THORLABS

Single Photon Detectors

SPDMH2, SPDMH3, SPDMH2F, SPDMH3F Operation Manual



2023

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We aim to develop and produce the best solutions for your applications in the field of optical measurement techniques. To help us to live up to your expectations and constantly improve our products, we need your ideas and suggestions. 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 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 SPDMHx Series modules detect single photons of light within the wavelength range from 400 nm to 1000 nm. Their high photon detection efficiency (PDE) with a low dark count rate across a wide dynamic range results from the combination of the ultra-low-noise silicon avalanche photodiode with specially developed quenching and signal processing electronics. Incoming photons generate corresponding electrical pulses and are converted to a TTL pulse which is output at the LEMO connector. A LEMO to BNC adapter is included.

The gating function allows the module to be disabled between measurements and to provide protection against accidental overload.

The detectors are available with different dark count rates: SPDMH2 and SPDMH2F are specified with a dark count rate of 100 Hz while for SPDMH3 and SPDMH3F, Thorlabs specifies a 250 Hz dark count rate.

The detectors can be purchased in a free space version (item #s SPDMH2 or SPDMH3) or with an FC-PC fiber-optic receptacle, pre-aligned to the optical detector to connect a multimode optical fiber with an FC connector (item #s SPDMH2F or SPDMH3F).

Applications range from quantum technologies and cryptography to particle sizing fluorescence analysis, LIDAR, and spectroscopy.

Attention

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

1.1 Ordering Codes and Accessories

SPDMH2	Free Space Avalanche Photodetector, Silicon APD, 400 - 1000 nm, Dark Count Rate 100 Hz, Active Area Diameter 100 µm, Free Beam
SPDMH2F	Avalanche Photodetector for Fiber Coupling, Silicon APD, 400 - 1000 nm, Dark Count Rate 100 Hz, Active Area Diameter 100 µm, FC/PC Connector for Fiber Coupling
SPDMH3	Free Space Avalanche Photodetector, Silicon APD, 400 - 1000 nm, Dark Count Rate 250 Hz, Active Area Diameter 100 µm, Free Beam
SPDMH3F	Avalanche Photodetector for Fiber Coupling, Silicon APD, 400 - 1000 nm, Dark Count Rate 250 Hz, Active Area Diameter 100 µm, FC/PC Connector for Fiber Coupling

Optional Accessories (Sold Separately)

- Optical Input Fiber for SPDMH2F or SPDMH3F. Fiber Requirements as Stated Under Technical Data
- Optical Component Threading Adapters for Mounting on the SM1 Internal Thread
- Thorlabs BA4 mounting base
- 3-Axis Translation Stage

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

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2 Getting Started

2.1 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 SPDMHx Series mechanically and electrically.

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

1. SPDMHx(F) Single Photon Detector with Protective Plastic Cap on the Input Aperture
2. Power Supply, Country Specific
3. Adapter LEMO to BNC
4. Quick Reference
5. Production Report Detailing Dark Count Rate, Dead Time, PDE, and Afterpulsing

3 Operation

3.1 Operating Elements

SPDMH2 and SPDMH3

The components of the SPDMH2 and SPDMH3 free space detectors are labeled in the image of the SPDMH2. SPDMH2 and SPDMH3 components look identical.



SPDMH2F and SPDMH3F

The components of the SPDMH2F and SPDMH3F detectors with fiber couplers are labeled in the image of the SPDMH2F. SPDMH2F and SPDMH3F components look identical.



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Rear View

The connectors on the back are labeled in the image of an SPDMH2 single photon detector. The rear sides the SPDMHx Series models SPDMH2, SPDMH2F, SPDMH3, and SPDMH3F look identical.



3.2 Mounting

The SPDMHx Series detectors can be integrated in an optical setup from the front side and mounted on the base plate.

Front Side Integration

1. All models of the SPDMHx Series provide two mounting holes on the front side of the unit (8-32 UNC threads, depth 8 mm). These can be used for mounting or integration in optical systems.
2. The SPDMH2 and SPDMH3 free space detectors additionally feature an internal SM1 thread, compatible with a variety of Thorlabs offers Optical Component Threading Adapters.

   Note Please take the weight of the detector into account when this mounting style is used!

