Single Photon Counting Module
SPCM-AQR Series

Description

The SPCM-AQR is a self-contained module which detects single photons of light over the wavelength range from 400 nm to 1060 nm... a range and sensitivity which often outperforms photomultiplier tubes.

The SPCM-AQR-1X utilizes a unique silicon avalanche photodiode which has a circular active area whose peak photon detection efficiency over a 180 µm diameter exceeds 70% at 650 nm.
The photodiode is both thermoelectrically cooled and temperature controlled, ensuring stabilized performance despite changes in the ambient temperature. The SPCM-AQR module can count to speeds exceeding 10 million counts per second (Mc/s) for the SPCM-AQR-1X. There is a "dead time" of 50 ns between pulses and single photon arrival can be measured with an accuracy of 350 ps FWHM.

The SPCM-AQR requires a +5 volt power supply. A TTL pulse of 2.5 volts (minimum) high in a 50 Ω load and 30 ns wide, is output at the rear BNC connector as each photon is detected. To avoid a degradation of the module linearity and stability, the case temperature should be kept between 5 C and 40 C during operation.

Saturation

The 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. Consequently, in certain applications, some tests should be performed by the operator to ensure that a low count rate is not caused by detector saturation.
Precautions should be taken to avoid any excessive light level that will damage the SPCM module.

Applications

- LIDAR
- Photon Correlation Spectroscopy
- Astronomical Observation
- Optical Range Finding
- Adaptive Optics
- Ultra Sensitive Fluorescence
- Particle Sizing

Features

- Peak Photon Detection Efficiency @ 650 nm:
- 70% Typical
- Active Area: SPCM-AQR-1X: 175 µm
- Timing Resolution of 350 ps FWHM
- User Friendly
- Gated Input
- Single +5v Supply

PerkinElmer™ optoelectronics.

Fiber Connection Option

Ordering Guide 1

The SPCM-AQR-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. Due to the wavelength dependence of the graded index coupling lens, the operating wavelength range must be specified; see Ordering Guide 2. The photon detection efficiency of connectorized modules is about 95% of that quoted for standard modules.

Fiber Shielding

When used with optical fibers, both the fiber itself and the connector shrouds must be completely opaque; if not, 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. It is useful when you are looking for a signal that occurs only in a small time frame 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 is disabled when a TTL low level is applied to the module gate input.*

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 light emitted 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-AQR is reflected back on itself. If these photons return 30 ns after the initial event, they will be detected.

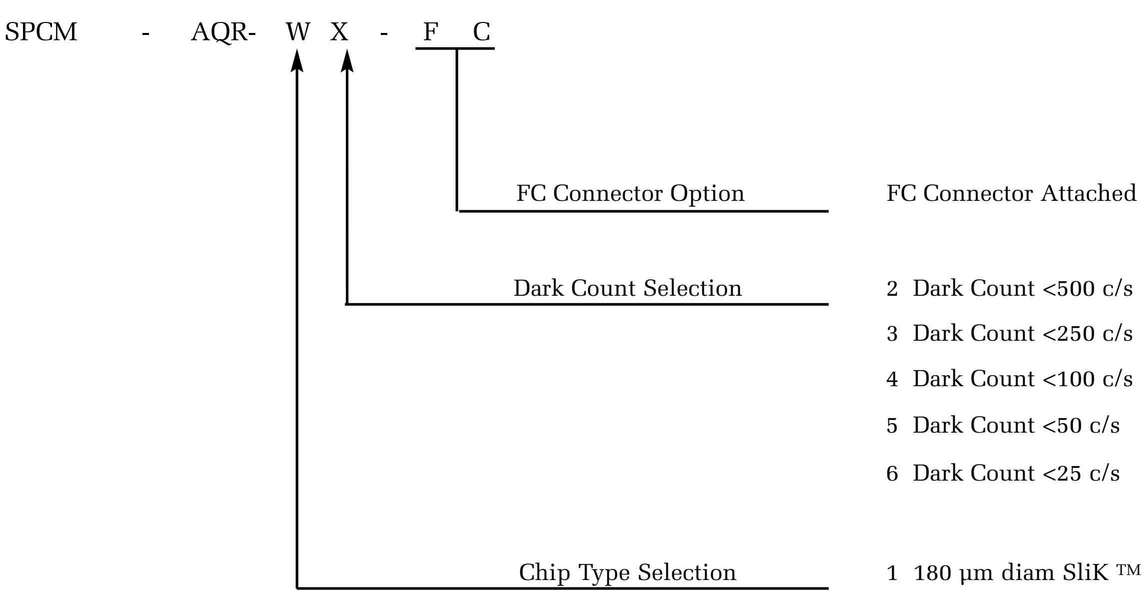
Safety

The SPCM-AQR contains a high voltage power supply. All internal settings are pre-set; *there are no user adjustments.* Units which appear defective or have suffered mechanical damage should not be used because of possible electrical shorting of the high voltage power supply.

