SPCM-AQ4C
Single Photon Counting Module 4 Channel Array

The SPCM-AQ4C is a 4-channel photon counting card capable of detecting single photons of light over the wavelength range from 400 nm to 1060 nm. Each channel is independent from the others.

The SPCM-AQ4C uses a unique silicon avalanche photodiode (SliK™) that has a circular active area of 180 μm with a peak photon detection efficiency exceeding 60% at 650nm. Each photodiode is both thermoelectrically cooled and temperature controlled, ensuring stabilized performance despite changes in the ambient temperature.

The SPCM-AQ4C card uses an improved circuit with a peak count rate >4 M c/s for short bursts of time on all 4 channels and a count rate of 1.5 M c/s for continuous operation. There is a "dead time" of 50 nanoseconds (ns) between pulses. The module requires +2 Volts, +5 Volt, and +30 Volt power supplies. The output of each channel – a TTL pulse that is 4.5 Volts high (into a 50 Ω load) and 25 ns wide – is available at the card edge behind the circuit board. Each TTL pulse corresponds to a detected photon. All input and output signals are available at the card connector.

Excelitas Technologies supports custom requirements of this module in screening for dark count, after pulse, and peak photon detection efficiency. Contact us to discuss your special needs on the SPCM-AQ4C.

Key Features

- Peak photon detection efficiency at 650 nm: 60% typical
- Afterpulsing probability 0.5%
- Gated input
- TTL output
- FC fiber connector mounted and aligned on each detector
- 4 channels in one package
- Self-contained APD module with integrated electronics

Applications

- Single molecule detection
- High throughput single photon experiments
- LIDAR
- Photon correlation spectroscopy
- Astronomical observation
- Optical range finding
- Adaptive optics
- Ultra sensitive fluorescence
- Particle sizing
- Quantum communication

SPCM-AQ4C

Single Photon Counting Module 4 Channel Array

Table 1   Specifications of SPCM-AQ4C , @ 22 ºC, unless otherwise indicated

Parameter	Min	Typ	Max	Unit

Supply current[7]
  @+2V
  @+5V
  @+30V
		
		1.0
		0.20
		0.01
			4.0*
			3.0**
			1.0**
			0.04**
				A

Maximum power consumption[7]
  @+2V
  @+5V
  @+30V
		
		2
		1
		0.3
			
			6**
			5**
			1.2**
				W

Supply voltages [1,7]	1.95 4.75 29	2 5 30	2.05 5.25 31	V
Case operating temperature (heat sink) [1, 3]	5		40	ºC
Active area (diameter) of each channel at minimum Pd	170	180		µm

Photon detection efficiency (Pd) at: 400nm
       650nm
       830nm
       1060nm
	1
	45
	35
	1
		2.5
		60
		45
		2
				%
				%
				%
				%

Pd variation at constant case temperature (2hrs at 25 ºC)		± 1	± 3	%
Pd variation from 5 ºC to 40 ºC[3]		± 4	± 10	%
Dark Count per channel[4, 5]			500	Counts /second
Average dark count variation at constant case temperature (6 hrs at 25 ºC) [4, 5, 6]			± 10	%
Average dark count variation at 5 ºC to 40 ºC case temperature [4, 5, 6]			± 20	%
Single photon timing resolution per channel		600		ps
Dead time (count rate below 5M/c)		50		ns
Output pulse width		25		ns

Linearity correction factor [7] at 200 Kc/s
       1 Mc/s
       1.5 Mc/s
		1.01
		1.08
		1.12
			1.10
			1.15
			1.20	

Afterpulsing probability		0.5		%
Gating turn-on delay before first edge of true output pulse (50Ω output)		60	75	ns
Gate turn-off delay for minimum last output pulse width of 10ns (50Ω output)		4	15	ns

Gating threshold voltage (at V supply = 5V)
        Low level (sink current <1.6mA)
        High level (Source current <5.5mA)
	
	0
	3.5
			
			0.8
			5.25
				V

Refer to Operating Instructions below for noted items

SPCM-AQ4C
Single Photon Counting Module 4 Channel Array

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 instrumentation environments.

3. The module dissipates a mean power of 3.5W and a maximum power of 14W 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.

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 PerkinElmer's 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. When connecting power to the module, good grounding techniques must be observed. All ground connections for the +30V and +5V supplies should connect through a single point on the user's interface. All ground pins on the card edge connector should be used. The +2V grounds should be connected together at a single point, but should be separate and isolated from the grounds of the other supplies.