Base Plate Mounting

The base plate of the SPDMHx Series detector can be fastened on a bread board using the CL4 table clamps. Alternatively, the detectors provide 6 mounting holes (3 holes each side) with a diameter of 3.9 mm.

The base plate can be mounted using 6-32 screws.

For controlled positioning of the SPDMHx Series device, we recommend the following:

1. Mount the SPDMHx Series detector on a Thorlabs BA4 mounting base.
2. Subsequently, mount the BA4 mounting base on a suitable 3-Axis translation stage or other means of positioning mechanics. This is highly recommended for precise positioning of the free space detectors.

Attention

In order to avoid damage to the module, heat management must be provided by placing or mounting the module onto a suitable heat sink, e.g. an optical table.

Attention

Before powering up the module it is strongly advised to make sure that no light reaches the sensor.

3.3 Optical Input

Attention

In order to avoid damage to the module, adequate heat sinking must be provided by placing or mounting the module onto a suitable heat sink, e.g. an optical table, bread board or base plate.

Avoid stray light impinging on the detector which affects the count rate. Employ appropriate shielding for the free space models SPDMH2 and SPDMH3 and make sure that any optical fiber assembly attached to the FC/PC connector of the SPDMH2F or SPDMH3F shields unwanted light.

Setup for the SPDMH2 or SPDMH3 free space detectors

- The SPDMH2 and SPDMH3 detectors have a free space input aperture and show best performance if the light is focused onto a small spot (<70 µm diameter) in the center of the sensor area. The photon detection efficiency will drop with increasing beam diameter.
- Off-center focusing or overfilling the sensor area might lead to a significantly lower detection efficiency and/or increased FWHM of the photon timing resolution.
- Mounting the SPDMH2 or SPDMH3 on a suitable 3-Axis translation stage or other means of positioning mechanics is therefore recommended. Please see the Mounting section for more information.
- Ensure that background light does not reach the photosensitive area. This can be achieved by mounting lens tubes onto the C-mount of the detector.

Setup for the SPDMH2F or SPDMH3F fiber coupling detectors

- The SPDMH2F and SPDMH3F detectors have a fiber optic receptacle, an FC/PC connector, pre-aligned with the photosensitive surface. The GRIN lens used in this assembly is optimized and AR-coated in accordance with the specified wavelength range of the detector.
- Please use an optical fiber which fulfills the requirements stated in the technical data.
- To avoid stray light impinging on the detector and affecting the count rate, the optical fiber assembly attached to the FC/PC connector needs to efficiently shield environmental light from the detector.

3.4 Operation

Powering up the device

Attention

Before powering up the device it is strongly advised to make sure that no light reaches the sensor. Please use the protective cap on the device to do so.

- Plug in the AC adapter in the power supply connector.
- After the detector is powered up, allow 30 seconds settling time in which the sensor will be cooled down to its operating temperature.

Note The SPDMHx Series devices will not generate any output signal until the operating temperature has been reached.

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Attention

The avalanche photodiode inside the SPDMHx Series device is an extremely sensitive device. It can be permanently damaged by over-exposure to intense light.

Excessive light level (even daylight) might damage a powered SPDMHx Series detector. Precautions should be taken to avoid such situations.

When the SPDMHx Series detector is mounted on another instrument, ensure that the optical connection is light-tight.

Heat Dissipation

In order to avoid damage to the detector, adequate heat sinking must be provided by placing or mounting the module onto a suitable heat sink, e.g. an optical table, bread board or base plate.

3.4.1 Gating Function and TTL Output

The SPDMHx Series detectors feature a gating input to disable or enable the output signal.

The output of the detector is disabled when a TTL low level signal is applied to the gate input. Applying a TTL high level will enable the device and permit signal processing and signal output. If the gate input is left unconnected, the device is enabled by default. Please see the Technical Data for the respective TTL levels.

Gating is very useful in applications with rare signals that occur only within a small, defined time window as gating can deselect longer time periods with no signal. Also, applications with very weak signal and high background light profit from the gating in that the background signal within periods without real signal are not recorded.

Attention

Always switch off the device before connecting or disconnecting the gating input and the TTL output.

