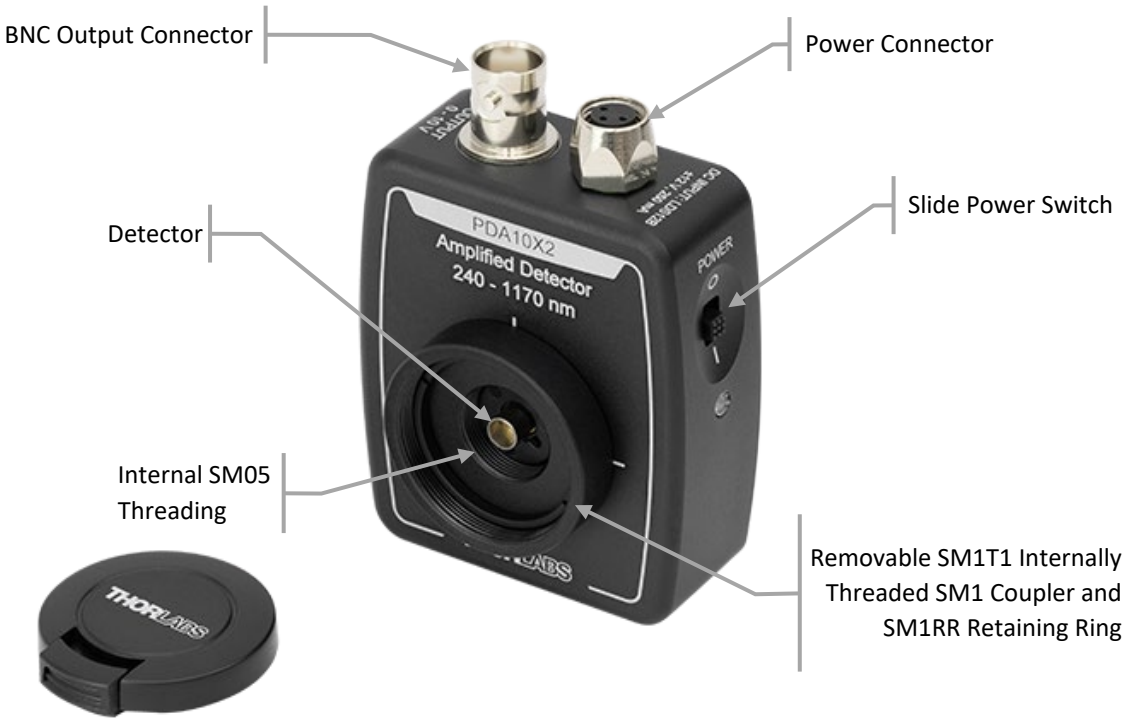


Figure 3 Features of the PDA10X2 Amplified Fixed Gain Detector

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/newgrouppage9.cfm?objectgroup_id=3257**.

1.7 FCC Designation

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules, and meets all requirements of the Canadian Interference Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference in an industrial installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

Chapter 2 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

Risk of Electrical Shock
This instrument should be kept clear of environments where liquid spills or condensing moisture are likely. It is not water resistant. To avoid damage to the instrument, do not expose it to spray, liquids, or solvents.

NOTICE

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation. Inputs and outputs must only be connected with shielded connection cables.

Only with written consent from Thorlabs may changes to single components be carried out or components not supplied by Thorlabs be used.

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).

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user. The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules. The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



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 Installation

3.1 Warranty Information

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.

3.2 Packing List

Packing List:

- Detector with Dust Cover
- SM1T1 Coupler
- SM1RR Retaining Ring
- 100 V / 120 V / 230 V AC/DC Linear Power Supply
- Quick Start Guide
- Download Card

3.3 Installation Instructions

The 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.

1. Unpack the optical head, install either an imperial or metric optical post into one of the mounting holes located on the bottom and side of the sensor, and mount using a post holder. Note that these detectors feature tapped holes that accept both 8-32 and M4 threads, so using either imperial or metric TR posts is possible.
2. Connect the LDS12B power supply 3-pin plug into the power receptacle on the PDA10X2 detector.
3. Set the voltage selector switch on the power supply to the appropriate input voltage (100, 120, or 230 VAC), then plug into a 50 - 60 Hz outlet.

NOTICE

If the voltage selector switch on the LDS12B power supply is set to the wrong voltage, the power supply may be damaged. Always ensure that the LDS12B voltage selector is set correctly before plugging the power supply into mains power.

4. Attach a 50 Ω BNC-type coaxial cable (i.e. RG-58U) to the output of the PDA. For best performance, we recommend terminating the cable with a 50 Ω load at the measurement instrument. If the instrument has a high impedance input, then adding an external 50 Ω load resistor may be an option. Do not add an external 50 Ω resistor if the instrument has an internal 50 Ω termination, as the resulting 25 Ω load could damage the output of the PDA10X2 detector.

