

Single Photon Counting Module COUNT®-Series User Manual

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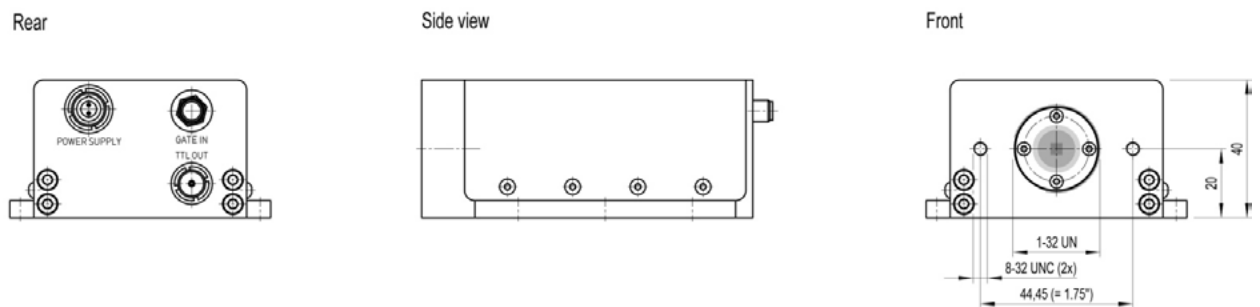
Introduction

LASER COMPONENTS' COUNT® series of single photon counting modules has been developed to offer a unique combination of high photon detection efficiency, wide dynamic range, low dark count rate and ease of use for photon counting applications. Combining LASER COMPONENTS' ultra-low-noise VLoK silicon avalanche photodiode with specially developed quenching and signal processing electronics, the module offers everything needed for single photon detection from 400 – 1000 nm. Incoming photons generate corresponding electrical pulses which may be conveniently read out at the TTL output. The optional FC connector provides a convenient method for connecting the module to the sample using a multimode optical fiber.

Mounting the Count® modules

The COUNT® can be either mounted from the front-side or by using the dedicated mounting holes on the base plate.

Free Space Version



The front side of the COUNT® provides two mounting options:

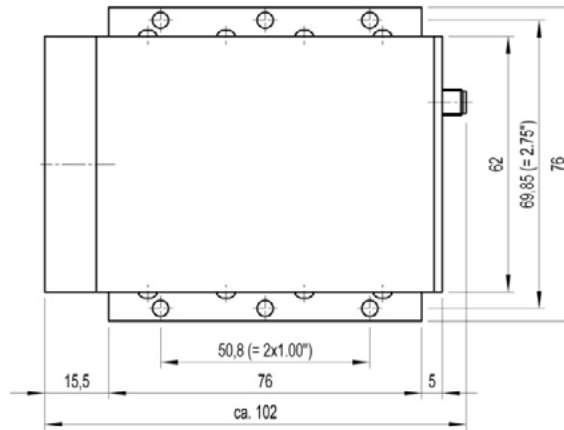
- 1 - a C-mount thread (1-32 UN).
- 2 - two mounting holes with 8-32 UNC thread, depth 8 mm.

Please note that you still have to take into account the weight of the detector when this mounting style is used!

Distance from top of the window to active area plane: typ. 1.35 mm.

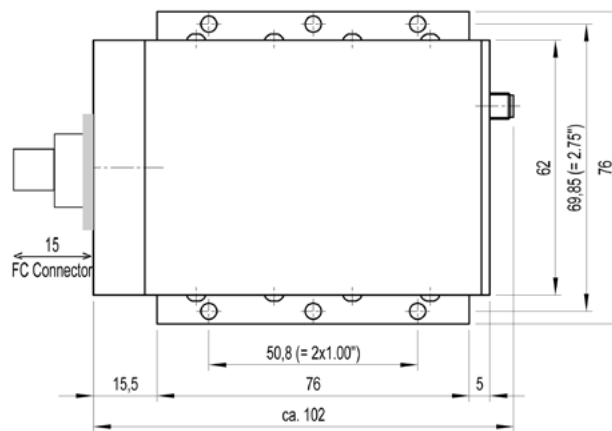
Dimensions in mm.

The base plate of the COUNT® provides 6 mounting holes (3 holes each side) with a diameter of 3.9 mm.



Top view

Fiber Connection Version



Top view

Interface Information

- Power Supply: LEMO connector, item number FGG.OB.302.CLAD42 (optional COUNT® power supply is available upon request).
- Gate input: SMA connector
- TTL output: LEMO connector, compatible with LEMO/BNC adapter ABF.00.250.CTA. An optional LEMO-to-BNC adapter is available upon request.
- Optical input (FC connector version): compatible with standard FC/PC-connector, suitable for fiber core diameters up to 105 μm .