3.4.2 Optimizing Performance

Active Sensor Area - Focusing the Beam

The SPDMH2 and SPDMH3 free space detectors show best performance if the light is focused to on a small spot (<70 µm diameter) in the center of the sensor active area. Off-center focusing or overfilling the sensor area might lead to a significantly lower detection efficiency and/or increased FWHM of the photon timing resolution. Mounting the detector on a suitable x, y, z-translation table or other means of positioning mechanics is therefore recommended.

The SPDMH2F and SPDMH3F detectors with FC/PC-connectors are pre-aligned for fibers specified in the Technical Data and require no further optimization.

Timing Resolution

The single photon timing resolution of the SPDMHx Series detectors depends on three factors and is different for every single detector. Please see the production report of your SPDMHx Series detector for details.

- Detection Wavelength: The best photon timing resolution (i. e. smallest FWHM) is achieved around 680 nm. The FWHM increases slightly towards blue and NIR detection wavelengths.

- Focusing Quality: For optimum timing resolution the light should be focused to a small spot (<70 µm) in the center of the sensor. Off-center focusing or overfilling the sensor area might lead to an increased FWHM of the photon timing resolution. This is particularly important for the free space detectors.
- Count Rate: High count rates decrease the timing resolution. Especially at count rates above 1 MHz the FWHM may be double the value compared to low count rates.

Temporal Stability

The temporal stability of the pulse output depends on the count rate. High count rates lead to a relative shift of the pulse to later times. The total shift may reach 800 ps at count rates above 1 MHz.

Saturation Level

The dead time limits the measurable count rate at high incoming light levels. The count rate at which the signal does not change significantly by increasing incident photon numbers is called saturation level. Precautions should be taken to avoid prolonged excessive light levels that may damage the SPDMHx Series detector.

Correction Factor

Every SPDMHx Series detector has an inherent dead time of approx. 43 ns after detecting a photon. The dead time is also noted in the included production report. During this dead time, the SPDMHx Series detector is "blind" and can not detect further photons. As a consequence, the measured count rate is lower than the true incident photon rate.

The photon rate can be calculated from the measured counting rate as follows:

$$R_{photon} = \frac{R_{measured}}{1\text{-}R_{measured} \bullet T_D}$$

where:

R_{photon} : actual incident photon rate

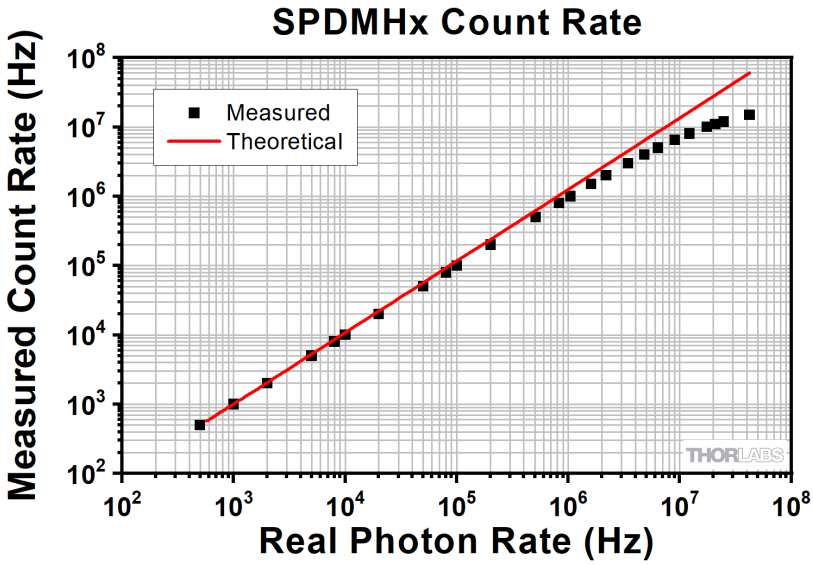
$R_{measured}$: measured count rate

T_D : detector dead time

The correction factor can be used to correct the non-linearity especially at high light levels.