Warranty

A standard twelve month warranty following shipment applies. Any warranty is null and void if the module case has been opened.

Ordering Guide Diagram 1



* *SliK is a trademark of PerkinElmer Canada Inc.*

Ordering Guide Diagram 2

Standard fiber pigtail options. Standard length is 1.0 ± 0.1 meters. Standard pigtail is FC terminated at one end, bare fiber at free end.

Part Number	Fiber Type	Manufacturer	Diameter			Numerical Aperture
			Core	Cladding	Outer	
SPCM-QC4	Multimode	Canstar	62.5 µm	125 µm	2.5 mm	0.27
SPCM-QC6	Multimode	Canstar	100 µm	140 µm	2.5 mm	0.29
SPCM-QC8		As SPCM-QC6 but 905 SMA on free end				
SPCM-QC9		As SPCM-QC6 but FC connector on free end				

Specifications SPCM-AQR-WX @ 22° C, all models, unless otherwise indicated

Parameter	Minimum	Typical	Maximum	Units
Supply current		0.5	1.9	Amps
Supply voltage: (1)	4.75	5.0	5.25	V
PerkinElmer power cable total resistance		0.2		Ω
Case operating temperature (1.3)	5		40	°C
Active area (diameter) @ minimum P_d	170	175		µm
Photon detection efficiency (P_d)@				
400 nm	2	5		%
650 nm	55	70		%
830 nm	40	50		%
1060 nm	1	2		%

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Specifications SPCM-AQR-WX @ 22° C, all models, unless otherwise indicated

Parameter	Minimum	Typical	Maximum	Units
Quantum Efficiency				
400 nm		2		%
650 nm		90		%
830 nm		92		%
1060 nm		18		%
P_d variation at constant case temperature (2h @ 25° C)		± 1	±3	%
P_d variation 5° C to 40° C case temperature		± 4	±10	%
Dark Count (4,5,6) =				
SPCM-AQR-12		250	500	Counts/Second
SPCM-AQR-13		150	250	Counts/Second
SPCM-AQR-14		50	100	Counts/Second
SPCM-AQR-15		—	50	Counts/Second
SPCM-AQR-16		—	25	Counts/Second
Average dark count variation at constant case temperature (6 hrs @ 25° C) for (4,5,6):				
SPCM-AQR-12 & 13			± 10	%
SPCM-AQR-14 & 15 & 16			± 1	σ
Average dark count variation at 5° C to 40° C case temperature for (4,5,6):				
SPCM-AQR-12 & 13			± 20	%
SPCM-AQR-14 & 15 & 16			± 2	σ
Single Photon Timing Resolution		350		ps @ FWHM
Dead Time (Count rates below 5 Mc/s)		50	60	ns

Specifications SPCM-AQR-WX @ 22° C, all models, unless otherwise indicated- continued

Parameter	Minimum	Typical	Maximum	Units
Output count rate before saturation	10	15		Mc/s
Linearity correction factor: (7) @200 kc/s @1 Mc/s @5 Mc/s		 1.01 1.08 1.40	 1.15 1.67	
Afterpulsing probability		0.3		%
Settling time following power up (1% stability) @ 1 meg counts/sec and 25° C		15	30	S
Threshold setting required on counter for digital output pulse (terminate in 50 Ohms)	0.75	1.0	2.0	V
Pulse Width		30		ns
Gating turn on/off: (50 Ω output) Disable = TTL Low Enable = TTL High		 2 45	 4 55	 ns ns
Gate Threshold Voltage: (@ V_{supply} = 5V) Low level (sink current >90mA) High level (sink current >30mA)		 0 3.5	 0.4 5.25	 V V

Absolute Maximum Ratings

Supply Voltage (1)	5.5V
Mean Count Rate	5 Mc/s (Above this point, dead time will increase due to diode self-heating)
Peak Light Intensity	10^4 photons per pulse and pulse width less than 1 ns.
Case Temperature (3)	50° C Storage, 40° C operating

Single Photon Counting Module

SPCM-AQR Series

1. Connection to incorrect voltage or reverse voltage may destroy the module. The warranty is invalid where such damage occurs.

