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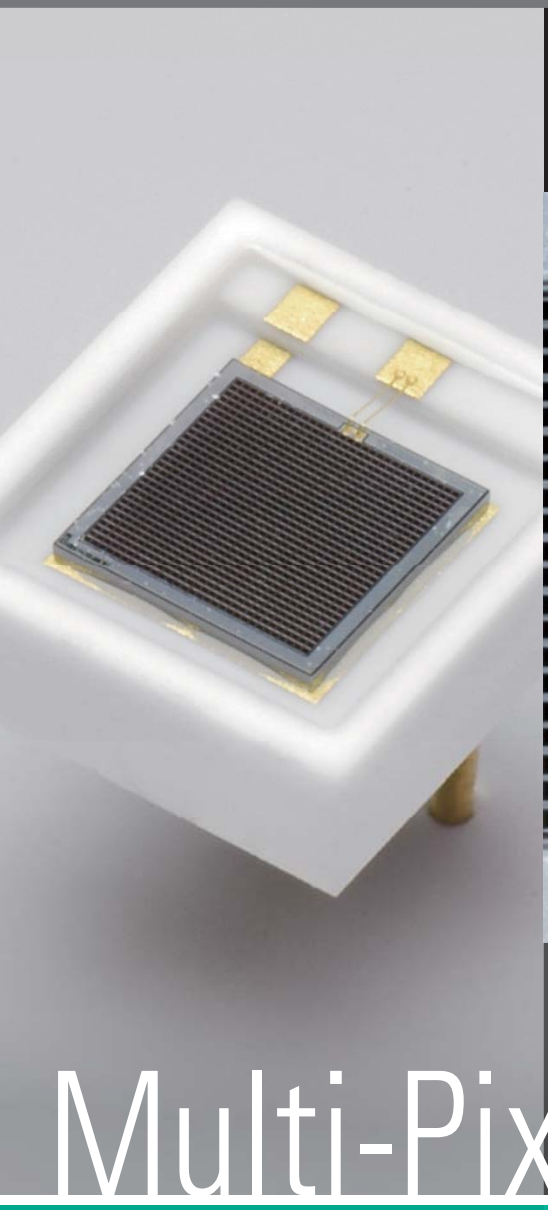
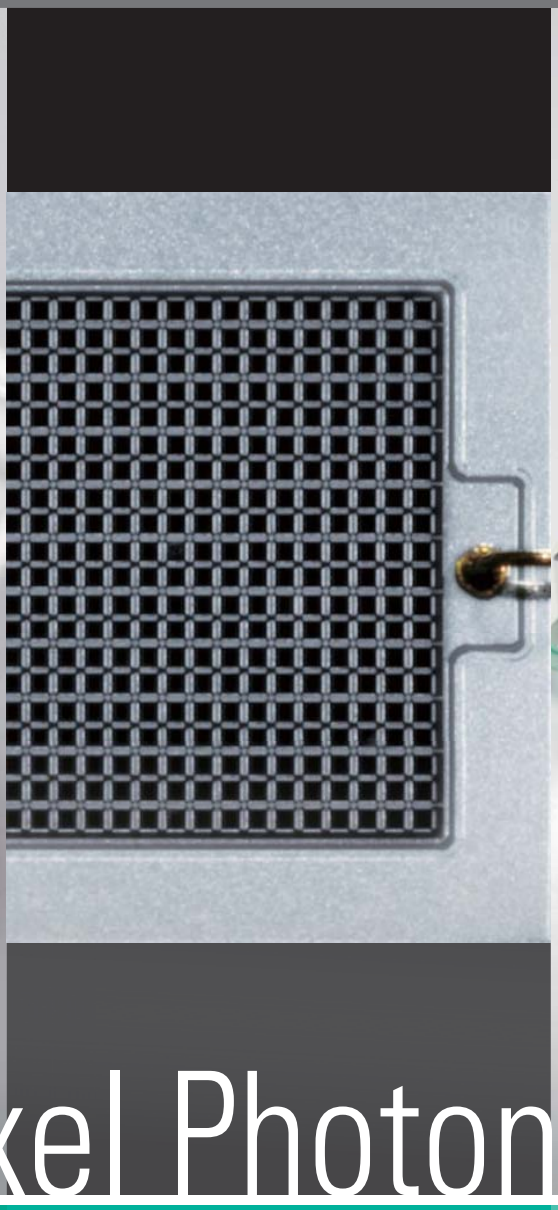
Selection guide - July 2013

MPPC®
MPPC Modules

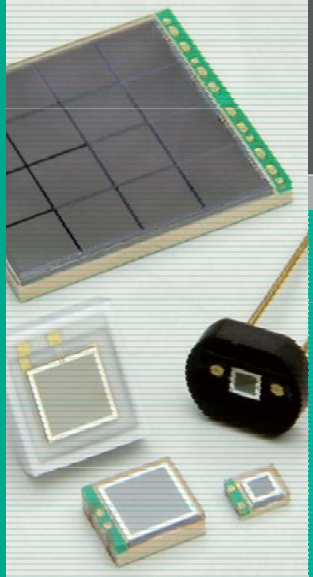
Compact opto-semiconductors with excellent photon-counting capability

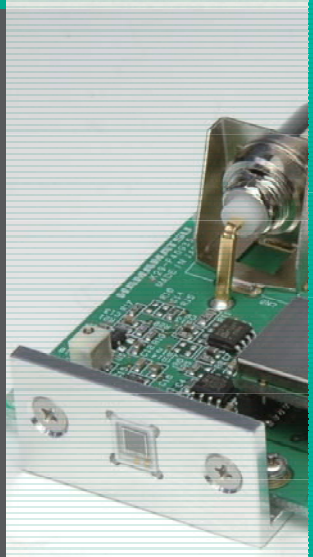




Multi-Pixel Photon Counter

HAMAMATSU PHOTONICS K.K.





