PDA015C2
InGaAs Amplified Fixed 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

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).

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.



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.

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.



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 2 Description

2.1 Introduction

The PDA015C2 detector, shown in Figure 1, is a high-speed amplified indium gallium arsenide (InGaAs) photodetector designed for detection of optical signals over the 800 nm to 1700 nm wavelength range. It has a frequency response from DC to 380 MHz, a 1 ns impulse response time, and a maximum transimpedance gain of 50 kV/A. A buffered output drives 50 Ω loads up to 5 V with an NEP of 20 pW/√Hz.

The LDS12B± 12 VDC 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 PDA015C2 detector 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 1 Features of the PDA015C2 Amplified Fixed Gain Detector

2.2 Maintenance and Care

There are no serviceable parts in the PDA015C2 detector's optical head or the LDS12B external 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 PDA015C2 detector, please contact us at techsupport@thorlabs.com and an engineer will be happy to assist you.

Chapter 3 Setup Guide

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 x 0.7 threads, so using either imperial or metric posts is possible.
2. Connect the LDS12B power supply 3-pin plug into the power receptacle on the PDA015C2 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.



Caution!
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.



Caution!
Immediately after the power switch on the PDA015C2 detector is switched on, the detector's output 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 PDA015C2 detector using the sliding switch before connecting to its output.

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 PDA015C2 detector.
5. Power the PDA015C2 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.
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 PDA015C2 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.



Caution!

The PDA015C2 detector was designed to allow maximum accessibility to the photodetector by having the front surface of the PD 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.

Chapter 4 Operation

4.1 Theory of Operation

Thorlabs' PDA015C2 detector is ideal for measuring both modulated/pulsed and CW light sources. As is shown in Figure 2, the PDA015C2 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.

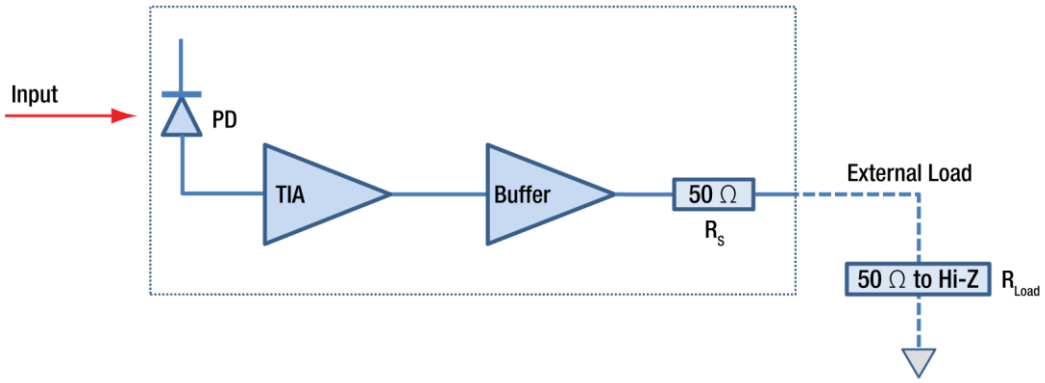


Figure 2 Block Diagram of the PDA015C2 Amplified InGaAs Photodetector

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):

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

The dark current is defined as the current from the photodiode when no light is applied. Depending on the photodiode size, material, and reverse-bias voltage, the dark current can range from less than 1 nA up to many µA. In the case of the PDA015C2 detector, in most cases the dark current is small enough to ignore (<3 nA).

Note that the PDA015C2 detector also has a dark output voltage (see specifications in Chapter 7), which is dominated by the input offset voltage error of the TIA. This is significantly larger than any contribution due to the PD dark current.

4.3 Transimpedance and Conversion Gain

The transimpedance gain (TG) of the PDA015C2 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 PDA015C2 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 PDA015C2 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 PDA015C2 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 PDA015C2 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 PDA015C2 detector. In these cases, an RF attenuator can be added between the PDA015C2 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. Note that RF attenuators are typically only meant to be used in systems where the load is 50 Ω. Also, note that the attenuator will not perform correctly with an instrument with high impedance inputs.

