

SPCM-UV Single Photon Counting Module



Features and Benefits

- Photon detection efficiency at 440 nm: up to 75%
- Active area: 180 μm
- Gated output
- Single +5 V supply
- FC receptacle option for fiber coupling
- RoHS compliant

Applications

- Photon correlation spectroscopy
- Ultra sensitive fluorescence
- Confocal Microscopy
- Particle sizing
- Single molecule detection
- Astronomical observation
- Optical range finding
- Adaptive optics

Si APD Single Photon Counting Module with Blue-Enhanced Photon Detection Efficiency

Overview

The new SPCM-UV, the latest addition to the Excelitas SPCM product family, is a self-contained module that detects single photons of light with enhanced photon detection efficiency in the range of 400 - 500 nm, with performance parameters often outperforming photomultiplier tubes as well as current Si APD-based single photon counting modules.

The SPCM-UV uses a unique silicon avalanche photodiode (UV-SiK™) with a circular active area that achieves a peak photon detection efficiency of up to 75% at 440 nm over a 180 μm diameter. The photodiode is both thermoelectrically cooled and temperature controlled, ensuring stabilized performance despite ambient temperature changes.

Excelitas' series of single photon counting modules offers high PDE, low afterpulsing, high dynamic range exceeding 25 Mcps with dead time of 30 ns, and highest uniformity over the active area.

As each photon is detected, a TTL pulse of 2.2 Volts (minimum) high in a 50 load and 15 ns wide is output at the rear BNC connector. This series of photon counting modules are designed and built to be fully compliant with the European Union Directive 2002/95/EEC – Restriction of the use of certain Hazardous Substances in Electrical and Electronic equipment (RoHS).

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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.

Fiber Connection Option

The SPCM-UV-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, Table 4). The standard fiber lens is optimized for 450 nm. Though the fiber/GRIN in the standard module will function through the complete range of 400 nm to 1100 nm, due to the wavelength dependence of the graded index coupling lens, improvements to other operating wavelengths are special orders. The photon detection efficiency of connectorized modules is about 95% of that quoted for standard modules at 450 nm.

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 pigtailed conform to this requirement (see Ordering Guide, Table 4).

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 2 μ s 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-UV is reflected back on itself. If these photons return 35 ns after the initial event, they will be detected.

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TABLE 1 Specifications of SPCM-UV, @ 22 °C, all other models, unless otherwise indicated

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	°C
Active area (diameter) at minimum Pd	170	180		μm
Photon detection efficiency (Pd) at:				
380 nm	25	28		%
400 nm	50	55		%
440 nm	65	70		%
550 nm	75	80		%
600 nm	70	75		%
Pd variation at constant case temperature (2 hrs at 25 °C)		± 1	± 3	%
Pd variation from 5 °C to 40 °C		± 4	± 10	%
Dark Count ^(4, 5, 6)				
SPCM-UV-10			1500	Counts/second
SPCM-UV-11			1000	Counts/second
SPCM-UV-12			500	Counts/second
SPCM-UV-13			250	Counts/second
SPCM-UV-14			100	Counts/second
SPCM-UV-15			50	Counts/second
SPCM-UV-16			25	Counts/second
Average dark count variation at constant case temperature (6 hrs at 25 °C) ^(4, 5, 6)				
SPCM-UV -10, 11, 12, 13			± 10	%
SPCM UV -14, 15, 16			± 1	σ
Average dark count variation at 5 °C to 40 °C case temperature for ^(4, 5, 6)				
SPCM- UV -10, 11, 12, 13			± 20	%
SPCM- UV -14, 15, 16			± 2	σ
Dead time (count rate below 5 M/c)		30	40	ns
Output count rate before saturation ⁽⁸⁾	25	30		Mc/s
Linearity correction factor ⁽⁷⁾ at				
200 Kc/s		1		
1 Mc/s		1.03		
5 Mc/s		1.2		
10 Mc/s		1.48		
20 Mc/s		2.8		
25 Mc/s		4.5		
Setting time following power up (1% stability) at 1 Mc/s and 25 °C		15	20	s
Threshold setting required on counter for digital output pulse (terminate in 50 Ω)		1.0		V
Output pulse width ⁽⁹⁾		15		ns
Gating turn on/off (50 Ω output)				
Disable = TTL low (< 0.8 V)		26	32	ns
Enable = TTL high (> 2.0 V)		52	61	
Gating threshold voltage (at V supply = 5 V)				
Low level (sink current > 90 mA)	0		0.4	V
High level (sink current > 30 mA)	2.0		5.25	

