PDA20X2
Black Si Switchable Gain Detector

User Guide



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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 lumberg connector applying +/- 12V. Gain is controlled through a dial on the side of the device.

1.2 Explanation of Safety Warnings

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


Caution


ESD Component Caution

CE UKCA 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 PDA20X2 is an amplified, switchable-gain, Black Silicon (b-Si) detector designed for detection of light signals ranging from 240 to 1170 nm. An eight-position rotary switch allows the user to vary the gain in 10 dB steps. A buffered output drives 50 Ω load impedances up to 5 V. The PDA20X2 housing includes a removable threaded coupler (Item # SM1T1) and retainer ring (Item # SM1RR) that is compatible with any number of Thorlabs 1" 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.


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.


Do NOT operate this device in explosive environments.

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

Performance Specifications[a]			
0 dB Setting		**40 dB Setting**	
Gain (Hi-Z)	1.51 x 10^3 V/A ±2%	**Gain (Hi-Z)**	1.51 x 10^5 V/A ±2%
Gain (50 Ω)	0.75 x 10^3 V/A ±2%	**Gain (50 Ω)**	0.75 x 10^5 V/A ±2%
Bandwidth[b]	11 MHz	**Bandwidth[b]**	110 kHz
Noise (RMS)	234 µV	**Noise (RMS)**	245 µV
NEP (@ λ_p)	6.0 x 10^{-11} W/√Hz	**NEP (@ λ_p)**	3.36 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
10 dB Setting		**50 dB Setting**	
Gain (Hi-Z)	4.75 x 10^3 V/A ±2%	**Gain (Hi-Z)**	4.75 x 10^5 V/A ±2%
Gain (50 Ω)	2.38 x 10^3 V/A ±2%	**Gain (50 Ω)**	2.38 x 10^5 V/A ±2%
Bandwidth[b]	1.3 MHz	**Bandwidth[b]**	40 kHz
Noise (RMS)	238 µV	**Noise (RMS)**	250 µV
NEP (@ λ_p)	6.15 x 10^{-12} W/√Hz	**NEP (@ λ_p)**	5.95 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
20 dB Setting		**60 dB Setting**	
Gain (Hi-Z)	1.5 x 10^4 V/A ±2%	**Gain (Hi-Z)**	1.5 x 10^6 V/A ±5%
Gain (50 Ω)	0.75 x 10^4 V/A ±2%	**Gain (50 Ω)**	0.75 x 10^6 V/A ±5%
Bandwidth[b]	1.4 MHz	**Bandwidth[b]**	11 kHz
Noise (RMS)	249 µV	**Noise (RMS)**	253 µV
NEP (@ λ_p)	3.27 x 10^{-12} W/√Hz	**NEP (@ λ_p)**	7.52 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)
30 dB Setting		**70 dB Setting**	
Gain (Hi-Z)	4.75 x 10^4 V/A ±2%	**Gain (Hi-Z)**	4.75 x 10^6 V/A ±5%
Gain (50 Ω)	2.38 x 10^4 V/A ±2%	**Gain (50 Ω)**	2.38 x 10^6 V/A ±5%
Bandwidth[b]	430 kHz	**Bandwidth[b]**	4 kHz
Noise (RMS)	246 µV	**Noise (RMS)**	265 µV
NEP (@ λ_p)	3.9 x 10^{-12} W/√Hz	**NEP (@ λ_p)**	5.01 x 10^{-12} W/√Hz
Offset	±8 mV (Typ.) ±12 mV (Max)	**Offset**	±8 mV (Typ.) ±12 mV (Max)

a. The PDA20X2 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. 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.

Electrical Specifications		
Detector	-	Black Silicon (b-Si)
Active Area	-	2.0 mm x 2.0 mm (4.0 mm^2)
Wavelength Range	λ	240 nm to 1170 nm
Peak Wavelength	λ_p	1010 nm (Typ.)
Peak Response	$\Re(\lambda_p)$	0.73 A/W (Typ.)
Amplifier GBP	-	600 MHz
Output Impedance	-	50 Ω
Max Output Current	I_{out}	100 mA
Load Impedance	-	50 to Hi-Z
Gain Adjustment Range	-	0 dB to 70 dB
Gain Steps	-	8 x 10 dB Steps
Output Voltage	V_{out}	0 V to 5 V (50 Ω) 0 V to 10 V (Hi-z)

General	
On/Off Switch	Slide
Gain Switch	8 Position Rotary
Output	BNC (DC Coupled)
Package Size	2.79” X 2.09” x 0.89” (70.9 mm x 52.5 mm x 22.5 mm)
PD Surface Depth[c]	0.1” (2.6 mm)
Weight, Detector Only	0.10 kg
Accessories	SM1T1 Coupler SM1RR Retainer Ring
Operating Temp	10 °C to 40 °C
Storage Temp	-20 °C to 70 °C
AC Power Supply	AC - DC Converter
Input Power[d]	6W 100 V / 120 V / 230 V, 50 - 60 Hz

c. Measured from the active area to the start of the threads on the housing body. The detector active area surface is flush with the font of the housing body.

d. Although the power supply is rated for 6 W, the detector’s actual usage is <5 W over the full operating range.