Chapter 5 Troubleshooting

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 spec. 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 6 Specifications

Electrical Specifications[a]		
Detector	-	InGaAs PIN Photodiode
Active Area	-	Ø150 µm (0.018 mm^2)
Wavelength Range	λ	800 to 1700 nm
Peak Wavelength	λ_p	1550 nm
Optical Input Power, Max[b]	-	180 µW
Peak Responsivity	$\Re(\lambda_p)$	0.95 A/W
Small Signal Bandwidth	-	380 MHz
Impulse Response	-	1 ns (FWHM)
NEP (λ_p)[c]	-	20 pW//√Hz (DC - 380 MHz)
Output Noise (RMS)[c]	-	9 mV_{RMS} (DC - 380 MHz)
Output Current, Max	I_{OUT}	100 mA
Output Dark Offset	-	20 mV
Load Impedance	-	50 Ω to Hi-Z
Transimpedance Gain **Hi-Z** **50 Ω**	-	 5 x 10^4 V/A 2.5 x 10^4 V/A
Output Voltage	V_{OUT}	0 to 5 V (50 Ω) 0 to 10 V (Hi-Z)
Linear Output[d], Max	-	3 V (50 Ω) 6 V (Hi-Z)
Output Slew Rate, Max	-	2.5 V/ns (50 Ω) 5 V/ns (Hi-Z)

a) All performance specifications are typical and assume a 50 Ω load unless stated otherwise.
b) For Linear Operation
c) Measured with a 50 Ω Load
d) Linear operating range is restricted due to slew rate limitations at the maximum bandwidth.

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]	0.16" (4.1 mm)
Weight, Detector Only	0.1 kg
Accessories	SM1T1 Coupler SM1RR Retaining Ring
Operating Temp	10 to 40 °C
Storage Temp	-25 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 VAC / 120 VAC / 230 VAC, Switch Selectable
Output Regulation	± 5% Measured at Output Connector
Output Power (Rated)	6 W (Max)
Input Current	0.25 A / 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

