PDB835C, PDB835C-AC

Balanced Amplified Photodetectors

User Guide

2022

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Chapter 1 Safety

LED Radiation Warning

Laser Radiation

Please connect the fibers from the light source carefully and in accordance with instructions. Failure to do so may result in radiation.

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 PDB835C and PDB35C-AC must not be operated in explosion endangered environments!

Do not obstruct the air ventilation slots in the housing!

Do not remove covers!

Do not open the cabinet. 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 inserts. 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 PDB835C or PDB835C-AC, 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!

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.

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 2 Introduction

Thorlabs PDB835C and PDB35C-AC Balanced Amplified Photodetectors consist of two well-matched, free space photodiodes and an ultra-low noise, ultra-low distortion high-speed transimpedance amplifier. This generates an output voltage (RF OUTPUT) proportional to the difference between the photo current in the two photodiodes, i.e. the two optical input signals. The PDB835C and PDB835C-AC excel in that they are artifact free devices and thus ideal for OCT.

Additionally, the unit has two fast monitor outputs (MONITOR+ and MONITOR-) to measure the individual optical input power level as well as low frequency modulated signals on each detector separately.

The PDB835C and PDB35C-AC housing has a very small footprint and is supplied with an external linear power supply.

Please see the section setup for an overview of how to get started using the PDB835C and PDB35C-AC Balanced Amplified Photodetectors.

Attention

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

2.1 Ordering Codes and Accessories

PDB835C	Ultra Low Noise Balanced Amplified Photodetector; NEP: 6.5 pW/√Hz; DC to 500 MHz; Fixed Gain; Wavelength Range: 800 nm to 1700 nm; Max Bandwidth 500 MHz
PDB835C-AC	Ultra Low Noise Balanced Amplified Photodetector; NEP: 6.5 pW/√Hz; DC to 500 MHz; Fixed Gain; Wavelength Range: 800 nm to 1700 nm; Max Bandwidth 500 MHz, AC Coupled

Chapter 3 Getting Started

3.1 Parts List

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 PDB835C and PDB35C-AC mechanically and electrically.

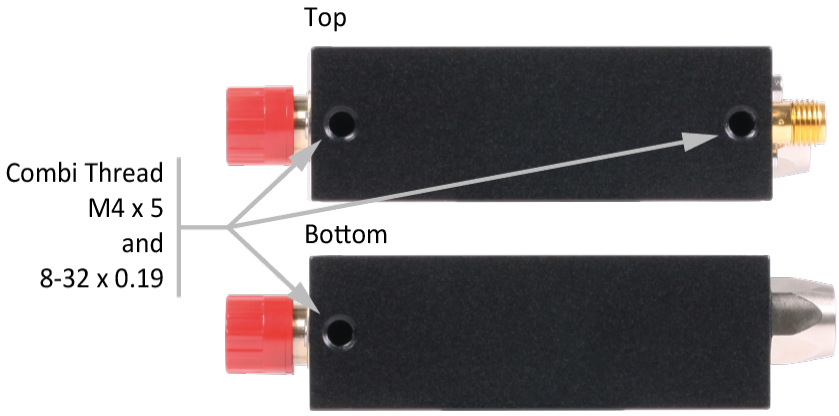
Verify that you have received the following items within the package:

1. PDB835C or PDB835C-AC Balanced Amplified Photodetector
2. LDS12B Power Supply (±12 V, 250 mA), Switchable to 100 V, 120 V, or 230 V Line Voltage
3. Quick Reference

Chapter 4 Operating Instructions

4.1 Operating Elements

Top and Bottom



4.2 Mounting

Housing

The PDB835C and PDB835C-AC are housed in a rugged, shielded, 76.7 mm x 60.0 mm x 20.0 mm aluminum enclosure.

Mounting PDB835C and PDB835C-AC on an Optical Table

Mount the PDB835C or PDB835C-AC on an optical post by using either of the three tapped combi thread mounting holes on the top 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.

