THORLABS

Avalanche Photodetectors

APD130x
Operation Manual

2015

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Contents

We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and improve our products permanently we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.

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 preceeded 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 these advices carefully!

1 General Information

The Thorlabs APD130x series of temperature-compensated Avalanche Photodetectors combine a high sensitivity Si or InGaAs Avalanche Photodiode with a specially designed ultra-low noise transimpedance amplifier for detection of light signals from DC to 50 MHz.

APD130x series Avalanche Photodetectors have an exceptional low NEP, making them ideal for fast low-level light detection applications, such as spectroscopy, fluorescence measurements, laser radar and optical rangefinders. Due to their very high sensitivity the APD130x series Avalanche Photodetectors can replace Photomultiplier Tubes (PMT) in many applications. The Avalanche Photodetectors cannot be damaged by unwanted ambient light, which is critical for many Photomultiplier Tubes.

The APD130x series Avalanche Photodetectors are temperature-compensated. A special electronic circuit compensates the temperature dependency of the M (multiplication) factor.

The slim line housing includes a removable threaded coupler that is compatible with any of Thorlabs 1" and ½" threaded accessories. This allows convenient mounting of external optics, filters, apertures or fiber adapters. The APD130x has three tapped mounting holes.

The APD130x series is powered by the included external power supply (±12 V, 200 mA) via a PICO M8 power connector.

1.1 Safety

Attention

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.

Prior to apply power to the APD130x, 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 with damages to your health or even death!

The APD130x must not be operated in explosion endangered environments!

Do not remove covers!

Refer servicing to qualified personnel!

Only with written consent from *Thorlabs* may changes to single components be made or components not supplied by *Thorlabs* be used.

This precision device is only serviceable if properly packed into the complete original packaging. If necessary, ask for a replacement package prior to return.

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).

1.2 Ordering Codes and Accessories

APD130C	Temperature Compensated Avalanche Photodetector, InGaAs APD, 900 - 1700 nm, 8-32 mounting holes
APD130C/M	Temperature Compensated Avalanche Photodetector, InGaAs APD, 900 - 1700 nm, M4 mounting holes
APD130A2	Temperature Compensated Avalanche Photodetector, UV-enhanced Silicon APD, 200 - 1000 nm, 8-32 mounting holes
APD130A2/M	Temperature Compensated Avalanche Photodetector, UV-enhanced Silicon APD, 200 - 1000 nm, M4 mounting holes
APD130A	Temperature Compensated Avalanche Photodetector, Silicon APD, 400 - 1000 nm, 8-32 mounting holes
APD130A/M	Temperature Compensated Avalanche Photodetector, Silicon APD, 400 - 1000 nm, M4 mounting holes

AC-coupled versions as well as open detector versions (detector cover glass removed) of each model can be ordered on request.

The **APD130C (/M)** is factory set to M = 10. It can be ordered on request with lower M-factor (2..10).

The **APD130A2 (/M)** is factory set to M = 50. It can be ordered on request with different M factor values (10...50).

The **APD130A (/M)** is factory set to M = 50. It can be ordered on request with different M factor values (10...100).

2 Getting Started

2.1 Parts List

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the APD130x mechanically and electrically.

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

1. **APD130x** Temperature-Compensated Avalanche Photodetector
2. SM1CP1 Metal cover cap
3. Power supply (±12 V, 200 mA), 110 V or 230 V line voltage
4. Operation manual

2.2 Preparation

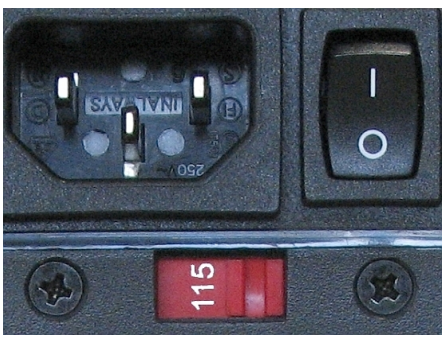
Note

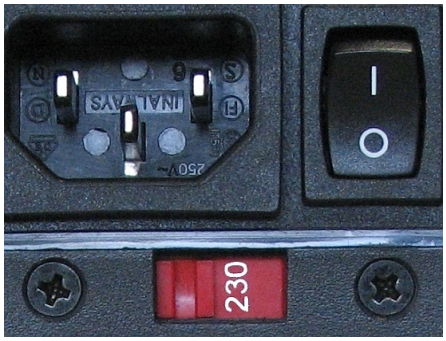
Please check prior to operation, if the indicated line voltage range on the power supply matches with your local mains voltage!

Note

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

- Carefully unpack the unit and accessories. If any damage is noticed, do not use the unit. Call Thorlabs and have us replace the defective unit.
- If necessary, mount the unit on your optical table or application. The unit has three tapped mounting holes (see section Mounting 8 for details).
- Remove the metal cover cap that protects the optical input.
- If necessary, mount external optics, filters, apertures or fiber adapters.
- Switch the power supply to your local main voltage (100-120 VAC or 220 V-240 VAC):





- Plug the power connector cable into the POWER IN.
- Plug the power supply into a 50-60 Hz, 100-120 VAC or 220V-240 VAC outlet, turn power supply on.
- Connect OUTPUT with coaxial cable to your data acquisition device. Please note, that a 50 Ω impedance device should be used for best RF performance.

3 Operating Instruction

3.1 Operating Principle

The Thorlabs APD130x series of temperature-compensated Avalanche Photodetectors combine a high sensitivity Si or InGaAs Avalanche Photodiode with a specially designed ultra-low noise transimpedance amplifier for detection of light signals from DC to 50 MHz. The buffered output stage can deliver up to 1.8 V into a 50 Ω impedance load. The ultra-low noise design includes an active low-pass filter to effectively suppress out-of-band noise. No external high voltage power supply is required for operation.

APD130x series Avalanche Photodetectors have an exceptional low NEP, making them ideal for fast low-level light detection applications, such as spectroscopy, fluorescence measurements, laser radar and optical rangefinders. Due to their very high sensitivity the APD130x series Avalanche Photodetectors can replace Photomultiplier Tubes (PMT) in many applications. The Avalanche Photodetectors cannot be damaged by unwanted ambient light, which is critical for many Photomultiplier Tubes.

Avalanche Photodiodes use an internal gain mechanism to increase the sensitivity. Incident photons generate electron-hole pairs, like in a normal photo diode. By applying a high reverse voltage, a strong electric field appears that accelerates these electrons and produces secondary electrons by impact ionization. This leads to an electron avalanche producing gain factors of up to several hundreds. The amplification depends on the reverse bias voltage and is described by the M factor (multiplication factor). Due to internal processes, the M factor is temperature dependent. At a fixed reverse bias voltage the M factor will change with temperature: in general, with lower temperatures the M factor will increase, with higher temperatures - decrease.

The APD130x series Avalanche Photodetectors are temperature-compensated. A thermistor senses the temperature inside the APD130x enclosure, and a special electronic circuit controls the applied to the APD reverse voltage in accordance with the temperature change. As the M (multiplication) factor depends on the applied reverse voltage, the temperature dependency of the M factor can reduced drastically.