Multi-Pixel Photon Counter

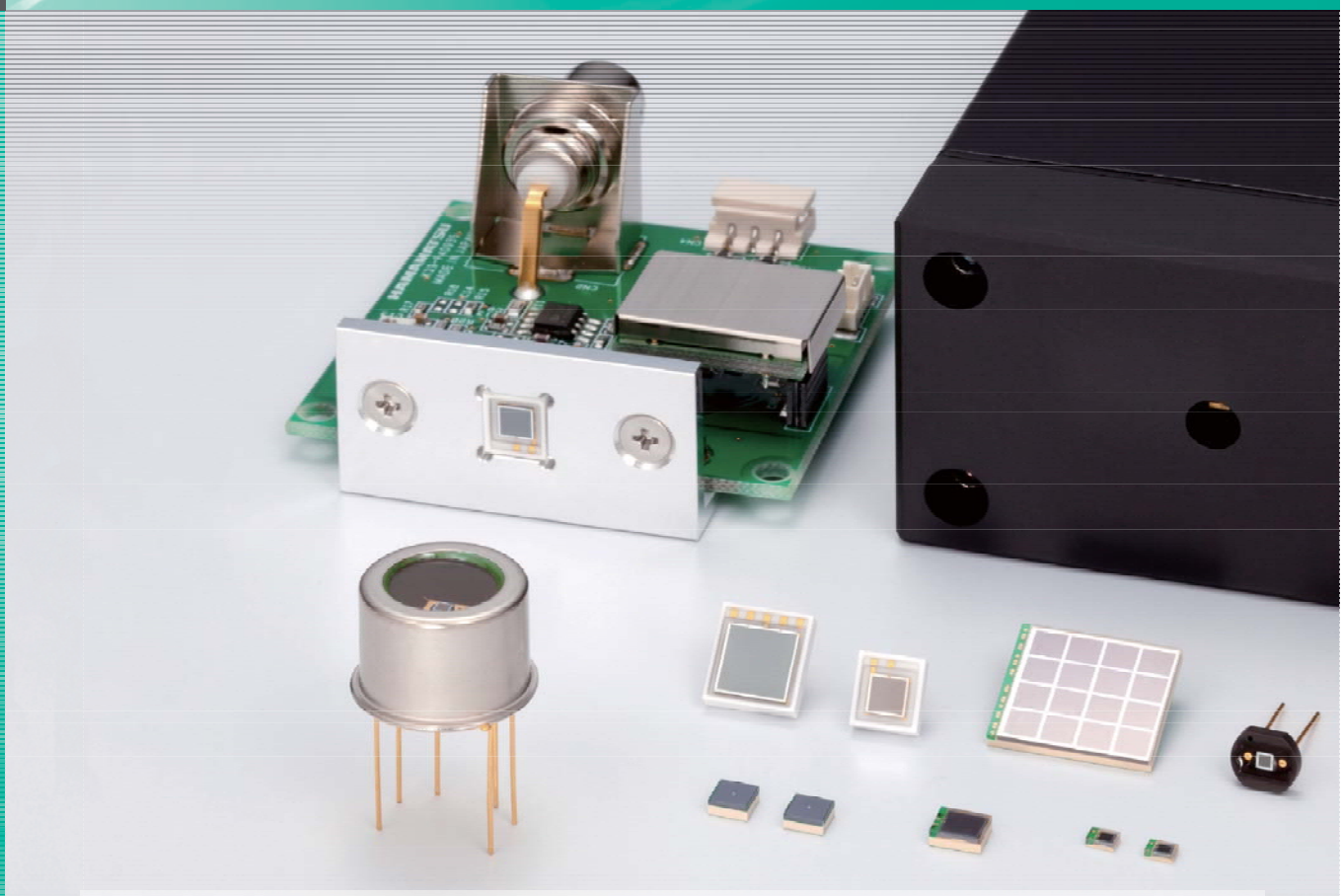
MPPC
MPPC Modules

New type of Si photon-counting device

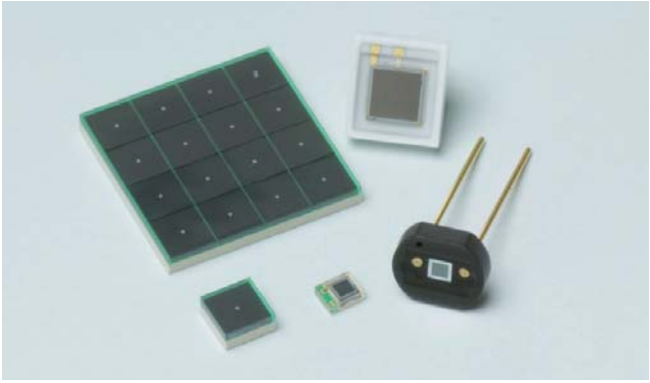
The MPPC (multi-pixel photon counter) is a new type of photon-counting device made up of multiple APD (avalanche photodiode) pixels operated in Geiger mode. The MPPC is essentially an opto-semiconductor device with excellent photon-counting capability and which also possesses great advantages such as low voltage operation and insensitivity to magnetic fields.