Note

Please see the chapter Dimesions for precise dimensions.

4.3 Setup

Note

Prior to operation, please check if the indicated line voltage range on the LDS12B power supply matches with your local mains voltage! If you choose to use your own power supply, Thorlabs offers a power connector cable.

- 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.
- If required, mount the unit on your optical table or application. As described in the chapter Mounting, use 8-32 or M4 thread on the bottom or top of the device (see chapter Dimensions).
- Set the power supply LDS12B to your local mains voltage (100, 120, or 230 VAC):

- Connect the DC output cable of the power supply to the DC Input jack.
- Connect the power supply to the AC outlet. Switch the power supply on.
- Connect RF OUTPUT with the coaxial cable to the data acquisition device. Please note, that a 50 Ω impedance device should be used for best RF performance.
- If necessary, connect monitor outputs (MONITOR+, MONITOR-) to measure the optical input power for each channel individually.

4.4 Optical Input

Please use fibers with Thorlabs FC/APC connectors on the left side of the balanced detector for optical input.

Note Please note the size of the photodiode. Failure to optimally align the inserted optical fiber will result in loss of signal.

When using FC/APC connectors, minimal alignment errors may occur due to the small detector size, which will result in a reduced output signal. The alignment of the detectors is optimized for Thorlabs APC connectors.

To achieve optimal alignment, use an optical input power below the saturation level while observing RF OUTPUT voltage on a digital voltmeter or other low-frequency measurement device. When using an AC-coupled version, use either MONITOR output (CW signal) or RF OUTPUT (modulated optical signal) with a connected oscilloscope for measurement.

In general, single mode or multi-mode fibers can be used for optical input. However, in the case of multi-mode fibers the light beam spot diameter may exceed the detectors active area. This results in a reduced output signal as well.

Attention

Do not exceed a maximum power of 5 mW for maximum linearity performance. Always try to illuminate the whole detector active area to prevent nonlinearities. Equal power densities on both detectors are important for maximum common mode noise suppression (CMRR).

The PDB835C(-AC) detectors can be used in balanced mode (both inputs are illuminated) as well as in single detector mode. In single detector mode, the RF OUTPUT swing depends on which INPUT is used: it is positive for INPUT+ and negative for INPUT-. In single detector mode, the optical input power should be below the specified CW saturation power (see Specifications) to avoid saturation of the RF OUTPUT amplifier.

In balanced mode the power difference between the optical inputs should be less than the CW Saturation Power. If necessary, use external neutral density filters or attenuators to reduce the input light level.

Attention

The optical damage threshold is 20 mW. Exceeding this value will permanently damage the photodiodes.

4.5 Electrical Output

The Thorlabs PDB835C and PDB35C-AC has three SMA output connectors:

- **MONITOR +**
- **MONITOR -**
- **RF OUTPUT**

RF OUTPUT delivers an output voltage proportional to the difference between the photo currents of the two photodiodes. This voltage can by calculated to:

$$U_{RF,OUT} = (P_{opt,1} - P_{opt,2}) \times \Re(\lambda) \times G$$

with: $\Re(\lambda)$: responsivity of the photo diode at given wavelength

$P_{opt,1}$ and $P_{opt,2}$: optical input power

G: transimpedance gain of the RF output

The responsivity $\Re(\lambda)$ for a given wavelength can be read from the chapter performance plots to estimate the RF OUTPUT voltage. Please note that the given responsivity curves represent typical values - individual responsivity may deviate.

The maximum output voltage swing of the RF OUTPUT can be found in the chapter Specifications.

The optical input saturation power of the balanced detector, as noted in the Specifications, is the minimum value, as it is given for the wavelength with the highest detector responsivity. At other wavelengths, saturation will be reached at higher input power levels. The output signal should not exceed the maximum output voltage to avoid saturation. Therefore the optical input power (or the power difference between the optical inputs) should not exceed CW Saturation Power listed in Specifications.

