THORLABS

Femtowatt Photoreceiver

PDF10C2
Operation Manual



2025

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Thorlabs GmbH

Warning

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully before performing the indicated procedure.

Attention

Paragraphs preceded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

Note

This manual also contains "NOTES" and "HINTS" written in this form.

Please read this advice carefully!

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1 General Information

The Thorlabs PDF10C2 Femtowatt Photoreceivers combines a low-noise InGaAs photodiode with a specially designed ultra-low-noise, fixed-gain transimpedance amplifier with extremely high gain of up to 10^{11} V/A. This combination results in a photoreceiver with femtowatt sensitivity and an exceptionally low NEP, making it ideal for low-light level detection applications, such as spectroscopy and fluorescence measurements. Direct detection of optical power down to ~10 fW is possible. In combination with an optional lock-in amplifier, sub-femtowatt sensitivity can be achieved.

Due to a very high sensitivity, the PDF10C2 Femtowatt Photoreceiver can replace photomultiplier tubes (PMTs), avalanche photodiodes (APDs), and liquid-nitrogen-cooled germanium photodiodes in many applications. No expensive high-voltage power supply or cooling is required. Another advantage is that the PDF10C2 cannot be damaged by unwanted ambient light, which is critical for many photomultiplier tubes.

The PDF10C2 detector housing can be integrated in optical setups using convenient 8-32 and M4 combi-thread mounting holes that are compatible with both imperial and metric threading. Please see the chapter Mounting 3 for details.

The housing accommodates Thorlabs' SM05 (0.535"-40) and SM1 (1.035"-40) threaded adapters and accessories. This allows convenient mounting of external optics, light filters, and apertures. The product includes an SM1 Coupler Body (SM1T1), which adapts the external thread to an internal thread and holds the SM1RR Retaining Ring, and a reusable protective plastic cover cap. For accessories, please visit our website or contact Thorlabs 15.

A ±12 VDC power supply is included with each amplified photodetector. The appropriate input voltage (100 VAC, 120 VAC, 230 VAC) can be selected with a switch on the power supply 2.

Attention

Please find all safety information and warnings concerning this product in the chapter Safety 12 in the Appendix.

1.1 Ordering Codes and Accessories

PDF10C2 Femtowatt Photoreceiver, InGaAs detector, 800 - 1700nm, Bandwidth DC-20Hz, Round Active Area 0.2 mm^2 (Ø 0.5 mm), Combi-Thread Mounting Holes Compatible with 8-32 and M4 Threads

Included Accessories

- LDS12B Power Supply (±12V, 0.2A), 100 VAC, 120 VAC or 230 VAC Line Voltage
- Plastic Cover Cap (Item # SM1EC2B) on an included SM1T1 SM1 Coupler with a SM1RR SM1 Retaining Ring.

Optional Accessories

- All Thorlabs internal SM1 (1.035"-40) and external SM05 (0.535"-40) threaded accessories are compatible with the PDF10C2.
- Fiber adapter of the Thorlabs S120-xx. These fiber adapter can be mounted on the optical input for fiber coupled applications.
- PDA-C-72 DC power supply cable to PDF10C2: This cable has a connector on one end and open wires at the other. The pin-out of the PDF10C2 DC power jack is shown in the appendix 11.

Please visit our homepage http://www.thorlabs.com for various accessories like fiber adapters, posts and post holders, data sheets and further information.

2 Getting Started

2.1 Parts List

Please inspect the shipping container for damage. Do not cut through the cardboard. You might need the box for storage or returns.

If the shipping container seems to be damaged, keep it until you have inspected the contents mechanically and electrically.

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

1. PDF10C2 Amplified Photodetector
2. Plastic Cover Cap (Item # SM1EC2B) on SM1T1-SM1 Coupler with an SM1RR-SM1 Retaining Ring
3. LDS12B Power Supply (±12V, 0.2A), 100 VAC, 120 VAC or 230 VAC Line Voltage
4. Quick Reference

2.2 Preparation

Carefully unpack the unit and accessories. If any damage is noticed, do not use the unit. Contact Thorlabs and have us replace the defective unit.