8. The actual photon rate could be calculated using the following equation, as indicated below:

Note # 8: Actual photon rate calculation

$$\text{ACTUAL COUNT RATE}_{Photons} = \frac{(\text{OUTPUT ModuleCountRate} \times \text{CORRECTION FACTOR @ the Module CountRate}) - \text{DARK COUNT}_{Module}}{\text{PHOTON DETECTION EFFICIENCY}_{Module}}$$

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

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

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:

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

$$= \left[\frac{1}{\text{Correction Factor}} \right] - 1$$
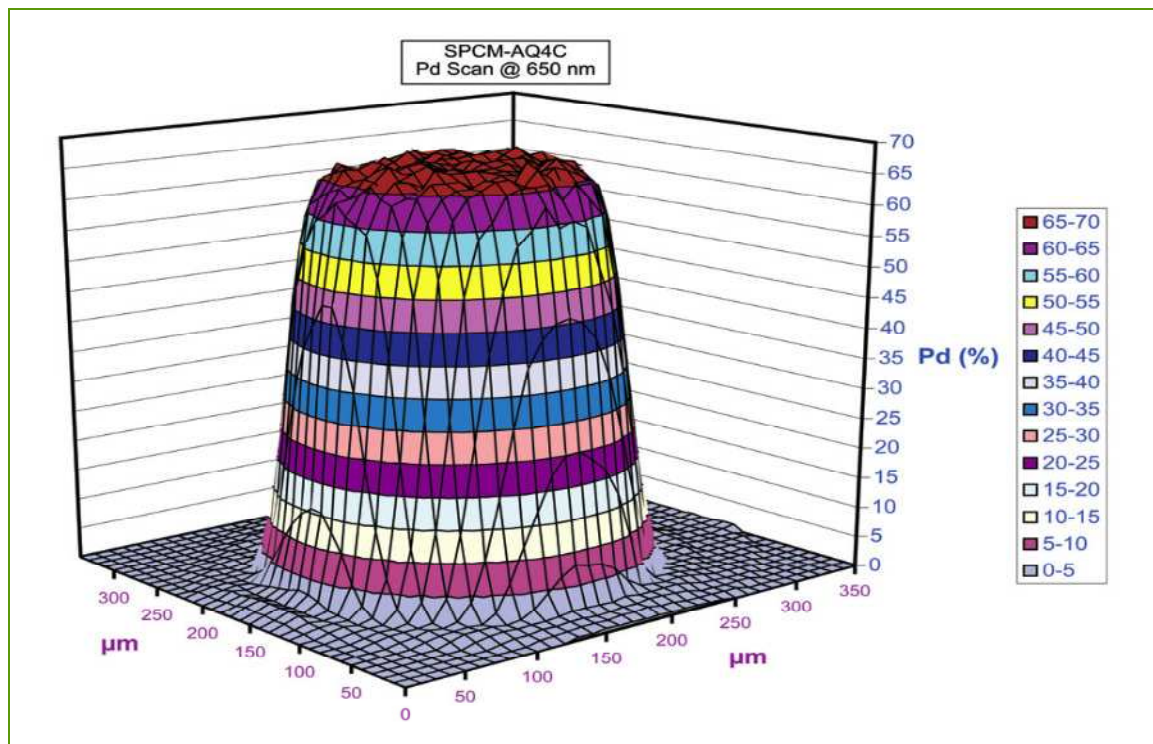
Single Photon Counting Module 4 Channel Array

Table 2. Absolute Maximum Ratings

Supply voltages [1, 7]	
@+2V	2.1V
@+5V	5.5V
@+30V	31.5V
Maximum count rate, continuous (per channel)	2Mc/s
Peak count rate, @25% duty cycle to 500ms (per channel)	5Mc/s
Peak light intensity (per channel)	10^4 photons per pulse and pulse width < 1ns
Case temperature [3]	-45 ºC/+50 ºC storage, +5 ºC /+40 ºC operating with heat sink