The APD130x series is powered by the included external power supply (±12 V, 200 mA) via a PICO M8 power connector.

3.1.1 Optical Input

The APD130C uses an InGaAs Avalanche Photodiode with a detector active area diameter of 0.2 mm, operating from 900 to 1700 nm nm.

The APD130A uses a Silicon Avalanche Photodiode with a detector active area diameter of 1 mm, operating from 400 to 1000 nm.

The APD130A2 uses an UV-enhanced Silicon Avalanche Photodiode with a detector active area diameter of 1 mm, operating from 200 to 1000 nm.

In the appendix 12, the typical responsivity curves can be found.

An open beam should be carefully aligned to the detector. Additional focusing lenses can be easily attached to the Avalanche Photodetectors. The housing is compatible with any number of Thorlabs 1” and ½” threaded accessories. This allows convenient mounting of external optics, filters, apertures or fiber adapters.

For fiber coupled application a fiber connector adapter like Thorlabs S120-FC or SM1xx can be easily used. The fiber adapter will accommodate multi-mode fiber as well as single-mode fiber. Please note, that coupling losses may occur due to small detector size, which will result in a reduced output signal. If angled connectors are used the fiber adapter can be rotated from its original position to check for an improved alignment. For this process use an optical input power below the saturation power while observing OUTPUT voltage on a digital voltmeter or other low-

frequency measurement device.

The maximum OUTPUT voltage swing is 3.6 V. Saturation of the OUTPUT will occur at optical input power greater than CW Saturation Power listed in specifications 12. If necessary, use external neutral density filters or attenuators to reduce the input light level. Please note, that the Avalanche Photodetectors are extremely sensitive to unwanted stray light. Carefully shielding of the Avalanche Photodetectors from any unwanted light sources is essential. Common techniques are baffling or other opaque barriers like black cloths, beam tubes or use appropriate band pass filters in front of the detector to minimize the influence of stray light.

Attention
The optical damage threshold is 1 mW. Exceeding this value will permanently destroy the Avalanche Photodetector!

3.1.2 Electrical Output

The Thorlabs APD130x Avalanche Photodetectors delivers an OUTPUT voltage, which is a function of incident light power P_{opt}, detector's responsivity $\Re(\lambda)$, multiplication factor M and transimpedance gain G given by:

$$V_{out} = P_{opt} \cdot \Re(\lambda) \cdot M \cdot G$$

- $\Re(\lambda)$ for a given wavelength can be read from the spectral responsivity curves (see Technical Data) to estimate the OUTPUT voltage.
- The factor is factory set to 50 (APD130A, APD130A2) or 10 (APD130C) at 23°C ambient temperature.
- The amplifier's transimpedance gain G is 100 kV/A. 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 of OUTPUT is 3.6 V for high impedance loads (1.8 V into 50 Ω). Depending on the wavelength responsivity $\Re(\lambda)$ of the detector and the M factor, the amplifier will reach saturation at optical input power greater than CW Saturation Power listed in specifications. To avoid saturation, keep the output signal below the specified maximum output voltage.

The output of the APD130x Avalanche Photodetectors 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 Avalanche Photodetectors in a constant temperature environment after a short warm up period (~5 min) for exact DC light level measurements.

In the appendix, typical curves for Output Frequency Response 15, Spectral Noise Distribution 17 and M Factor Temperature Dependency 19 can be found.

3.2 Mounting

The APD130x series is housed in a rugged 2 x 2.5 x 1 inch shielded aluminum enclosure. The slim line housing comes with a removable threaded coupler that is compatible with any number of Thorlabs 1" and ½" threaded accessories. This allows convenient mounting of external optics, filters, apertures or fiber adaptors, as well as providing an easy mounting mechanism using the Thorlabs cage assembly accessories. The electrical connectors and the ON/OFF switch are conveniently located on the side walls of the housing for easy access and to minimize the thickness of the Avalanche Photodetectors so it can fit into tight spaces. For maximum flexibility the APD130x has three 8-32 (M4 for metric version) tapped mounting holes to mount the unit to a post or pedestal.

3.3 Operation

- Turn the power switch to **I**. The green LED on the APD130x indicates correct power supply.
- Adjust the optical source to the optical input. The maximum OUTPUT voltage swing is 3.6 V for high impedance loads (1.8 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.
- Do not exceed a maximum power density of 4 W/cm^2 for maximum linearity performance when measuring focused beams, fiber outputs, or small diameter beams.
- For fiber coupled applications fiber adapters like Thorlabs S120-xx series can easily mounted on the optical inputs. The fiber adapter will accommodate multi-mode as well as single-mode fiber.
- Turn the power switch to **O** when you are finished the measurements.

Note

Avoid saturation of the amplifier! Therefore, make sure that the optical input power does not exceed the saturation power level listed in specifications 12.

Attention

Exceeding the optical damage threshold input power will permanently destroy the detector!

3.4 Recommendations

Please always remember that the Avalanche Photodetectors are extremely sensitive devices. Carefully shielding of the Avalanche Photodetectors from any unwanted light sources is essential. Common techniques are baffling or other opaque barriers like black cloths or beam tubes.

It is highly recommended to use appropriate band pass filters in front of the detector to minimize the influence of stray light.

Since stray light has its strongest frequencies at DC and line frequency or harmonics, optical chopping and Lock-In detection can further improve measurement sensitivity.

It is not necessary to switch off the Avalanche Photodetectors 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.

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. You should always try to identify the electrical noise sources and increase the distance to the Avalanche Photodetectors. If possible, you can also rotate the Avalanche Photodetectors input away from the noise source. Different common ground points can also be tested.

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 may affect offset voltage. Therefore it is recommended to use the Avalanche Photodetectors in a constant temperature environment after a short warm up period (~5min) for exact DC light level measurements.

The M factor is set at factory at 23°C ambient temperature. The APD130x are operated at an internal reverse bias voltage that is temperature-compensated, and their actual M factor will remain nearly constant within the specified ambient temperature range of (23±5) °C.

4 Maintenance and Service

Protect the APD130x from adverse weather conditions. The APD130x 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 himself. If a malfunction occurs, please contact Thorlabs 28 for return instructions.

Do not remove covers!

