Customer Specification

Educational Use Single Photon Counting Module

SPCM-EDU CD3375

Features and Benefits

- High photon detection efficiency
- User Friendly
- ROHS compliant
- Single +5V supply
- Gated output function

Applications

- Single-photon quantum mechanics experiments
- Photon existence demonstrations
- Photon interference experiments
- Educational and instructional demonstrations on Photon counting

Customer: Members of ALPhA (Advanced Laboratory Physics Association)

Educational Use Single Photon Counting Module SPCM-EDU CD3375

Rev. No	Date	Revision Record	Author
0	Dec. 22, 2010	Initial Version	Bernicy Fong

List of Referenced Documents	
Doc 1	SPCM-AQRH data sheet

EXCELITAS TECHNOLOGIES

Introduction

SPCM-EDU CD3375 from Excelitas Technologies Inc. is a self-contained module that detects single photons over the wavelength range of 400 nm to 1060 nm - a range and sensitivity that often outperforms a photomultiplier tube.

The SPCM-EDU CD3375 uses a unique silicon avalanche photodiode with a circular active area that achieves peak photon detection efficiency at 650 nm over a 170 µm diameter. The photodiode is both thermoelectrically cooled and temperature controlled, ensuring stabilized performance despite changes in ambient temperature.

As each photon is detected, a TTL pulse of around 2.2 Volts (into a 50 load) and 15 ns wide is output at the rear BNC connector. To avoid a degradation of the module linearity and stability, a case temperature between 5˚C and 40˚C should be maintained.

This photon counting module is designed and built for educational and instructional purposes; and is limited to be operated within these laboratory environments. The availability of this module is limited to registered and active members of ALPhA (Advanced Laboratory Physics Association), and proof of membership and registered institution is mandatory for the purchase of this module.

The SPCM-EDU CD3375 is fully compliant with the European Union Directive 2002/95EEC – Restriction of the use of certain Hazardous Substances in Electrical and Electronic equipment (RoHS).

Specifications of SPCM-EDU CD3375

Parameter	Min	Typ.	Max	Unit
Supply current		0.3	1.2	A
Supply voltage[1]	4.75	5.0	5.25	V
Power cable total resistance		0.1	0.2	Ω
Case operating temperature [1,3]	5		40	ºC
Active area (diameter) at minimum Pd	140	170		µm
Photon detection efficiency (Pd) at: 400nm 550nm 650nm 830nm	 1 45 55 30			 % % % %
Dark Count[4,5,6]		3000	4000	Counts /second
Single photon timing resolution		1000		ps
Dead time (count rate below 5M/c)		35		ns
Output count rate before saturation[8]		10		Mc/s
Linearity correction[7] factor at 200 Kc/s 1 Mc/s 5 Mc/s 10 Mc/s 20 Mc/s 25 Mc/s		 1 1.03 1.2 1.48 2.8 4.5		
After pulsing probability			4	%
Setting time following power up (1% stability) at 1 Mc/s and 25 ºC		30		s
Threshold setting required on counter for digital output pulse (terminate in 50Ω)		1.0		V
Output pulse width[9]		15		ns
Gating turn on/off (50Ω output) Disable = TTL low (<0.8V) Enable = TTL high (>2.0V)		 26 52	 32 61	ns
Gating threshold voltage (at V supply = 5V) Low level (sink current >90mA) High level (sink current >30mA)	 0 2.0		 0.4 5.25	V
Fiber optic option		FC Connectorized		