Operation

Handling single photon counting modules

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



The COUNT® contains a high voltage supply. Users may be injured if the case has been opened. All internal settings are pre-set; there are no user adjustments necessary. Opening the case will invalidate the warranty.

Excessive light level (e.g. daylight) might damage a powered COUNT®. Precautions should be taken to avoid such situations or, alternatively, to monitor the count rate (e. g. the DSN102 from PicoQuant GmbH) and eventually interrupt the power supply to the COUNT® using.

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

Handle the COUNT® detector with care. Do not drop it or expose it to excessive mechanical shocks or vibrations.

Heat dissipation

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.

Gating function, TTL output

The COUNT® module features a gating input provided as standard. This can be used for viewing a signal that occurs only in a small timeframe window, or in applications with very weak signals and higher background light. The output of the module is disabled when a TTL low level is applied to the gate input. Applying a TTL high level will enable the module and permit photon detection. If the gate input is left unconnected, the module is enabled by default.



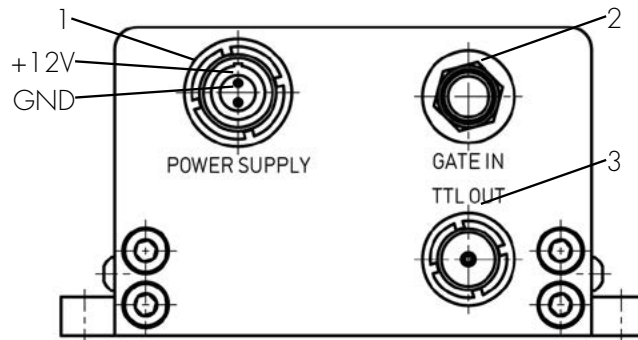
Always switch off the module before connecting or disconnecting the gating input and the TTL output.

Optical fiber connection

The COUNT®-XX-FC has a fiber-optic receptacle pre-aligned to the optical detector surface. The GRIN lens used in this assembly is optimized and AR-coated in accordance to the COUNT® module type: classic, NIR or blue.

To avoid stray light impinging on the detector and affecting the count rate, any optical fiber assembly attached to the FC connector must be completely opaque.

Electrical connections (rear side)



- 1 - Power Supply (2-pin LEMO connector, type EXG.0B.302). This is for the optional +12 V DC power adapter COUNT®-PSU (sold separately). Alternatively, the appropriate cable from the COUNT®-PSU is connected here. The appropriate mating connector is the LEMO FGG.0B.302.CLAD42.
- 2 - Gating input (SMA female). Connect a TTL signal to this input in order to enable (TTL high, >2.4 V) or disable (TTL low) counting.
- 3 - TTL signal output (LEMO connector, type EPS-00.250). A double shielded RG233/U coaxial cable is recommended. Suited Lemo connector types are e. g. FFS.00.250 or the Lemo/BNC adapter type ABF.00.250.CTA (available upon request).

Note: the output should be terminated into a 50 Ohms load.

**Powering up the module**

Before powering up the module it is strongly advised to make sure that no light reaches the sensor. In order to power up the module, simply plug-in the AC adapter in the power supply connector. After power on, allow 30 seconds settling time in which the sensor will be cooled down to its operating temperature.

NOTE: the COUNT® will not generate any output signal until the operating temperature has been reached.

Optimizing performance

The COUNT® shows best performance if the light is focussed to a small spot (<50 µm diameter) in the center of the sensor area. Please also see Fig. 2 of the COUNT® datasheet. Mounting the COUNT® on a suitable x, y, z-translation table or other means of positioning mechanics is therefore recommended. Off-center focussing or overfilling the sensor area might lead to a significant lower detection efficiency and/or increased FWHM of the photon timing resolution.

The FC-connector version is pre-aligned for fibers of core diameter <105 µm, NA ≤0.29, and requires no further optimisation.

Performance

Spectral response

The COUNT® can be used to detect single photons in the spectral range between approx. 400 nm and 1000 nm. It is possible to detect below 400 nm and above 1000 nm, the values are however not specified. The typical detection efficiency of COUNT®-series as a function of wavelength is shown in figure 1.