5 Appendix

5.1 Technical Data

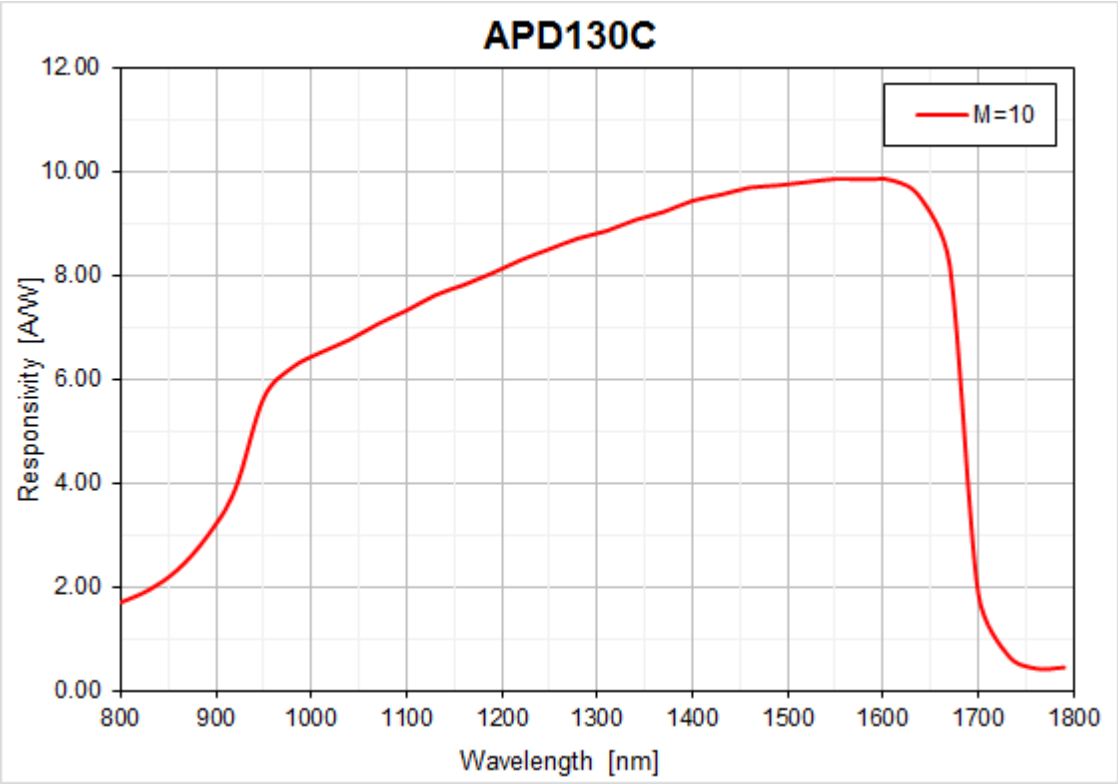
	APD130C	APD130A	APD130A2
Parameter			
Detector Material/Type	InGaAs APD	Silicon APD	UV-enhanced Silicon APD
Wavelength Range	900 to 1700 nm	400 to 1000 nm	200 to 1000 nm
Maximum APD Responsivity	9 A/W @ 1500 m, M = 10	25 A/W @ 800 nm, M = 50	25 A/W @ 600 nm, M = 50
M Factor Temperature Stability [1])	typ. ± 2 %; max. ± 3 %		
Detector Active Area Diameter	0.2 mm	1 mm	1 mm
Transimpedance Gain	100 kV/A 50 kV/A with 50 Ω termination	100 kV/A 50 kV/A with 50 Ω termination	100 kV/A 50 kV/A with 50 Ω termination
Maximum Conversion Gain	0.9 x 10^6 V/W	2.5 x 10^6 V/W	2.5 x 10^6 V/W
OUTPUT Bandwidth (3 dB)	DC to 50 MHz	DC to 50 MHz	DC to 50 MHz
CW Saturation Power	4.2 µW	1.5 µW	1.5 µW
Maximum Input Power (Photodiode Damage Threshold)	1 mW	1 mW	1 mW
Minimum NEP (DC - 50 MHz)	0.46 pW / √ Hz	0.20 pW / √ Hz	0.21 pW / √ Hz
Integrated Noise (DC - 50 MHz)	3.3 nW (RMS)	1.4 nW (RMS)	1.5 nW (RMS)
Electrical Output, Impedance	BNC, 50 Ω		
Maximum Output Voltage	3.6 V (High Z load) 1.8 V (50 Ω)		
DC-Offset Electrical Output	< ±15 mV		
Power Supply	±12 V, 200 mA		
General			
Operating Temperature Range [2])	0 - 40 °C		
Storage Temperature Range	-40 to 70 °C		
Dimensions (W x H x D)	2 x 2.5 x 1"		
Weight	< 0.1 kg		