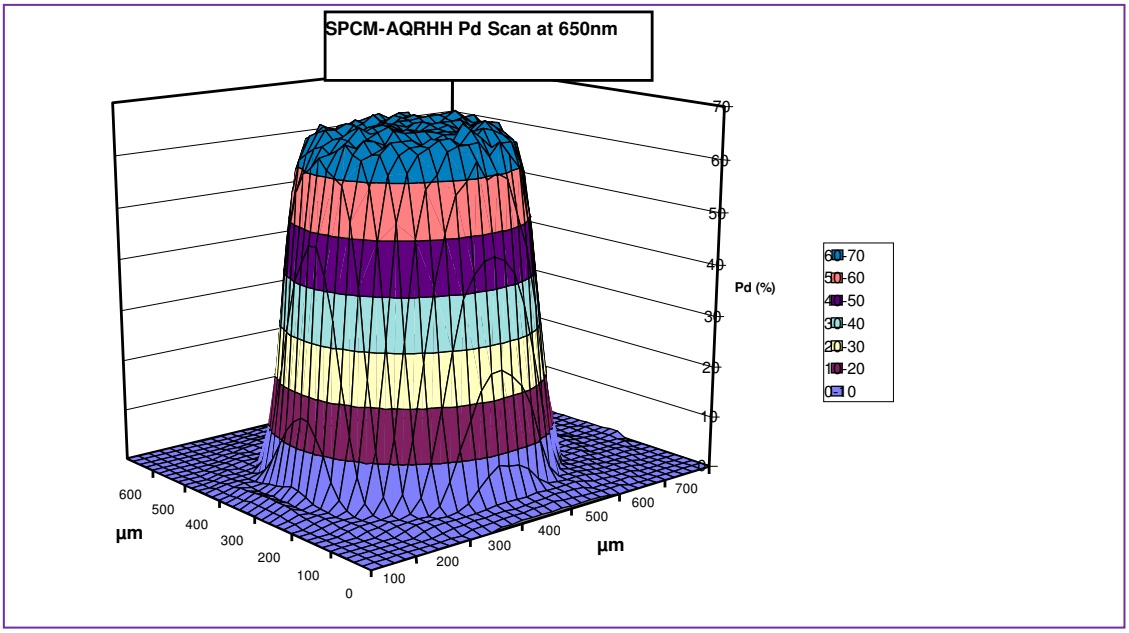
Maximum Ratings for SPCM-EDU CD3375

Parameter	Absolute Maximum Ratings
Supply voltage [1]	5.5 V
Maximum count rate	5 Mc/s (above this point, dead-time will increase due to diode self heating effects)
Peak light intensity	10^4 photons per pulse and pulse width < 1ns
Case temperature [3]	-20 ºC/+70 ºC storage, +5 ºC /+40 ºC operating.