MONITOR Outputs

The signal monitor outputs (MONITOR+ and MONITOR-) allow to observe the input power level and can be used as individual power indicators. These outputs can also be used to measure low frequency modulated signals on each detector separately. The maximum output voltage swing of the MONITOR output is

+10 V for high impedance loads (+1.5 V into 50 Ω). Saturation of MONITOR outputs will occur at optical input power level greater than 1 mW, depending on the detectors wavelength response.

MONITOR outputs can be used to roughly adjust equal input power levels on each detector for balanced operation. While the DC component of the RF OUTPUT in balanced mode is zero, the MONITOR outputs provide the individual optical input power.

The amplifier offset voltage is factory set to zero at 23°C ambient temperature. A small drift during a short warm-up period (~5min) may occur. For exact DC light level measurements a constant temperature environment is recommended.

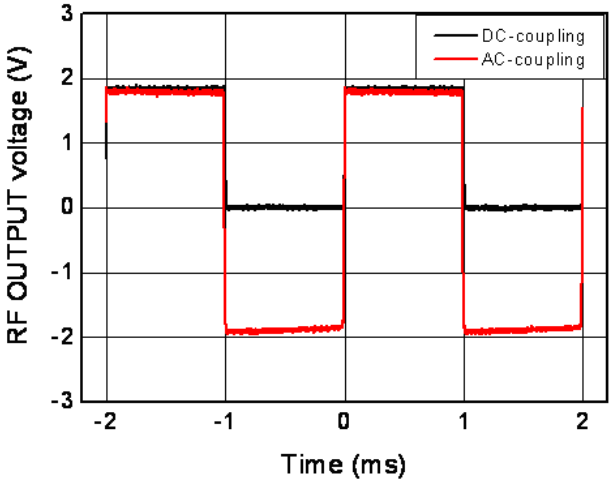
4.5.1 AC Coupling of the Outputs

For the AC coupled version PDB835C-AC, AC coupling blocks the CW component (the unmodulated part) of the optical input signal. However, large CW components of the optical input signal will decrease linearity of the detectors.

AC coupling helps to improve the measurement capabilities in applications, where a comparably weak frequency modulated signal shall be measured on a strong CW background signal, which could saturate the amplifier. With AC coupling, equalizing of CW power levels on both inputs is not mandatory for noise cancellation. However, for optimal noise suppression the signal of interest (e.g. the modulated part) should be well balanced. AC coupling is also recommended when using the balanced detector in combination with a chopper and lock-in amplifier to further decrease noise level.

The lower cut-off frequency of the AC coupled versions is ≤ 100 Hz; typically below 5 Hz.

Please note, that AC coupling slightly increases noise figures at lower frequencies. The measurement bandwidth of the RF OUTPUT is not affected by AC coupling.



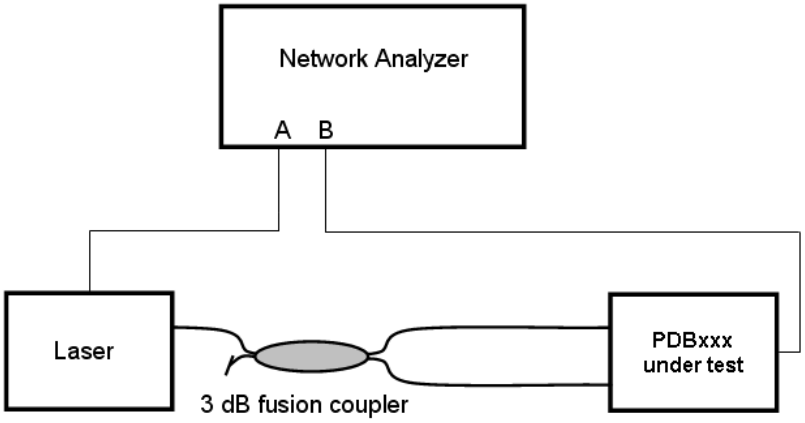
The figure to the left shows the comparison of AC and DC coupled RF Output signals when modulating the input signal with a mechanical chopper at a frequency of 500 Hz.