6.1 Responsivity

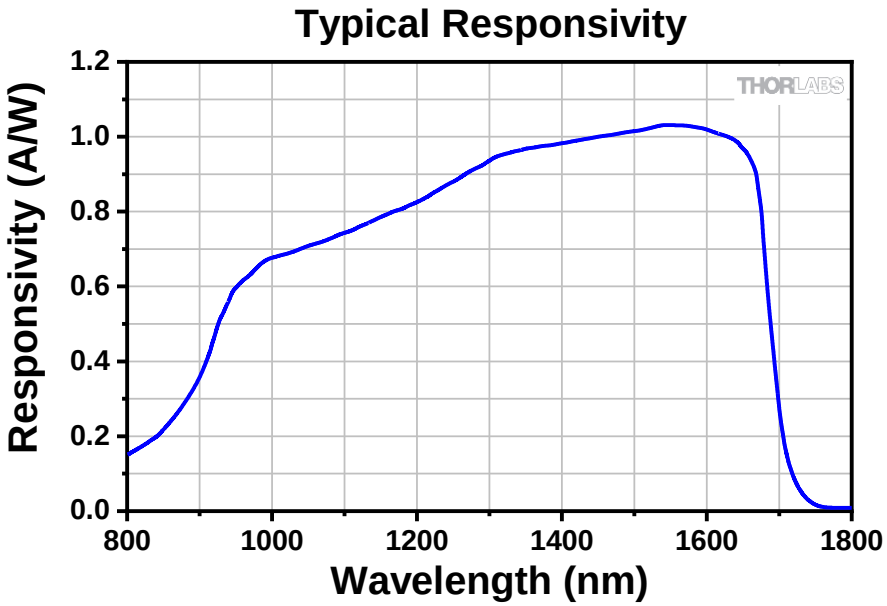


Figure 3 Typical Responsivity of the PDA015C2 Detector

6.2 Temporal Response

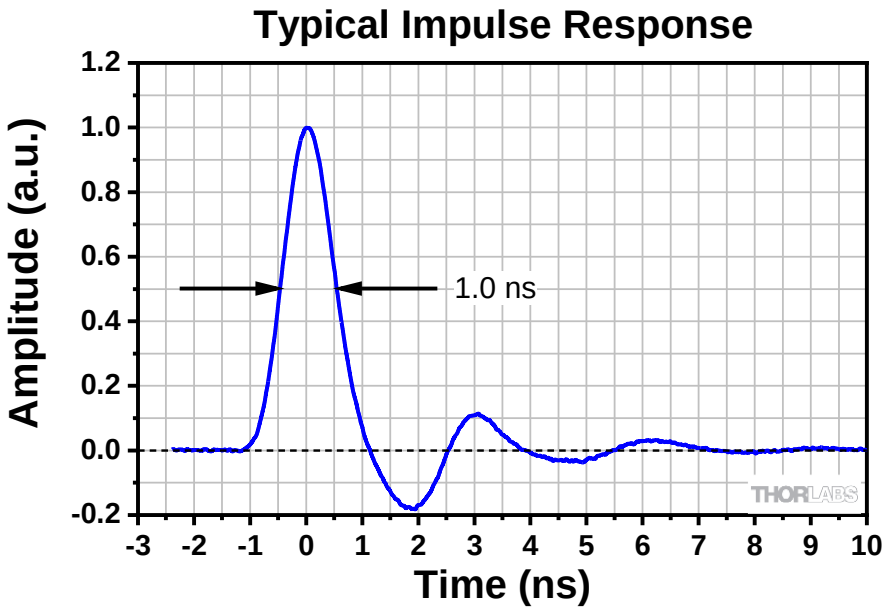


Figure 4 Typical Impulse Response of the PDA015C2 Detector

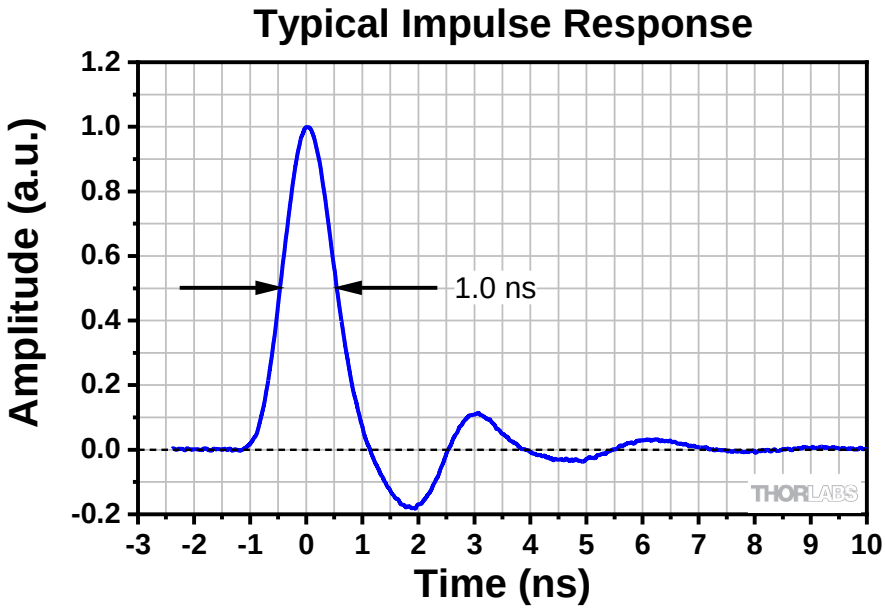


Figure 5 Typical Step Response of the PDA015C2 Detector

6.3 Frequency Response

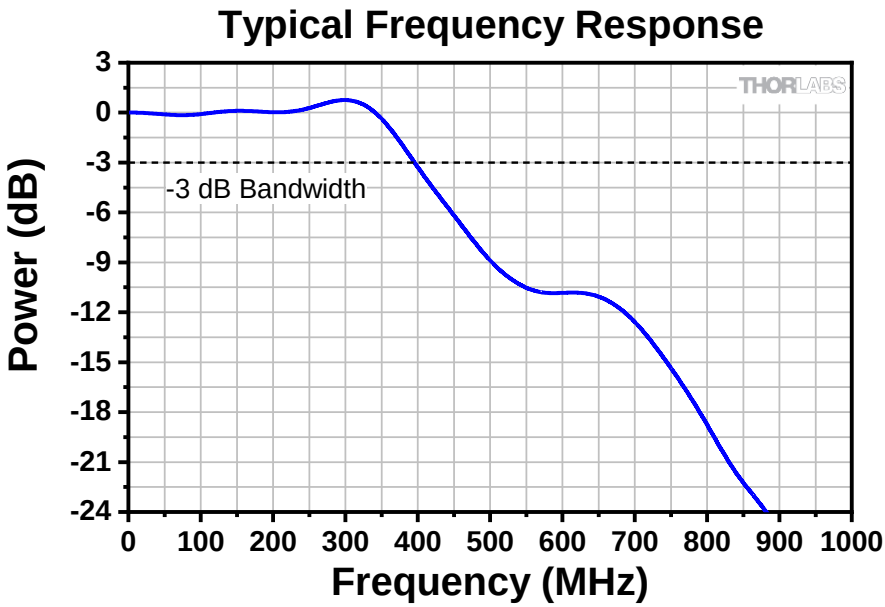