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

3. The module dissipates a mean power of 2.5W, and a maximum power of 6.5W 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 that 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 which depends on 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 outside PerkinElmer's control. Warranty claims will not be entertained against bi-stability alone. 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 counts. 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:

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

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:

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

$$= \frac{1}{\text{Correction Factor}} - 1$$

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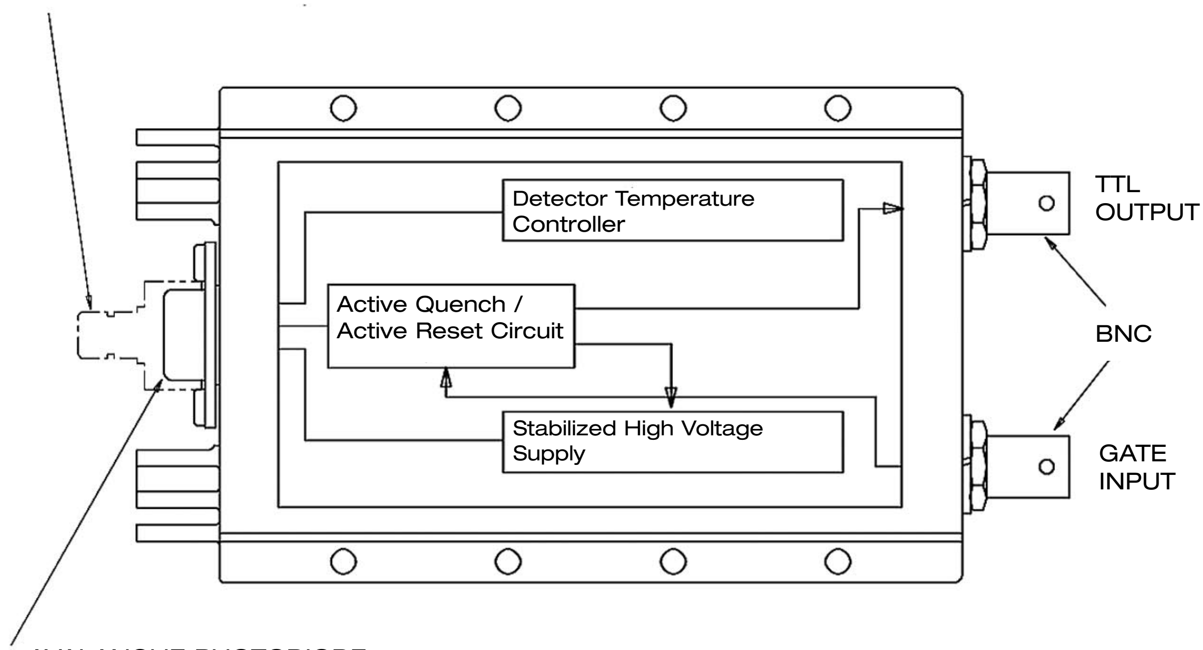
Single Photon Counting Module

Block Diagram of Module



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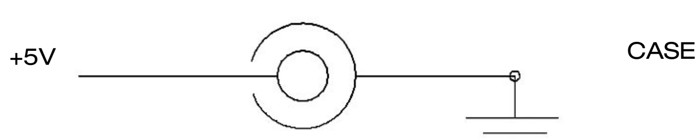
Electrical Connections

The digital output pulse, ≥2.5V, should be terminated with a 50 Ω load to avoid distortion and ringing. A 1.0V triggering level is recommended. The gate input impedance is 50 Ω and is connected through an internal pull-up resistor to the +5V supply.