Features
- Excellent photon-counting capability (excellent detection efficiency versus number of incident photons)
- Small size
- Room temperature operation
- Low bias (below 80 V) operation
- High gain: 10^5 to 10^6
- Excellent time resolution
- Insensitive to magnetic fields
- Simple readout circuit operation
- MPPC module available

Contents



The MPPC is a kind of so-called Si-PM (silicon photomultiplier) device. It is a photon-counting device consisting of multiple APD pixels operating in Geiger mode. Each APD pixel of the MPPC outputs a pulse signal when it detects one photon. The signal output from the MPPC is the total sum of the outputs from all APD pixels. The MPPC offers the high performance needed in photon counting and is used in diverse applications for detecting extremely weak light at the photon-counting level.



1 Operating principle

Photon counting

Light has the properties of both a particle and a wave. When the light level becomes extremely low, light behaves as discrete particles (photons) allowing us to count the number of photons. Photon counting is a technique for measuring the number of individual photons.

The MPPC is suitable for photon counting since it offers excellent time resolution and a multiplication function having high gain and low noise. Compared to ordinary light measurement techniques that measure the output current as analog signals, photon counting delivers a higher S/N and higher stability even in measurements at very low light levels.

Geiger mode and quenching

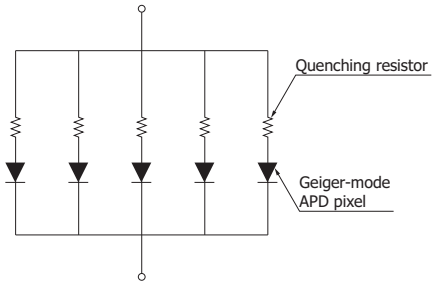
When the reverse voltage applied to an APD is set higher than the breakdown voltage, the electric field in the APD becomes high enough to cause a discharge (Geiger discharge) even by input of very weak light. The condition where an APD operates at this voltage level is called Geiger mode. Geiger mode allows obtaining a large output by way of the discharge even when detecting a single photon. Once Geiger discharge begins, it continues for as long as the electric field in the APD is maintained.

To halt a Geiger discharge and detect the next photon, an external circuit outside the APD must lower the operating voltage. One specific example for halting Geiger discharge is a technique using a so-called quenching resistor connected in series with the APD. This quickly stops avalanche multiplication in the APD because a drop in the operating voltage occurs when the output current caused by the Geiger discharge flows in the quenching resistor. The output current caused by Geiger discharge is a pulse waveform with a sharp rise time, while the output current when Geiger discharge is halted by the quenching resistor is a pulse waveform with a relatively slow fall time.

Structure

Figure 1 shows a structure of an MPPC. The basic element (pixel) of an MPPC is a combination of Geiger mode APD and quenching resistor, and a large number of these pixels are electrically connected and arranged in two dimensions.

[Figure 1] Structure



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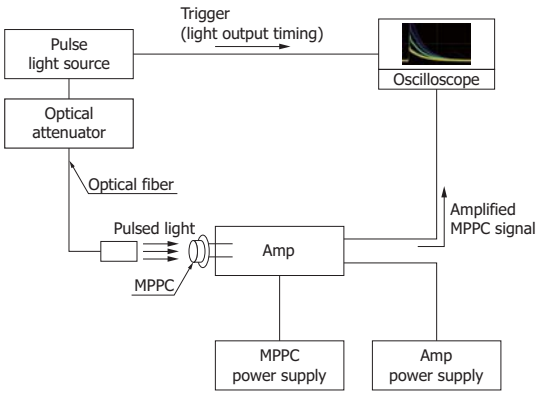
[Figure 2] Block diagram for MPPC evaluation (with an oscilloscope)



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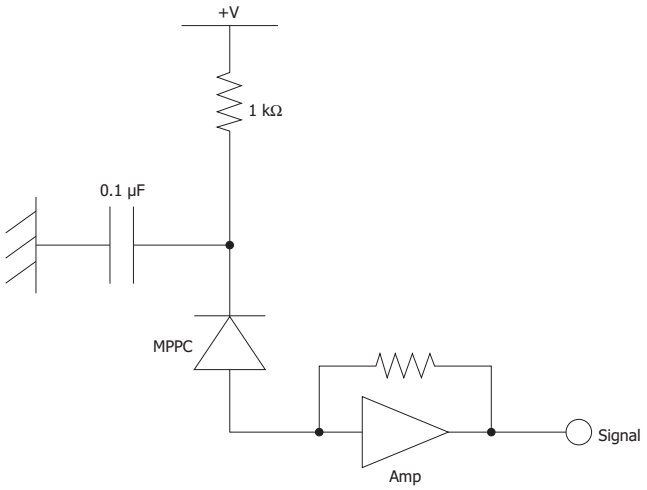
[Figure 3] Basic connection diagram for MPPC



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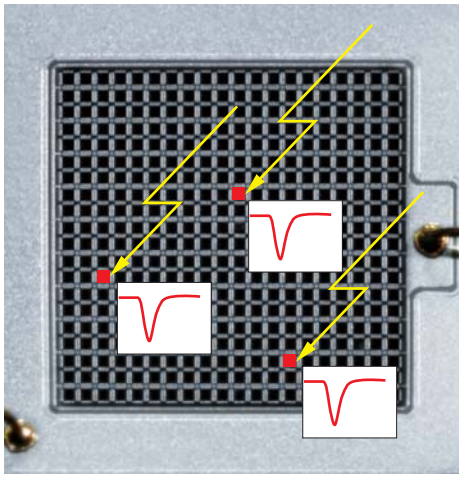
[Figure 4] Image of MPPC's photon counting



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Basic operation

Each pixel in the MPPC outputs a pulse at the same amplitude when it detects a photon. Pulses generated by multiple pixels are output while superimposed onto each other. For example, if four photons are incident on different pixels and detected at the same time, then the MPPC outputs a signal whose amplitude equals the height of the four superimposed pulses.