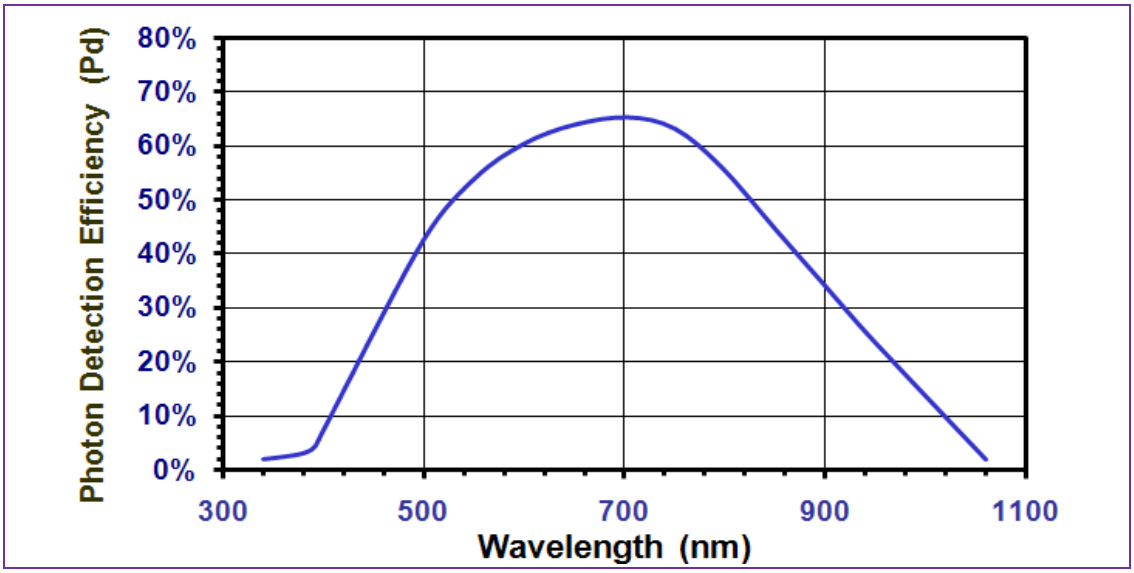
Fiber Guide

Part Number	Fiber Type	Connector Type	Diameter			Numerical Aperature
			Core	Cladding	Outer	
SPCM-QC4	Multimode	FC / Bare	62.5 µm	125 µm	2.5 mm	0.27
SPCM-QC6	Multimode	FC / Bare	100 µm	140 µm	2.5 mm	0.29
SPCM-QC8	As SPCM-QC6 but 905 SMA on free end, 100 microns core fiber					
SPCM-QC9	As SPCM-QC6 but FC connector on free end, 100 microns core fiber					