Table 3. Fiber Ordering 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					

Figure 1   Detector scan without FC fiber

Single Photon Counting Module 4 Channel Array

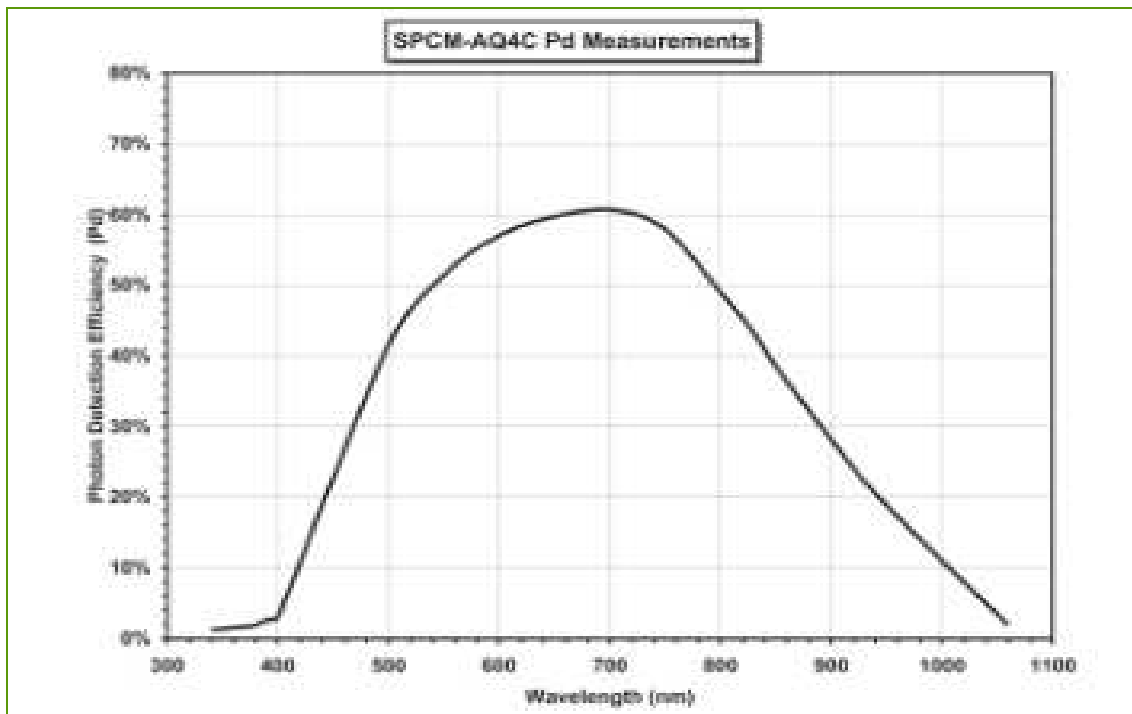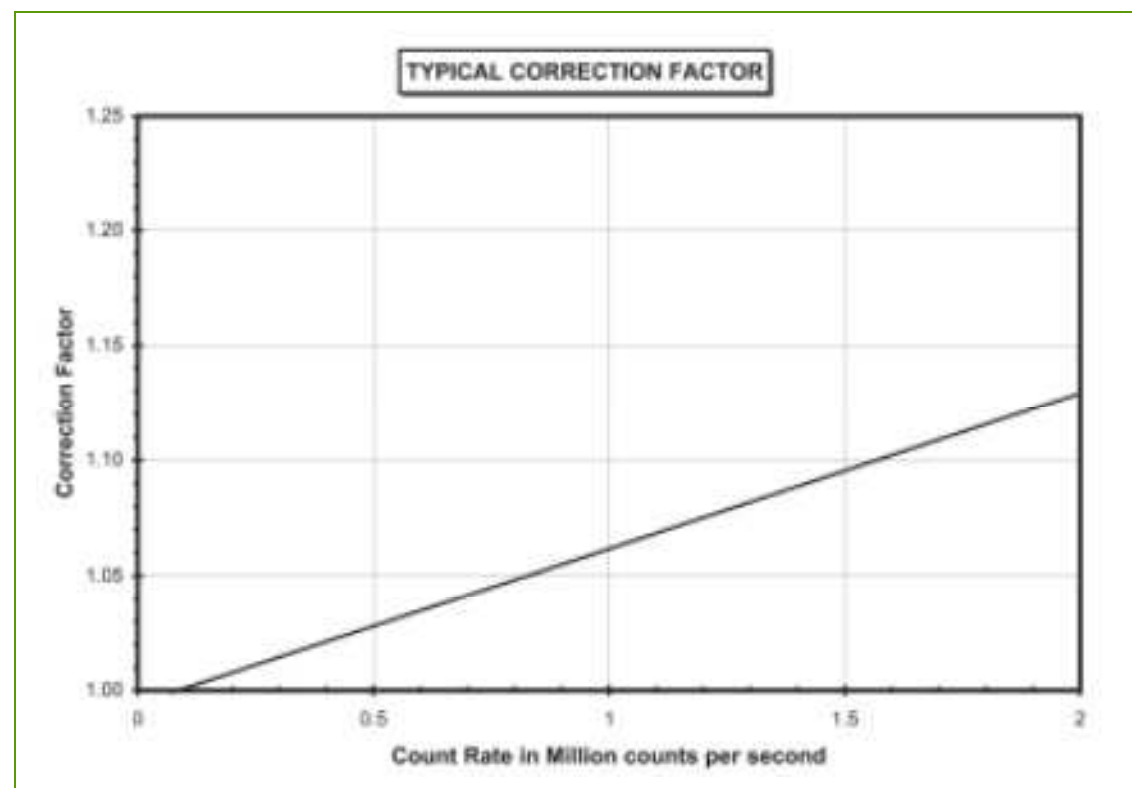### Figure 2   Photon detection efficiency (pd) vs. wavelength