Note

Prior to operation, please check if the indicated line voltage range on the power supply matches with your local mains voltage! Adjust the power supply accordingly to 100 VAC, 120 VAC or 230 VAC.



Note

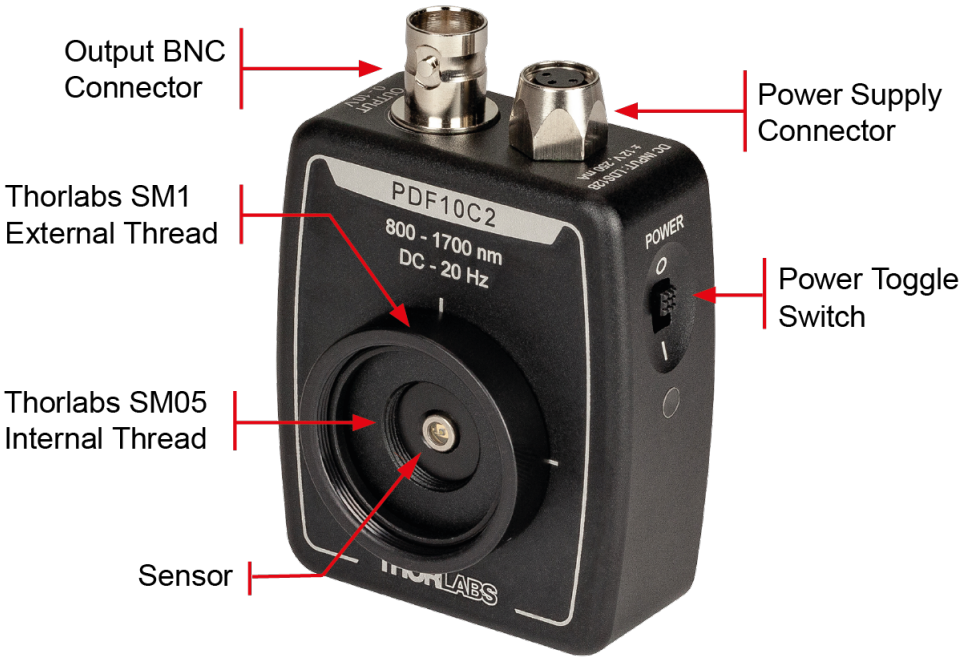
If you prefer to use your own power supply, please ask Thorlabs for an appropriate power connector cable.

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3 Operating Instruction

3.1 Operating Elements

PDF10C2



3.2 Mounting

Housing

The PDF10C2 is housed in a rugged, shielded, 70.9 mm x 49.9 mm x 22.5 mm aluminum enclosure.

Mounting PDF10C2 on an Optical Table

Mount the PDF10C2 on an optical post by using either of the two tapped mounting holes on the side and bottom. The combi-thread tapped holes accept both 8-32 and M4 threads, such that using either imperial or metric TR posts is possible.

Mounting External Optics

The PDF10C2 housing accommodates Thorlabs' SM05-threaded (0.535"-40) and SM1-threaded (1.035"-40) adapters that are compatible with any number of Thorlabs 1" and ½" threaded accessories. This allows to mount external optics, filters, apertures, fiber adapters, lens tubes, or cage systems. For accessories, please visit our website or contact Thorlabs 15.

The PDF10C2 comes with an SM1T1 SM1 coupler that adapts the external thread to an SM1 internal thread. A retaining ring in the coupler holds the protective cover cap. Please unscrew the coupler if needed.

3.3 Operation

Attention

Ensure that the correct mains voltage is selected on the power supply 2 prior to connecting the power supply to the mains power. Wrong settings for the mains voltage may damage the power supply. The ±12 V, 250 mA power supply is included; no high voltage power supply is required for operation.

Attention

Refer to the Technical Data[8] and pay attention to the optical damage threshold of 10 mW! Exceeding this value will permanently destroy the detectors!