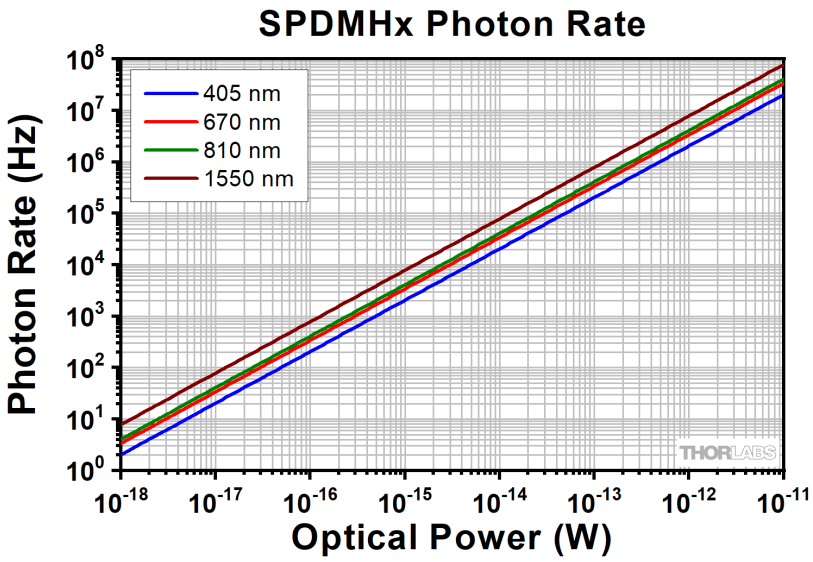
The following plot shows the effect of the dead time as the measured count rate does not proportionally increase with the real photon rate for high count rates due to the dead time effect. The correction factor is required to receive the real photon rate.

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Impact of Optical Power

Single photon detection is applicable to very low light levels. The measured photon rate decreases with increasing optical power. Thus, at high optical power, the measured photon rate will differ from the real photon rate. The following graph helps to understand the optical power level for which the actual single photon counting method is relevant.



4 Maintenance and Service

Protect the SPDMHx Series module from adverse weather conditions. The SPDMHx Series 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 see the chapter Return of Devices and contact Thorlabs for return instructions.

Do not remove covers!

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5 Appendix

5.1 Technical Data

Item #	SPDMH2	SPDMH2F	SPDMH3	SPDMH3F
Detector				
Detector Type	Si APD			
Wavelength Range	400 nm - 1000 nm			
Diameter of Active Detector Area (nominal)[1]	100 µm			
Typical Photon Detection Efficiency (PDE) [2]	10% @ 405 nm 50% @ 520 nm 70% @ 670 nm 60% @ 810 nm			
PDE Variation at Constant Temperature (Typ)	~ 1%	~ 5%	~ 1%	~ 5%
Count Rate (Max)	20 MHz			
Timing Resolution (Typ)	1000 ps			
Dark Count Rate (Max)	100 Hz		250 Hz	
Dead Time (Typ)	45 ns			
Output Pulse Width @ 50 Ω Load	15 ns (Typ); 17 ns (Max)			
Output Pulse Amplitude @ 50 Ω Load TTL High (Typ)	3 V			
Trigger Input TTL Signal [3] Low (closed) High (open)	0.5 V 2.4 V			
Trigger Input Response Time Closing Signal Opening Signal	15 ns (Typ) to 20 ns (Max) 60 ns (Typ) to 65 ns (Max)			
Afterpulsing Probability	0.2% (Typ)			
Delay between Photon Impact and TTL Pulse	30 ns (Typ)			
Input Fiber Specifications				
Fiber Connector		FC/PC Connector		FC/PC Connector
Input Fiber Core Diameter (Max)		<105 µm		<105 µm
Numerical Aperture		NA ≤ 0.29		NA ≤ 0.29

[1]) The active area of the integrated Si-APD is larger than 100 µm.

SPDMH2F and SPDMH3F are optimized for optical fibers as specified above. The pre-aligned GRIN lens focuses the light onto a spot of <70 µm diameter in the center of the detector.

[2]) Specifications are valid for modules without FC-connector.

[3]) Default in the absence of a TTL signal is > 2.4 V, allowing signal to the pulse output.