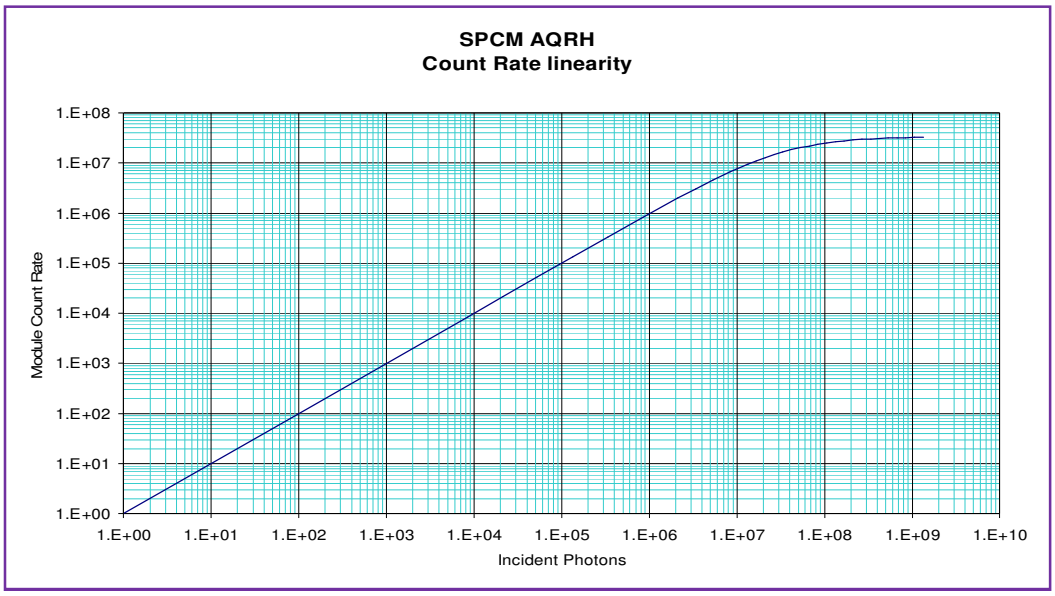
Typical Pd Scan



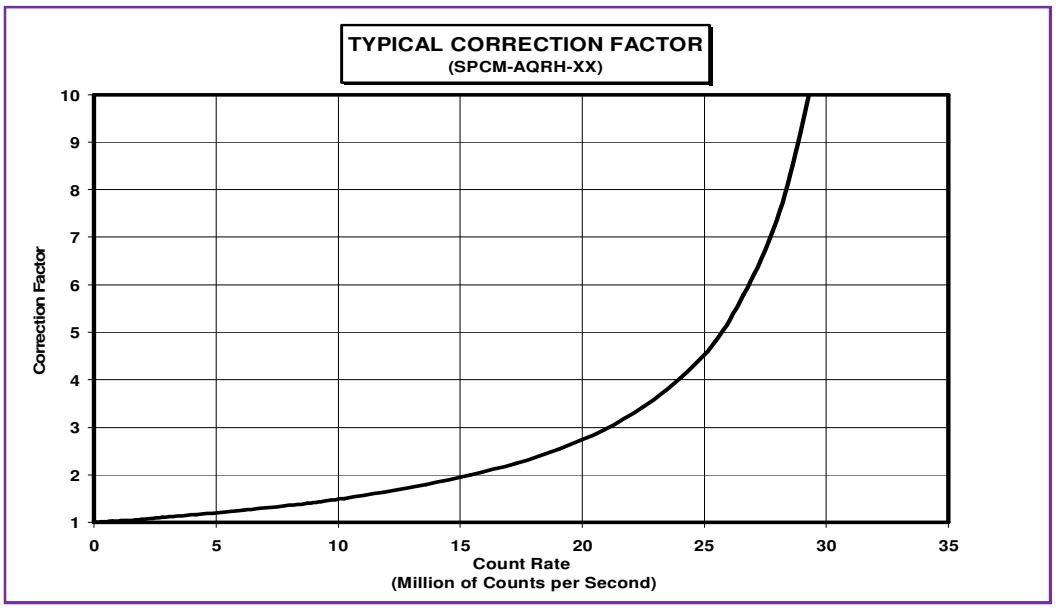
Typical Photon Detection Efficiency Curve



