PRELIMINARY

COUNT® C-SERIES

Single Photon Counting Module



LASER COMPONENTS' COUNT® C-series of single photon counting modules was developed to offer a unique combination of high photon detection efficiency, low dark count rate, low afterpulsing probability, and ease of use for applications with very low light levels. The module combines LASER COMPONENTS' ultra-low-noise silicon avalanche photodiode with specially developed quenching, high voltage and temperature managing circuit. The wide variability of dead time, convenient readout of the TTL output, gating function and optional FC connection provide our customers with the greatest freedom to solve their complex challenges in single photon detection.

FEATURES

/ Extremely low dark count rates below 10 Hz
/ Peak photon detection efficiency >70 % @ 670 nm
/ Selectable dead time between 25 ns and 60 ns
/ Short timing jitter below 500 ps
/ Optional fiber coupling connection

APPLICATIONS

/ Quantum cryptography
/ Particle sizing
/ LiDAR
/ Confocal microscopy
/ Fluorescence analysis
/ Photon correlation spectroscopy
/ Fast imaging techniques
/ Astronomy

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beyond borders

10/26 / V1 / MH-CC / lc-photon-counter/count-c-series

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SPECIFICATIONS

Parameter	Min.	Typ.	Max.
Spectral range [nm]	400		1000
Dark count rate [counts/s] COUNT-10C-YY COUNT-20C-YY COUNT-50C-YY COUNT-100C-YY COUNT-250C-YY			 10 20 50 100 250
Photon detection efficiency PDE[1] [%] @ 405 nm 520 nm 670 nm 810 nm	 35 55 40	 15 55 75 50	
PDE loss with FC-connection [%]		5	
PDE variation at constant temperature [%]		1	
Dark count rate variation at constant temperature [%]		5	
Active area diameter (nominal) [µm][2]		100	
Timing resolution [ps][3] Measured using a 30 µm diameter light spot		 500	
Afterpulsing probability [%][4]		0.2	1
Dead time selectable [ns][5]	25	45	60
Gating input voltage [V] Gating on (= disable module) Gating off (= enable module)		 TTL low (<0.8) TTL high (>2.0)	
Gating input response time [ns] Gating on (= disable module) Gating off (= enable module)		 26 51	
TTL output pulse length [ns]		10	
TTL output pulse amplitude (into 50 Ohm) [V]		4	
Delay between photon impact and TTL pulse [ns]		14	
Supply voltage [V]	11	12	13
Supply current (switch on) [A]		0.8	
Supply current (operation at 1 Mcps) [A]		0.2	

Foot Notes / Abbreviations
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. Please also see Fig. 4 The NA of the fiber used with the module is recommended to be ≤ 0.29.
3 Timing resolution depends on the light spot size, count rate and wavelength. The tests of the individual modules are performed with 30 µm diameter light spot size, 100 kHz count rate and at 405 nm, 520 nm, 670 nm and 810 nm.
4 Afterpulsing probability is defined for a time interval after the initial peak to 500 ns and varies with the dead time – see table 1 and fig. 3. The afterpulse probability specification refers to a default dead time of 45 ns.
5 Dead time can be selected and is set by the manufacturer. All specifications are measured at the default dead time of 45 ns.

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Absolute Maximum Ratings

	Min.	Typ.	Max.
Supply voltage [V]	11	12	13
Operating temperature [°C]	10		50
Storage temperature [°C]	-20		70
Count rate [MCounts/s][6]			18

6 Maximum count rate depends on the dead time. 18 Mcps correspond to 25 ns dead time. For more details please refer to the correction factor non-linearity section at the operating instructions.

Fiber connection option

COUNT®-XXXC-YY-FC has an FC connection pre-aligned to the central part of the optical detector surface. The GRIN lens is AR-coated for the range of 400 – 1000 nm and focuses the light onto the spot of approx. 70 µm diameter in the center of the detector. The FC-connection is optimized for the optical fibers with core diameter of 105 µm and NA = 0.29. Other fiber sizes and NA can have an impact on the coupling efficiency and the associated measuring results.