[1]) Ambient temperature within (23 ± 5)°C

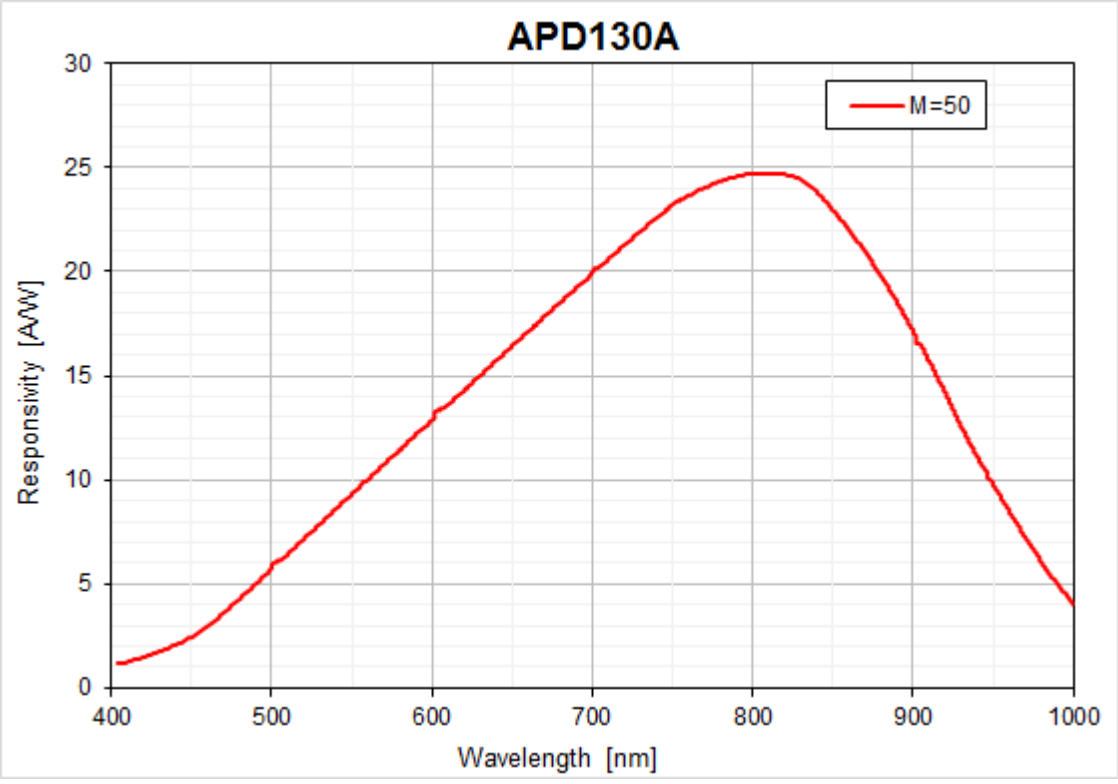
[2]) Non-condensing

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

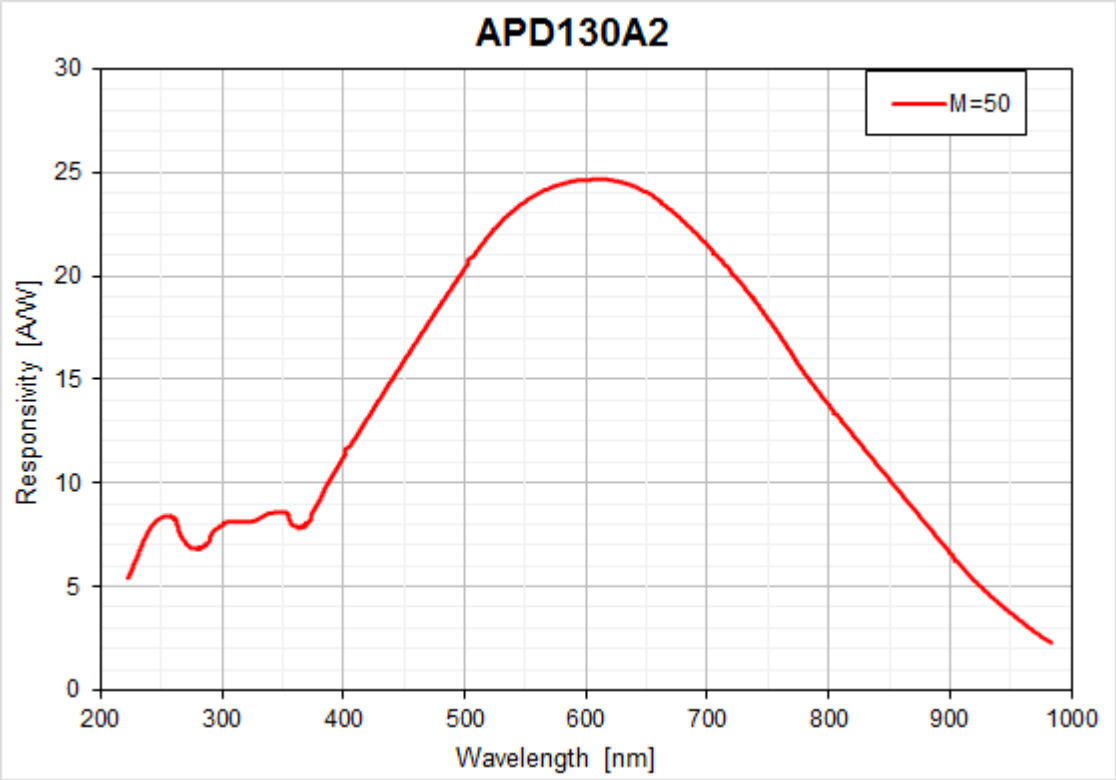
5.2 Typical Detector Responsivity Curves



Typical Detector Responsivity APD130C; M = 10



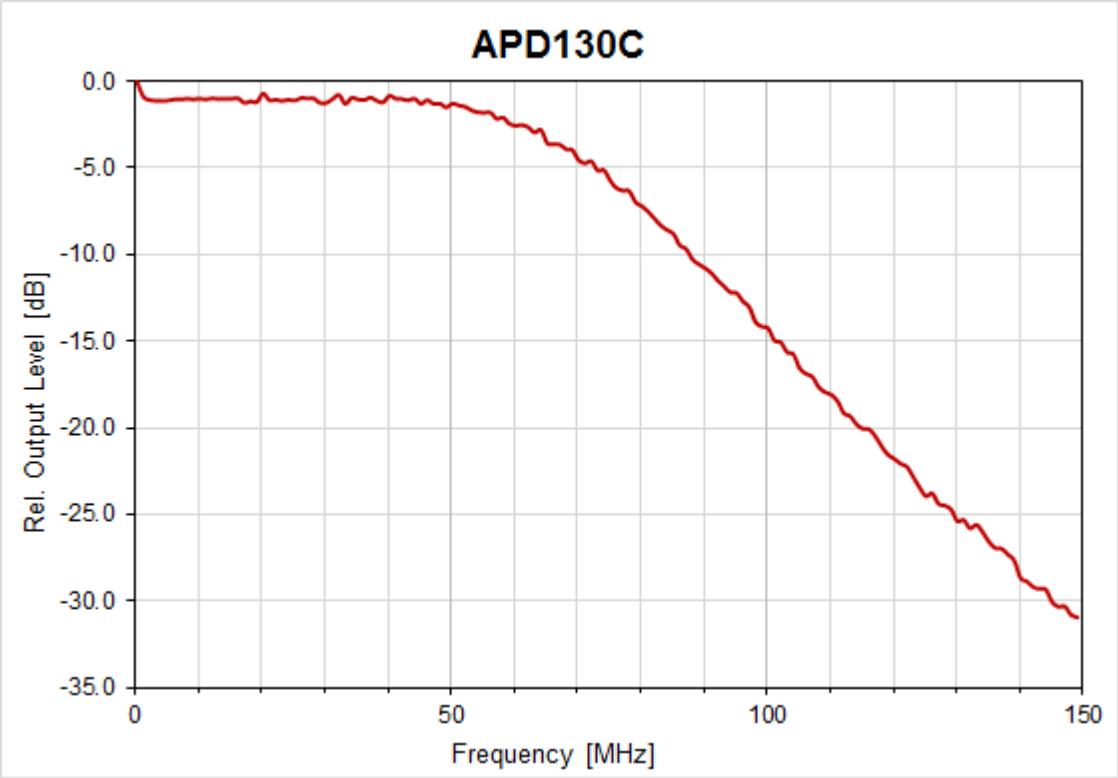
Typical Detector Responsivity APD130A; M = 50



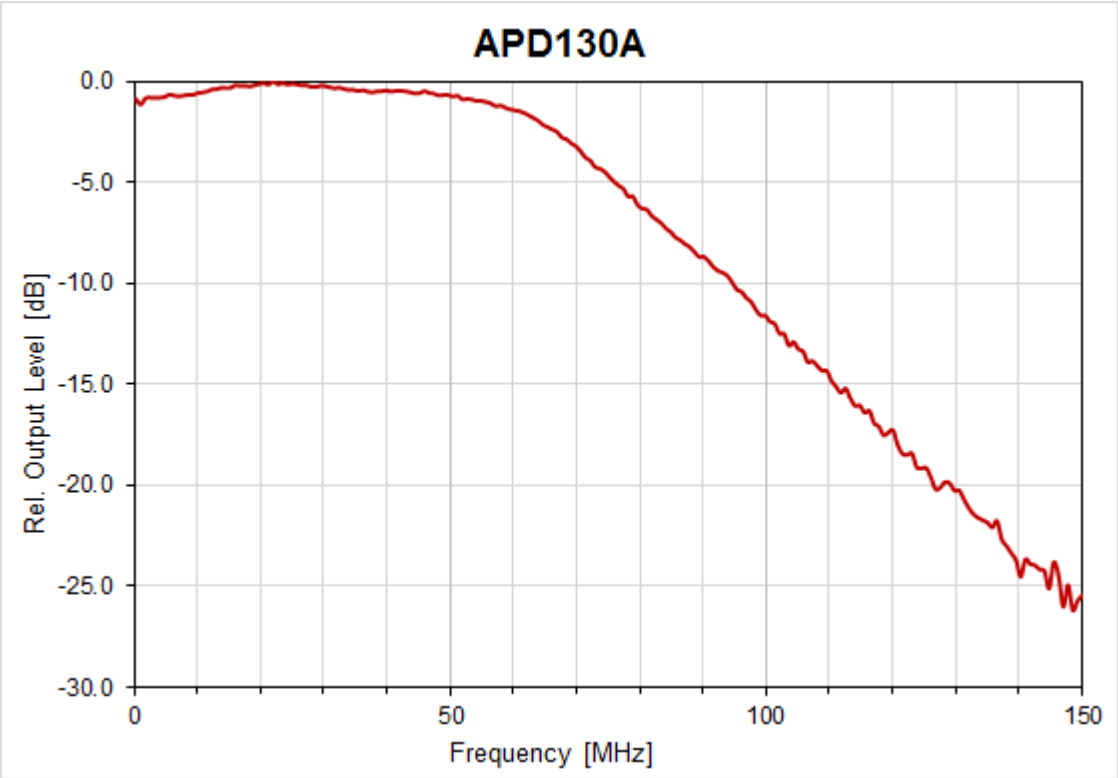
Typical Detector Responsivity APD130A2; M = 50