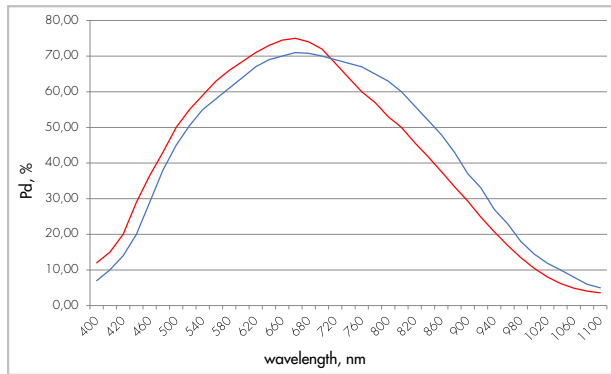


Fig. 1: Typical detection efficiency COUNT®-series and COUNT®-NIR series as a function of wavelength

Timing resolution

The single photon timing resolution of the COUNT® depends on three factors and is generally different for every single module (please see the test report of your COUNT® for details):

1. Detection wavelength - the best photon timing resolution (i. e. smallest FWHM) is generally achieved around 680 nm. The FWHM increases slightly towards blue and NIR detection wavelengths.
2. Focusing quality - for optimum timing resolution the light should be focused to a small spot (<50 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.
3. Count rate - the FWHM of the photon timing resolution increases at high count rates. Especially at count rates >1 million counts/second the FWHM may be double the value at low count rates.

The temporal stability of the pulse output also depends on the count rate. In general, high count rates lead to a relative shift of the pulse to later times.

The total shift may reach 800 ps at count rates >1 million counts/second.

Correction factor

Every COUNT® has an inherent dead time of approx. 43 ns after detecting a photon. During this dead time, the COUNT® 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:

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

where R_{photon} = actual incident photon rate

R_{measured} = measured count rate

T_D = dead time of the module

The dead time effect can also be seen as a deviation from the unity of the ratio between the incident photon rate and the measured count rate.

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

$$\text{Correction Factor} = \frac{R_{\text{photon}}}{R_{\text{measured}}} = \frac{1}{(1 - R_{\text{measured}} \cdot T_D)}$$

The following two figures demonstrate the effect of the dead time on the measured count rate and its correction factor.

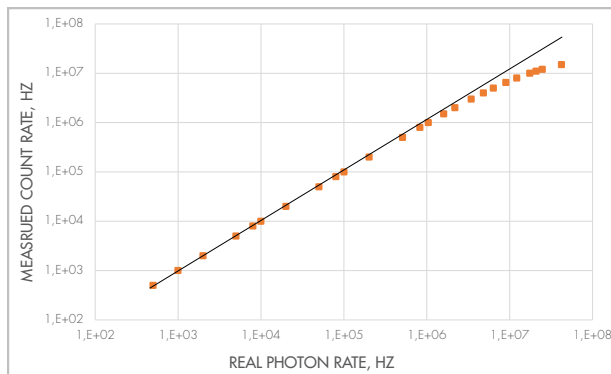


Fig. 2: Measured count rate vs. actual photon rate for a dead time of 43 ns.