Timing resolution

Timing resolution depends on the wavelength, count rate and light spot size. The timing resolution measured using 10 µm diameter light spot size is 220 ps, using 30 µm – 500 ps. The tests of the individual modules are performed with 30 µm diameter light spot size, 100 kHz count rate and at 405 nm, 520 nm, 670 nm and 810 nm.

Afterpulsing probability

Afterpulsing probability is measured in the time interval after the initial peak to 500 ns and varies with the dead time – see table 1 and fig. 3. The afterpulsing probability specification refers to a default dead time of 45 ns.

Dead time

LASER COMPONENTS offers to the users the possibility to select the dead time of the module before shipment. The span is between 25 ns and 60 ns in 5 ns steps. Short dead time presets the maximum count rate to higher values. The longer the dead time the better the afterpulsing probability. For both effects - max. count rate and AP probability - please consult fig. 3 and table 1, and details of the correction factor non-linearity. The specifications and individual data tests are performed at the default dead time of 45 ns.

Gating function

COUNT® module features a gating input as standard, which can be used to detect a signal that only occurs in a small-time window, or in applications with very weak signals and higher background. The module's output is disabled when a TTL low level is applied to the gate input. Applying a TTL high level activates the module and enables photon detection. If the gate input is not connected, the module is enabled by default.

⚠ Always switch off the module before connecting or disconnecting the gating input.

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Individual module test data

Each module is tested using lasers at 405 nm, 520 nm, 670 nm and 810 nm. The light spot has a diameter of 30 µm, the count rate is 100 kHz. The dark count rate, P_d, timing jitter and afterpulsing probability are tested; the dead time is set between 25 ns and 60 ns - default 45 ns unless otherwise selected.

GRAPHS / CURVES

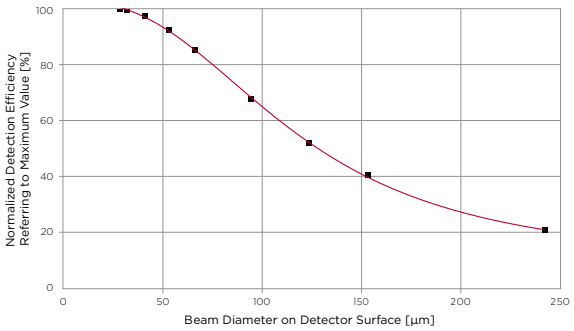


Fig. 1: Beam diameter on detector surface vs. relative intensity of P_d referring to maximum value at 670 nm

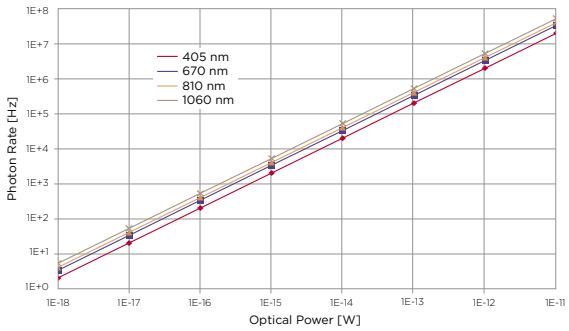


Fig. 2: Photon number vs. optical power at different wavelengths

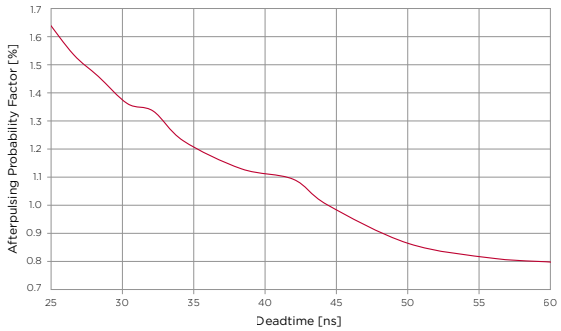


Fig. 3: Dead time vs. afterpulsing probability

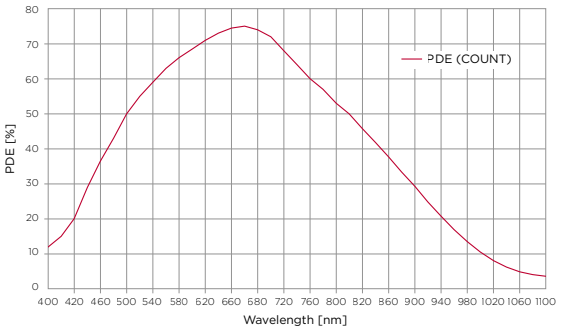


Fig. 4: Typical photon detection efficiency (PDE) vs. wavelength

AFTERPULSING PROBABILITY

Dead time	Typical Factor of Afterpulsing Probability
25	1.65
30	1.35
35	1.20
40	1.10
45	1.00
50	0.85
55	0.82
60	0.80