5.3 Typical Output Frequency Response

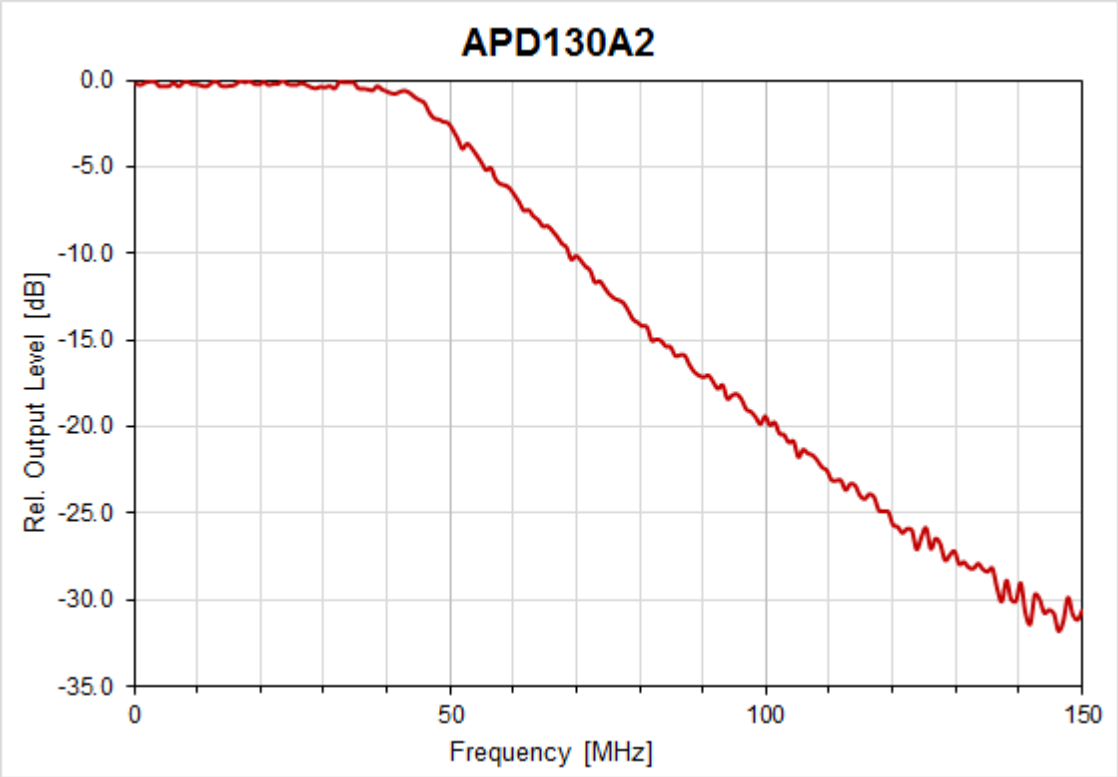
For this measurement a test signal, generated by an optical transmitter, was fiber-coupled to the Avalanche Photodetector. The OUTPUT frequency response was measured using a optical network analyzer.



Typical Output Frequency Response APD130C



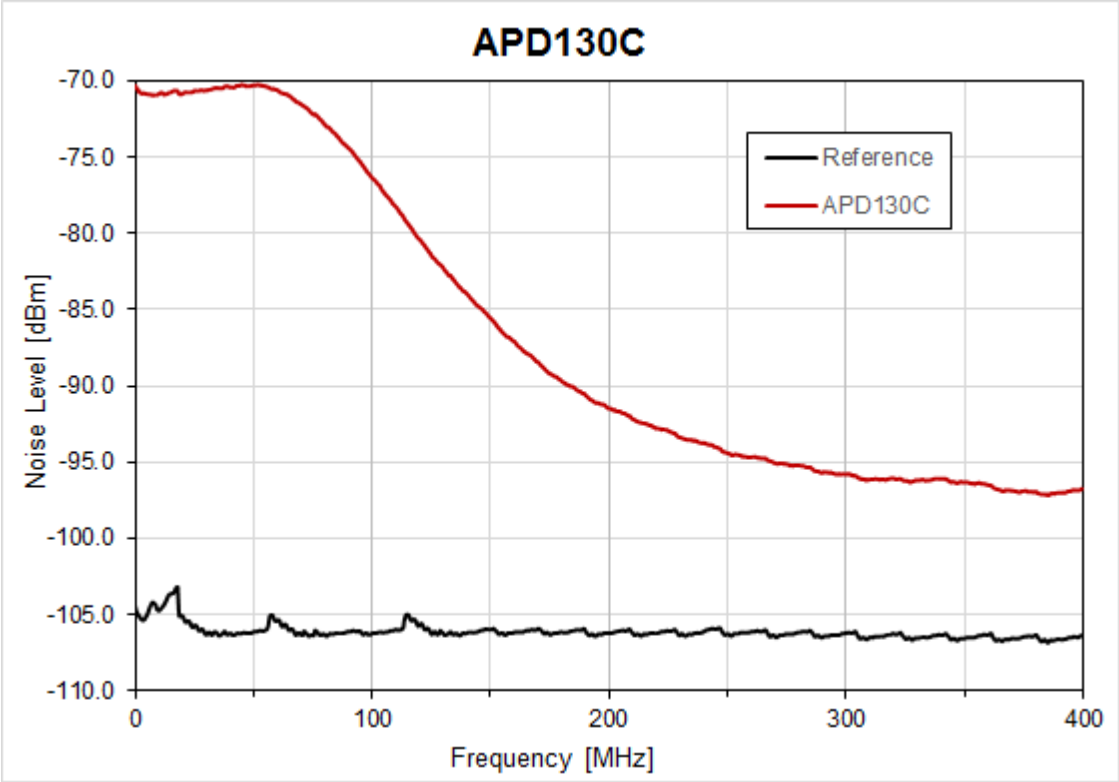
Typical Output Frequency Response APD130A