Figure 6 Typical Frequency Response of the PDA015C2 Detector

6.4 Electrical Return Loss

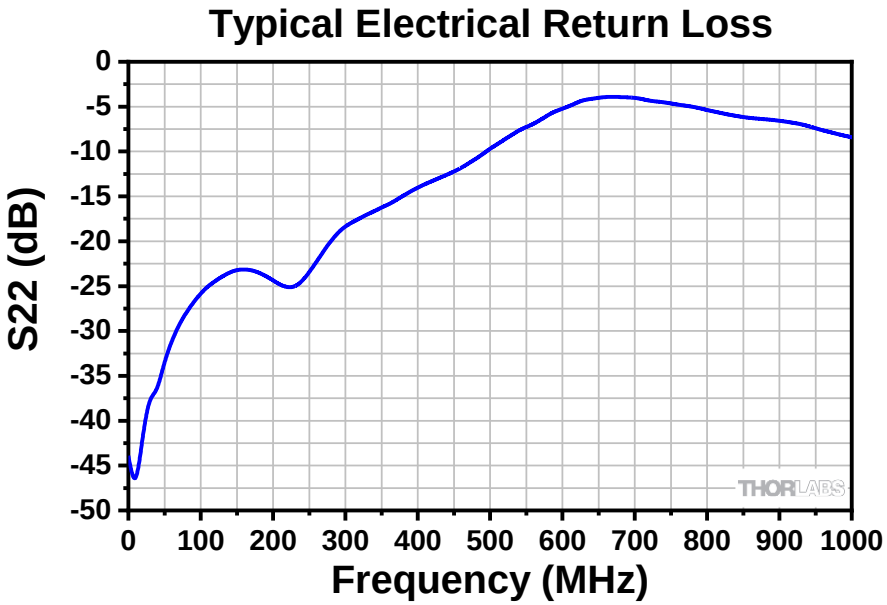


Figure 7 Typical Electrical Return Loss of the PDA015C2 Detector

6.5 Noise Spectrum

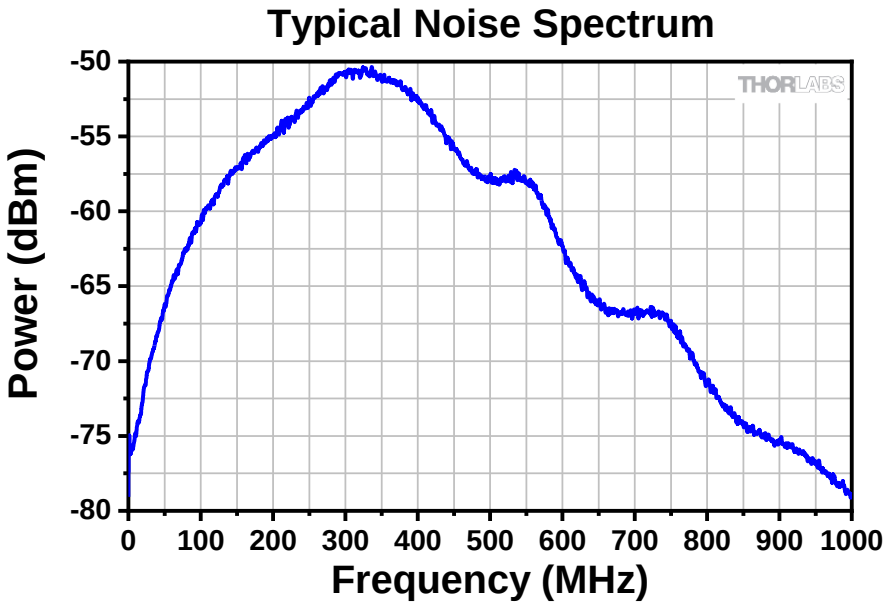


Figure 8 Typical Noise Spectrum for the PDA015C2 Detector, Measured with a 50 Ω Load and 900 kHz Resolution Bandwidth

6.6 Noise Equivalent Power (NEP)

Each point on this curve was calculated by integrating the noise power from DC to the given frequency value and then dividing by the square root of that bandwidth. The NEP gives the amount of input optical power required to match the output noise level. The actual output noise level (in mV_{RMS}) can be calculated by multiplying the data in this graph by the conversion gain and the square root of the bandwidth.