NOTICE

Immediately after the power switch on the PDA10X2 is switched to on, the output of the PDA10X2 detector will go to its maximum voltage (5 V for 50 Ω load or 10 V for Hi-Z) for approximately 200 ms. For sensitive equipment, turn on the PDA10X2 before connecting to its output.

5. Power the PDA10X2 detector on by moving the power switch located on the side of the unit to the "I" position. ("O" indicates the unit is off.) Note that Steps 4 and 5 can be reversed when using sensitive test equipment.
6. Install any desired filters, optics, or fiber adapters to the input aperture.

NOTICE

The PDA10X2 detector was designed to allow maximum accessibility to the photodetector by having the front surface of the photodiode TO-can nearly flush with the outside of the PDA housing. When using fiber adapters, make sure that the fiber ferrule does not crash into the TO-can window. Failure to do so may cause damage to the TO-can window and/or the fiber.

7. Apply the light source to the detector. Be sure not to overfill the detector area, as this can affect the frequency response.
8. The maximum output of the PDA10X2 detector is 10 V for high impedance loads and 5 V for 50 Ω loads. The output signal should be below the maximum output voltage to avoid saturation. If necessary, use external neutral density filters to reduce the input light level.

Chapter 4 Operation

4.1 Theory of Operation

Thorlabs' PDA10X2 detector is ideal for measuring both modulated/pulsed and CW light sources. As is shown in Figure 2, the PDA10X2 detector includes a reverse-biased PIN photodiode (PD) mated to a fixed gain transimpedance amplifier (TIA) followed by a buffer amplifier and packaged in a rugged housing. The photodiode generates a current in response to the optical input which is then converted to a voltage and amplified by the TIA. The buffer amplifier adds yet another level of gain. Note that the output is passed through a 50 Ω series resistor before reaching the output connector. The user can apply either a 50 Ω or high-impedance external load depending on the situation.

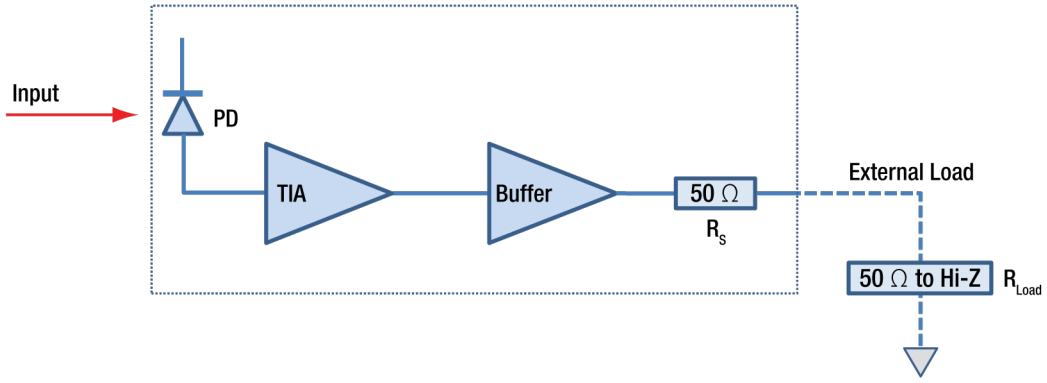


Figure 4 Block Diagram of the PDA10X2 Amplified b-Si Photodetector

4.2 Responsivity and Dark Current

The responsivity of a photodiode can be defined as a ratio of generated photocurrent (I_{PD}) to the incident light power (P) at a given wavelength (in units of A/W):

$$\Re(\lambda_p) = \frac{I_{PD}}{P}$$

Dark current is leakage current which flows when a bias voltage is applied to a photodiode. The PDA with Transimpedance Amplifier does control the dark current flowing out. Looking at the figure above, it can be

noted that Point B is held at ground and the amplifier will try to hold point A to "Virtual Ground". This minimizes the effects of dark current present in the system. The dark current present is also affected by the photodiode material and the size of the active area. Silicon devices generally produce low dark current compared to germanium devices which have high dark currents. The table below lists several photodiode materials and their relative dark currents, speeds, sensitivity, and costs. Please note that sensitivity values in the table are typical values; Thorlabs offers photodetectors with sensitivity ranges that vary from those shown below.