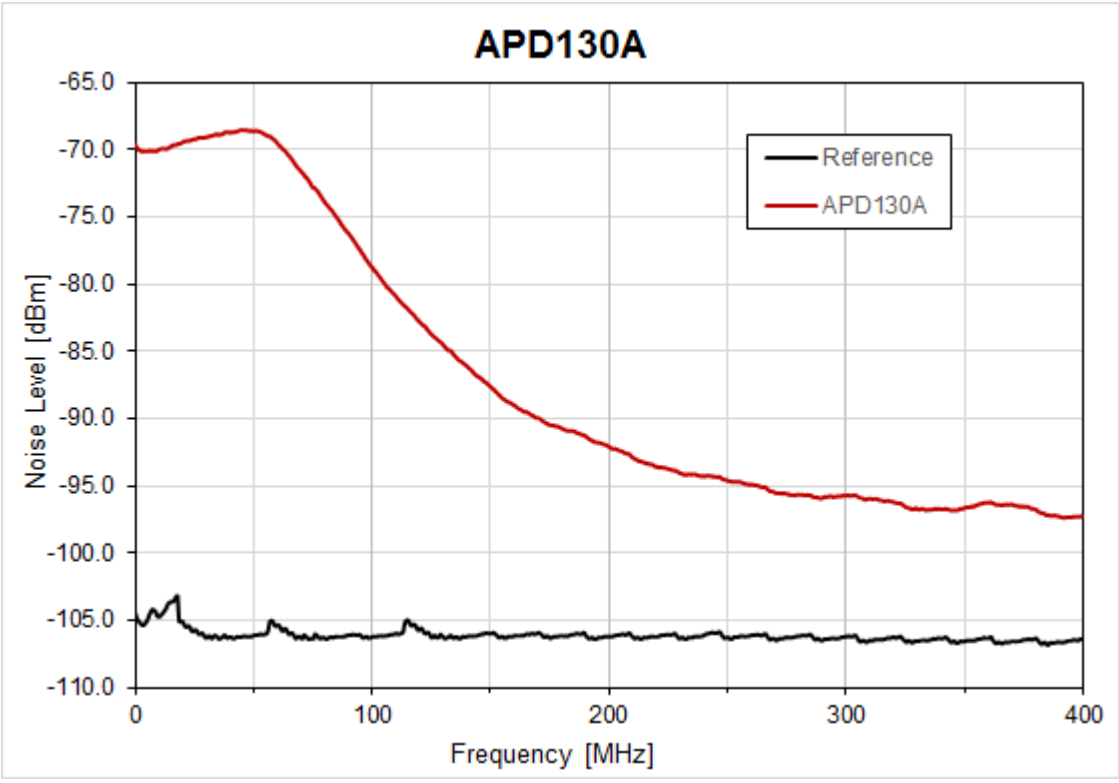
Typical Output Frequency Response APD130A2

5.4 Typical Spectral Noise

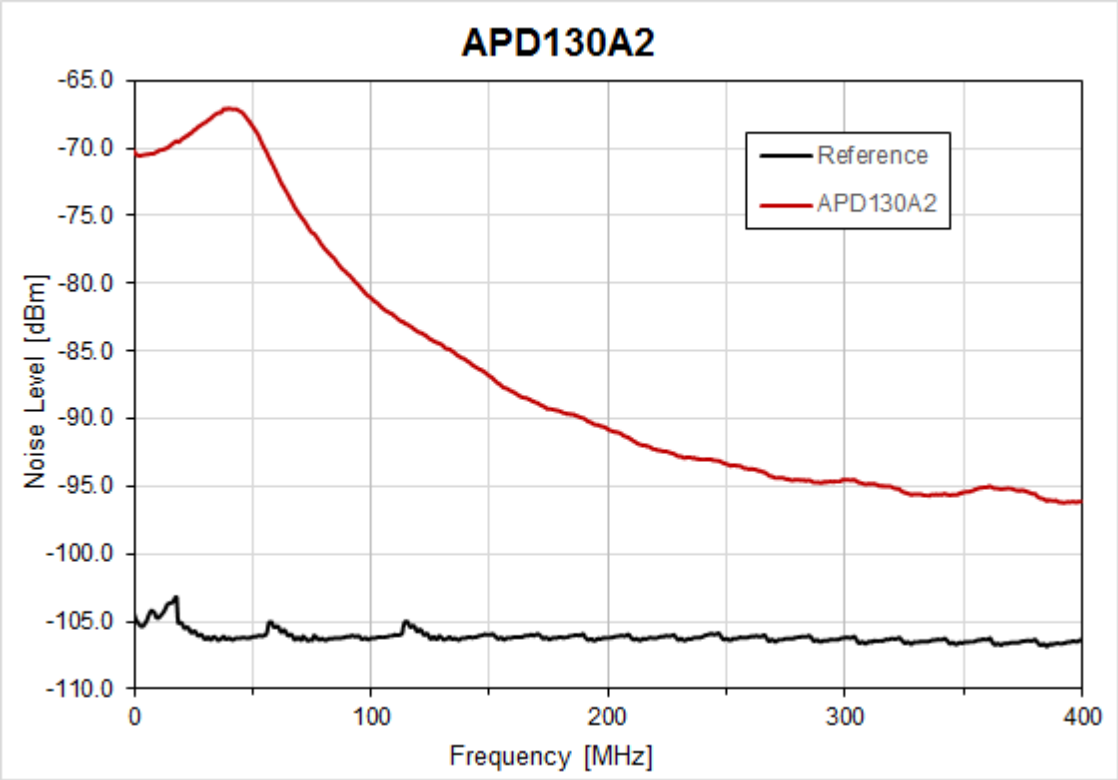
The typical noise spectrum was measured using an electrical spectrum analyzer (resolution bandwidth 10 kHz, video bandwidth 10 kHz). The optical input of the detector was blocked. The black curve ("Reference") was measured with the same setup and the detector switched off , i.e., it represents the measurement system's noise floor.