Each pixel outputs only one pulse and this does not vary with the number of incident photons. So the number of output pulses is always one regardless of whether one photon or two or more photons enter a pixel at the same time. This means that MPPC output linearity gets worse as more photons are incident on the MPPC such as when two or more photons enter one pixel. This makes it essential to select an MPPC having enough pixels to match the number of incident photons.

The following two methods are used to estimate the number of photons detected by the MPPC.

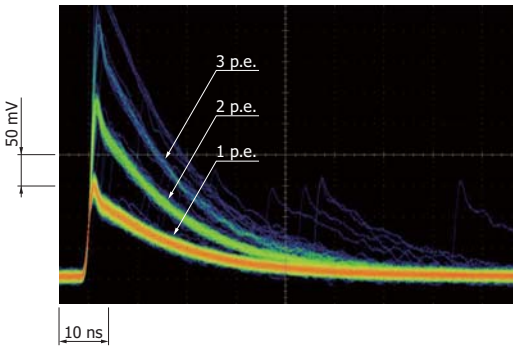
(1) Observing the pulse

(2) Integrating the output charge

(1) Observing the pulse

When light enters an MPPC at a particular timing, its output pulse height varies depending on the number of photons detected. Figure 5 shows output pulses from the MPPC obtained when it was illuminated with pulsed light at photon counting levels and then amplified with a linear amplifier and observed on an oscilloscope. As can be seen from the figure, the pulses are separate from each other according to the number of detected photons such as one, two, three photons and so on. Measuring the height of each pulse allows estimating the number of detected photons.

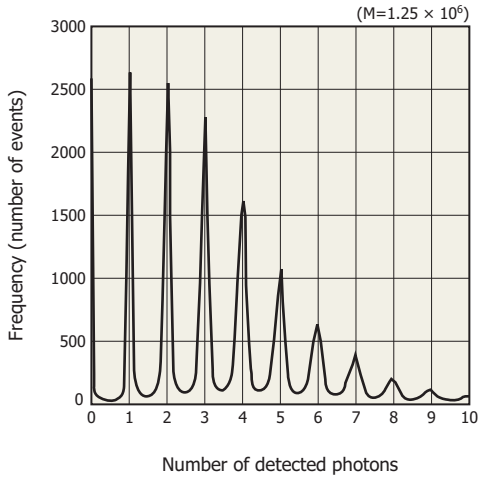
[Figure 5] Pulse waveforms (S12571-050C, M=1.25 × 10^6) when using linear amplifier (120 times)



(2) Integrating the output charge

When the timing at which light enters an MPPC is different, the number of photons detected within a certain time period can be estimated by integrating the MPPC output using an integrating amplifier or similar device. Figure 6 shows the distribution plotted for the amount of charge accumulated in the integration time. Each peak from the left corresponds to the pedestal, one photon, two photons, three photons and so on. Since the MPPC gain is high enough to produce a large amount of charge, the distribution can show discrete peaks according to the number of detected photons.

[Figure 6] Pulse height spectrum when using charge amplifier (S12571-050C, M=1.25 × 10^6)



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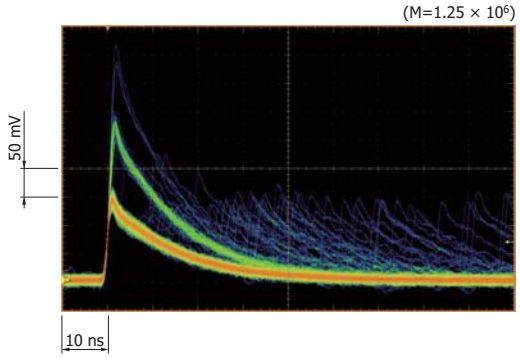
2 Features

Low afterpulse

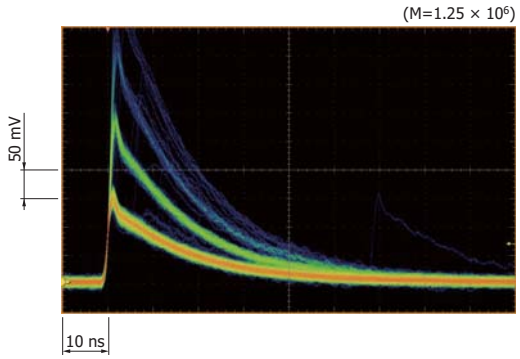
When an MPPC detects photons, the output may contain spurious signals appearing with a time delay from the light input to the MPPC. These signals are called afterpulses. Compared to our previously marketed products, all MPPCs listed in this catalog have drastically reduced afterpulses due to use of improved materials and wafer process technologies. Reducing afterpulses brings various benefits such as a better S/N, a wider operating voltage range, and improved time resolution and photon detection efficiency in high voltage regions.