1.4.2 Graphs

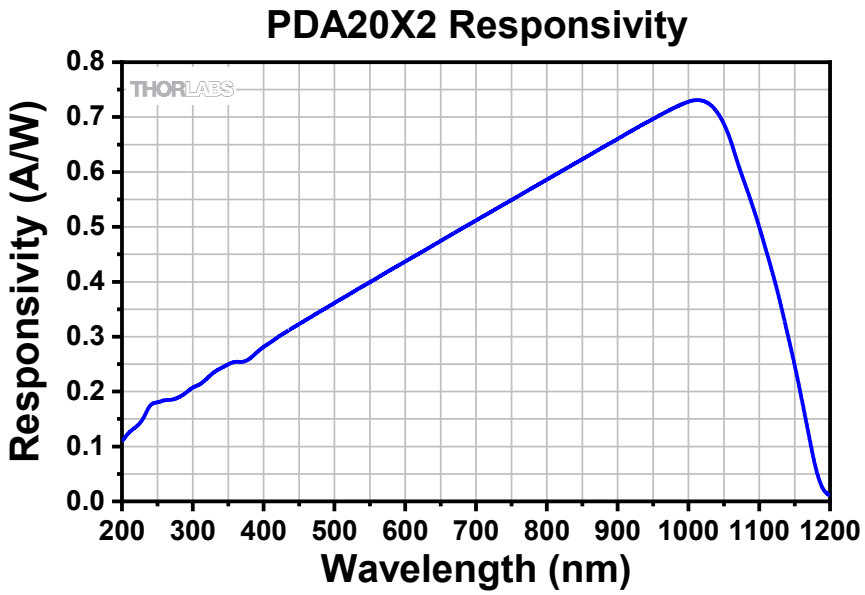


Figure 1 Typical Response Curve

1.4.3 Mechanical Drawings

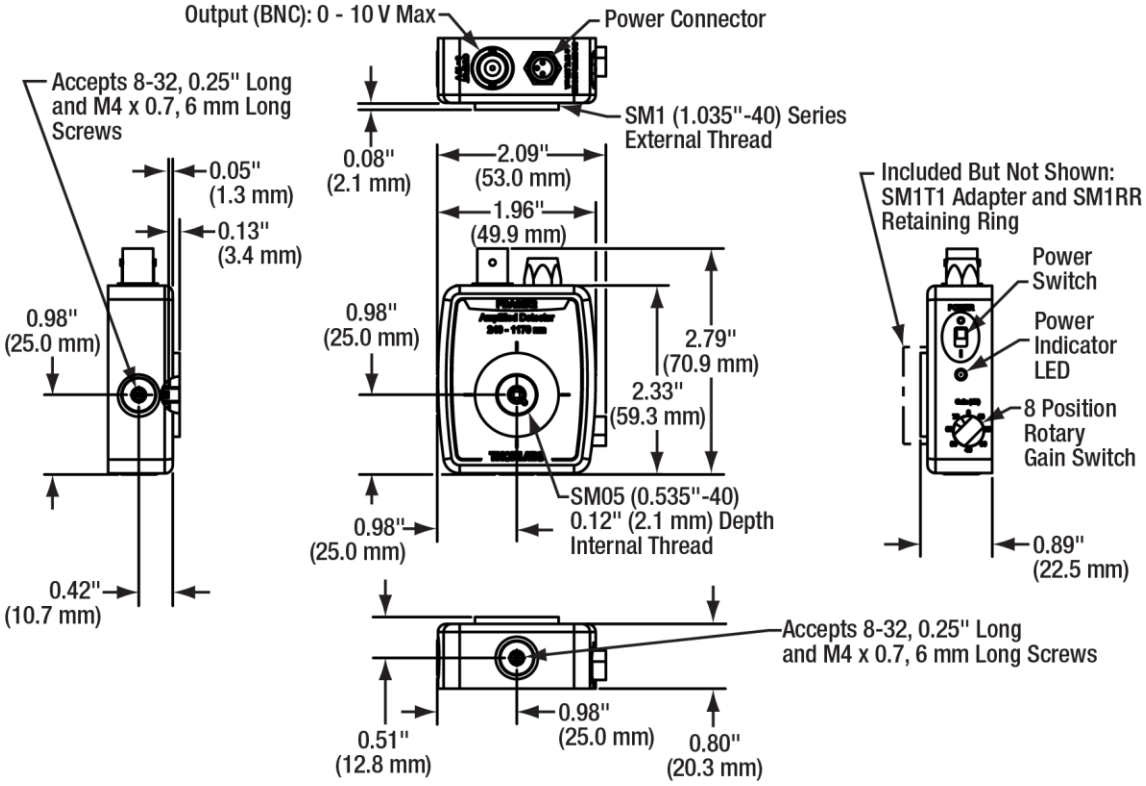


Figure 2 Mechanical Drawing

1.5 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

Chapter 2 Installation

2.1 Packing List/Special Tools Required for Installation

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

2.2 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 detector, 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 x 0.7 threads, so using either imperial or metric TR posts is possible.
2. Connect the power supply 3-pin plug into the power receptacle on the PDA20X2.
3. Plug the power supply into a 50 to 60 Hz, 100 V / 120 V / 230 V power outlet.
4. The PDA20X2 must be operated with proper shielded connection cables. Attach a 50 Ω coax cable (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 (Thorlabs 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 damage the output driver of the PDA20X2.
5. Power the PDA20X2 on using the power switch located on the top side of the unit.