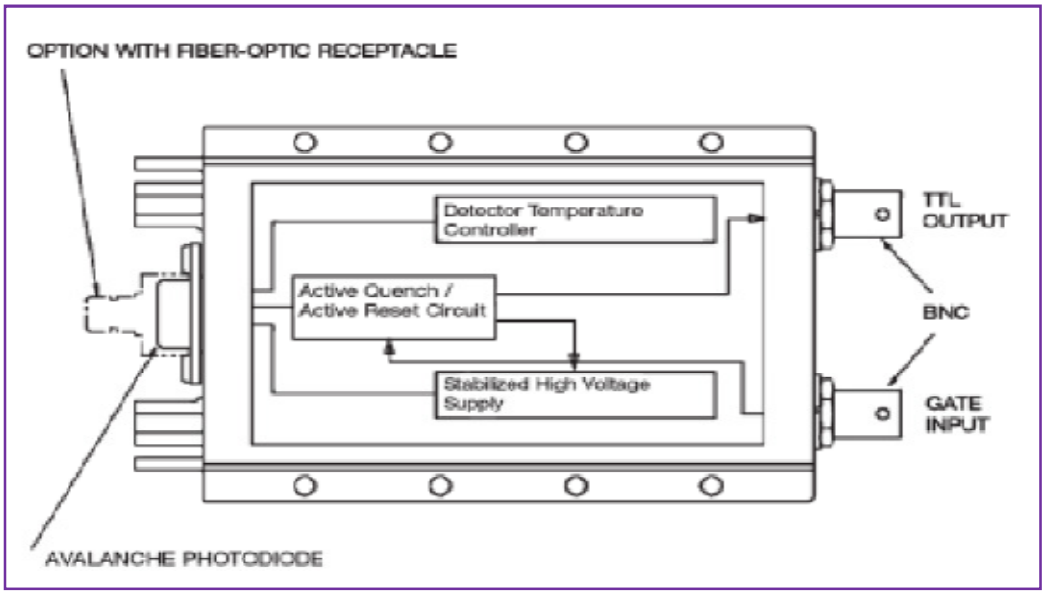
Typical Count Rate Linearity



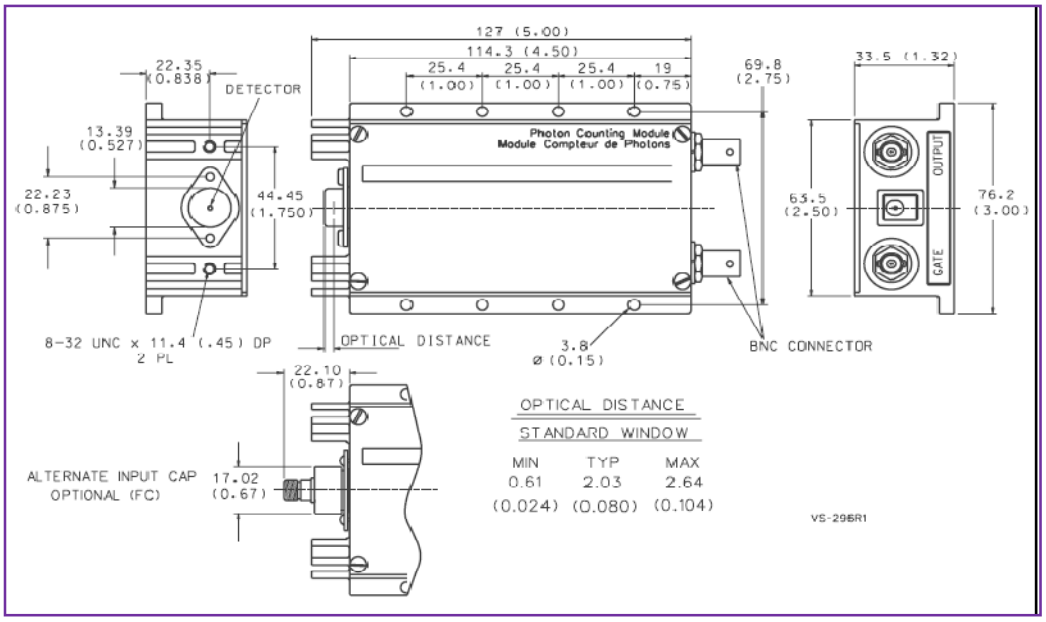
Typical Correction Factor



Module Block Diagram



Dimensional Outline



Operating Instructions

1. Connection to incorrect voltage or reverse voltage may damage or destroy the module. The warranty is invalid where such damage occurs. The center contact of the barrel type power connector (corresponds to the white stripe on the wire) is +5V.

2. These modules are not qualified for shock or vibration other than normal laboratory environments.

3. The module dissipates a mean power of 2.5W and a maximum power of 6W at high count rate and 40°C. Adequate heat sinking must be provided by clamping the module to a suitable heat sink via the holes in the module base. For the specification performance, the module case temperature must not exceed 40°C. The maximum case operating temperature can reach 50°C at reduced count rate.

4. Bi-stability of the dark count: On a small percentage of delivered modules, bi-stability of the dark count has been observed. Research indicates this bi-stability is probably due to transitions at a single impurity site between a low energy and a high energy state.

The phenomenon is seen as an abrupt change in the dark count rate, e.g., 3500 to 3900 c/s., and the dark count switches between the two states at a rate dependent upon the detector temperature. Multilevel switching has also been observed, where more than one impurity site is switching.

5. Long-term bi-stability is related to fundamental semiconductor physics and is beyond Excelitas' control. Warranty claims will not be considered against bi-stability alone.

Warranty claims will only be considered if the high level of the dark count exceeds the maximum level in the specification.

6. In the dark, the module generates random counts that follow a Poisson distribution. In a Poissonian process, the standard deviation is equal to the square root of the average count. In this specification the "dark count variation" refers to the stability of the average count of the module.

7. The actual photon rate could be calculated using the following equation, as indicated below in table 1.

8. Output pulse width is set at the standard of 15ns.

Saturation

The photon count decreases at higher incoming light levels. The count at which the output rate starts to decrease is called the saturation point. As an extreme example, if the module is exposed to intense light the count rate will fall to zero. While the module is protected against light overload, precautions should be taken to avoid any excessive light level that will damage the SPCM module.