Table 1: Dead time vs. afterpulsing probability factor

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PRELIMINARY

OPERATING INSTRUCTIONS

Correction factor non-linearity

Every COUNT® module has an inherent dead time of selectable 25 – 60 ns (5 ns step) after detecting a photon. During this dead time, the COUNT® module is »blind« and cannot detect further photons. As the consequence, the measuring counting rate is lower than the true incident photon rate. The photon rate can be calculated from the measured counting rate as follows:

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

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.

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

The following table shows the dead time-dependent correction factor that needs to be applied to account for the non-linearity of measured and real photon rate, growing with higher count rates. For COUNT modules the dead time can be selected between 25 ns and 60 ns in 5 ns steps. The defeault setting is 45 ns. Unless explicitly specified otherwise, all module testing, final inspection measurements and published specifications are based on a dead time of 45 ns.

Correction Factor

Count Rate	25 ns	35 ns	45 ns	60 ns
100 kC/s	1.00	1.00	1.00	1.00
500 kC/s	1.01	1.02	1.02	1.03
1 MC/s	1.03	1.04	1.05	1.06
3 MC/s	1.08	1.12	1.16	1.22
10 MC/s	1.33	1.54	1.82	2.50

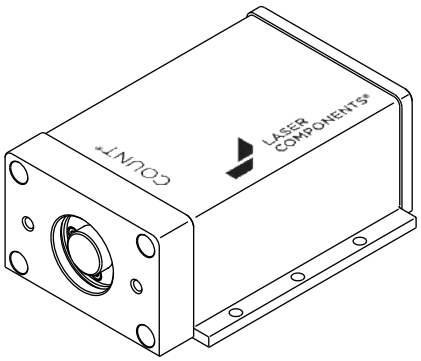
Table 2: Correction factors for exemplary count rates and dead times derived from the formula above.

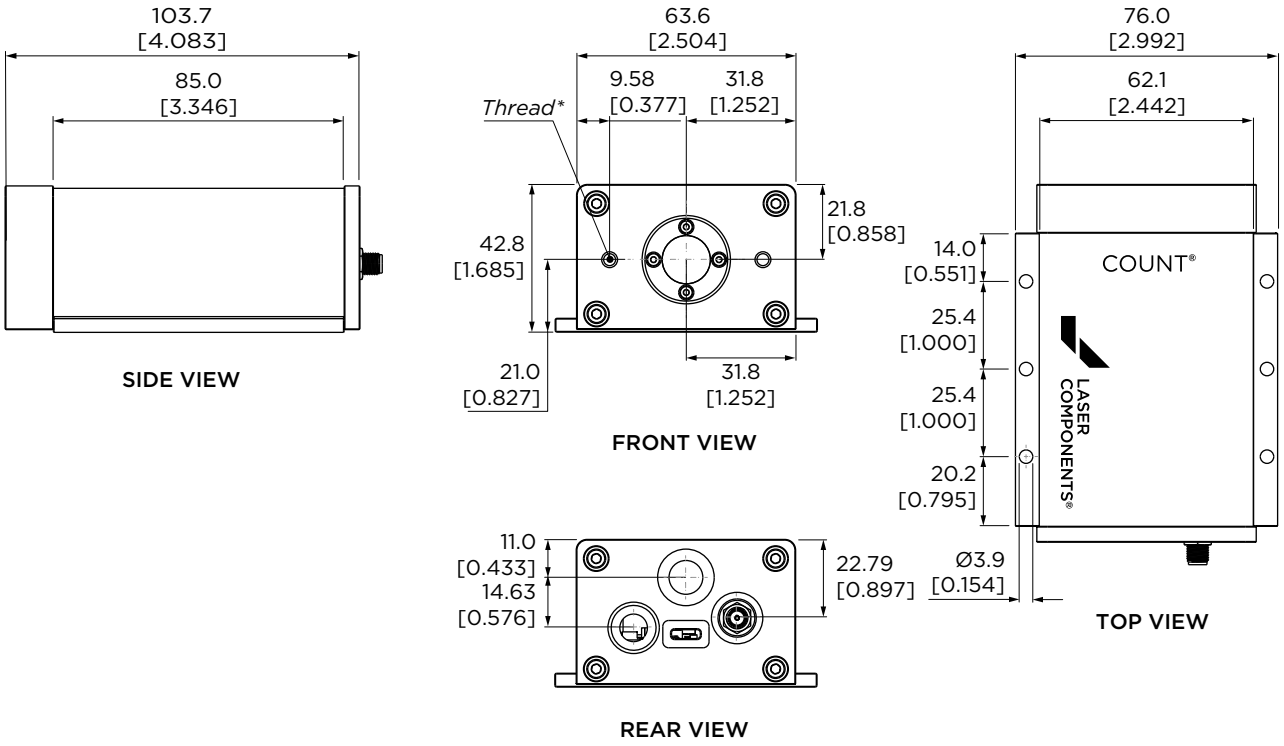
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TECHNICAL DRAWING