[Figure 7] Pulse waveforms

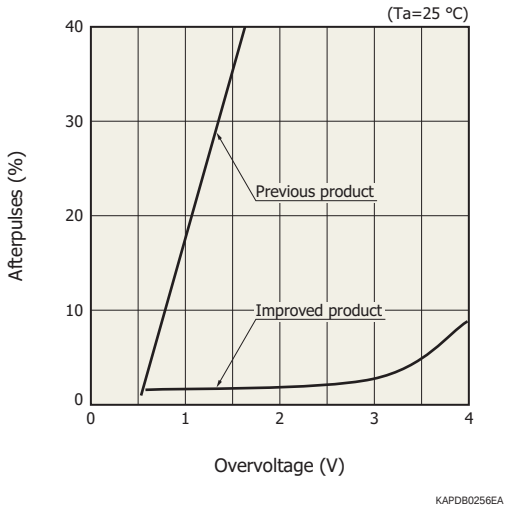
S10362-11-050C (previous product)



S12571-050C (improved product)



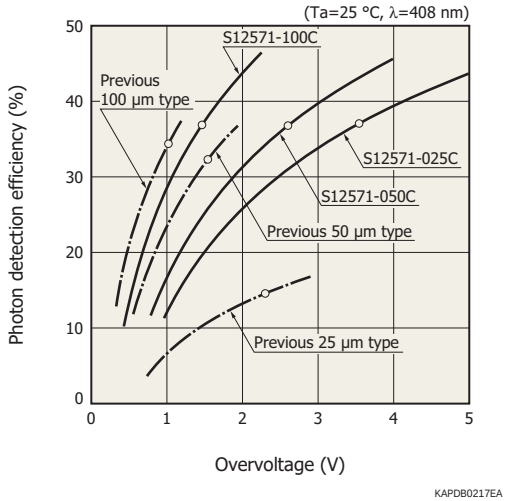
[Figure 8] Afterpulses vs. overvoltage (typical example)



High photon detection efficiency

MPPC has peak sensitivity at a wavelength around 400 to 500 nm. MPPC sensitivity is referred to as photon detection efficiency (PDE) and is calculated by the product of the quantum efficiency, fill factor, and avalanche probability. Among these, the avalanche probability is dependent on the operating voltage. Our 25 µm pitch MPPC is designed for a high fill factor that vastly improves photon detection efficiency compared to our previous types. Using this same design, we also developed 10 µm and 25 µm pitch MPPC that delivers high-speed response and wide dynamic range as well as high photon detection efficiency. The fill factor of 50 µm and 100 µm pitch MPPC is almost the same as that of previous types because increasing the fill factor also causes a significant rise in crosstalk.

[Figure 9] Photon detection efficiency vs. overvoltage (typical example)



[Table 1] Recommended overvoltage

Pixel pitch (µm)	Recommended overvoltage Vov	
	Previous type (V)	S12571 series (V)
25	2.3	3.5
50	1.5	2.6
100	1.0	1.4

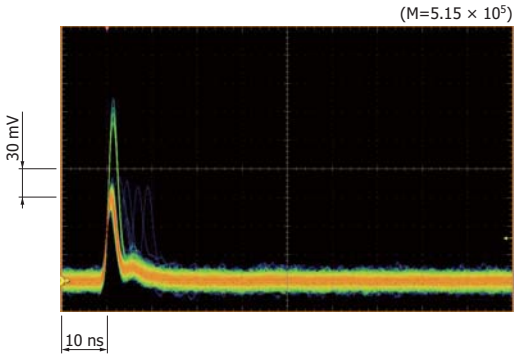
Overvoltage (Vov) = Operating voltage (Vop) – Breakdown voltage (V_{BR})
Photon detection efficiency does not include crosstalk and afterpulses.

Wide dynamic range

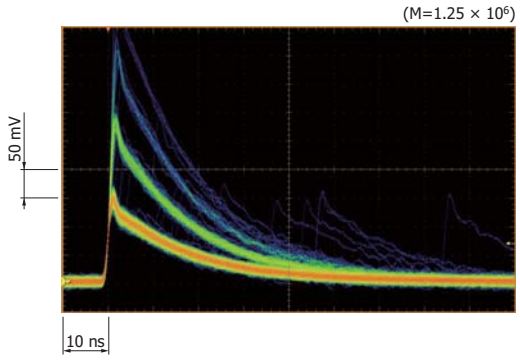
The MPPC dynamic range is determined by the number of pixels and the pixel recovery time. Hamamatsu has developed MPPC with a smallest pixel pitch of 10 µm, which increases the number of pixels per unit area and shortens the response time. This drastically extends the MPPC dynamic range.

[Figure 10] Pulse waveforms

High-speed, wide dynamic range type S12571-010C (pixel pitch: 10 µm)



General measurement type S12571-050C (pixel pitch: 50 µm)

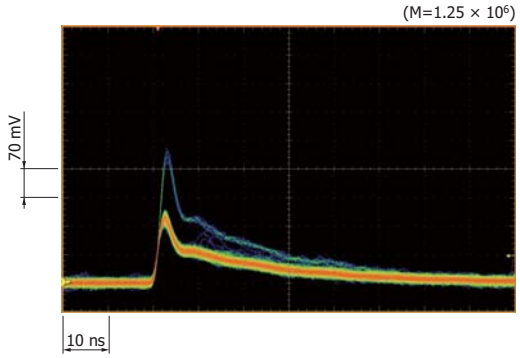


Low crosstalk

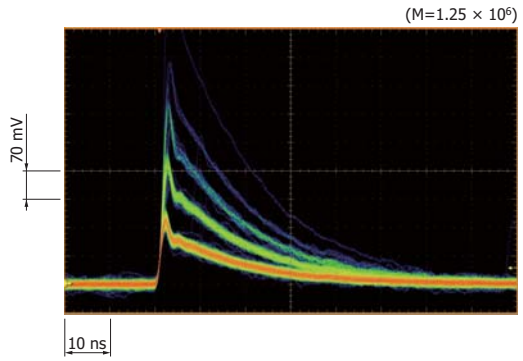
Pixels that detect photons may affect other pixels, making them produce spurious pulses. This phenomenon is called crosstalk. Hamamatsu has drastically reduced crosstalk in precision measurement MPPC by creating barriers between pixels.