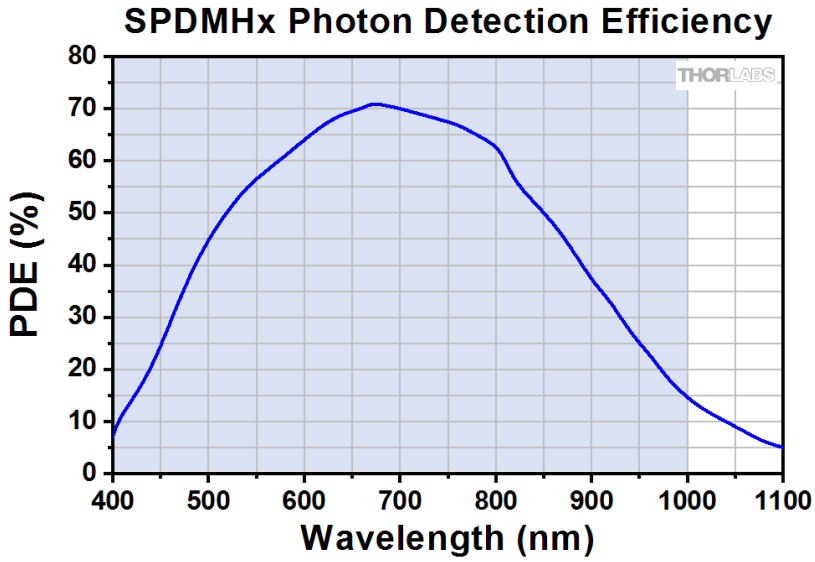
Item #	SPDMH2	SPDMH2F	SPDMH3	SPDMH3F
General				
Connector	Free Beam	FC Fiber Connector	Free Beam	FC Fiber Connector
Power Supply	12 V, 0.8 A			
Power Supply for operation @ 1MHz	12 V, 0.2 A			
Operating Temperature Range [4]	10 to 40 °C			
Storage Temperature Range	-20 °C to 70 °C			
Dimensions (W x H x D)	105.6 x 40.1 x 76.0 mm (4.16" x 1.58" x 2.99")	116.0 x 40.1 x 76.0 mm (4.57" x 1.58" x 2.99")	105.6 x 40.1 x 76.0 mm (4.16" x 1.58" x 2.99")	116.0 x 40.1 x 76.0 mm (4.57" x 1.58" x 2.99")
Weight [5]	315 g	327 g	315 g	327 g

[4]) Non-condensing, Max Humidity: 85% at 40 °C.

[5]) Weight of the Detector with the protection cap only, excluding all shipped accessories.