TABLE 2. Absolute Maximum Ratings

Supply voltage ⁽¹⁾	5.5 V
Maximum count rate	Maximum count rate can be sustained if case temperature is maintained within limit specified limits.
Peak light intensity	10 ⁴ photons per pulse and pulse width < 1 ns
Case temperature ⁽³⁾	-20 °C/+70 °C storage, +5 °C /+40 °C operating (+50 °C at reduced count rates).

⁽¹⁻⁹⁾ Refer to Operating Instructions for noted items.

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FIGURE 1 Typical Pd Scan

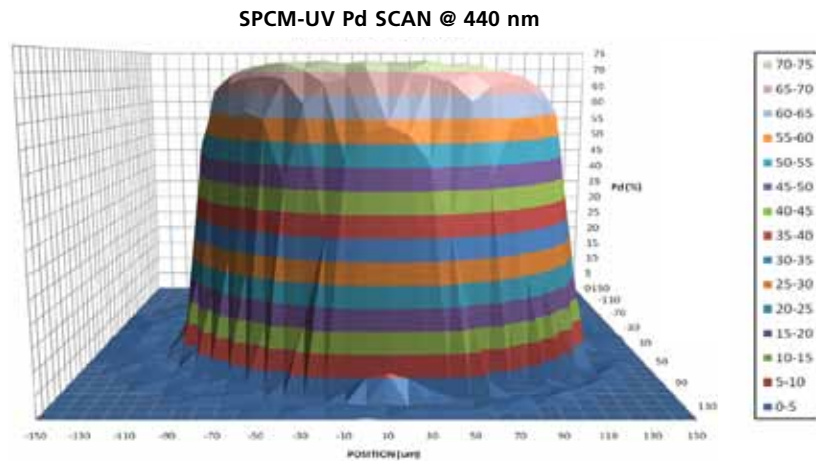


FIGURE 2 Typical Correction Factor

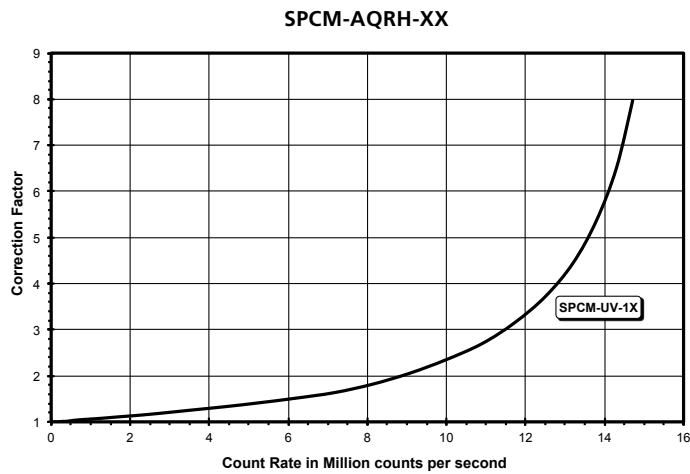
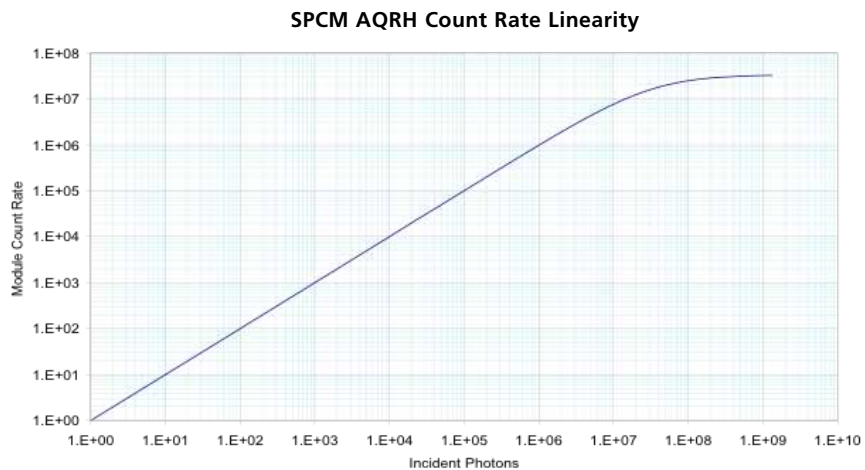