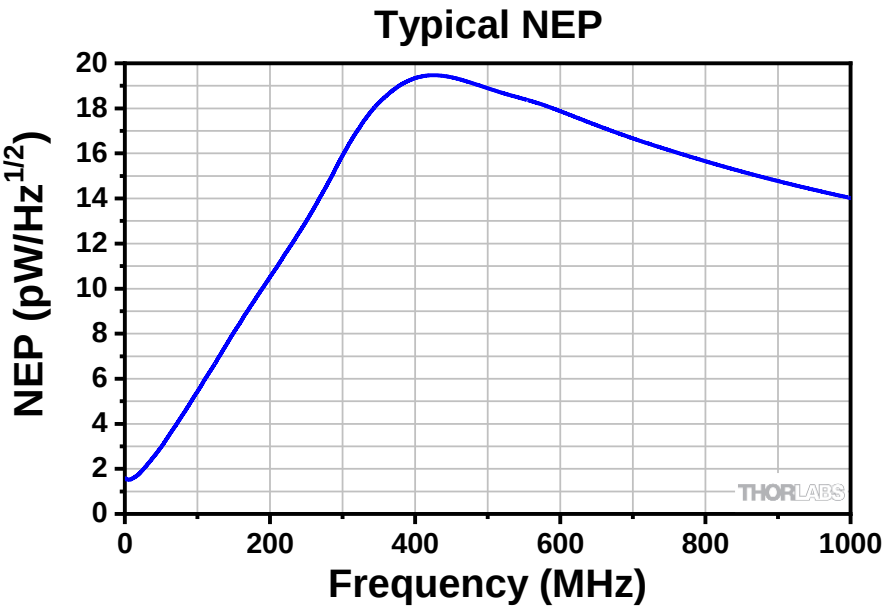
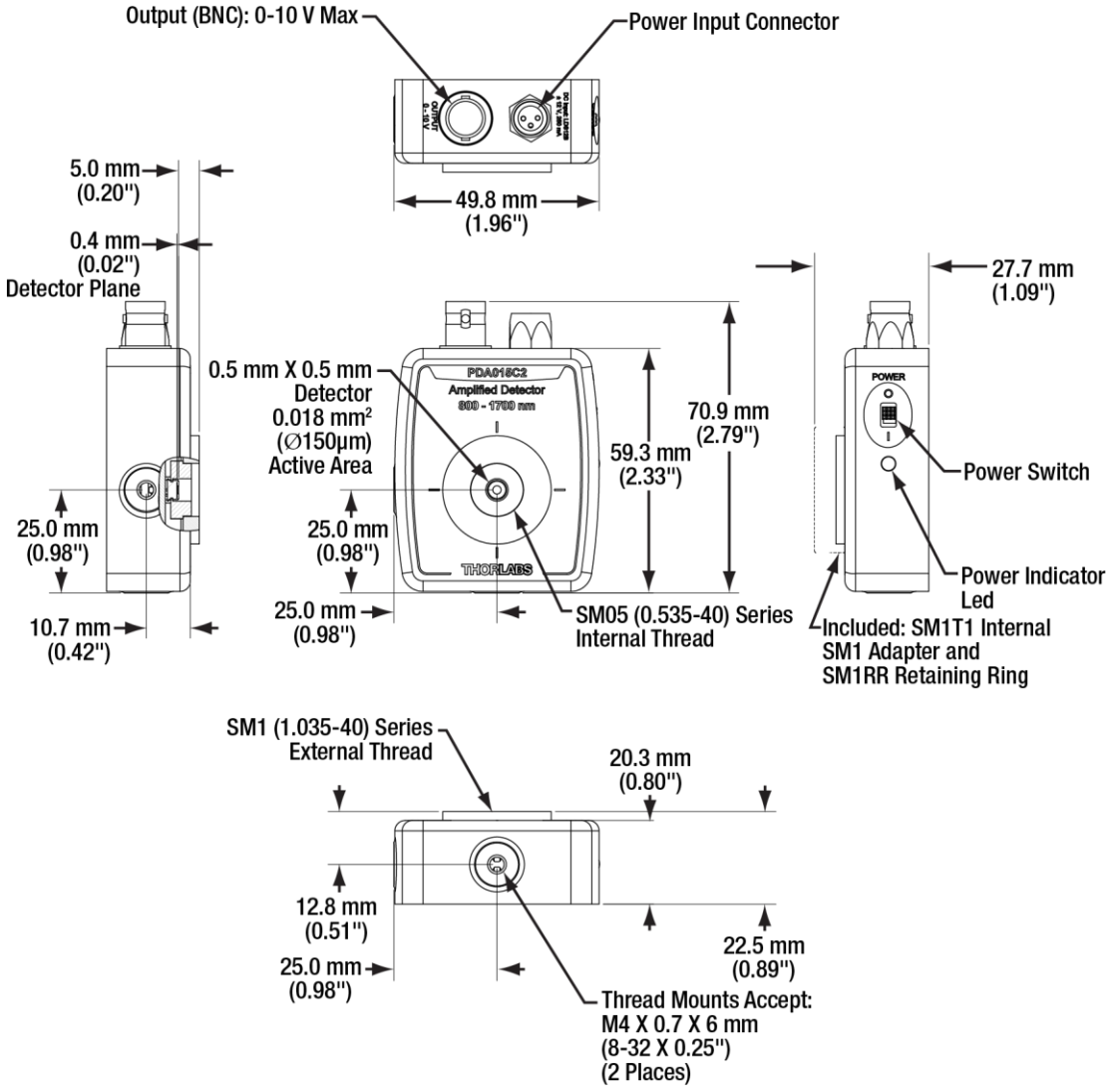


Figure 9 ***Typical NEP for the PDA015C2 detector at the Maximum Responsivity Wavelength, Measured with a 50 Ω Load***

6.7 Mechanical Drawing



Chapter 7 Certificate of Conformance



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: ***PDA015A2 and PDA015C2***

Equipment: ***Si & InGaAs Amplified Detectors***

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:

contains no 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 June 2023

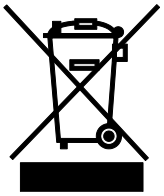
Name: Danielle Strong

Position: Director of Quality and Compliance

EDC - PDA015A2 and PDA015C2 -2C

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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