Material	Dark Current	Speed	Sensitivity (nm)[a]	Cost
Silicon (Si)	Low	High	400 - 1000	Low
Black Silicon (b-Si)	Low	Medium	240 - 1170	Med
Germanium (Ge)	High	Low	900 - 1600	Low
Gallium Phosphide (GaP)	Low	High	150 - 550	Med
Indium Gallium Arsenide (InGaAs)	Low	High	800 - 1800	Med
Extended Range: Indium Gallium Arsenide (InGaAs)	High	High	1200 - 2600	High
Lead Sulfide (PbS)	N/A[b]	Low	1000 - 2900	Med
Lead Selenide (PbSe)	N/A[b]	Low	1500 - 4800	Med
Indium Arsenide Antimonide (InAsSb)	N/A[c]	High	1000 - 5300[d]	Med

a. Approximate values; actual wavelength values will vary.
b. These are photoconductive detectors, normally AC coupled.
c. Photovoltaic Detectors, Generally Unbiased
d. At 25 °C

4.3 Transimpedance and Conversion Gain

The transimpedance gain (TG) of the PDA10X2 detector is the total gain of both amplifier stages (in units of V/A).

The conversion gain (CG) (in units of V/W) is simply the product of the photodiode responsivity ($\Re(\lambda_p)$) and the transimpedance gain.

As a result, the output voltage for a given optical power and wavelength is given by the input optical power times the conversion gain.

However, the user should be aware that changing the final load resistance on the PDA10X2 detector changes the conversion gain of the system. This is due to the internal 50 Ω series resistor shown in the block diagram.

The final load resistance creates a voltage divider with the 50 Ω series resistor (R_s). This changes the CG according to the following scale factor.

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

The actual CG is then given by the CG times the scale factor. Note that for a high impedance external load, the CG and actual CG are the same. For a 50 Ω external load, the actual CG is a factor of two smaller than the CG.

It is for this reason that the maximum output of the PDA10X2 detector is 10 V for high impedance loads and 5 V for 50 Ω loads. The user should also be aware that the linear, low distortion output range of the PDA10X2 detector is limited to about 6 V (3 V with a 50 Ω load) at maximum bandwidth to avoid saturation. This is limited by the maximum slew rate of the amplifier. Larger, linear swing can be achieved when not running at maximum bandwidth.

For best signal integrity, we recommend using a 50 Ω coaxial cable with a 50 Ω terminating resistor at the output end of the cable. This will minimize ringing by matching the cable with its characteristic impedance. If more output voltage is required, the load resistance can be increased. However, when the load resistance does not match the cable impedance, the length of the coaxial cable can have a negative impact on the signal integrity, unless the cable is kept very short.

The PDA10X2 detector is DC coupled, which means there is no low frequency cutoff and the output voltage will have a DC component that is proportional to the average optical power. Some instruments such as spectrum analyzers may require a DC block to prevent damage to the instrument. If a DC block is used, ensure that it has a flat frequency response up to 1 GHz to avoid adding distortion.

Some instruments may not support the high output voltage capability of the PDA10X2 detector. In these cases, an RF attenuator can be added between the PDA10X2 detector and the instrument to prevent damage to the instrument. If an attenuator is added, ensure that it supports at least 1 GHz bandwidth to avoid adding distortion. Also, note that RF attenuators are typically only meant to be used in 50 Ω systems and the attenuator will not perform correctly with an instrument with high impedance inputs.

Chapter 5 Maintenance and Cleaning

There are no serviceable parts in the PDA10X2 detector's optical head or power supply. The housing may be cleaned by wiping with a soft damp cloth. The window of the detector should only be cleaned using optical grade wipes. If you suspect a problem with your PDA10X2 detector, please contact us at techsupport@thorlabs.com and an engineer will be happy to assist you.

Chapter 6 Troubleshooting and Repair

Problem	Suggested Solutions
There is no signal response.	Verify that the power is switched on and all connections are secure.
	Verify that the power indicator LED on the power supply and the LED on the PDA are both on.
	Verify that the optical signal wavelength is within the specified wavelength range.
	Verify that the optical signal is illuminating the detector active area.
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 table. Be sure that no stray or unwanted light is entering the detector. Install a 1" Lens Tube (SM1L10) to the thread coupler (SM1T1) to baffle any external light sources to see if this improves the response.

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.



Corporate Headquarters
Thorlabs, Inc.
43 Sparta Ave
Newton, New Jersey 07860
United States

sales@thorlabs.com
techsupport@thorlabs.com

Product Manufacturer
Thorlabs, Inc.
43 Sparta Ave
Newton, New Jersey 07860
United States

sales@thorlabs.com
techsupport@thorlabs.com

EU Importer
Thorlabs GmbH
Münchner Weg 1
D-85232 Bergkirchen
Germany

sales.de@thorlabs.com
europe@thorlabs.com

UK Importer
Thorlabs Ltd.
204 Lancaster Way Business Park
Ely CB6 3NX
United Kingdom

sales.uk@thorlabs.com
techsupport.uk@thorlabs.com



THORLABS

www.thorlabs.com