[Figure 11] Pulse waveforms

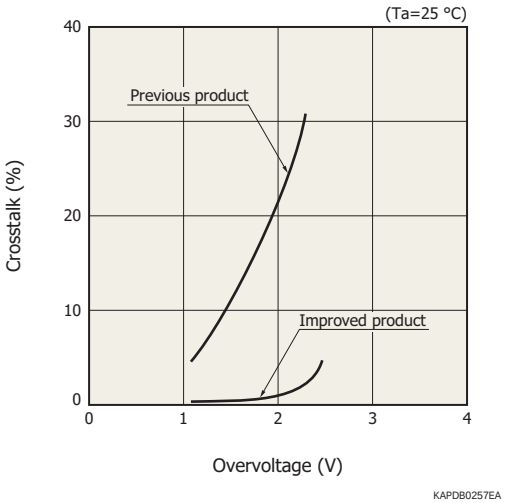
Precision measurement type S12651-050C (pixel pitch: 50 µm)



General measurement type S12571-050C (pixel pitch: 50 µm)



[Figure 12] Crosstalk vs. overvoltage (typical example)

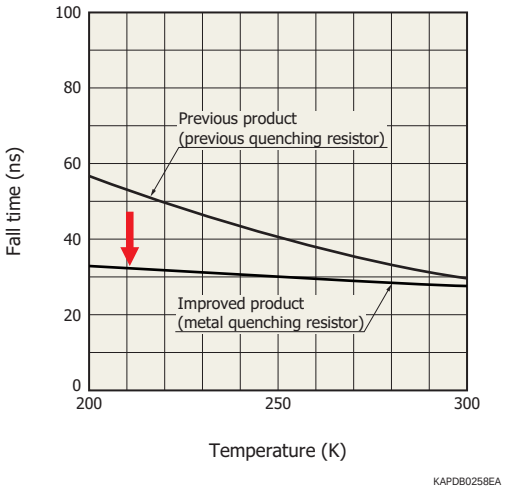


Metal quenching resistor

Using a metal quenching resistor has reduced the resistance temperature coefficient to one-fifth of the previous types. This suppresses variations in the fall time in the low temperature region and so improves the output waveforms at low temperatures.

For information on the operating temperature range, refer to the individual datasheets.

[Figure 13] Fall time vs. temperature (photosensitive area: 1 × 1 mm, pixel pitch: 50 µm, typical example)



MPPC lineup

For general measurement NEW

These MPPCs are suitable for general low-light-level measurement.

Type. no	Previous product	Photosensitive area (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	High speed, wide band-width	Low crosstalk	Cooling
S12571-025C	S10362-11-025C	1 × 1	25	Ceramic	○	○	○			
S12571-050C	S10362-11-050C		50		○	○	○			
S12571-100C	S10362-11-100C		100		○	○	○			
S12571-025P	S10362-11-025P		25	Surface mount type	○	○	○			
S12571-050P	S10362-11-050P		50		○	○	○			
S12571-100P	S10362-11-100P		100		○	○	○			
S12572-025C	S10362-33-025C	3 × 3	25	Ceramic	○	○	○			
S12572-050C	S10362-33-050C		50		○	○	○			
S12572-100C	S10362-33-100C		100		○	○	○			
S12572-025P	S10931-025P		25	Surface mount type	○	○	○			
S12572-050P	S10931-050P		50		○	○	○			
S12572-100P	S10931-100P		100		○	○	○			

High-speed, wide dynamic range NEW

This type of MPPC has a large number of pixels, making it suitable for applications where background light may cause saturation.

Type. no	Previous product	Photosensitive area (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	High speed, wide band-width	Low crosstalk	Cooling
S12571-010C	-	1 × 1	10	Ceramic	○	○	○	○		
S12571-015C	-		15		○	○	○	○		
S12571-010P	-		10	Surface mount type	○	○	○	○		
S12571-015P	-		15		○	○	○	○		
S12572-010C	-	3 × 3	10	Ceramic	○	○	○	○		
S12572-015C	-		15		○	○	○	○		
S12572-010P	-		10	Surface mount type	○	○	○	○		
S12572-015P	-		15		○	○	○	○		

For very low light level measurement NEW

These MPPCs allow accurate measurements with lower dark count by cooling.

Type. no	Previous product	Photosensitive area (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	High speed, wide band-width	Low crosstalk	Cooling
S12576-050	S11028-050	1 × 1	50	Metal (Two-stage TE-cooled)	○	○	○			○
S12577-050	-	3 × 3			○	○	○			○

For precision measurement Preliminary

This type of MPPC has low crosstalk and decreases counting errors during measurement at low count rates.

Type. no	Previous product	Photosensitive area (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	High speed, wide band-width	Low crosstalk	Cooling
S12651-050C	S10362-11-050C	1 × 1	50	Ceramic	○	○			○	
S12651-100C	S10362-11-100C		100		○	○			○	
S12652-050C	S10362-33-050C	3 × 3	50		○	○			○	
S12652-100C	S10362-33-100C		100		○	○			○	
S12671-050	S11028-050	1 × 1	50	Metal (Two-stage TE-cooled)	○	○			○	○
S12671-100	S11028-100		100		○	○			○	○
S12672-050	-	3 × 3	50		○	○			○	○
S12672-100	-		100		○	○			○	○

Buttable type (semi-custom made) Preliminary

These MPPCs employ a structure that reduced insensitive portions formed along the periphery of the photosensitive area. The 4-side buttable structure allows them to be arrayed in two dimensions at equal intervals.