Note: Input signal for AC coupling was increased by factor 2 to allow direct waveform comparison.

4.6 CMRR and Frequency Response

An important specification for balanced amplifiers is the Common Mode Rejection Ratio (CMRR) that reflects the ability to suppress common mode noise.

In the setup as described below, the Device under Test (DuT) - here a PDB835C balanced detector - is tested for CMRR. A common mode signal is generated, which is canceled out when the amplifier is in balanced mode.



A network analyzer is used as signal generator (output A) and receiver (input B) The receiver is synchronized with the signal generator and measures selectively at the same frequency. A laser light source is modulated by the signal generator (port A) and acts as transmitter. To the laser output a 3 dB fusion coupler is connected, splitting the modulated light signal into two paths. Depending on the measurement task, one or both coupler outputs are connected to the inputs of the DuT, for example using S120-FC adapters. One of the DuT's outputs is connected to the network analyzers Port B.

Frequency response measurements

The frequency response of each signal path can be measured by connecting only one coupler output to the appropriate input. This way, the frequency response curves of the RF OUTPUT from INPUT + and INPUT- can be measured, as well as the frequency responses of the MONITOR outputs, as shown in the individual technical data.

CMRR measurement

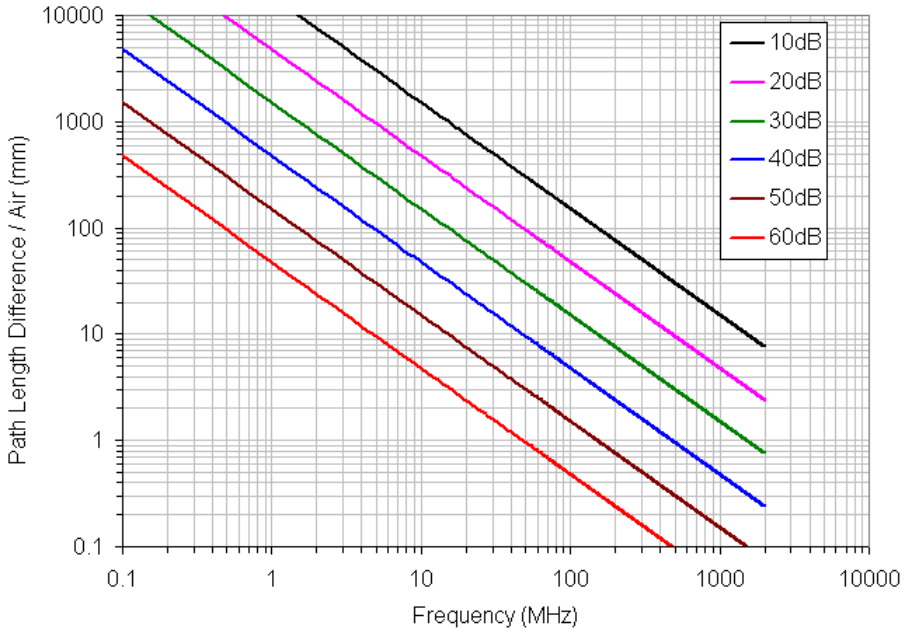
For Common Mode Rejection measurement, both outputs of the fusion coupler are connected to both inputs of the DuT. The optical power level at both inputs must be well matched ("balanced") in order to achieve the optimal common mode suppression. Now the common mode rejection can be measured as a function of frequency. The frequency response of the RF OUTPUT must be considered when calculating the CMRR - it is the difference between the RF OUTPUT signal at a given frequency and the measured common mode or balanced output signal - at the same frequency. Typical measurement curves can be found in the individual technical data.