NOTICE The unit should always be powered up using the power switch on the power supply or the unit itself. Hot plugging the unit is not recommended.

NOTICE

The PDA20X2 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.
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 desired setting.

NOTICE

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 3 Operation

3.1 Theory of Operation

Thorlabs PDA series are ideal for measuring both pulsed and CW light sources. The PDA20X2 includes a reverse-biased PIN photo diode, mated to a switchable gain transimpedance amplifier, and packaged in a rugged housing.

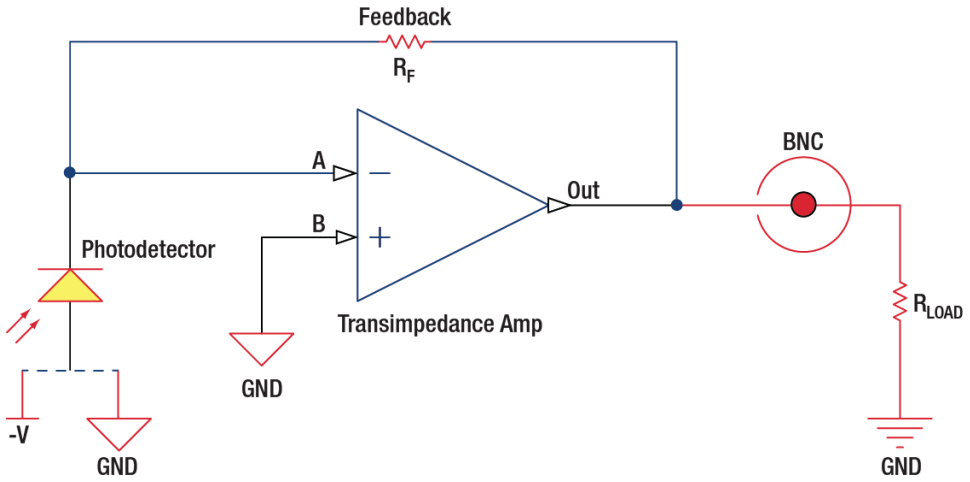


Figure 3 Photodetector with Transimpedance Amplifier Circuit Diagram

3.2 Responsivity

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:

$$R(\lambda) = \frac{I_{PD}}{P}$$

3.3 Dark Current

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[a]	Cost
Silicon (Si)	Low	High	400 - 1000 nm	Low
Black Silicon (b-Si)	Low	Medium	240 - 1170 nm	Med
Germanium (Ge)	High	Low	900 - 1600 nm	Low
Gallium Phosphide (GaP)	Low	High	150 - 550 nm	Med
Indium Gallium Arsenide (InGaAs)	Low	High	800 - 1800 nm	Med
Extended Range: Indium Gallim Arsenide (InGaAs)	High	High	1200 - 2600 nm	High

a. Approximate values; actual wavelength values will vary.

3.4 Bandwidth and Response

For the PDA detectors, the gain of the detector is dependent on the feedback element (R_f). The bandwidth of the detector can be calculated using the following:

$$f(-3dB) = \sqrt{\frac{GBP}{4\pi R_f \times C_D}}$$

Where GBP is the amplifier gain bandwidth product and C_D is the sum of the photodiode junction capacitance and the amplifier capacitance.

3.5 Terminating Resistance

The maximum output of the PDA20X2 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 PDA20X2 detector is below 10 V (5 V with a 50 Ω load) to avoid saturation.

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

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

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

Note that we already include the scale factor in our specification for the gain at 50 Ω. Refer to the table in Chapter 1 for additional performance specifications.

3.6 Gain Adjustment

The PDA20X2 includes a low noise, low offset, high gain transimpedance amplifier that allows gain adjustment over a 70 dB range. The gain is adjusted by rotating the gain control knob, located on the top side of the unit. There are 8 gain positions incremented in 10 dB steps. It is important to note that the bandwidth will decrease as the gain increases. See the specifications table on page 7 to choose the best gain verse bandwidth for a given input signal.

Chapter 4 Troubleshooting and Repair

Below are a few checks to help in troubleshooting problems that may arise. Please contact your local Thorlabs Technical Support office with any questions.

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 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 spec. in the Specifications table. Install a 1" Lens tube (SM1L10) to the thread coupler (SM1T1) to baffle any external light sources to see if this improves the response.

NOTICE

Do not remove the cover of the PDA20X2. There are no user serviceable parts in this product. Refer servicing to qualified personnel. Do not cover the device in order to prevent overheating of the instrument.

Chapter 5 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 6 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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