Typical Spectral Noise APD130C

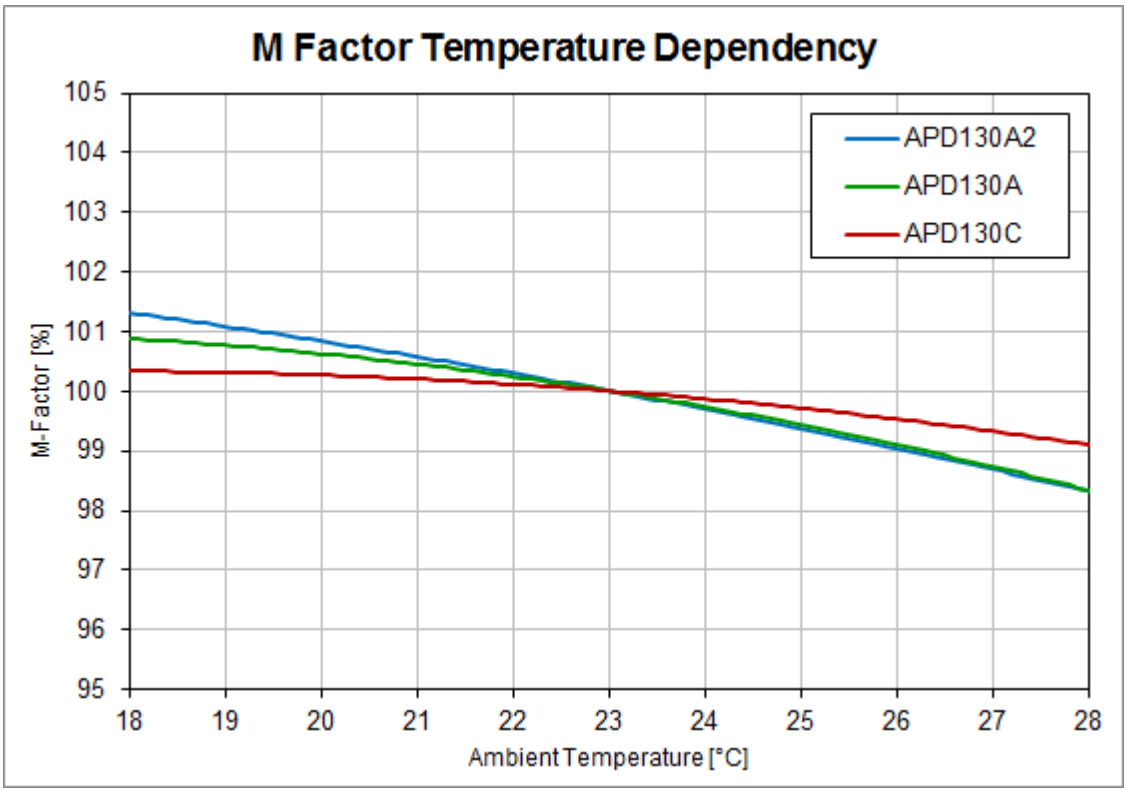


Typical Spectral Noise APD130A



Typical Spectral Noise APD130A2

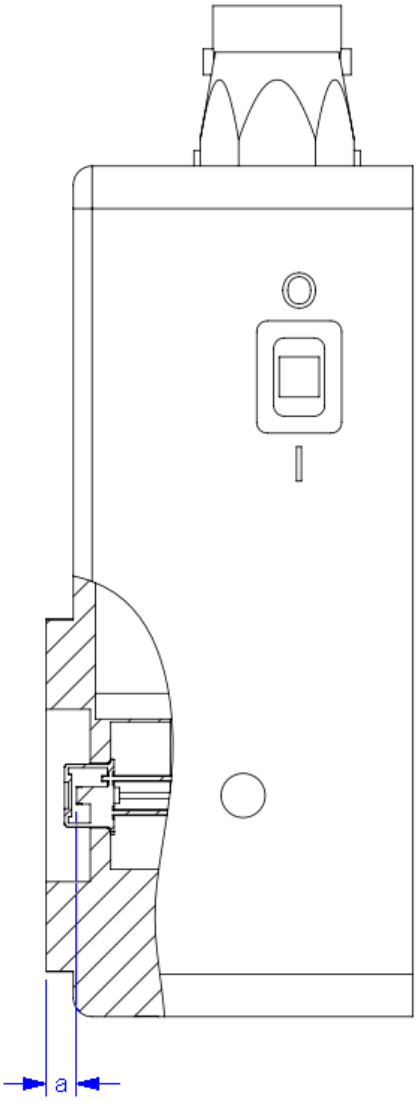
5.5 Typical M Factor Temperature Dependency



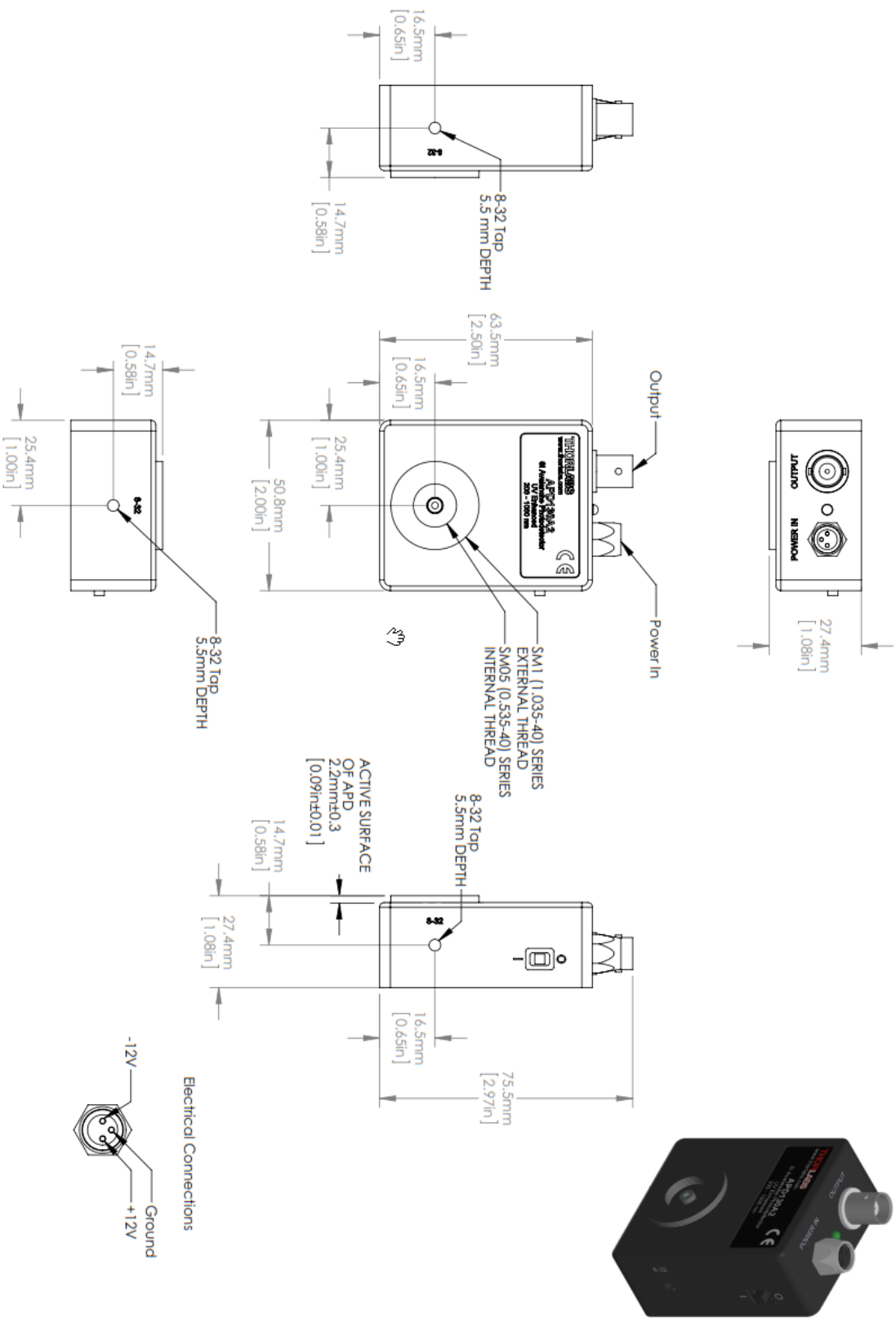
Typical Dependency of the M Factor vs. Temperature - APD130x