Attention

Due to limitations in the IC, the high-speed amplifier used in these devices may become unstable, exhibiting oscillations or negative output, if the power supply voltage is initially applied when the module is switched on. Therefore, please make sure the power-on switch on your PDF10C2 is in OFF position **0** (see Operating Elements[3]) prior to connecting the external power supply.

Electrical Setup

- Mount[3] the detector as described above and make sure the PDF10C2 is switched off.
- Plug the power connector cable into the DC INPUT LDS12B connector of the PDF10C2.
- Plug the power supply into an outlet.
- Connect OUTPUT to your data acquisition device with a coaxial cable. The PDF10C2 with femtowatt sensitivity is a low-frequency device that should only be terminated into high impedance (Hi-Z) loads.
- Switch on the power supply.
- Switch on the PDF10C2 by moving the power slider to **I** while the optical input is protected by the cover cap.
- The maximum OUTPUT voltage swing is ±10 V for high impedance loads (>10 kΩ). The OUTPUT signal should stay below this maximum output voltage to avoid amplifier saturation.

Optical Setup

- Ensure that OUTPUT offset voltage is within the range listed in Technical Data[8]. A small drift during the warm up period (~5 min) is typical.
- Check whether the noise level is below 5 mV_{RMS}. If the noise level is significantly higher, please refer to recommendations[4] and optimize your setup.
- Remove the plastic cover cap that protects the optical input.
- Mount[3] external optics if needed.
- Align the light source with the optical input.
- It is recommended[4] to focus the optical signal out of a fiber onto the detector.
- To prevent saturation of the amplifier keep the optical input powers below the CW saturation power listed in Technical Data[8]. External neutral density filters or attenuators are recommended to reduce the input light level in critical cases.
- For maximum linearity performance and to prevent damage to the detector when measuring focused beams, fiber outputs, or small diameter beams, do not exceed a maximum input power of 10 mW/cm^2.

Turning off the PDF10C2

Move the power slider to **0** after finishing the measurements.

3.4 Recommendations

- **Optical Alignment**
  - o An open beam should always be carefully aligned with the detector. Due to the small active area of the PDF10C2 photodiode, it is recommended to focus the optical signal out of a fiber onto the detector. For this and other fiber-coupled applications, fiber adapters like Thorlabs

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S120-xx series can be mounted on the optical input. The fiber adapters accommodate multi-mode or single-mode fibers.

- o Please note that coupling losses may occur due to the small detector size. This will result in a reduced output signal. If angled connectors are used, an FC adapter can be rotated from its original position to improve the alignment. For this process apply an input signal with power below the saturation level while observing the output voltage using a digital voltmeter or other low-frequency measurement device.

- **Ambient or Stray Light**
  - o PDF10C2 photodetector is an extremely sensitive device. To reduce the noise level, careful shielding of the PDF10C2 from any unwanted light sources is essential. Common techniques are baffling or other opaque barriers like black cloths or beam tubes. Even a small power-on indicator LED far away from the PDF10C2 can affect power measurements at femtowatt levels.
  - o It is not necessary to switch off the PDF10C2 when it is exposed to ambient light. The amplifier will saturate but, unlike photomultiplier tubes, it will not be damaged or saturated for a long period of time.
  - o It is highly recommended to use appropriate bandpass filters in front of the detector to minimize the influence of stray light.

- **High Optical Input Power**
  - o To avoid permanent damage to the detector, do not exceed the specified optical damage threshold of 10 mW as specified in section Technical Data 8.
  - o Keep the optical input power below the CW saturation power listed in the Technical Data 8 to avoid electrical saturation.

- **Amplifier Saturation**

  To avoid electrical saturation of the amplifier keep the output voltage V_{out} below the maximum listed in Technical Data 8. External neutral density filters or attenuators are recommended to reduce the input light level in critical cases.