4.7 Recommendations

Thorlabs PDB835C and PDB35C-AC Balanced Amplified Photodetectors can eliminate noise sources to allow precise measurements. The PDB835C and PDB35C-AC are designed to be used in a dual beam setup: one optical path for measurement and one invariant reference path. If set up properly, the PDB835C and PDB35C-AC can reduce common mode noise for more than 35 dB over the specified frequency range. Below are given some recommendations to achieve an optimal common mode suppression:

- To obtain the maximum possible common mode rejection (common mode noise suppression), equal power levels on each photodetector are essential. Any power imbalance will be amplified and hence decrease the possible noise reduction
- Equal power densities on both detectors are important as well to obtain maximum possible common mode rejection. Always try to illuminate the whole active area of the detectors to prevent nonlinearities. Focused high power beams may lead to frequency response degradation, resulting in dramatically reduced common mode rejection.

- Equal optical path lengths are very important for common mode noise suppression especially at higher frequencies. Any path length difference will introduce a phase difference between the two signals, which will decrease the noise reduction capability of the balanced detector. The figure on next page shows the maximum allowed path length difference in air to obtain a desired CMRR. For fiber based application the maximum path length difference must divided by 1.5.



- Avoid etalon effects (interference fringes caused between two optical surfaces) in optical paths. Using angle polished optical connectors will greatly reduce etalon effects in a fiber based setup. Effects like residual frequency modulation, polarization noise, polarization wiggle or spatial modulation can also degrade common mode noise suppression. For further details contact Thorlabs. In general, reducing sources of differential losses in the optical paths (other than the measurement itself) will improve the common mode noise reduction.
- Another critical point can be electrostatic coupling of electrical noise associated with ground loops. In most cases an electrically isolated post (see Thorlabs parts TRE or TRE/M) will suppress electrical noise coupling. Always try to identify the electrical noise sources and increase the distance to the PDB835C and PDB35C-AC balanced detectors. Different common ground points can also be tested.

Chapter 5 Specifications

Item #	PDB835C	PDB835C-AC
Detector		
Detector Type	InGaAs/PIN	
Optical Inputs	FC/APC Receptacle (Not Removable)	
Wavelength Range	800 nm - 1700 nm	
Typical Max Responsivity	1.0 A/W @ 1550 nm	
Active Detector Diameter	0.08 mm	
Photodiode Damage Threshold	20 mW	
RF OUTPUT		
RF Output Impedance	50 Ω	
RF Output Bandwidth (3 dB)	DC - 500 MHz	1 kHz - 500 MHz
Common Mode Rejection Ratio	>25 dB	
RF OUTPUT Transimpedance Gain[a]	10 x 10^3 V/A	
RF OUTPUT Conversion Gain[a, b]	10 x 10^3 V/W @ 1550 nm	
RF OUTPUT CW Saturation Power	360 µW @ 1550 nm	
Minimum NEP	6.5 pW/√Hz (DC to 500 MHz)	
RF OUTPUT Voltage Swing High Z 50 Ω Load	 ±3.6 V (linear: 0 V to 2.5 V) ±1.8 V	
Overall Output Voltage Noise	<1.5 mV_{RMS}	
DC Offset	<±5 mV	
MONITOR Outputs		
MONITOR Output Impedance	200 Ω	
MONITOR Output Bandwidth (3 dB)	DC - 1 MHz	
MONITOR Output Conversion Gain, High Z Load[b]	10 V/mW @ 1550 nm	
MONITOR Output Voltage Swing, High Z 50 Ω Load	 10 V Max (linear: 0 V to 5 V) 1.5 V Max	
Overall Output Voltage Noise	<0.6 mV_{RMS}	
DC Offset	<±5 mV	
General		
Optical Input	Thorlabs FC/APC connectors	
Electrical Outputs	SMA, 50 Ω	
Operating Temperature Range[c]	0 °C to 40 °C	
Storage Temperature Range	-40 °C to 70 °C	
Dimensions (W x H x D)	76.7 mm x 60.0 mm x 20.0 mm; 3.02" x 2.36" x 0.79"	
Weight [d]	0.13 kg	
Included Power Supply LDS12B	±12 V @ 250 mA; (100/120/230 VAC, 50-60 Hz, Switchable)	

[a]) Value is given for high-impedance load. For a 50 Ω load, divide the value by 2.