Free-space version





COUNT MODULE

**Thread:*
8-32 UNC

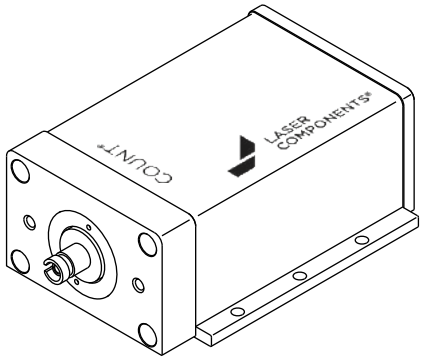
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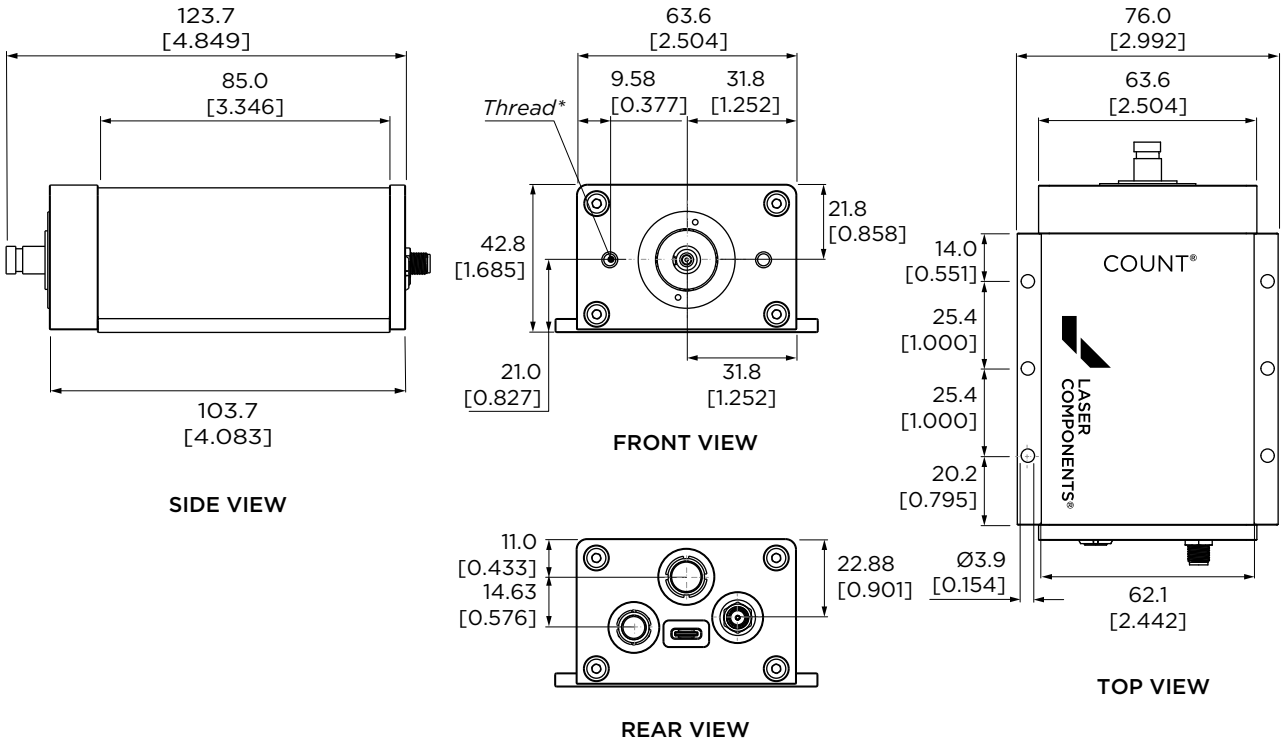
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PRELIMINARY