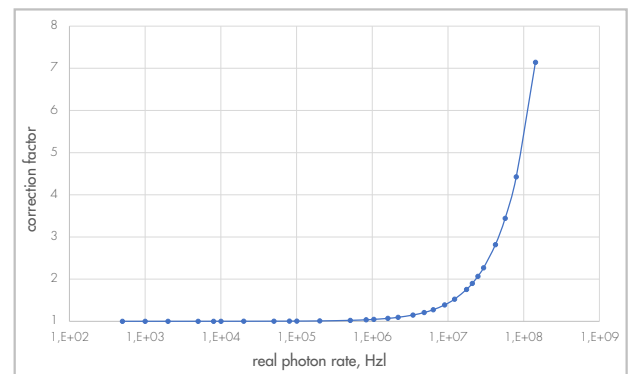


Fig. 3: Correction factor vs. photon rate for a dead time of 43 ns

Technical Data

Technical specifications for COUNT® module

Parameter	Min.	Typ.	Max.	Unit
Spectral range	400		1000	nm
Dark count rate				
COUNT®-10C			10	Counts/s
COUNT®-20C			20	Counts/s
COUNT®-50C			50	Counts/s
COUNT®-100C			100	Counts/s
COUNT®-250C			250	Counts/s
Photon detection efficiency Pd ¹ at:				
405 nm	5	15		%
520 nm	40	55		%
670 nm	60	75		%
810 nm	40	50		%
Pd variation with FC-connection		5		%
Pd variation at constant temperature		1		%
Dark count rate variation at constant temperature		5		%
Active area diameter (nominal) ²		100		µm
Timing resolution ³		1000		ps
Afterpulsing probability ⁴		0.2	1	%
Dead time	42	45	48	ns
Gating input voltage				
Gating on (= disable module)		TTL low (<0.5)		V
Gating off (= enable module)		TTL high (>2.4)		V
Gating input response time				
Gating on (= disable module)		15	20	ns
Gating off (= enable module)		60	65	ns
TTL output pulse length		15	17	ns
TTL output pulse amplitude (into 50 Ohm)		3		V
Delay between photon impact and TTL pulse		30		ns
Supply voltage	11.5	12.0	12.5	V
Supply current (switch on)		0.8		A
Supply current (operation at 1 Mcps)		0.2		A

¹ Specifications valid for modules without FC-connector.

² The active area of the integrated Si-APD is larger than 100 µm. The FC-version is optimised for optical fibers with core diameter < 105 µm. The pre-aligned GRIN lens focuses the light onto a spot of < 70 µm diameter in the centre of the detector. The NA of the fiber used with the module is recommended to be ≤ 0.29.

³ Timing resolution depends on count rate and wavelength.

⁴ Defined for a time interval from 0 to 500 ns.

Technical specifications for COUNT® BLUE module

Parameter	Min.	Typ.	Max.	Unit
Spectral range	350		1000	nm
Dark count rate				
COUNT®-10B			10	Counts/s
COUNT®-20B			20	Counts/s
COUNT®-50B			50	Counts/s
COUNT®-100B			100	Counts/s
COUNT®-250B			250	Counts/s
Photon detection efficiency Pd ¹ at:				
405 nm	50	55		%
520 nm	60	70		%
670 nm	50	55		%
Pd variation with FC-connection		5		%
Pd variation at constant temperature		1		%
Dark count rate variation at constant temperature		5		%
Active area diameter (nominal) ²		100		µm
Timing resolution ³		1000		ps
Afterpulsing probability ⁴		0.2		%
Dead time	42	45	48	ns
Gating input voltage				
Gating on (=disable module)		TTL low (<0.5)		V
Gating off (=enable module)		TTL high (>2.4)		V
Gating input response time				
Gating on (=disable module)		15	20	ns
Gating off (=enable module)		60	65	ns
TTL output pulse length		15	17	ns
TTL output pulse amplitude (into 50 Ohm)		3		V
Delay between photon impact and TTL pulse		30		ns
Supply voltage	11.5	12.0	12.5	V
Supply current (switch on)		0.8		A
Supply current (operation at 1 Mcps)		0.2		A

¹ Specifications valid for modules without FC connector.

² The active area of the integrated Si-APD is larger than 100 µm. The FC-version is optimised for optical fibers with core diameter <105 µm. The pre-aligned GRIN lens focuses the light onto a spot of < 70 µm diameter in the centre of the detector. The NA of the fiber used with the module is recommended to be ≤ 0.15. For fibers with a NA ≤ 0.29 and a core diameter of ≤ 105 µm special FC-versions are available for wavelengths ≥ 500 nm.

³ Timing resolution depends on count rate and wavelength.

⁴ Defined for a time interval from 0 to 500 ns.

Technical specifications for COUNT® NIR module

Parameter	Min.	Typ.	Max.	Unit
Spectral range	400		1000	nm
Dark count rate COUNT-50N COUNT-100N COUNT-250N COUNT-500N			50 100 250 500	Counts/s Counts/s Counts/s Counts/s
Photon detection efficiency Pd ¹ at: 405 nm 520 nm 670 nm 810 nm		10 50 70 60		% % % %
Pd variation with FC-connection		5		%
Pd variation at constant temperature		1		%
Dark count rate variation at constant temperature		5		%
Active area diameter (nominal) ²		100		µm
Timing resolution ³		1000		ps
Afterpulsing probability ⁴		0.2	1	%
Dead time	42	45	48	ns
Gating input voltage Gating on (= disable module) Gating off (= enable module)		TTL low (<0.5) TTL high (>2.4)		V V
Gating input response time Gating on (= disable module) Gating off (= enable module)		15 60	20 65	ns ns
TTL output pulse length		15	17	ns
TTL output pulse amplitude (into 50 Ohm)		3		V
Delay between photon impact and TTL pulse		30		ns
Supply voltage	11.5	12.0	12.5	V
Supply current (switch on)		0.8		A
Supply current (operation at 1 Mcps)		0.2		A

¹ Specifications valid for modules without FC-connector

² The active area of the integrated Si-APD is larger than 100 µm. The FC-version is optimised for optical fibers with core diameter <105 µm. The pre-aligned GRIN lens focuses the light onto a spot of <70 µm diameter in the centre of the detector. The NA of the fiber used with the module is recommended to be ≤ 0.29.