Power Connector Polarity



CONNECTOR: BARREL TYPE
I.D. = 2.5 mm (0.10”)
O.D. 5.5 mm (0.22”)
LENGTH = 12.0 mm (0.47”)

CABLE: CENTER WHITE STRIPED LEAD
WIRE GAUGE = 22 AWG
LENGTH = 1.8 M (72”)

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Figure 1. Detector Scan

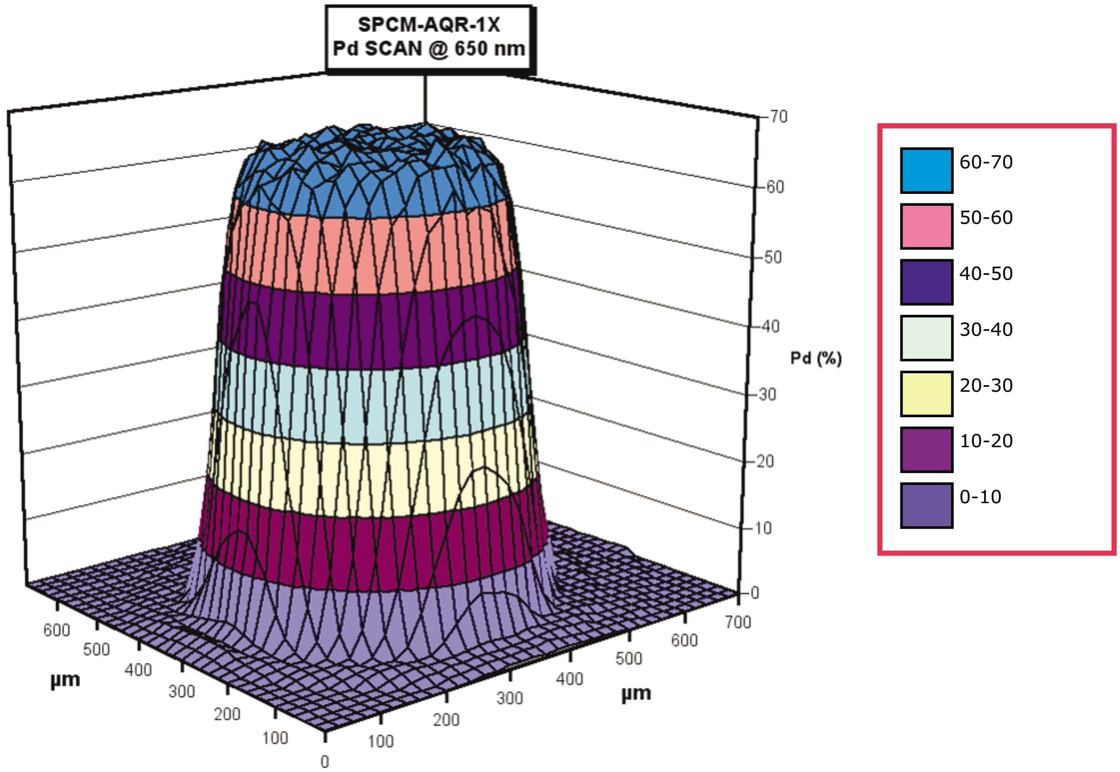

Figure 2. Photon Detection Efficiency (pd) vs. Wavelength

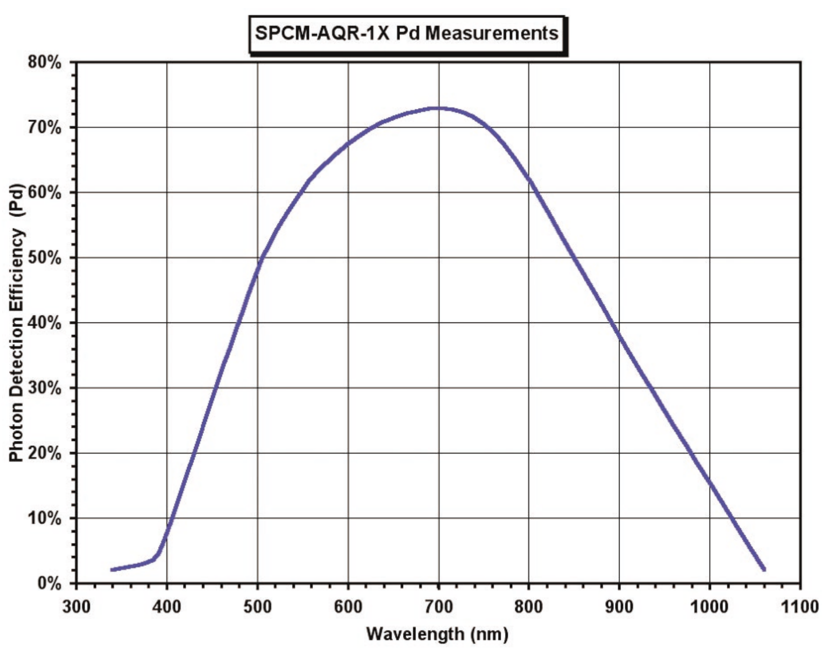

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Figure 3. Typical Afterpulse Probability