FIGURE 3 Typical Photon Detection Efficiency (Pd) vs. Wavelength



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FIGURE 4 Count Rate Linearity

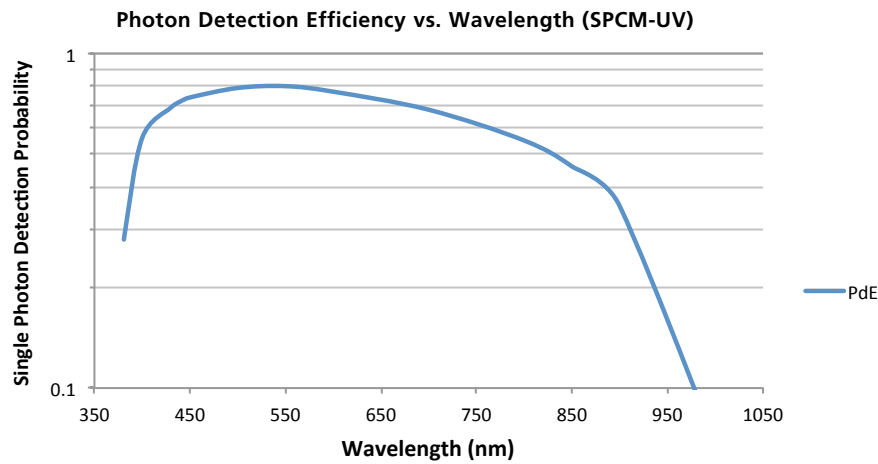
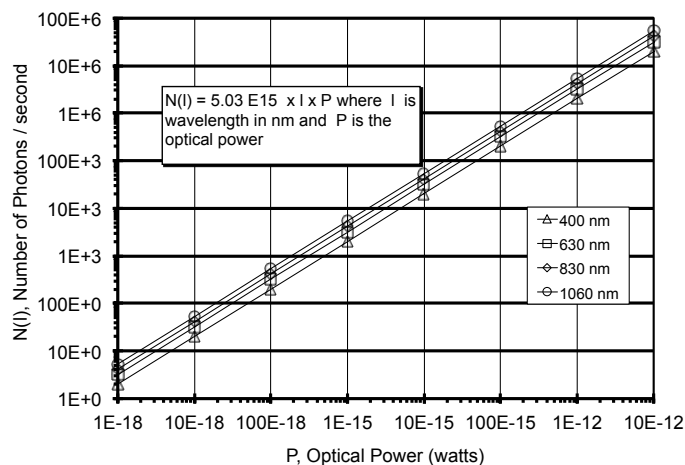


FIGURE 5 Optical Power vs. Number of Photons



Safety Warning



The SPCM-UV 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.

RoHS Compliance

This series of avalanche photodiode modules are designed and built to be fully compliant with the European Union Directive 2002/95/EC – Restriction of the use of certain Hazardous Substances in Electrical and Electronic equipment.



Warranty

A standard 12-month warranty following shipment applies. Any warranty is null and void if the module case has been opened. Warranty is null and void if the module input exceeds 5.5 V or the polarity of the +5 V supply is reversed.

EDS Warning

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

Individual Module Test Data

Each module is supplied with test data indicating the module's actual dark count, dead time, output pulse width, photon detection efficiency at 450 nm and linearity correction factor.

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TABLE 3 SPCM Ordering Guide

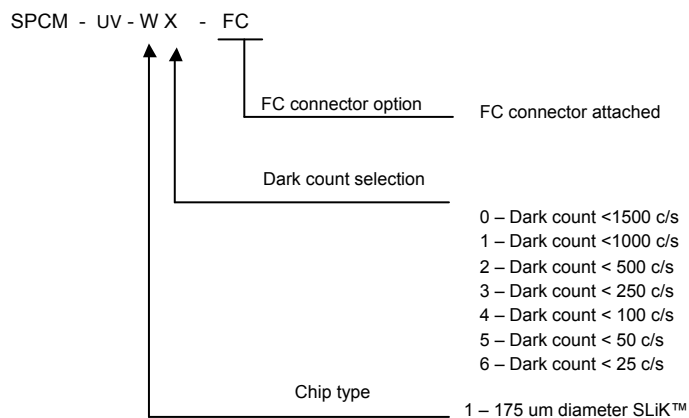


TABLE 4 Fiber Ordering Guide

Part Number	Fiber Type	Connector Type	Diameter			Numerical Aperture
			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					