Type. no	Previous product	Photosensitive area per 1 ch (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	Low crosstalk	3-side buttable	4-side buttable
S12641-050	S10931-050P	3 × 3	50	TSV, Surface mount type	○	○	○			○
S12642-050	S11064-050P	3 × 3 (4 × 4 ch array)			○	○	○			○

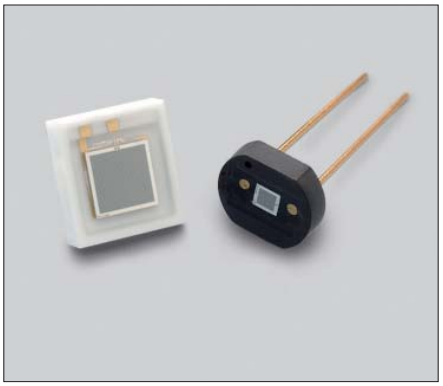
Large area arrays Preliminary

These are monolithic arrays comprised of multiple 3 × 3 mm MPPCs formed on a single chip.

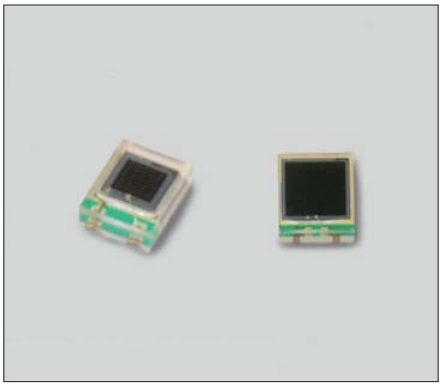
Type. no	Previous product	Photosensitive area per 1 ch (mm)	Pixel pitch (μm)	Package	Low dark count	Low afterpulse	High photon detection efficiency	Low crosstalk	3-side buttable	4-side buttable
S12657-050	S11827-3344MG	3 × 3 (4 × 4 ch array)	50	Wire bonding, PWB	○	○	○			
S12658-050	S11828-3344M			Wire bonding, surface mount type	○	○	○		○	
S12659-050	S11829-3344MF			Wire bonding, surface mount type with FPC	○	○	○		○	
S12660-050	S11830-3344MF				○	○	○		○	
S12573-025C	S10985-025C	3 × 3 (2 × 2 ch array)	25	Ceramic	○	○	○			
S12573-050C	S10985-050C		50		○	○	○			
S12573-100C	S10985-100C		100		○	○	○			

MPPC packages

Ceramic

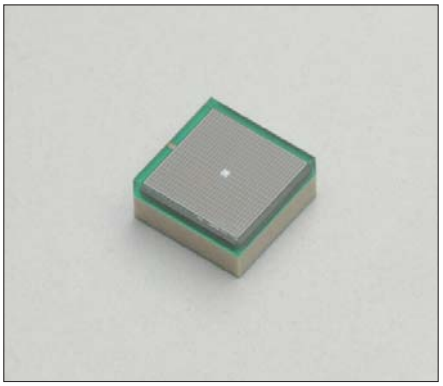


Surface mount type

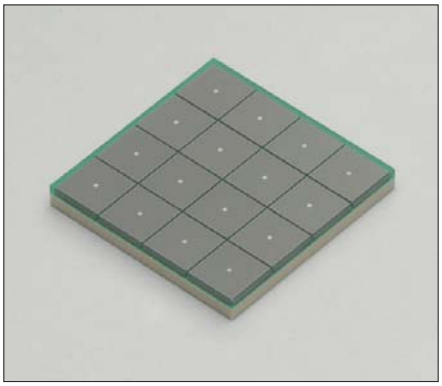


Metal (TE-cooled)

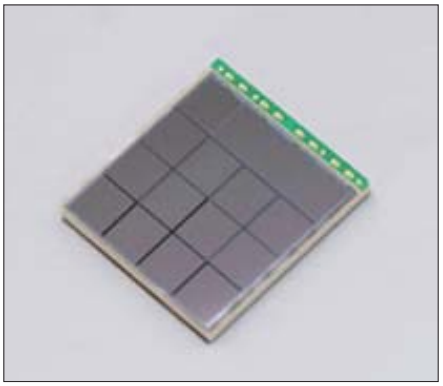
4-side buttable type



4-side buttable type (16 ch array)



3-side buttable type (16 ch array)

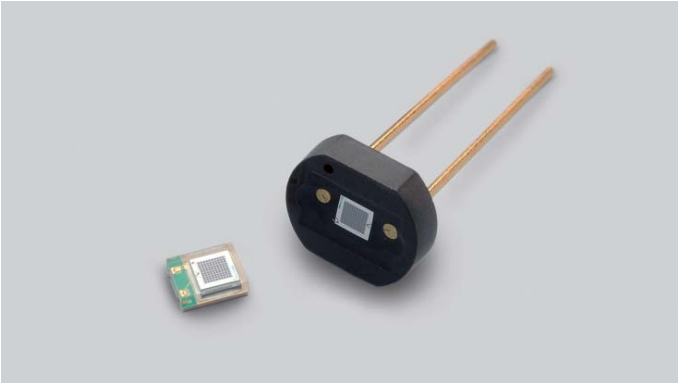


MPPC for general measurement

S12571-025, -050, -100C/P

The S12571 series are general-purpose MPPC with drastically reduced afterpulses compared to our previously marketed products. By widening the operating voltage range and improving the time resolution and photon detection efficiency, the S12571 series offer the characteristics needed for a variety of applications. These MPPCs have a photosensitive area of 1 × 1 mm and are available in a ceramic package or surface mount type.