- **Electrostatic Coupling**

  Electrostatic coupling of electrical noise associated with ground loops can be critical. In most cases an electrically isolated post (e.g. Thorlabs item# TRE or TRE/M) will suppress electrical noise coupling. Always try to identify electrical noise sources and increase the distance to the PDF10C2. If possible, rotate the PDF10C2 input away from the noise source. Different common ground points can also be tested.

- **Impact of Temperature**
  - o The amplifier offset voltage is factory set to zero at 23 °C ambient temperature. Due to the very high transimpedance gain, even small temperature changes or even humidity changes may affect the offset voltage. Therefore it is recommended for precise DC light level measurements to use the PDF10C2 in an environment with constant temperature after a short warm up period (~5 min).

3.5 Operating Principle

The Thorlabs PDF10C2 Femtowatt Photoreceiver combines a low noise InGaAs photodiode with a specially designed ultra low noise transimpedance amplifier with extremely high gain. This unique combination results in a photoreceiver with femtowatt sensitivity due to its exceptional low NEP and makes it ideal for low-light level detection applications, such as spectroscopy and fluorescence measurements. Direct detection of optical power down to ~10 fW is possible.

3.5.1 Optical Input

Optical Beam Alignment

The InGaAs Photodiode of the PDF10C2 has a round detector active area of 0.2 mm^2 with a diameter of ∅ 0.5 mm.

Due to this small active area of the PDF10C2 photodiode, it is recommended to focus the optical signal out of a fiber onto the detector.

Because the housing is compatible with any number of Thorlabs 1" and ½" threaded accessories, external optics, filters or apertures can be easily attached to the PDF10C2.

Detector Sensitivity

The PDF10C2 is specified for determined wavelength ranges[8]. The typical responsivity curve can be found in the appendix[9]. Please note that this femtowatt photoreceiver is extremely sensitive to unwanted stray light.

3.5.2 Electrical Output

Responsivity

The Thorlabs PDF10C2 delivers an output voltage, which is a function of incident light power P_{OPT}, detector responsivity $\Re(\lambda)$ and transimpedance gain G given by:

$$V_{OUT} = P_{OPT} \cdot \Re(\lambda) \cdot G$$

The responsivity $\Re(\lambda)$ for a given wavelength can be read from the diagram Typical Responsivity[9] to estimate the output voltage. Please note that transimpedance gain tolerance is ±10% for an individual unit due to extremely high feedback resistors used for the transimpedance amplifier. Temperature changes or even humidity changes may affect transimpedance gain.

Output Voltage

The maximum output voltage is 10 V for high impedance loads (>10 kΩ). The output signal should stay below the maximum output voltage to avoid saturation. Depending on wavelength responsivity $\Re(\lambda)$ of the detector, the amplifier will reach saturation at optical input power greater than the CW Saturation Power listed in Technical Data[8].

Note

Typical curves for the Frequency Response[9], Spectral Noise Distribution[10] and Output Time Response[10] can be found in the appendix.

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4 Maintenance and Service

Protect the PDF10C2 from adverse weather conditions. The PDF10C2 is not water resistant.

Attention

To avoid damage to the instrument, do not expose it to spray, liquids or solvents!

The unit does not need a 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 contact Thorlabs 15 for return instructions.

Do not remove covers!

Do not open the power supply unit!

Cleaning

To clean the PDF10C2 housing, use a mild detergent and damp cloth. Do not soak the unit in water or use solvent based cleaners.

When cleaning the window of the photodetector, please remember that is a sensitive optical device. Gently blow off any dust using compressed air and wipe gently with an optic tissue wetted with isopropanol.