5.6 Drawings

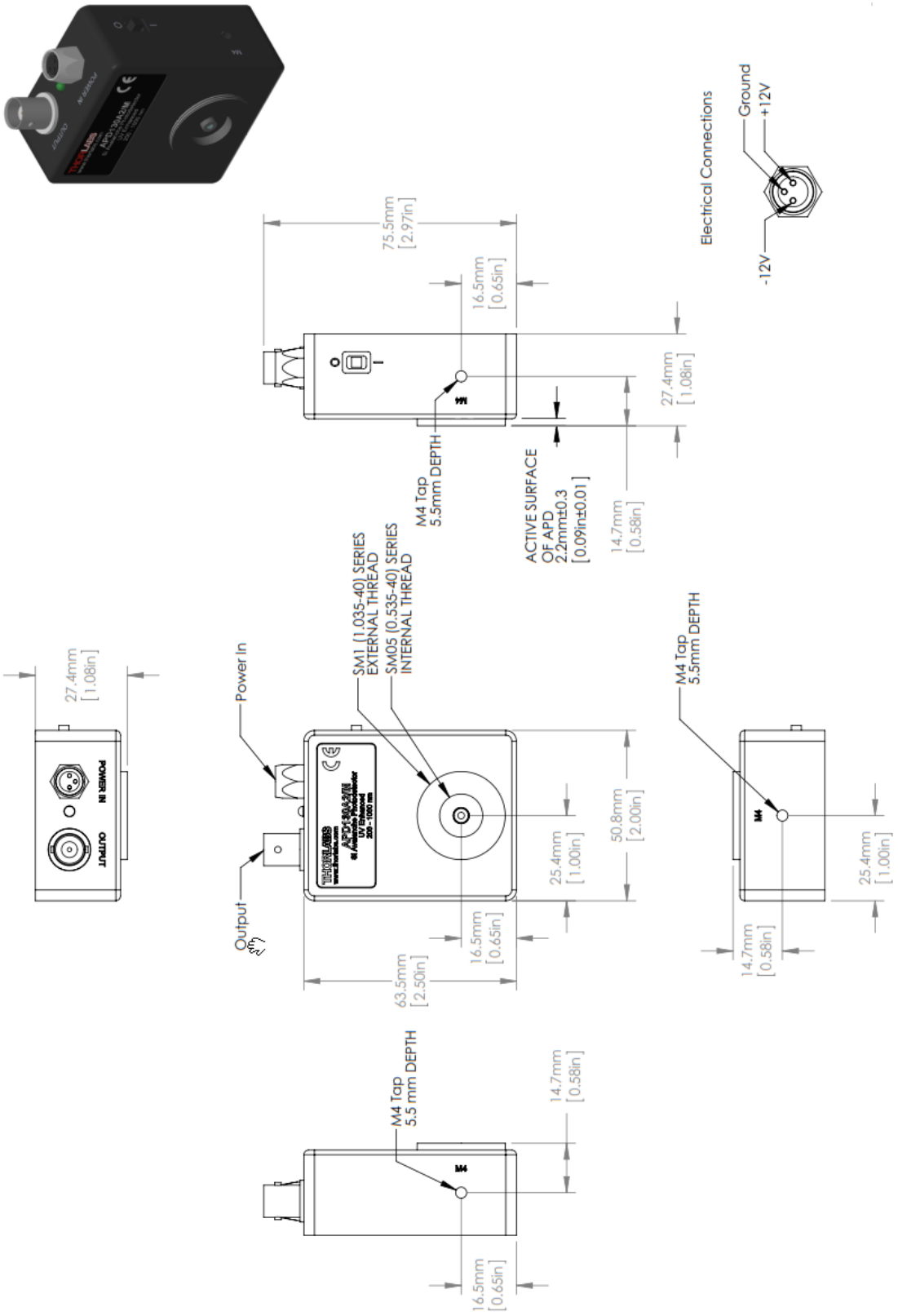
Distance between the surface of the active detector area and the front of the flange



Distance	A Type	A2 Type	C Type
a=	(2.2 ± 0.3) mm	(2.2 ± 0.3) mm	(2.8 ± 0.3) mm



Dimensions APD13X Series (Imperial)



Dimensions APD13X/M Series (Metric)

5.7 Certifications and Compliances

Category	Standards or description	
EC Declaration of Conformity - EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance is given to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326	EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions[1] and Immunity[2]
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance Criterion C)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance Criterion B)[2]
FCC EMC Compliance	Emissions comply with the Class B Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B [1]	
Australia / New Zealand Declaration of Conformity - EMC	Complies with the Radiocommunications Act and demonstrated per EMC Emission standard1,2	
	AS/NZS 2064	Industrial, Scientific, and Medical Equipment: 1992

[1] Using high-quality shielded interface cables.

[2] Minimum Immunity Test requirement.

5.8 Warranty

Thorlabs warrants material and production of the APD130x for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs will see to defaults by repair or by exchange if these are entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs is not liable for consequential damages.

Restriction of warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. Thorlabs does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit at any time.

5.9 Copyright and Exclusion of Reliability

Thorlabs has taken every possible care in preparing this Operation Manual. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this manual is regularly updated and adapted to reflect the current status of the software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

Under no circumstances can we guarantee that a particular objective can be achieved with the purchase of this product.

Insofar as permitted under statutory regulations, we assume no liability for direct damage, indirect damage or damages suffered by third parties resulting from the purchase of this product. In no event shall any liability exceed the purchase price of the product.

Please note that the content of this User Manual is neither part of any previous or existing agreement, promise, representation or legal relationship, nor an alteration or amendment thereof. All obligations of *Thorlabs* result from the respective contract of sale, which also includes the complete and exclusively applicable warranty regulations. These contractual warranty regulations are neither extended nor limited by the information contained in this User Manual. Should you require further information on this product, or encounter specific problems that are not discussed in sufficient detail in the User Manual, please contact your local *Thorlabs* dealer or system installer.

5.10 Thorlabs 'End of Life' Policy

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out “wheelie bin” logo (see figure below)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this “end of life” take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB’s, housings etc.).

Waste treatment on your own responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

WEEE Number (Germany) : DE97581288

Ecological background

It is well known that waste treatment pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS Directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE Directive is to enforce the recycling of WEEE. A controlled recycling of end-of-life products will thereby avoid negative impacts on the environment.

Crossed out
"Wheelie Bin" symbol

5.11 List of Acronyms

AC	Alternating Current
APD	Avalanche Photo Diode
CW	Continuous Wave
DC	Direct Current
LED	Light Emitting Diode
NEP	Noise Equivalent Power
RF	Radio Frequencies
Si	Silicon
UV	Ultraviolet

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