TECHNICAL DRAWING

Fiber connector version





COUNT MODULE

**Thread:*
8-32 UNC

Units: mm [inch]
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ORDERING CODE

		Dark Count Rate [c/s]			Dead Time [ns]*		Option
COUNT®	-	**XXX**	**C**	-	**YY**	-	**FC**
		10 **20** **50** **100** **250**			**25 – 60**		**Fiber Connector**

Example: COUNT®-250C-45-FC

Foot Notes / Abbreviations
* = Values in 5 ns steps on request, **default value is 45 ns**

Heat dissipation

Adequate heat management is essential for the module. High temperatures can cause permanent damage to the module. To avoid this, the module must be connected to a suitable heat sink across the entire surface of the base plate. If the connection is not maintained across the entire surface, or if heat dissipation is interrupted by non-thermally conductive materials, heat management may be impaired.

⚠ At higher operating temperatures — even within the specifications — photon detection efficiency may deviate significantly from the initial test results. The temperature of the module housing must not exceed 50 °C.

Setup shielding

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 and suitable for single photon detection.

⚠ ⚠ Avoid excess light impinging on the detector which affects the count rate. Employ appropriate shielding for the free-space models and make sure that any optical fiber assembly attached to the FC/PC connector shields unwanted light.

CE, EMC and RoHS

The modules are CE compliant. EMC directive 2014/30/EU is a distinct part of CE compliance and ensures modules do not cause or suffer from electromagnetic interference.

RoHS directive 2011/65/EU is a distinct part of CE compliance.

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Safety

⚠ ⚠ The COUNT® series contains a high-voltage power supply. Users may be injured if the housing is opened. All internal settings are preset; there are no adjustment options for the user. Opening the housing may damage sensitive components and expose the user to the risk of electric shock.

Devices that appear defective or show mechanical damage should not be used, as this may cause a short circuit in the high-voltage power supply.

Please contact the manufacturer for repairs.

Warranty

A standard warranty of 12 months from shipment applies. The warranty is void if the module housing has been opened. The warranty is no longer valid if the module input power exceeds 13 V.

Interface information

/ Power supply: LEMO connection, item number FGC.OB.302.CLAD42
(optional COUNT® power supply is available upon request)
/ Gain input: SMA connection
/ TTL output: LEMO connector, compatible with LEMO/BNC adapter ABF.00.250.CTA
(optional LEMO-to-BNC adapter is available upon request)
/ Optional input (FC connection version):
compatible with standard FC/PC-connector, optimized for fiber core diameter of 105 µm.

The module has a USB-C port for internal use by the manufacturer only. This port is not relevant for the user.

PRODUCT CHANGES AND LIABILITY

LASER COMPONENTS reserves the right to make changes to the product specifications and/or discontinue products without prior notice. While every effort has been made to ensure the accuracy and reliability of the information provided in this datasheet, LASER COMPONENTS accepts no liability for any errors, omissions, or the consequences of product use. It is the responsibility of the customer to ensure that the product is suitable for their specific application and to comply with all applicable laws and regulations.

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PRELIMINARY

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

Custom designed products are available on request.

SAFETY AND HANDLING INFORMATION

RoHS compliant

Handling Precautions

Products are subject to the risks normally associated with sensitive electronic devices including static discharge, transients, and overload.

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