[b]) Given at detector peak responsivity.

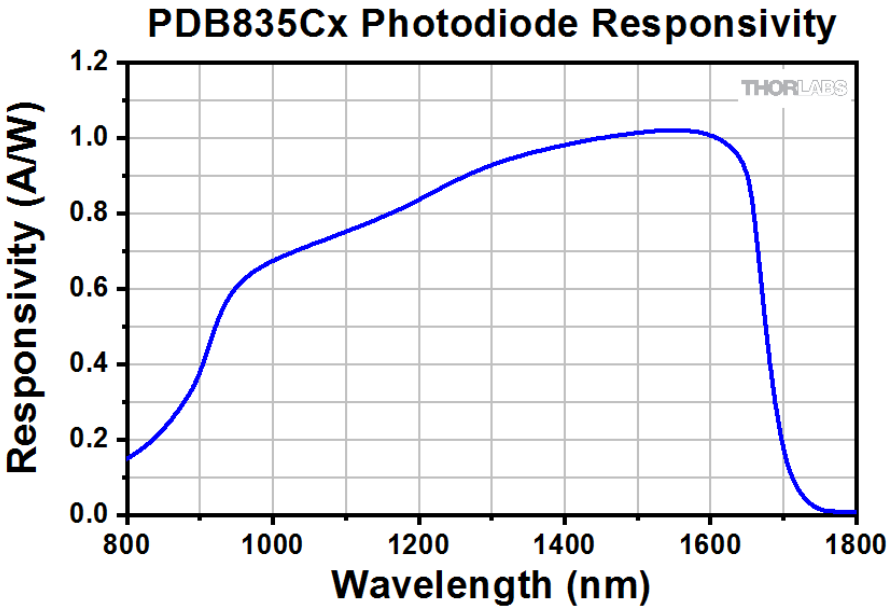
[c]) non-condensing

[d]) Weight of the PDB835C and PDB835C-AC, excluding all shipped accessories.

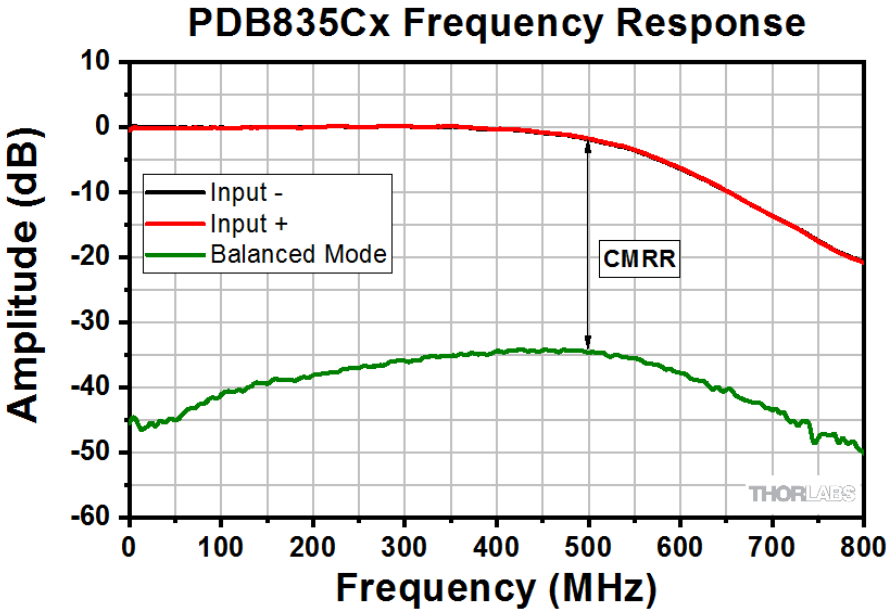
All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