5 Appendix

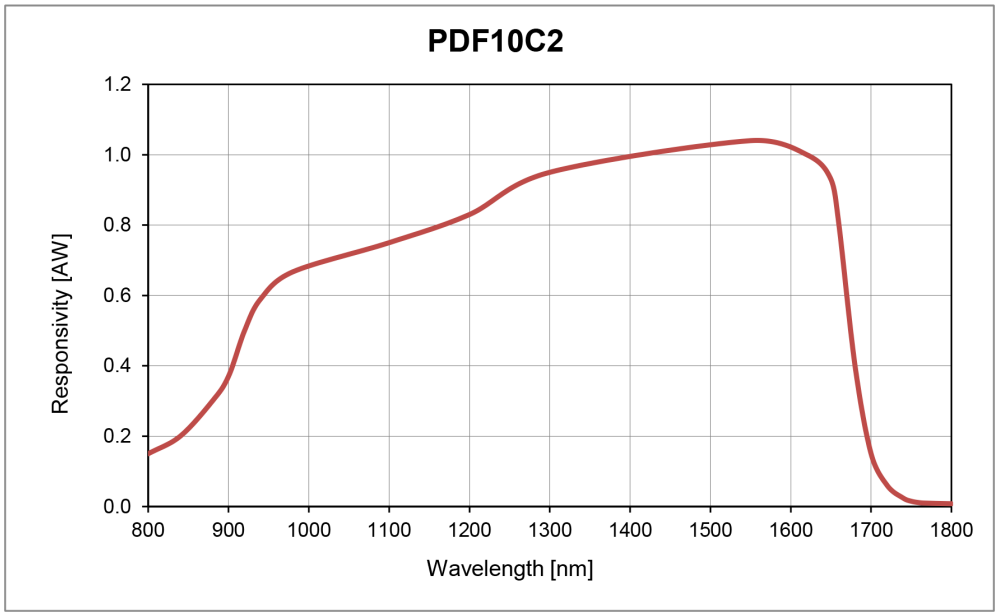
5.1 Technical Data

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

Item#	PDF10C2
Specifications	
Detector Material	InGaAs / PIN
Detector Wavelength Range	800 - 1700 nm
Typical Max. Responsivity	1.0 A/W @ 1550 nm
Detector Active Area	0.2 mm^2 (∅ 0.5 mm)
Transimpedance Gain	1 x 10^{11} V/A ±10%
Max. Conversion Gain	1 x 10^{11} V/W ±10%
Output Bandwidth (3dB)	DC - 20 Hz
Rise/Fall Time (10% -90%)	19 ms
CW Saturation Power	100 pW
Max. Input Power (Photodiode Damage Threshold))	10 mW
Minimum NEP (DC - 3dB bandwidth)	7.5 fW/√Hz
Integrated Noise (DC - 3dB bandwidth)	35 fW_{RMS}
Overall Output Voltage Noise (Typ.)	3.5 mV_{RMS}
Electrical Output, Impedance	BNC, 200 Ω
Maximum Output Voltage	10 V
DC-Offset Electrical Output	< ±75 mV
General Specifications	
Size	70.9 mm x 49.9 mm x 22.5 mm
Power Supply	±12V, 250 mA
Operating Temperature Range	10°C to 50°C
Storage Temperature Range	-25°C to 70°C

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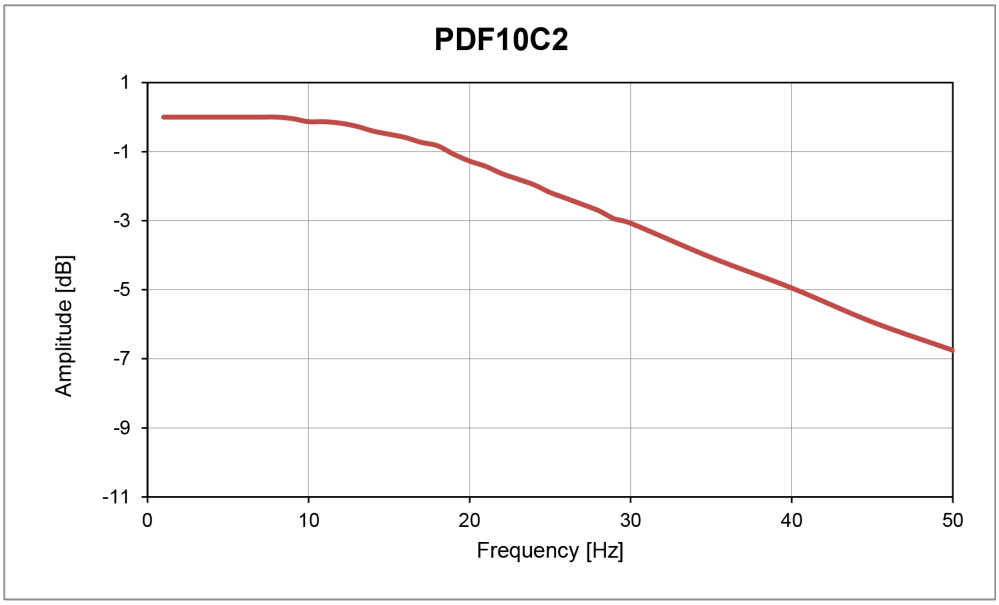
5.2 Typical Responsivity



