THORLABS

APD431A, APD431C

Fiber-Coupled Avalanche Photodetector

User Guide



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Chapter 1 Introduction

1.1 Intended Use

The APD431x Fiber-Coupled Avalanche Photodetector is intended to detect weak light intensities in laboratory environment in laboratory settings under compliance with the regulations of EN 61326-1:2021.

The APD431x Fiber-Coupled Avalanche Photodetector 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 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 or moderate injury.

NOTICE

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





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 temperature-compensated APD431x Fiber-Coupled Avalanche Photodetector combines a highly sensitive InGaAs (APD431C) or Si (APD431A) avalanche photodiode with a specially developed, extremely low-noise transimpedance amplifier for detecting optical signals from DC to 400 MHz.

The APD431x Fiber-Coupled Avalanche Photodetector has an exceptionally low Noise Equivalent Power (NEP) value, making it ideal for fast detection applications in low light (see below).

- Spectroscopy
- Fluorescence Measurements
- Laser Radar
- Optical Rangefinders

Due to its very high sensitivity, the APD431x Fiber-Coupled Avalanche Photodetector can replace photomultiplier tubes (PMT) in many applications. The APD431x Fiber-Coupled Avalanche Photodetector cannot be damaged by unwanted ambient light, which is an advantage over many photomultiplier tubes.

The APD431x Fiber-Coupled Avalanche Photodetector features a continuously adjustable gain that is based on the adjustment of the M Factor (multiplication factor). It also incorporates a special electronic circuit to compensate for the temperature dependency of the M Factor.

The slim line housing includes a threaded coupler that is compatible with the SM1A610 mechanical adapter. This allows mounting of external optics, filters, apertures and other standard optomechanical components.

The APD431x Fiber-Coupled Avalanche Photodetector is compatible with the following fiber connector types:

- FC/PC (Narrow-Key)
- FC/APC (Narrow-Key)
- LC/PC
- SC/PC

Please see the Ordering Codes and Accessories for a full list of compatible fiber and mechanical adapters.

The APD431x Fiber-Coupled Avalanche Photodetector has three universal 8-32 / M4 x 0.7-tapped mounting holes.

The APD431x Fiber-Coupled Avalanche Photodetector is powered by the included external power supply LDS12B (±12 VDC, 250 mA) via a PICO M8 power connector. The LDS12B features a current limit for short circuit and overload protection, an On/Off switch with LED Indicator, and a switchable AC input voltage (100 VAC, 120 VAC or 230 VAC). This power supply ships with a location-specific power cord. The appropriate input voltage can be selected with a switch on the power supply LDS12B.

1.4 Technical Data

1.4.1 Specifications

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

Item #	APD431A	APD431C
Detector Type	Si	InGaAs
Wavelength Range	400 to 1000 nm	900 to 1700 nm
Maximum APD Responsivity	53 A/W @ 800 nm, M = 100	18 A/W @ 1550 nm, M = 20
M Factor	10 to 100 (Continuous)	4 to 20 (Continuous)
M Factor Temperature Stability	±2% (Typical) ±3% (Max)	
Detector Active Area Diameter	0.5 mm (0.002")	0.2 mm (0.008")
Transimpedance Gain[a]	5 kV/A (50 Ω Termination), 10 kV/A (High-Z Termination)	
Maximum Conversion Gain[b]	5.3 x 10^5 V/W	1.8 x 10^5 V/W
Output Bandwidth (3 dB)[c]	DC to 400 MHz	
CW Saturation Power[d]	8.0 µW @ 800 nm (M = 100) 80 µW @ 800 nm (M = 10)	22 µW @ 1550 nm (M = 20) 110 µW @ 1550 nm (M = 4)
Maximum Input Power[e]	1 mW	
Minimum NEP	0.14 pW / √ Hz (DC - 100 MHz)	0.45 pW / √ Hz (DC - 100 MHz)
Integrated Noise	5.5 nW (RMS, DC - 400 MHz)	17 nW (RMS, DC - 400 MHz)
Connector Threading	External M12 x 0.5	
Electrical Output, Impedance	BNC, 50 Ω	
Maximum Output Voltage Swing[a]	2.0 V (50 Ω Termination), 4.1 V (High-Z Termination)	
DC-Offset Electrical Output	<±3 mV	
Power Supply	±12 V, 250 mA (100 VAC/120 VAC/230 VAC, Switchable, 50 to 60 Hz)	
General		
Operating Temperature Range	0 °C to 40 °C	
Storage Temperature Range	-40 °C to 70 °C	
Dimensions (W x H x D)	74.5 mm x 55.8 mm x 33.7 mm (2.93" x 2.20" x 1.33")	
Weight	0.122 kg (0.269 lbs)	

a. 50 Ω termination is recommended for the best performance.
b. At the Peak Responsivity Wavelength
c. At Maximum Gain Setting
d. For Free-Space Input
e. This value is the damage threshold for the photodiode.