EDS Warning

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

Fiber Connection Option

The SPCM-EDU CD3375-WX-FC has an “FC” fiber-optic receptacle pre-aligned to the optical detector. Optical fibers with an FC connector on one end are available separately, (see Ordering Guide 2). The standard fiber lens is optimized for 550nm. Though the fiber / GRIN in the standard module will function through the complete range of 400nm to 1060nm, due to the wavelength dependence of the graded index coupling lens, improvements to operating wavelengths other than 550nm are special orders. The photon detection efficiency of connectorized modules is about 95% of that quoted for standard modules at 550nm.

Fiber Shielding

When used with optical fibers, both the fiber itself and the connector shrouds must be completely opaque. Otherwise, stray light will increase the count rate. The SPCM-QCX pigtails conform to this requirement (see Ordering Guide 2).

Gating Function

A gating function is provided with each module – useful for viewing a signal that occurs only in a small timeframe window. Also, in some applications the background light flux is higher than the signal. In this case. the gating option could be used to improve the S/N ratio by opening a window only when the light signal is present. The output of the module and the active quench function are disabled when a TTL low level is applied to the module gate input. When a TTL high level is applied to the module gate input, the output of the module and the active quench circuit are enabled again. Any photon detection that occurs less than 2us before the module gate input changes can result in an output pulse. However, this output pulse has lost timing accuracy.

Light Emission during Photon Detection

One peculiarity of silicon avalanche photodiodes is that as an incoming photon is detected, a small amount of light is emitted from the avalanche region. The emitted light has a broad spectral distribution. In most cases, this is not a problem. However, it can cause some confusion if another detector is monitoring light, or if the optical system is such that light emitted from the SPCM-EDU CD3375 is reflected back on itself. If these photons return 35 ns after the initial event, they will be detected.

Safety Warning

The SPCM-EDU CD3375 contains a **high voltage power supply.** Users may be injured if the case is 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.

Individual Module Test Data

Each module is supplied with test data indicating the module’s actual dark count, dead time, pulse width, photon detection efficiency @ 550nm, correction factor and linearity.

Actual module count rate calculation

$$ACTUAL\,COUNTRATE_{Photons} = \frac{(OUTPUT\ \ ModuleCountRate \times CORRECTIONFACTOR\ @\ the\ Module\ CountRate) - DARK\ COUNT\ Module}{PHOTON\ DETECTION\ EFFICIENCY\ Module}$$

The theoretical value, at low count rate, of the Correction Factor follows this equation:

$$Correction\ Factor = \frac{1}{1 - (t_d \times C_R)}$$

Where: t_d = Module Dead Time

C_R = Output Count Rate

The deviation from an ideal linear system is another way of looking at the saturation effect. The following equations show how to calculate this departure from the linearity:

$$LINEARITY = \left[\frac{OUTPUT\ ModuleCountRate}{(PHOTONS\ Actual\ Count\ Rate \times PHOTON\ DETECTION\ EFFICIENCY\ Module) + DARK\ COUNT\ Module}\right]^{-1}$$

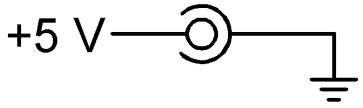
$$= \left[\frac{1}{Correction\ Factor}\right]^{-1}$$