PDF10C2 Typical Detector Responsivity

5.3 Typical Frequency Response

For the measurement of the frequency response, a test signal was fed through an optical chopper and fiber-coupled to the PDF10C2 input. The output voltage amplitude was measured with an oscilloscope.

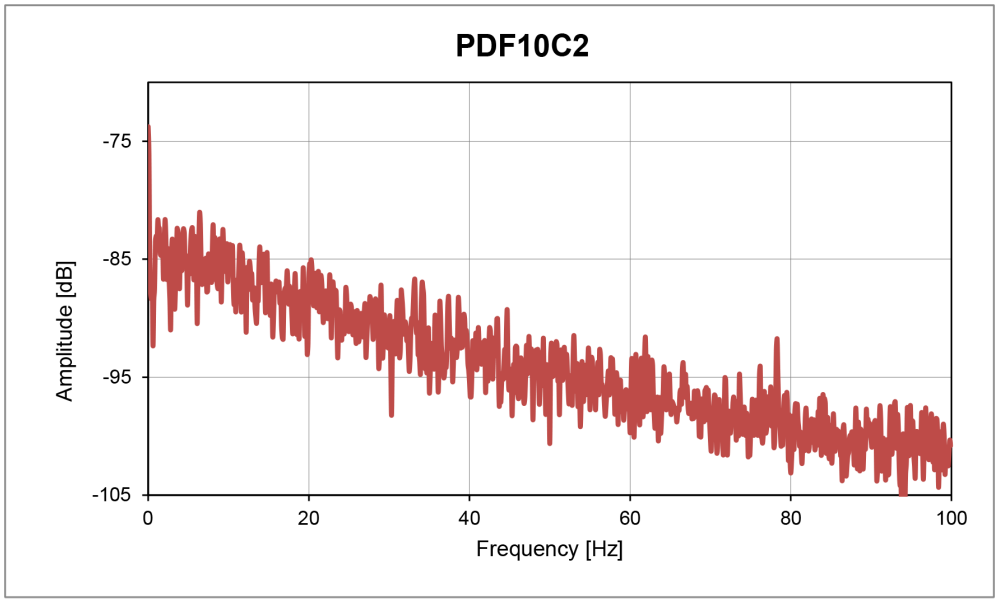


PDF10C2 Typical Frequency Response

5.4 Typical Spectral Noise

Noise is being characterized by different specifications. The spectral noise of PDF10C2 was measured using a 200 kSample/s A/D converter. The power density spectrum was calculated from the sampled values with respect to transimpedance gain and detector responsivity. The optical input of the PDF10C2 was blocked.