Table 1 Specifications for the APD431x Fiber-Coupled Avalanche Photodetector

1.4.2 Graphs

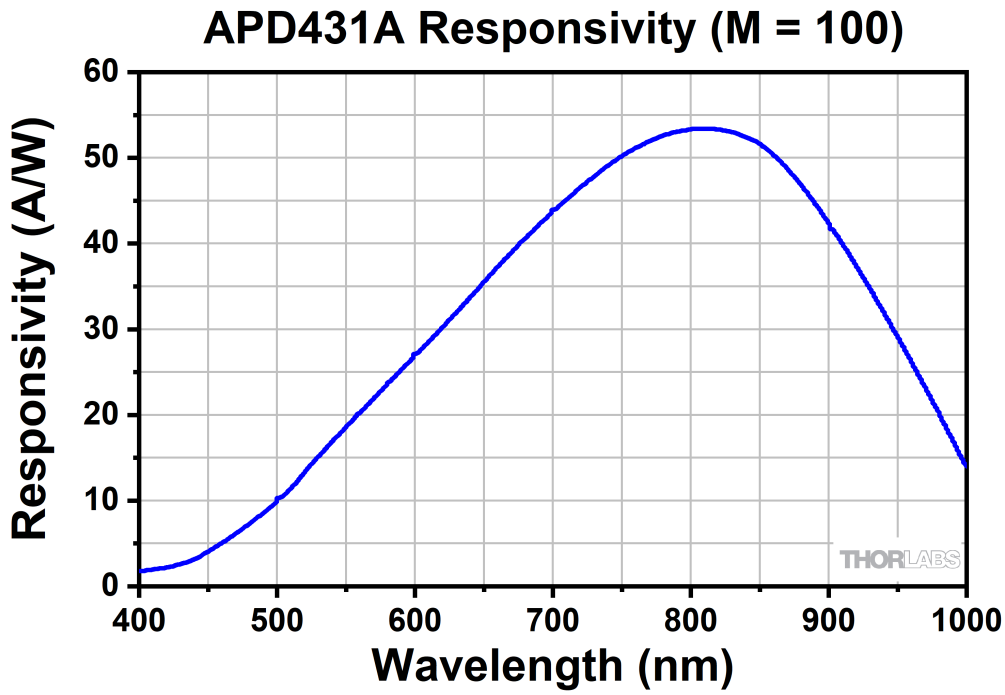


Figure 1 Typical Responsivity Curves for the APD431A

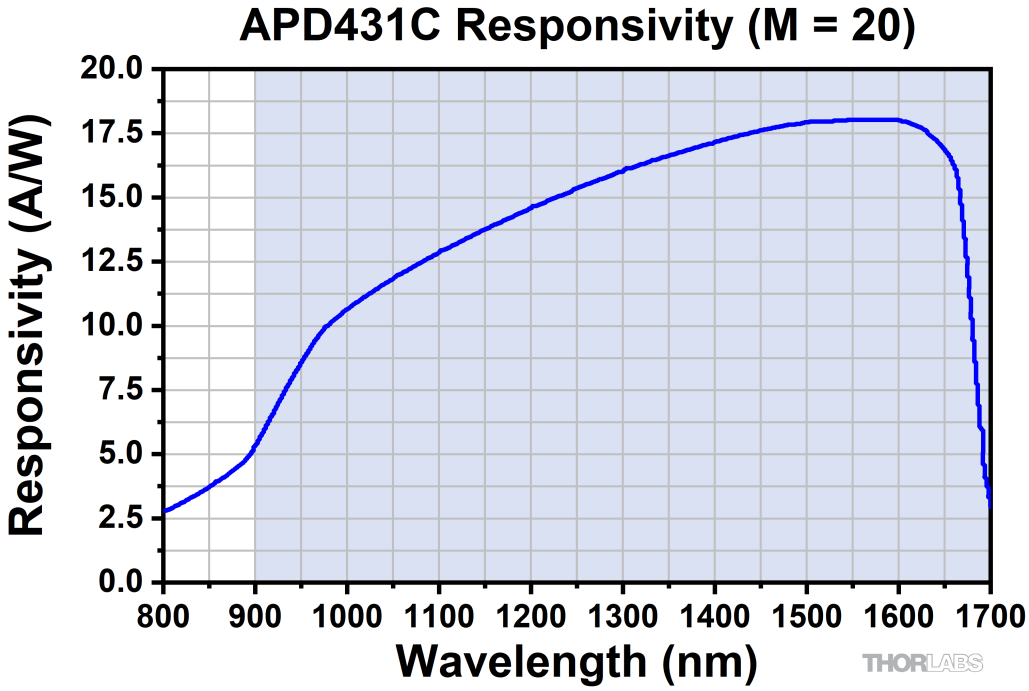


Figure 2 Typical Responsivity Curves for the APD431C[a]

a. The blue highlighted region denotes the operating wavelength range.