Electrical Connection

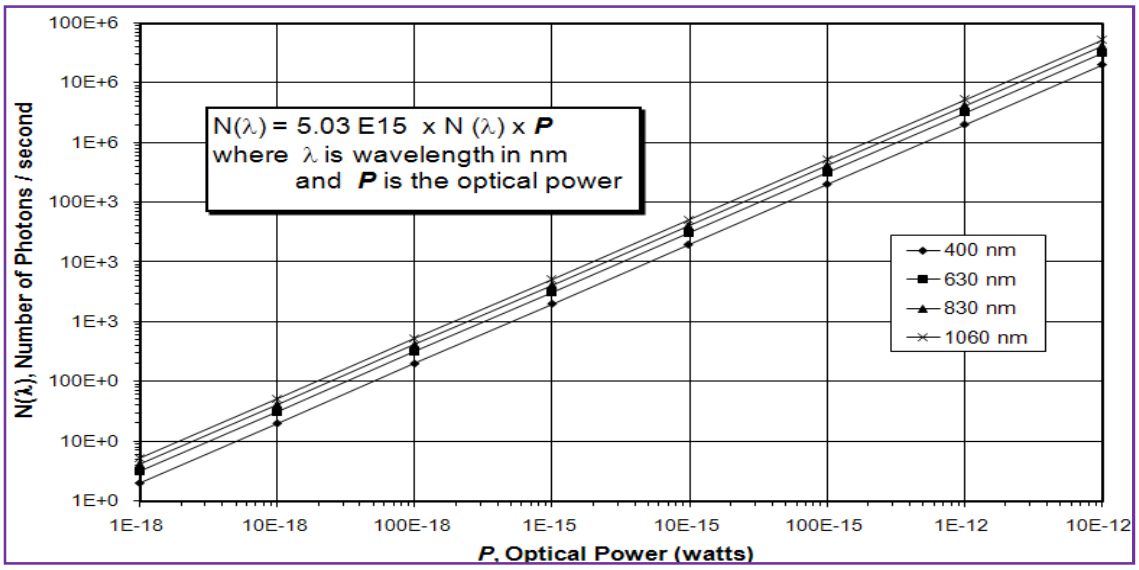
OUTPUT CONNECTOR
The digital OUTPUT pulse (BNC connector, TTL levels, >2.0v) should be terminated into a 50 ohm load to avoid distortion and ringing. A 1.0 volt triggering level is recommended on counters and oscilloscopes to avoid triggering on noise. Note that TTL stands for Transistor -Transistor Logic.

GATE CONNECTOR
The GATE input (BNC connector) impedance is 50 ohms and internally connected to the +5 volt supply through a pull-up resistor (standard module versions). It can be driven by standard TTL level signals.

POWER CONNECTOR
The +5volt power connector is a standard barrel connector (2.5mm I.D., 5.5mm O.D.) with an 18 AWG cable. The center stripe corresponds to the center of the barrel and connects to the positive terminal of the 5 volt supply. Reversal of the wires may damage the module.



Optical power vs. Number of Photons



Declaration of Conformity

This product is eligible to bear the CSA mark with adjacent indicator ‘C’ and ‘US’.

Products:

CLASS 8721 84 ELECTRICAL EQUIPMENT FOR LABORATORY USE – Certified to US standards
CLASS 8721 04 LABORATORY EQUIPMENT – Electrical.

Single photon counting module SPCM series, rated 5 Vdc, 1.9 A, Continuous operation, installation category I, pollution degree 2

Altitute of Operation: 0 – 5000 Meters
Humidity of Operation: 15% - 95% relative humidity, non condensing

APPLICABLE REQUIREMENTS:

CAN/CSA-C22.2 No. 1010.1-92 (R1999) – Safety requirements for electrical equipment for measurement, control, and laboratory use, part 1: General requirements

CAN/CSA-C22.2 No. 1010.1B-92 – Amendment 2:1997 to CAN/CSA 22.2 No. 101.1-92, Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements

UL std no. 61010A-1 – Electrical equipment for laboratory use ; part 1:General requirements

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This product is eligible to bear the CE mark in accordance with:

EN 61326:1997 Electrical equipment for measurement, control and laboratory use
EN 61010-1:2001 Safety requirements for electrical equipment for measurement, control and laboratory use

This product has been tested as per the following standards:

- Emission CISPR 11
- IEC 61000-4-2 ESD
- IEC 61000-4-3 Radiated susceptibility
- IEC 61000-4-4 Burst
- IEC 61000-4-5 Surge
- IEC 61000-4-6 Conducted susceptibility
- IEC 61000-4-11 Voltage dips and interruptions

This equipment is intended for Indoor Use Only. There is no applicable maintenance manual. The data sheet is used also as an instruction manual.

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