³ Timing resolution depends on count rate and wavelength.

⁴ Defined for a time interval from 0 to 500 ns.

Absolute maximum ratings

	Min.	Typ.	Max.	Unit
Supply voltage	11.5	12.0	12.5	V
Operating temperature	10		40	°C
Humidity at 40°C			85	%
Storage temperature	-20		70	°C
Count rate			20	MCOUNTS/s

Interface information

- Power Supply: LEMO connector, item number FGG.OB.302.CLAD42 (optional COUNT power supply is available upon request product code COUNT-PSU).
- Gate input: SMA connector
- TTL output: LEMO connector, compatible with LEMO/BNC adapter ABF.00.250.CTA (available upon request).
- Optical input (FC connector version): compatible with standard FC/PC-connector, suitable for fiber core diameters up to 105 µm.

Individual module test data

Each module is supplied with test data indicating the module's actual dark count, dead time, photon detection efficiency @ 405 nm, 520 nm, 670 nm and 810 nm, timing jitter and afterpulsing probability.

ESD Information

Modules should only be handled at an ESD-safe work station.

Safety

The COUNT®-Series contains a high voltage power supply. Users may be injured if the case has been opened. All internal settings are pre-set; there are no user adjustments.

Units that appear defective or have suffered mechanical damage should not be used because of possible electrical shorting of the high voltage power supply. Opening the case may damage sensitive components and expose the user to the risk of electrical shock. Please contact factory for repairs.



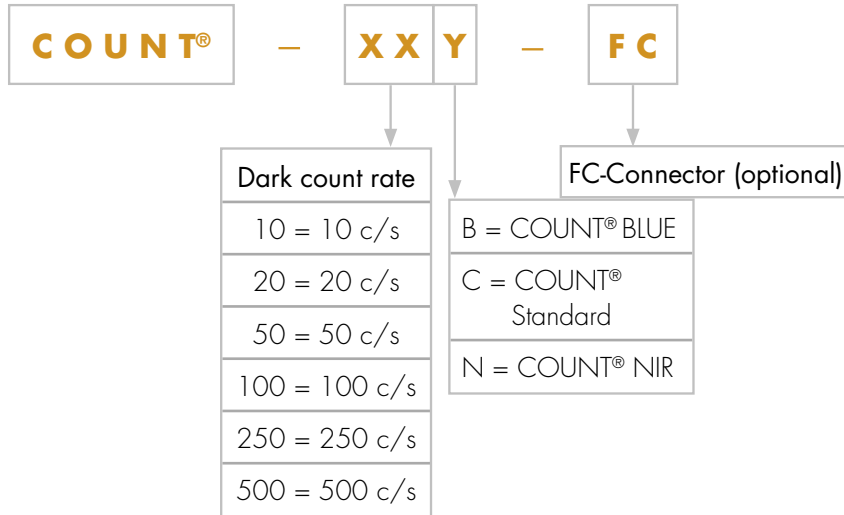
RoHS compliance

The COUNT®-Series is designed and built to be fully compliant with the European Union Directive 2011/65/EU.

Warranty

A standard 12-month warranty following shipment applies. Any warranty expires if the module case has been opened. The warranty is void if the module input exceeds 12.5 V.

Product number designations



Support

Your COUNT® module has undergone thorough tests at LASER COMPONENTS. It is stable and reliable. Nevertheless, we continually make improvements that will be incorporated into future versions.

In any case, we would like to offer you our best support. Please do not hesitate to contact LASER COMPONENTS if you need assistance with your system. If you observe any errors, please e-mail a detailed description of the problem and relevant circumstances, to info@lasercomponents.com. Your feedback will help us to improve the product and documentation.

Of course we also appreciate good news. If you have obtained exciting results with one of our systems, please let us know, and where appropriate, mention us in your publications.

Retraction of old devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling center for safe treatment.

WEEE-Reg.-No. De96457402

Product Changes

LASER COMPONENTS reserves the right to make changes to the product(s) or information contained herein without notice. No liability is assumed as a result to their use or application.

Ordering Information

Products can be ordered directly from LASER COMPONENTS or its representatives. For a complete listing of representatives, visit our website at www.lasercomponents.com