FIGURE 6 Dimensional Outline

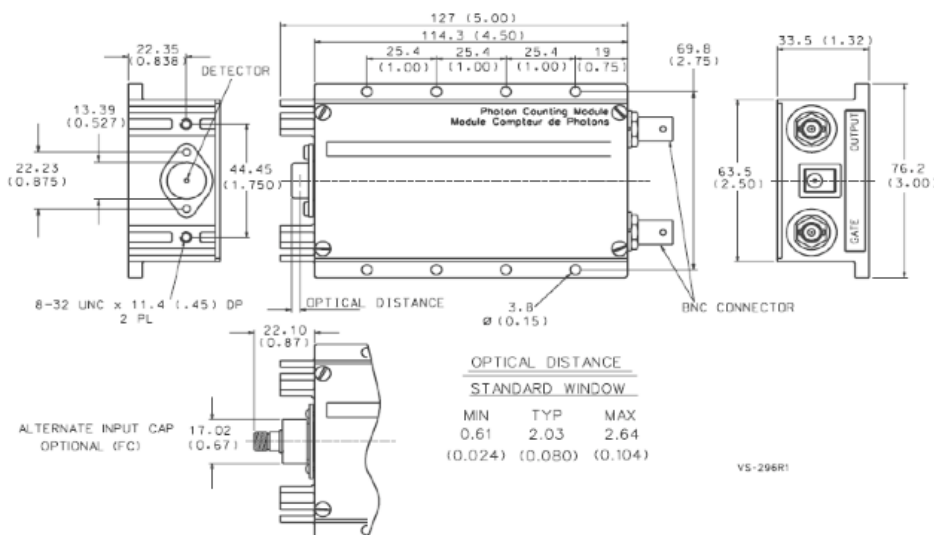


FIGURE 7 Electrical Connections

Output Connector

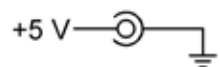
The digital OUTPUT pulse (BNC connector, TTL levels, >2.0 v) should be terminated into a 50 ohm load to avoid distortion and ringing. A 1.0 volt triggering level is recommended on counters and oscilloscopes to avoid triggering on noise. Note that TTL stands for Transistor Transistor Logic.

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 (2.5 mm I.D., 5.5 mm 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.



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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 +5 V.
2. These modules are not qualified for shock or vibration other than normal instrumentation environments.
3. The module dissipates a mean power of 2.5 W and a maximum power of 6 W 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., 350 to 390 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:

$$ACTUAL\ COUNTER\ RATE\ Photons = \frac{(OUTPUT\ Module\ Count\ Rate \times CORRECTION\ FACTOR\ @\ the\ Module\ Count\ Rate) - DARK\ COUNT\ Module}{PHOTON\ DETECTION\ EFFICIENCY\ Module}$$

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

$$Correction\ Factor = \frac{1}{1 - (t_d \times C_R)} \quad \text{Where: } t_d = \text{Module Dead Time}$$

$$C_R = \text{Output Count Rate}$$

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:

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

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

8. Typical count rate can go up to 35 Mc/s on some units.
9. Output pulse width is set at the standard of 15 ns. Optional output pulse width is 28 ns. If the application requires a 28 ns output pulse width, it should be requested at the time of order.

About Excelitas Technologies

Excelitas Technologies is a global technology leader focused on delivering innovative, customized solutions to meet the lighting, detection and other high-performance technology needs of OEM customers.

From analytical instrumentation, clinical diagnostics and life sciences applications to medical lighting, industrial, safety and security, and aerospace and defense applications, Excelitas Technologies is committed to enabling our customers' success in their specialty end-markets. Excelitas Technologies has approximately 3,000 employees in North America, Europe and Asia, serving customers across the world. The company was previously the Illumination and Detection Solutions (IDS) business unit of PerkinElmer.

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