5.1 Performance Plots

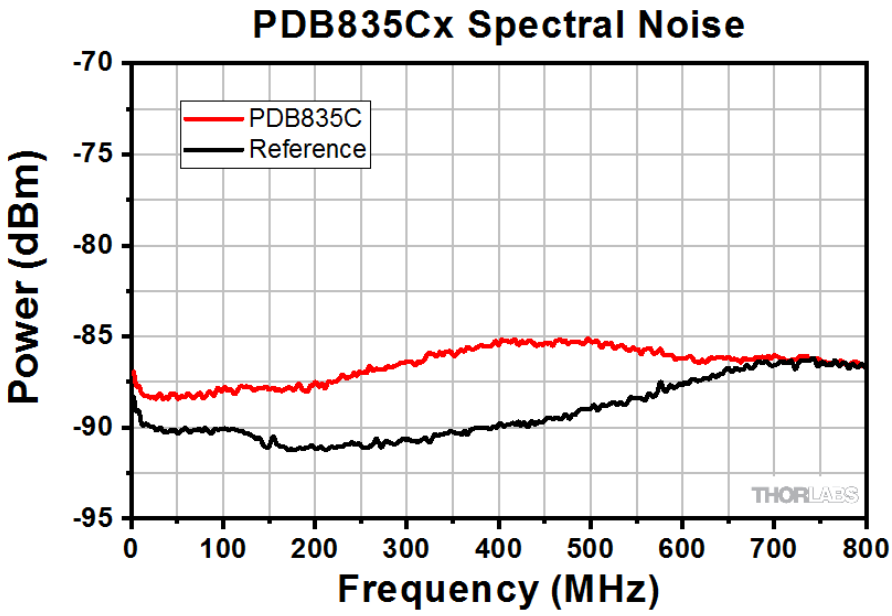
This plot shows the responsivity for PDB835C and PDB835C-AC.



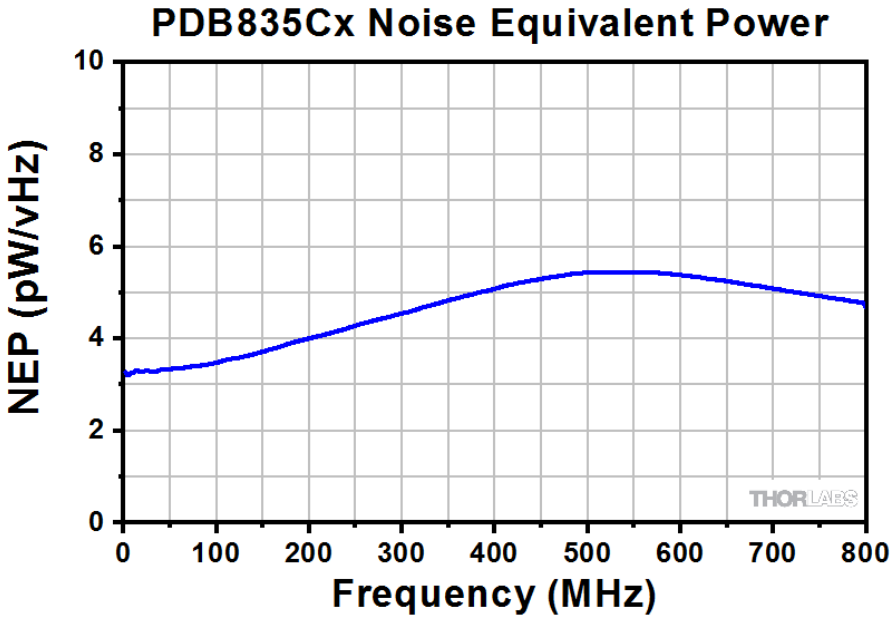
This plot shows the typical frequency response for PDB835C and PDB835C-AC.