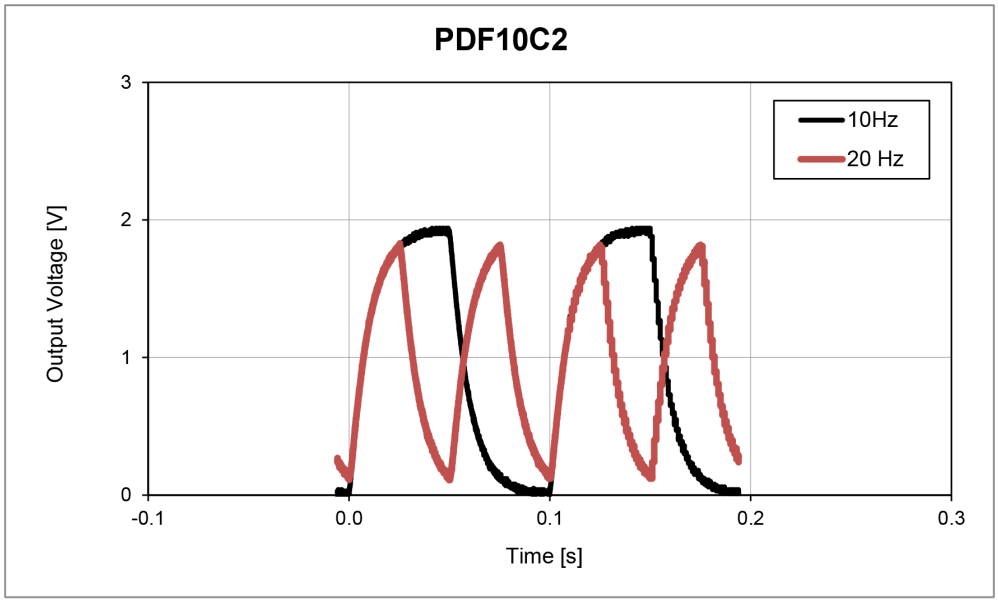
Other noise specifications are the NEP (Noise Equivalent Power) and the overall RMS output noise, specified for a defined bandwidth. These parameters are stated in Technical Data[8]).



PDF10C2 Typical Spectral Noise

5.5 Typical Output Time Response

Rise/fall time measurements were carried out with the same setup described in the typical frequency response.