5.2 Performance Plots

5.2.1 Photon Detection Efficiency

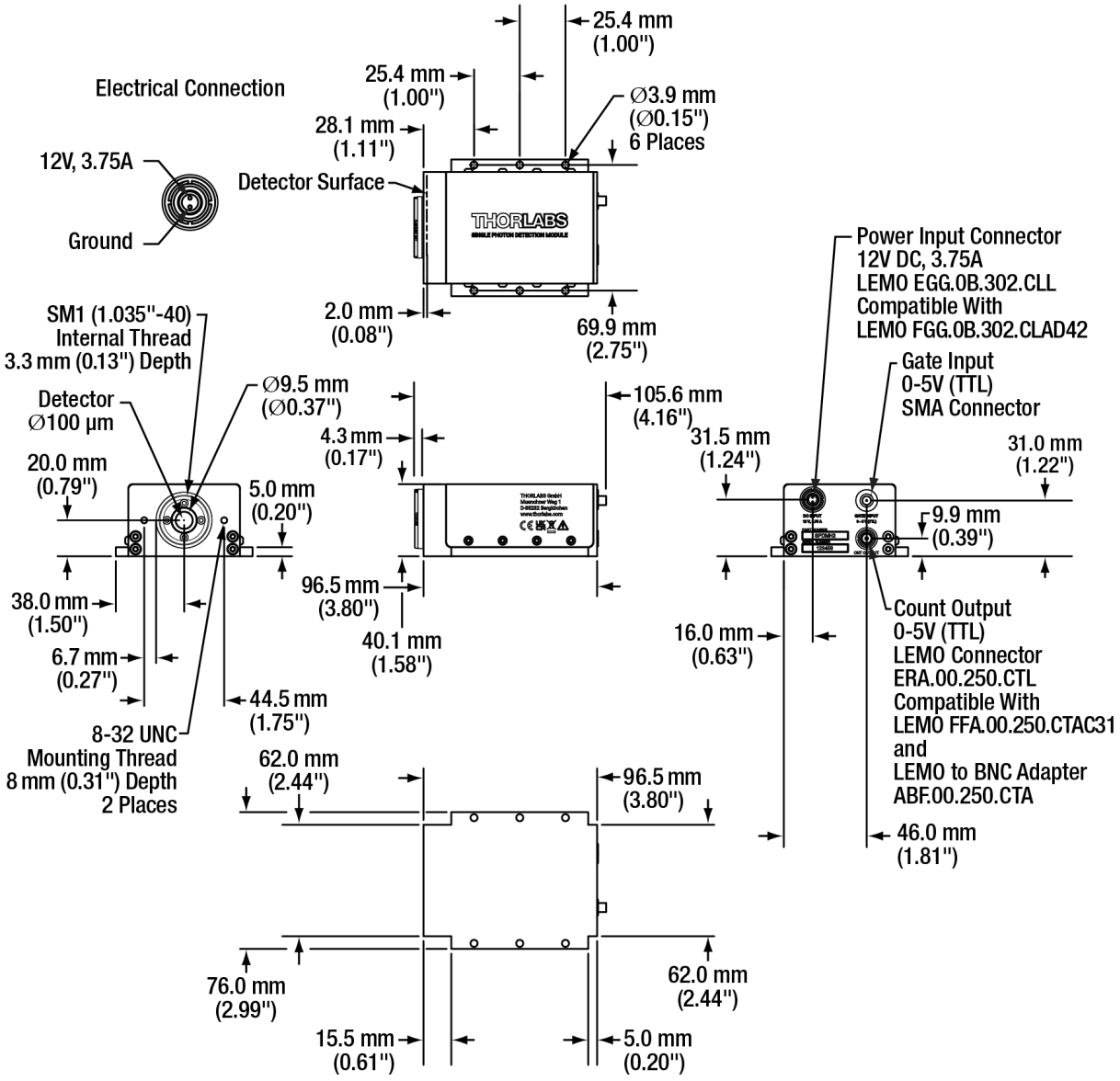


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5.3 Dimensions

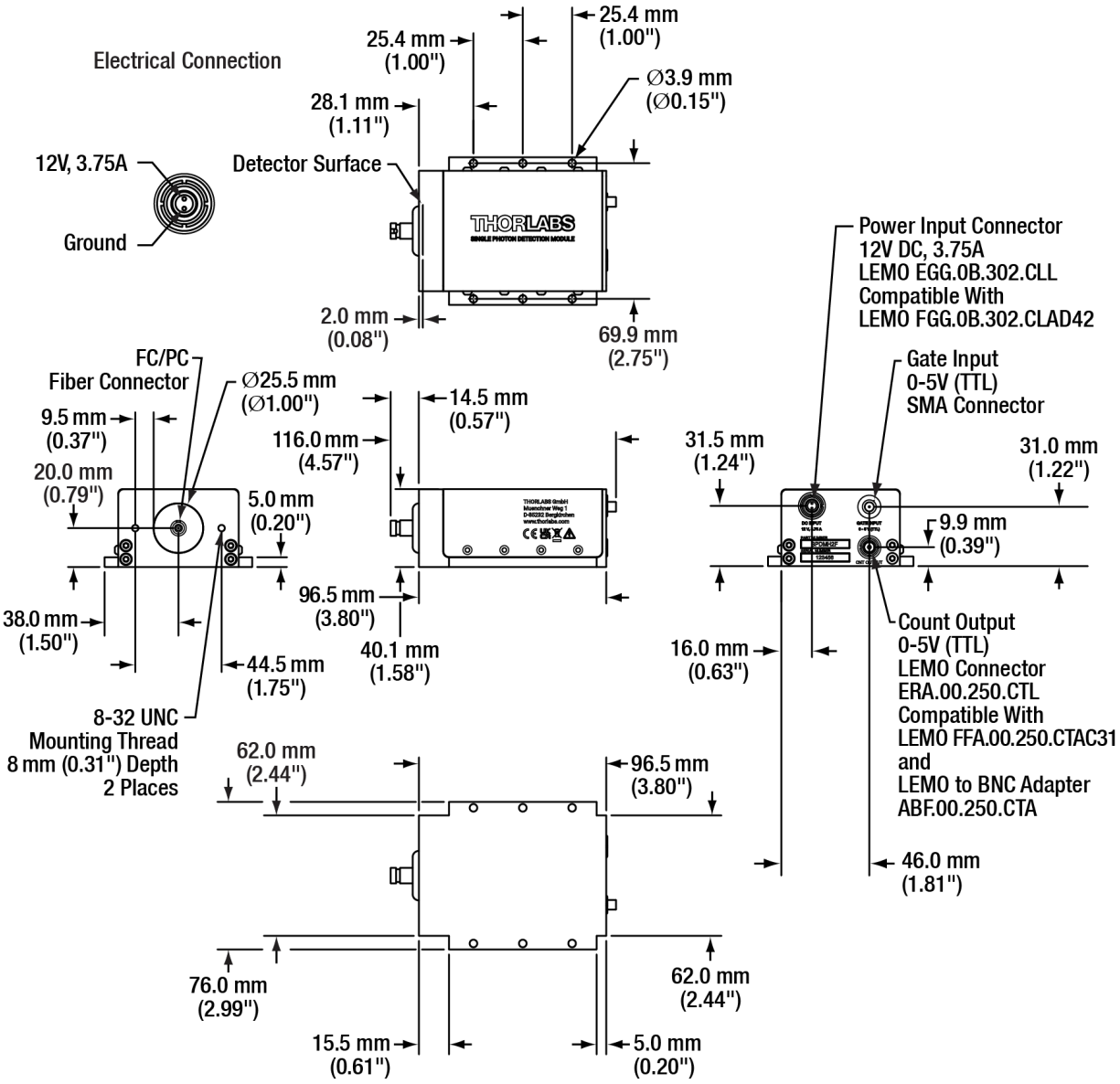
SPDMH2

SPDMH2 and SPDMH3 outer dimensions are identical.



SPDMH2F

SPDMH2F and SPDMH3F outer dimensions are identical.



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5.4 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.

The SPDMHx Series must not be operated in explosion endangered environments!

Do not obstruct any air ventilation slots in the housing!

Do not remove covers or open the cabinet. There are no user-serviceable parts inside!

Handle the SPDMHx Series devices with care. Do not drop it or expose it to excessive mechanical shocks or vibrations.

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 SPDMHx Series, 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!

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

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).

5.5 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: ***SPDMH2(F), SPDMH3(F)***

Equipment: ***Single Photon Detection Module Family***

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: 04 April 2022

Name: Dr. Bruno Gross

Position: General Manager

EDC - SPDMH2(F), SPDMH3(F) -202...

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5.6 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.

5.7 Manufacturer Address

Manufacturer Address Europe
Thorlabs GmbH