Figure 2   Typical Correction Factor

Single Photon Counting Module 4 Channel Array
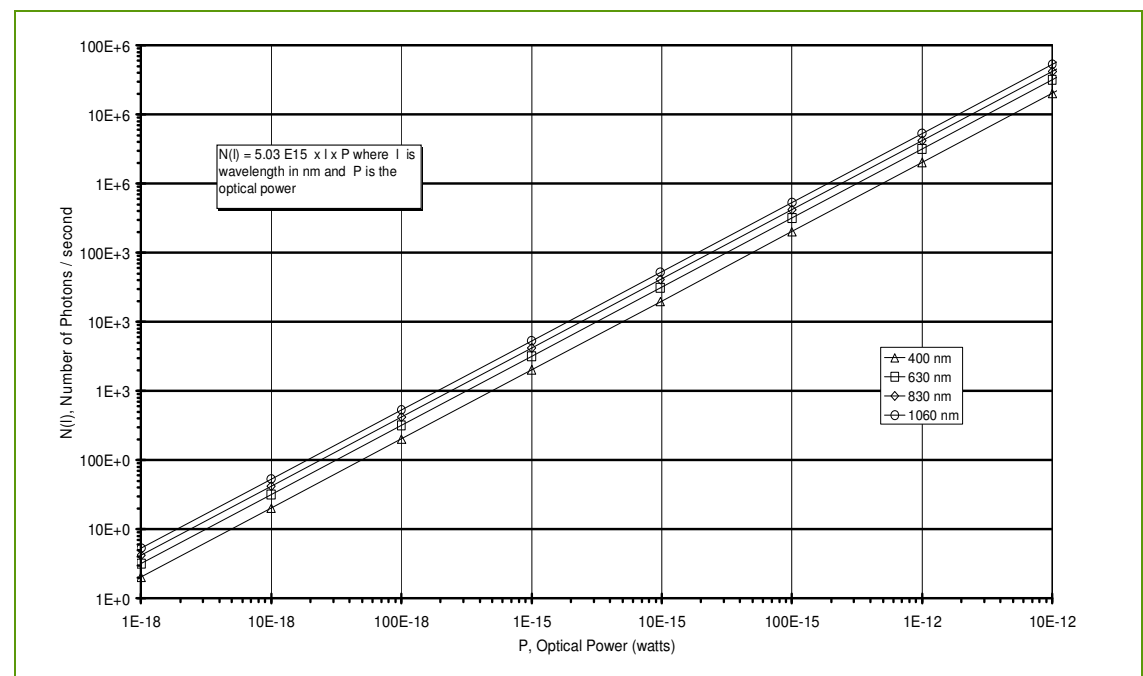
Figure 4   Optical power vs. number of photons

$N(l) = 5.03\ E15\ \times l \times P$ where l is wavelength in nm and P is the optical power
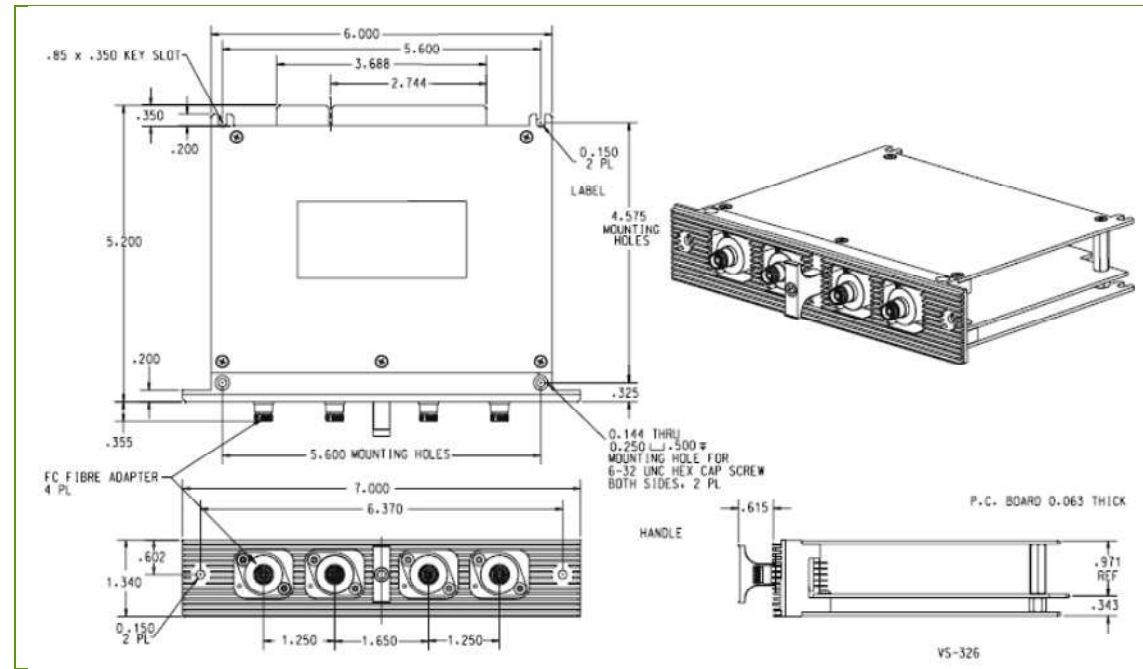
Figure 5 Dimensional Outline