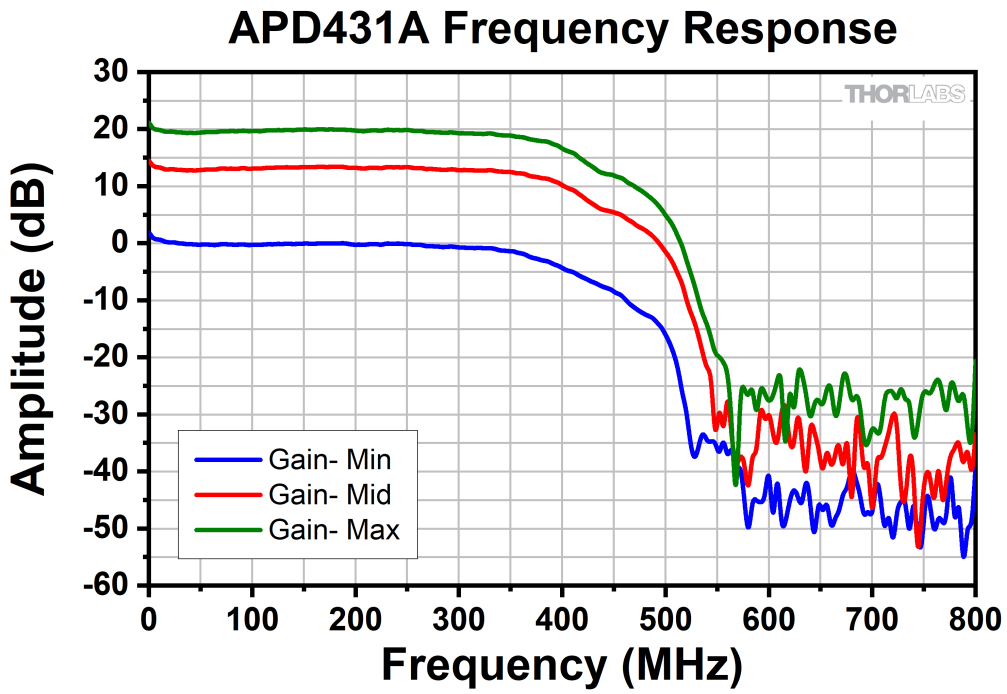


Figure 3 *Typical Output Frequency Response for the APD431A*

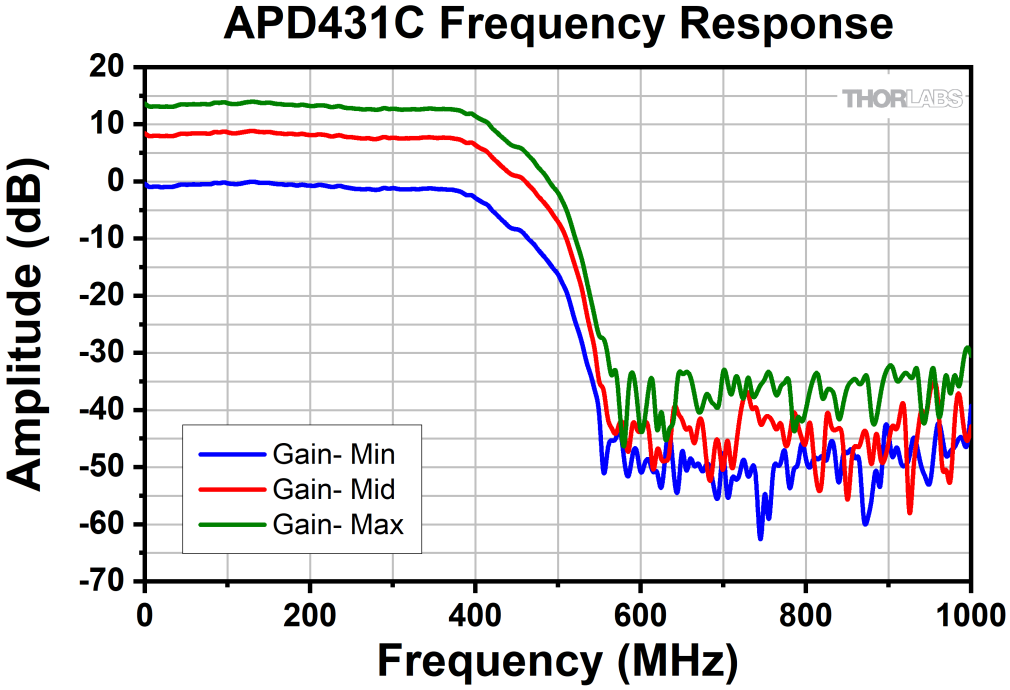


Figure 4 *Typical Output Frequency Response for the APD431C*

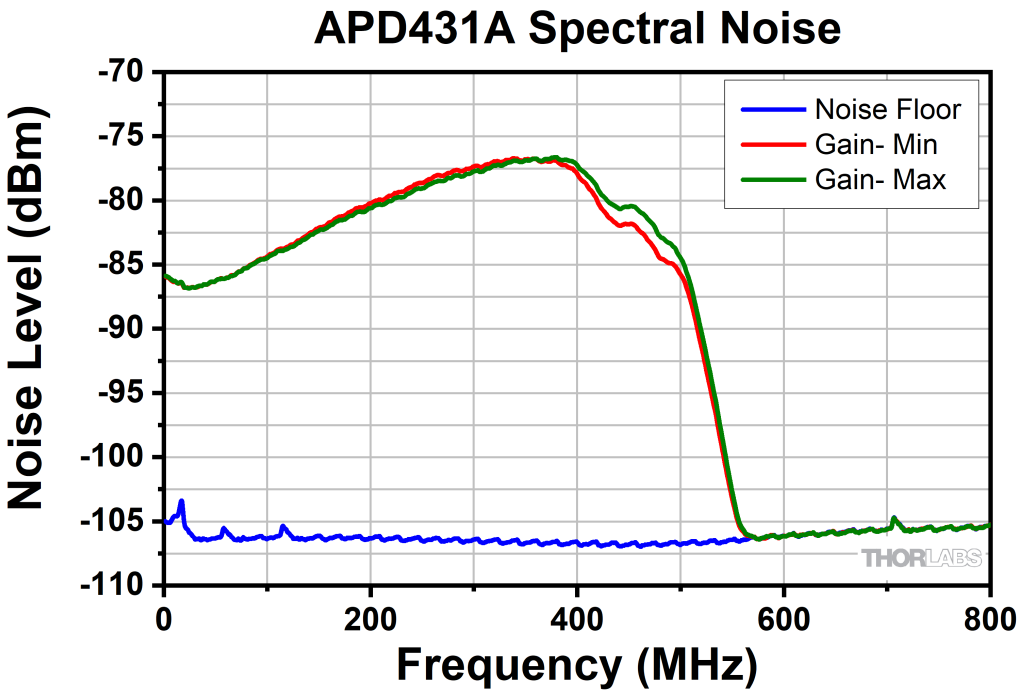


Figure 5 Typical Spectral Noise Distribution for the APD431A

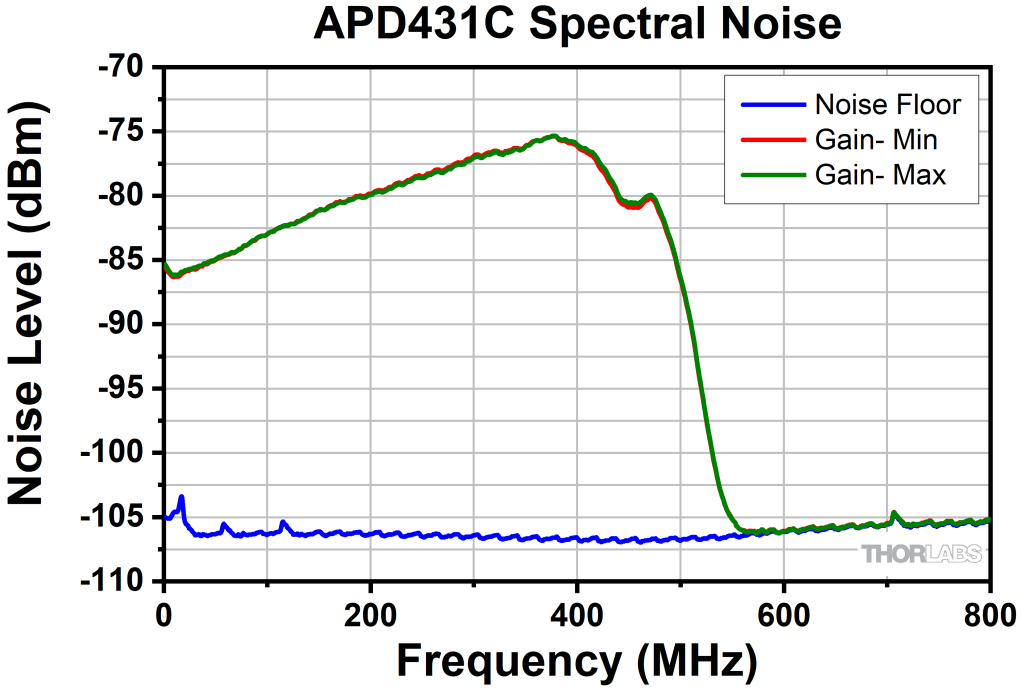


Figure 6 Typical Spectral Noise Distribution for the APD431C

1.4.3 Mechanical Drawings

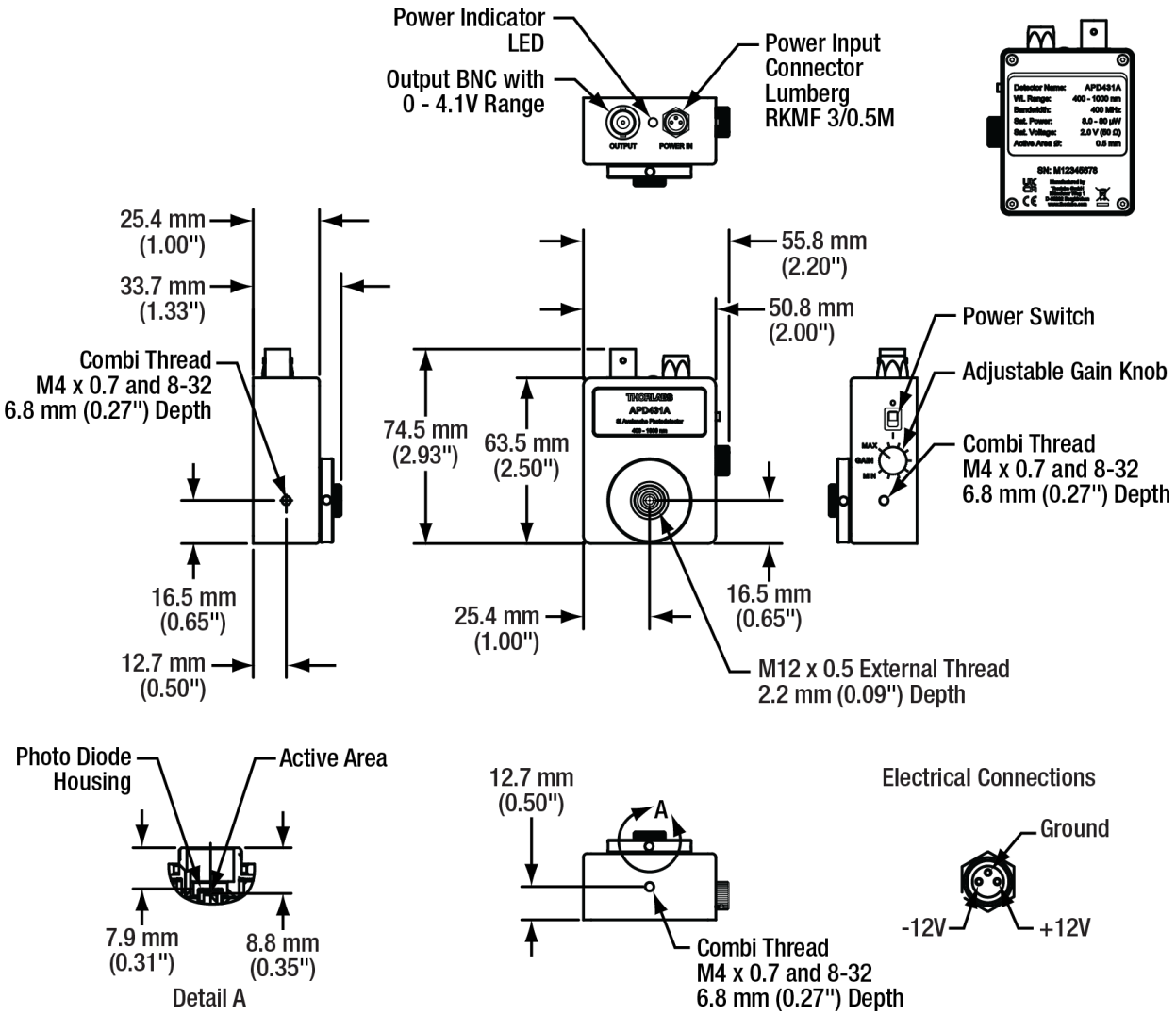


Figure 7 Mechanical Drawing of the APD431A

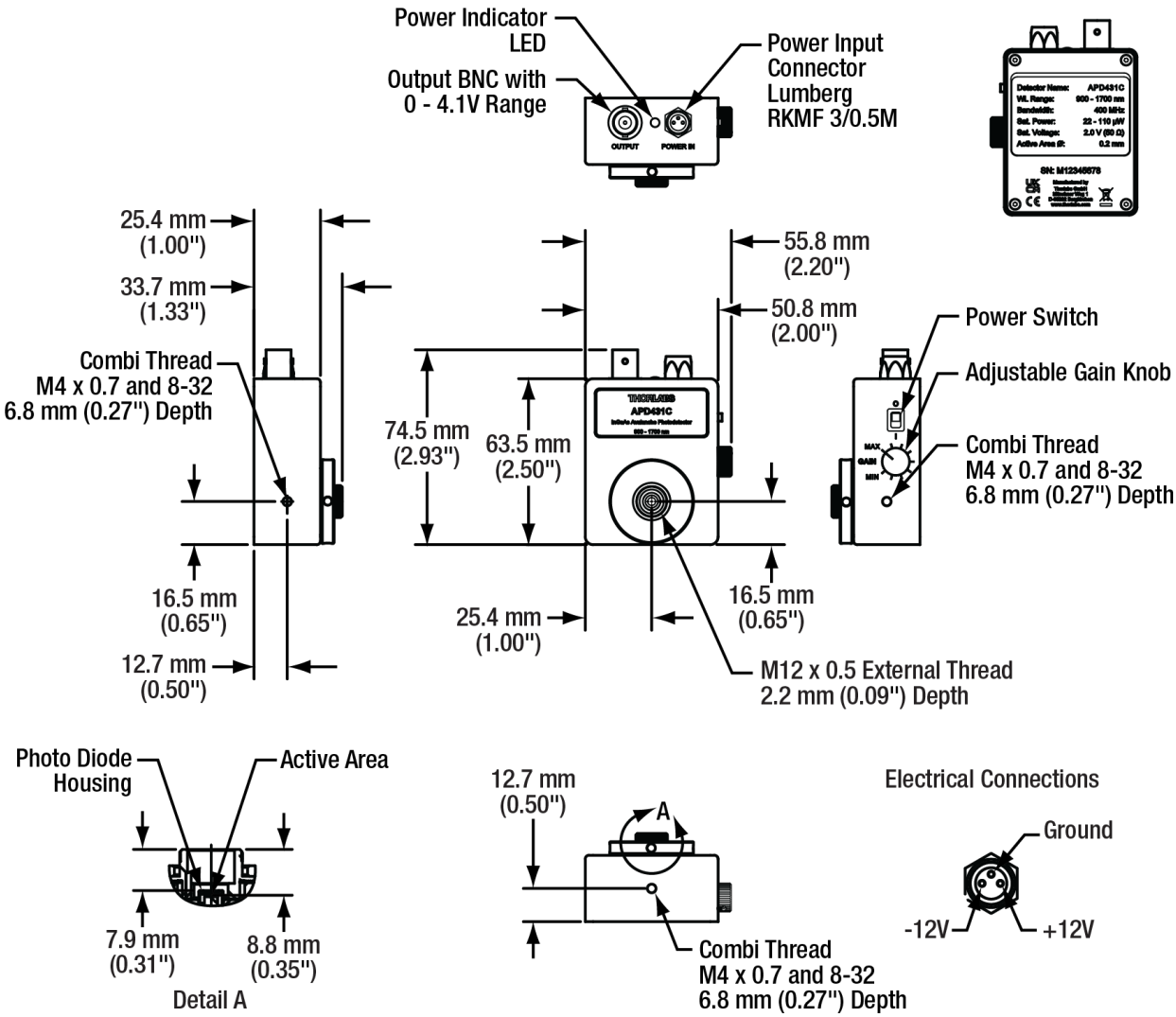


Figure 8 Mechanical Drawing of the APD431C

1.5 Ordering Codes and Accessories

Item #	