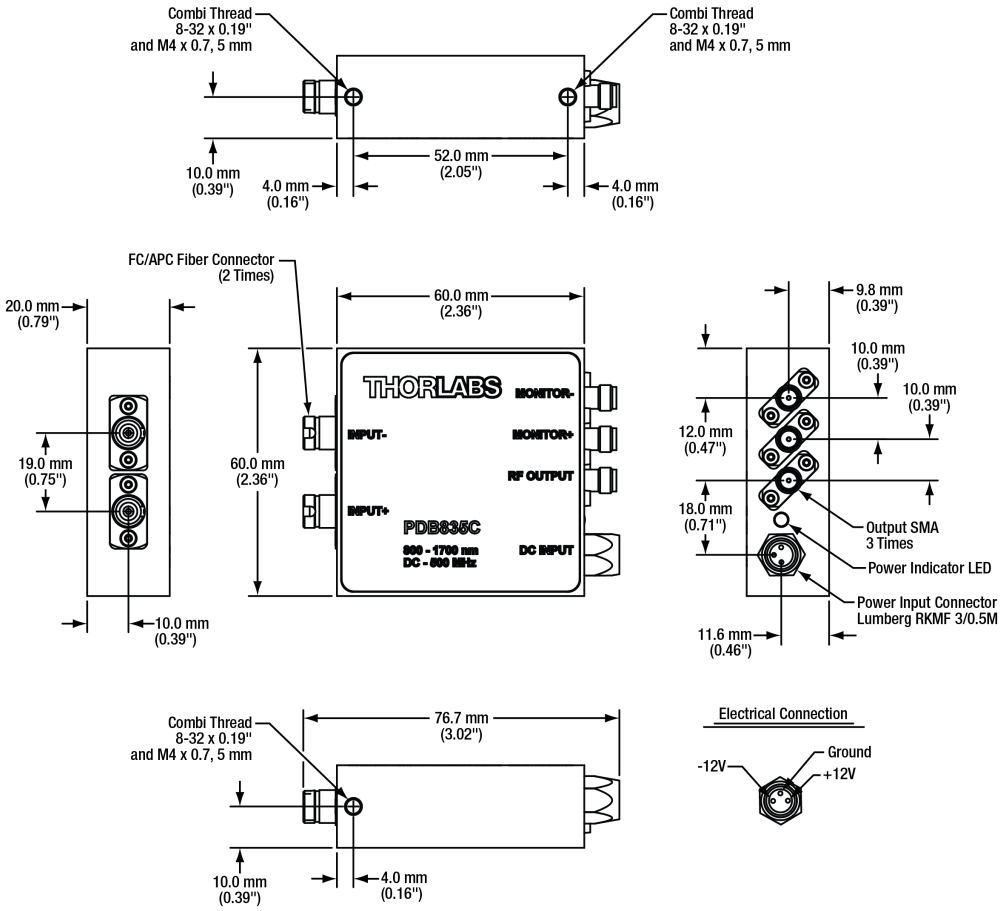
This plot shows the typical RF-Output spectral noise for PDB835C.



This plot shows the typical noise equivalent power (NEP) over the frequency range for PDB835C.



5.2 Dimensions



Chapter 6 Maintenance and Service

Protect the PDB835C and PDB35C-AC from adverse weather conditions. The PDB835C and PDB35C-AC 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 regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please see the Return of Devices section and contact Thorlabs for return instructions.

Do not remove covers!

Chapter 7 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: ***PDB2*, PDB4*, PDB5*, PDB8****

Equipment: ***Fixed and switchable gain balanced amplifiers***

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

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:* 29 November 2022

Name: Dr. Bruno Gross

Position: General Manager

EDC - PDB2, PDB4*, PDB5*, PDB8'*

CE

Chapter 8 Warranty and RMA Information

Thorlabs warrants material and production of the PDB835C and PDB35C-AC 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

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.

8.2 WEEE Policy

Thorlabs 'End of Life' Policy (WEEE)

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 users responsibility to delete all private data stored on the device prior to disposal.

Chapter 9 Manufacturer Address

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Email:
techsupport.uk@thorlabs.com

Chapter 10 Copyright and Liability

Thorlabs has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the product.

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

Chapter 11 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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THORLABS

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