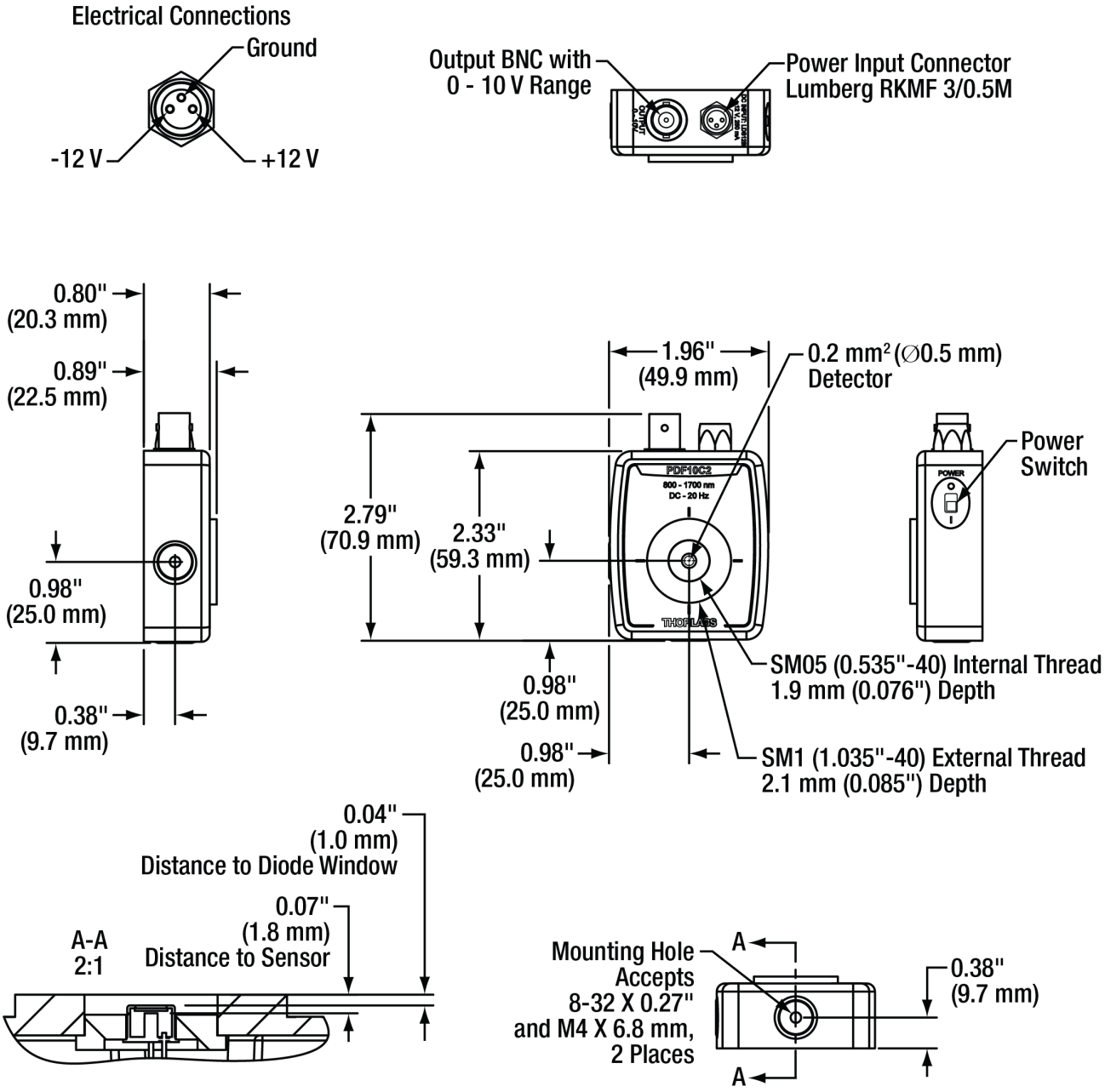


PDF10C2 Typical Output Time Response

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5.6 Drawings

Dimensions of PDF10C2



5.7 Safety

Attention

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.

The PDF10C2 must not be operated in explosion endangered environments.

Do not remove covers. There are no user-serviceable parts inside.

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. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

Changes to this device cannot be made nor may components not supplied by Thorlabs be used without written consent from Thorlabs.

Attention

Prior to applying power to the PDF10C2, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth ground contact of the socket outlet! Improper grounding can cause electric shock resulting in damage to your health or even death!

Ensure that the line voltage setting of the power supply agrees with your local supply and that the corresponding fuses are inserted. If not, please change the line voltage setting (see section Preparation 2).

To avoid risk of fire, only the appropriate fuses for the corresponding line voltage must be used.

All modules must only be operated with duly shielded connection cables.

Users that change or modify the product described in this manual in a way not expressly approved by Thorlabs (party responsible for compliance) could void the user's authority to operate the equipment.

Thorlabs GmbH 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.

Attention

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.

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5.8 Certifications and Compliances

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs GmbH

Of: Münchner Weg 1, 85232 Bergkirchen, Deutschland

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***PDF10C2***

Equipment: ***Variable-/ Fixed Gain Amplified Detector***

is 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
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

and which, issued under the sole responsibility of Thorlabs, is 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:

does not contain 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:* 20 November 2019

Name: Bruno Gross

Position: General Manager

EDC - PDAVJ5/8/10, PDA20C2, PDA8A2, P...

CE

5.9 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.

5.10 Manufacturer Address

Manufacturer Address Europe
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5.11 Warranty

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General Terms and Conditions:

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and

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Please refer to the general terms and conditions linked under Warranty 14.

5.13 Thorlabs Worldwide Contacts and WEEE poilicy

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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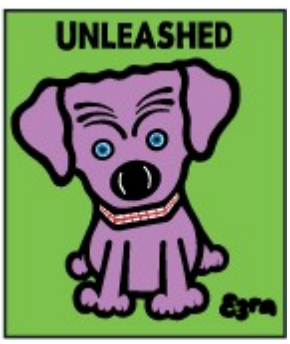
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