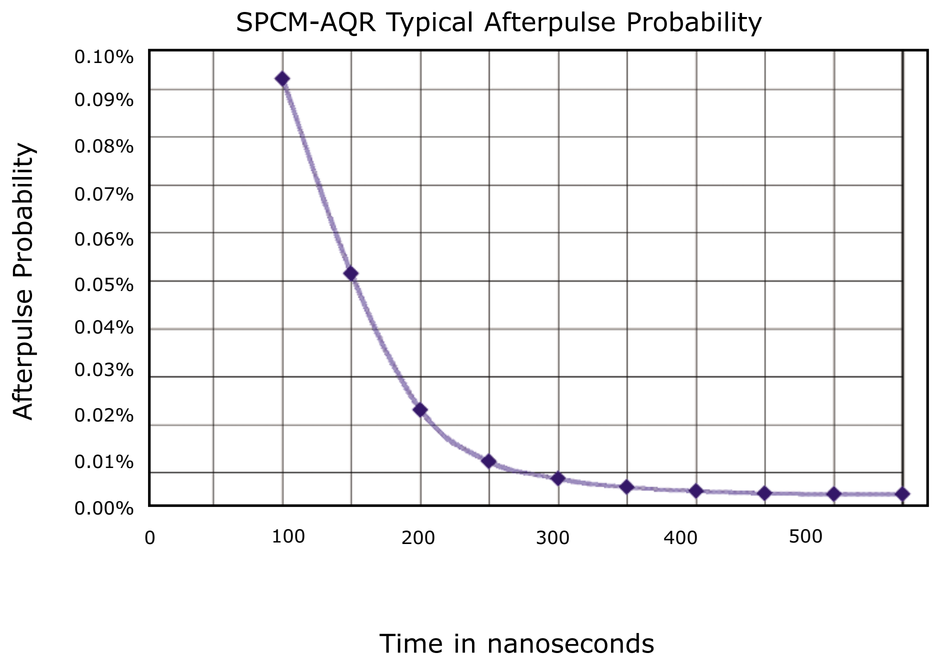

Figure 4. Typical Correction Factor

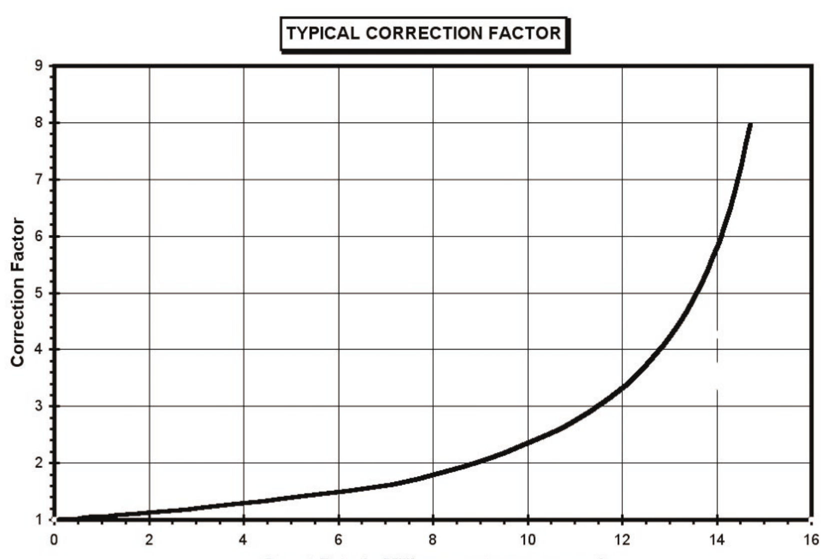

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Figure 5. Dimensional Outline