APD431A	Si Variable-Gain Avalanche Detector, Fiber-Flange, Temperature Compensated, 400 - 1000 nm, DC - 400 MHz, Three Universal 8-32 / M4 x 0.7-Tapped Mounting Holes
APD431C	InGaAs Variable-Gain Avalanche Photodetector, Fiber-Flange, Temperature Compensated, 900 - 1700 nm, DC - 400 MHz, Three Universal 8-32 / M4 x 0.7-Tapped Mounting Holes

Accessories

Item #	
APDA2-A	Narrow-Key (2.0 mm) FC/APC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 350 - 700 nm
APDA2-B	Narrow-Key (2.0 mm) FC/APC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 600 - 1050 nm
APDA2-C	Narrow-Key (2.0 mm) FC/APC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 1050 - 1700 nm
APDF2-A	Narrow-Key (2.0 mm) FC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 350 - 700 nm
APDF2-B	Narrow-Key (2.0 mm) FC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 600 - 1050 nm
APDF2-C	Narrow-Key (2.0 mm) FC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 1050 - 1700 nm
APDL-A	LC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 350 - 700 nm
APDL-B	LC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 600 - 100 nm
APDL-C	LC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 1050 - 1700 nm
APDS-A	SC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 350 - 700 nm
APDS-B	SC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 600 - 1050 nm
APDS-C	SC/PC Avalanche Photodetector Fiber Connector Adapter, AR Coating: 1050 - 1700 nm
SM1A610	Adapter with External SM1 Threads and Internal M12 x 0.5 Threads, Knurled Edge

1.6 Components



Figure 9 Components of the APD431x Fiber-Coupled Avalanche Photodetector

Callout	Description
1	Inidication LED
2	Power In
3	On/Off Swich
4	Adjustable Gain Knob
5	M12 x 0.5 mm Adapter
6	Locking Ring
7	BNC Output

Table 2 Components of the APD431x Fiber-Coupled Avalanche Photodetector

NOTICE

NOTICE: Risk of Damaging the APD431x Fiber-Coupled Avalanche Photodetector!

Loosening the locking ring can change the alignment of the optic and possibly damage the APD431x Fiber-Coupled Avalanche Photodetector!