Münchner Weg 1
D-85232 Bergkirchen
Germany
Tel: +49-8131-5956-0
Fax: +49-8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

EU-Importer Address
Thorlabs GmbH
Münchner Weg 1
D-85232 Bergkirchen
Germany
Tel: +49-8131-5956-0
Fax: +49-8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

UK-Importer Address
Thorlabs, LTD.
204 Lancaster Way Business Park
Ely, CB6 3NX
UK
Tel: +44-1353-654440
Fax: +44 (0)1353-654444
www.thorlabs.com
Email:
techsupport.uk@thorlabs.com

5.8 Warranty

Thorlabs warrants material and production of the SPDMHx Series 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

5.9 Copyright and Exclusion of 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.

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

5.10 Thorlabs Worldwide Contacts - WEEE Policy

For technical support or sales inquiries, please visit us at https://www.thorlabs.com/locations.cfm for our most up-to-date contact information.



USA, Canada, and South America
Thorlabs, Inc.
sales@thorlabs.com
techsupport@thorlabs.com

UK and Ireland
Thorlabs Ltd.
sales.uk@thorlabs.com
techsupport.uk@thorlabs.com

Europe
Thorlabs GmbH
europe@thorlabs.com

Scandinavia
Thorlabs Sweden AB
scandinavia@thorlabs.com

France
Thorlabs SAS
sales.fr@thorlabs.com

Brazil
Thorlabs Vendas de Fotônicos Ltda.
brasil@thorlabs.com

Japan
Thorlabs Japan, Inc.
sales@thorlabs.jp

China
Thorlabs China
chinasales@thorlabs.com

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.



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