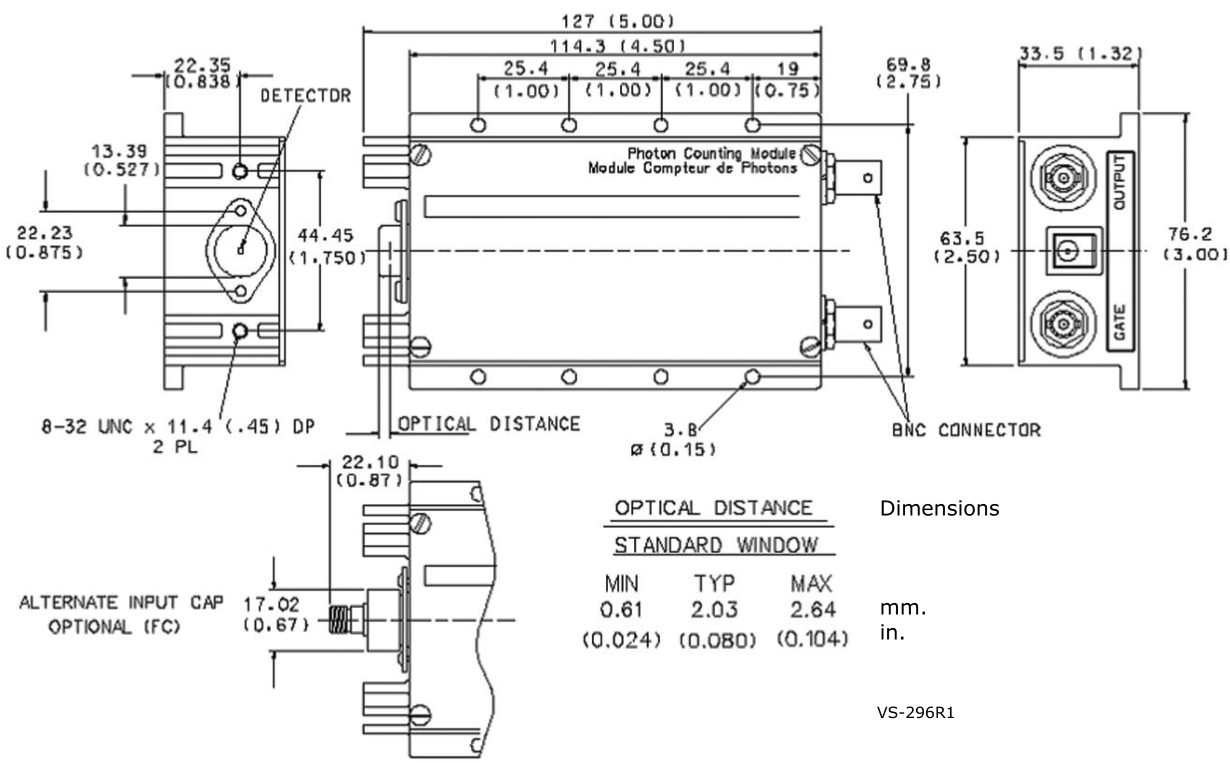
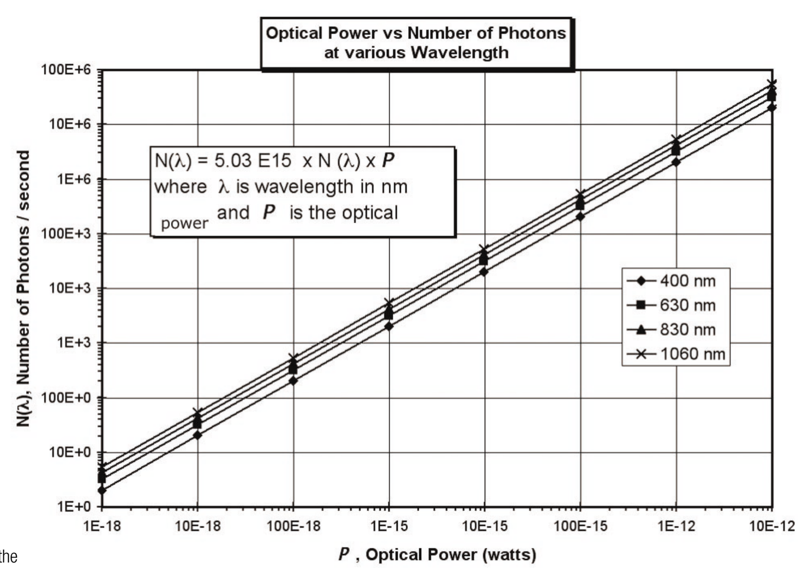


Figure 6. Optical Power vs. Number of Photons



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