Do not open the lock ring under any circumstances. If you have any questions about the APD431x Fiber-Coupled Avalanche Photodetector, please contact the Tech Support.

Chapter 2 Safety

The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly as it was designed for.



WARNING: Risk of Serious Injury and Even Death Due to Explosion!

The APD431x Fiber-Coupled Avalanche Photodetector 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! There are no user-serviceable parts inside!
- Refer servicing to qualified personnel!
- Changes to this APD431x Fiber-Coupled Avalanche Photodetector cannot be made nor may components not supplied by Thorlabs be used without written consent from Thorlabs.

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.

NOTICE

The APD431x Fiber-Coupled Avalanche Photodetector has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.9 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 and RMA Information

Thorlabs warrants material and production of the APD431x Fiber-Coupled Avalanche Photodetector for a period of 24 months starting with the date of shipment in accordance with and subject to the terms and conditions set forth in Thorlabs' General Terms and Conditions of Sale which can be found at:

General Terms and Conditions:

https://www.thorlabs.com/Images/PDF/LG-PO-001_Thorlabs_terms_and_%20agreements.pdf

and

https://www.thorlabs.com/images/PDF/Terms%20and%20Conditions%20of%20Sales_Thorlabs-GmbH_English.pdf

3.2 Packing List

Verify that you have received the following items within the package:

- APD431x Fiber-Coupled Avalanche Photodetector
- LDS12B Power Supply (±12V, 250 mA), 100/120/230 VAC Line Voltage
- Printed Quick Reference

3.3 Unpacking Instructions

Please inspect the shipping container for damage. Please do not cut through the cardboard, as the box might be needed for storage or returns.

If the shipping container appears to be damaged, keep it until you have inspected the contents for completeness and tested the APD431x Fiber-Coupled Avalanche Photodetector mechanically and electrically.

Verify that you have received the items listed in the chapter Packing List within the package.

3.4 Installation Instructions

3.4.1 Installing Hardware

1. Unpack the unit and accessories carefully.
   ➤ If any damage is noticed, do not use the unit. Call Thorlabs and have us replace the defective unit.
2. Mount the unit on your optical table or application by using one of the three tapped mounting holes (see chapter Mounting).
3. Remove the tape that protects the optical input.
4. Mount the fiber adapters, the external optics, the filters or the apertures.



Figure 10 LDS12B Power Supply

Callout	Description
1	On/Off Switch
2	Power Supply Switch
3	Power Connection

Table 3 LDS12B Power Supply

5. Adjust the power supply to accommodate your local mains voltage (100 VAC/120 VAC/230 VAC) using the power supply switch.
6. Plug the power connector cable into the "power in".
7. Plug the power supply into the outlet of the APD431x Fiber-Coupled Avalanche Photodetector.
8. Switch on the power supply.
9. Connect the BNC output of the APD to your data acquisition device with a coaxial cable.
   ➤ Note that a 50 Ω impedance device should be used for best RF performance.

3.4.2 Mounting

Mounting External Optics

The APD431x Fiber-Coupled Avalanche Photodetector housing allows for the mounting of external optics, filters or apertures via the SM1A610 mechanical adapter.

Mounting Fiber Adapters

The APD431x Fiber-Coupled Avalanche Photodetector housing only allows for the mounting of the fiber adapters listed in the chapter Ordering Codes and Accessories.

Note that all of the fiber optic adapters listed in the chapter Ordering Codes and Accessories are installed in the same way as shown in the following steps using the APDL-A fiber adapter as an example.

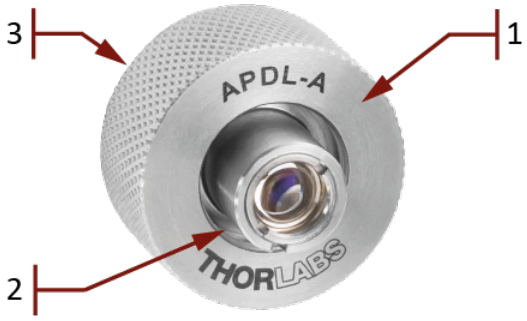


Figure 11 Mounting the Fiber Adapter APDL-A

Callout	Description
1	Fiber Optic Adapter Housing
2	Locking Ring
3	Fiber Connector Side

Table 4 Mounting the Fiber Adapter APDL-A

1. Push the adapter with the side labeled "Thorlabs" onto the fiber adapter connection port
2. Screw the locking ring on the adapter to the port.
   ➤ The connection is secured.
3. Mount the fiber connector to the adapter on the APD431x Fiber-Coupled Avalanche Photodetector.

Mounting on an Optical Table

Mount the APD431x Fiber-Coupled Avalanche Photodetector on an optical post by using one of the three tapped mounting holes on the sides and bottom. The combi-thread tapped holes accept both 8-32 and M4 x 0.7 threads, such that using either imperial or metric 1/2" optical posts is possible.

Please see the chapter Mechanical Drawings for dimensions.