Single Photon Counting Module 4 Channel Array

Card edge connector parameters

The electrical connections to the card edge connector are shown below. Each connector has 72 contacts, 36 on each side. The contact spacing is 0.100". Mating connector is

Sullins Electronics Corp, P/N EBC36DCAN
801 E. Mission Rd., San Marcos, CA. 92069
888-774-3100   *Http://www.edgecards.com/dsww100.php*

Any equivalent connector may be used.

Component Side		Solder Side	
Contact #	Value	Contact #	Value
1	+2V	2	NC
3	+2V	4	NC
5	+30V	6	NC
7	2V GROUND	8	2V GROUND
9	TTL OUT 0	10	NC
11	GROUND	12	NC
13	GATE 0	14	NC
15	GROUND	16	NC
17	+5V	18	NC
Key Slot		Key Slot	
19	+2V	20	NC
21	+2V	22	NC
23	+30V	24	NC
25	2V GROUND	26	2V GROUND
27	TTL OUT 1	28	NC
29	GROUND	30	NC
31	GATE 1	32	NC
33	GROUND	34	NC
35	+5V	36	NC
37	+2V	38	NC
39	+2V	40	NC
41	+30V	42	NC
43	2V GROUND	44	2V GROUND
45	TTL OUT 2	46	NC
47	GROUND	48	NC
49	GATE 2	50	NC
51	GROUND	52	NC
53	+5V	54	NC
55	+2V	56	NC
57	+2V	58	NC
59	+30V	60	NC
61	2V GROUND	62	2V GROUND
63	TTL OUT 3	64	NC
65	GROUND	66	NC
67	GATE 3	68	NC
69	GROUND	70	NC
71	+5V	72	NC

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-AQ4C 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 Fiber Type Ordering Guide on page 7). The photon detection efficiency is typically 60% at 650nm.

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 Table 3 Fiber Ordering Guide).

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 enabled when a TTL low level (0 to 0.8V) is applied to the module gate input. When a TTL high level (3.5 to 5.25V) is applied to the module gate input, the output of the module and the active quench circuit are disabled 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-AQRH is reflected back on itself. If these photons return 35 ns after the initial event, they will be detected.

Safety Warning

The SPCM-AQRH 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.

Single Photon Counting Module 4 Channel Array

RoHS Compliance

This series of avalanche photodiode modules are designed and built to be fully compliant with the European Union Directive 2002/95EEC – 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 5.5V or the polarity of the +5V 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, pulse width, photon detection efficiency @ 630nm, correction factor and linearity.

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 to clinical diagnostics, medical, 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.

Excelitas Technologies
22001 Dumberry Road
Vaudreuil-Dorion, Quebec
Canada J7V 8P7
Telephone: (+1) 450.424.3300
Toll-free: (+1) 800.775.6786
Fax: (+1) 450.424.3345
detection@excelitas.com

European Headquarters
Excelitas Technologies
GmbH & Co. KG
Wenzel-Jaksch-Str. 31
D-65199 Wiesbaden
Germany
Telephone: (+49) 611 492 430
Fax: (+49) 611 492 165
detection.europe@excelitas.com

Asia Headquarters
Excelitas Technologies
47 Ayer Rajah Crescent #06-12
Singapore 139947
Telephone: (+65) 6775-2022
Fax: (+65) 6775-1008

EXCELITAS
TECHNOLOGIES

2011-07-19