Figure 12 Mounting Positions of the APD431x Fiber-Coupled Avalanche Photodetector

3.5 Return of Devices

This precision device is only serviceable if returned and properly packed into the complete, original packaging including the cardboard insert that holds the enclosed devices.

Chapter 4 Operation

4.1 Operation Principle

1. Turn the power switch to "I".
   ➤ The green LED indicates correct power supply.
2. Set the gain knob to its "MIN" position.
3. Adjust the optical source to the optical input.
   ➤ The maximum OUTPUT voltage swing is 4.1 V for high impedance loads (2.0 V into 50 Ω loads).
   ➤ The output signal must not exceed this maximum output voltage to avoid saturation.
   ➤ External neutral density filters or attenuators are recommended to reduce the input light level in critical cases.
4. Use the gain knob to adjust the output voltage to an appropriate value.
5. Turn the power switch to "O".
   ➤ The green LED goes off.

4.1.1 Optical Input

The APD431C Fiber Coupled Avalanche Photodetector uses an InGaAs avalanche photodiode with a detector active area diameter of 0.2 mm, operating from 900 to 1700 nm.

The APD431A Fiber Coupled Avalanche Photodetector uses a Si avalanche photodiode with a detector active area diameter of 0.5 mm, operating from 400 to 1000 nm.

The typical responsivity curves can be found in the chapter Graphs.

An open beam should be carefully aligned to the detector. The slim line housing includes a threaded coupler that is compatible with the SM1A610 mechanical adapter. This allows mounting of external optics, filters, apertures or fiber adapters.

Please note that coupling losses may occur due to the small detector size, which will result in a reduced output signal.

The Maximum Output Voltage Swing is 4.1 V at High-Z Termination. The saturation of the output will occur at optical input power greater than CW Saturation Power listed in the Specifications. If necessary, use external neutral density filters or attenuators to reduce the input light level. Please note that the APD431x Fiber-Coupled Avalanche Photodetector is extremely sensitive to unwanted stray light. Carefully shielding of the APD431x Fiber-Coupled Avalanche Photodetector from any unwanted light sources is essential. Common techniques to minimize the influence of stray light include baffling or other opaque barriers like black cloths, beam tubes or using appropriate band pass filters in front of the detector.

4.1.2 Electrical Output

Thorlabs APD431x Fiber-Coupled Avalanche Photodetector delivers an output voltage, which is a function of incident light power P_{opt}, $\Re_M(\lambda)$ at a given wavelength and M Factor (see chapter Graphs), and transimpedance gain G

$$V_{out} = P_{opt} \times \Re_M(\lambda) \times G$$

- The wavelength responsivity $\Re_M(\lambda)$ for a given wavelength can be read from the spectral responsivity curves (see chapter Graphs) to estimate the output voltage. The M Factor (gain) settings range is 10 to 100 (APD431A) and 4 to 20 (APD431C) at 23 °C ambient temperature.

- The amplifier's transimpedance gain G is 10 kV/A (High-Z Termination). Please note that output voltage is reduced by a factor of 0.5 if connected to a 50 Ω load.

The maximum output voltage swing is 4.1 V for high impedance loads (2.0 V into 50 Ω). Depending on the wavelength responsivity $\Re_M(\lambda)$ of the detector and the M Factor, the amplifier will reach saturation at an optical input power greater than the CW Saturation Power listed in the chapter Specifications. To avoid saturation, keep the output signal below the specified maximum output voltage.

The output of the APD431x Fiber-Coupled Avalanche Photodetector is a BNC connector.

The amplifier offset voltage is factory set to zero at 23 °C ambient temperature. Due to the very high transimpedance gain, small temperature changes may affect offset voltage. Therefore it is recommended to use the APD431x Fiber-Coupled Avalanche Photodetector in a constant temperature environment after a short warm up period (5 min) for exact DC light level measurements.

Typical curves can be found in the chapter Graphs.

Chapter 5 Maintenance and Cleaning

NOTICE*:* **Risk of Damaging the APD431x Fiber-Coupled Avalanche Photodetector!**

NOTICE

The APD431x Fiber-Coupled Avalanche Photodetector is not water resistant. If the APD431x Fiber-Coupled Avalanche Photodetector gets into contact with fluids, the APD431x Fiber-Coupled Avalanche Photodetector can be damaged.
To avoid damaging, do not expose the APD431x Fiber-Coupled Avalanche Photodetector to:

- Spray
- Liquids
- Solvents
- Adverse weather conditions

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. If a malfunction occurs, please see the Return of Devices section and contact Thorlabs for return instructions.

Do not remove covers!

Chapter 6 Troubleshooting and Repair

Below are a few checks to help in troubleshooting problems that may arise.

If the unit does not appear to turn on correctly, please check the following items:

- Ensure that the main AC receptacle is powered.
- Ensure that main power cable is fully seated at both ends.

Please contact your local Thorlabs Technical Support office with any questions.

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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