· MPPC modules: C11205-150/-350 (analog output type)



The following characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

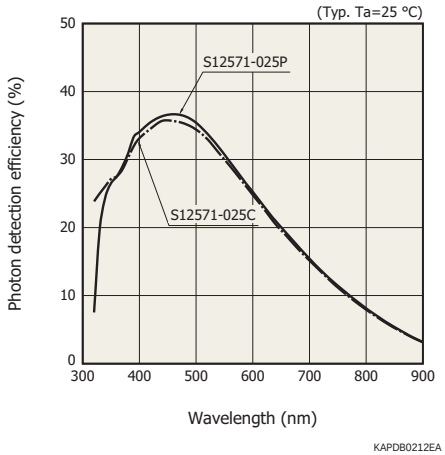
(Typ. Ta=25 °C, unless otherwise noted)

Parameter		Symbol	S12571			Unit
			-025C, -025P	-050C, -050P	-100C, -100P	
Effective photosensitive area		-	1 × 1			mm
Pixel pitch		-	25	50	100	μm
Number of pixels		-	1600	400	100	-
Spectral response range		λ	320 to 900			nm
Peak sensitivity wavelength		λp	450			nm
Photon detection efficiency (λ=λp)*1		PDE	35			%
Breakdown voltage		VBR	65 ± 10			V
Operating voltage		Vop	VBR + 3.5	VBR + 2.6	VBR + 1.4	V
Dark count*2	Typ.	-	100			kcps
	Max.		200			
Terminal capacitance		Ct	35			pF
Time resolution (FWHM)*3		-	250	250	300	ps
Temperature coefficient of operating voltage		-	60			mV/°C
Gain		M	5.15×10^5	1.25×10^6	2.8×10^6	-
Temperature coefficient of gain		-	8.2×10^3	2.7×10^4	1.2×10^5	/°C

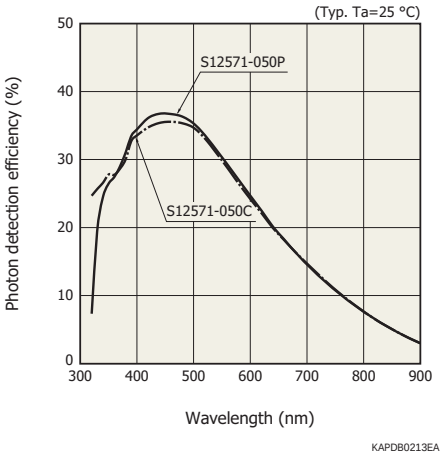
*1: Photon detection efficiency does not include crosstalk and afterpulses.
*2: Threshold=0.5 p.e.
*3: Single photon level
Note: The last letter of each type number indicates the package type (C: ceramic, P: surface mount type).

Photon detection efficiency vs. wavelength

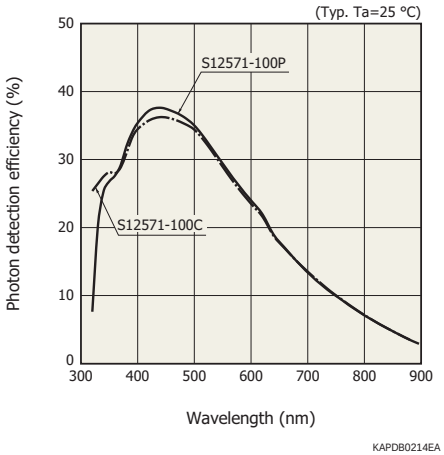
S12571-025C/P (Vop=VBR + 3.5 V)



S12571-050C/P (Vop=VBR + 2.6 V)

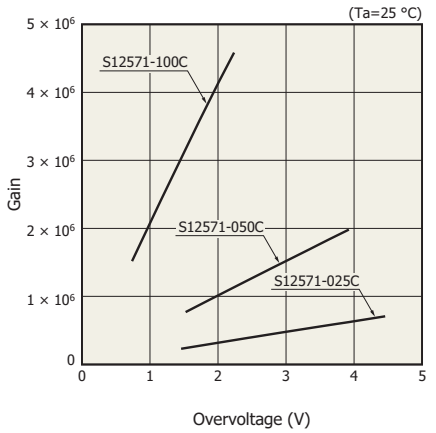


S12571-100C/P (Vop=VBR + 1.4 V)



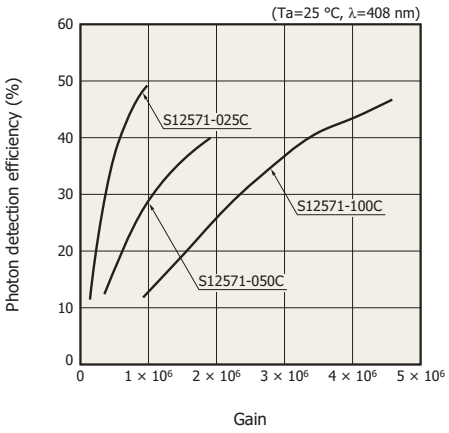
Photon detection efficiency does not include crosstalk and afterpulses.

Gain vs. overvoltage (typical example)



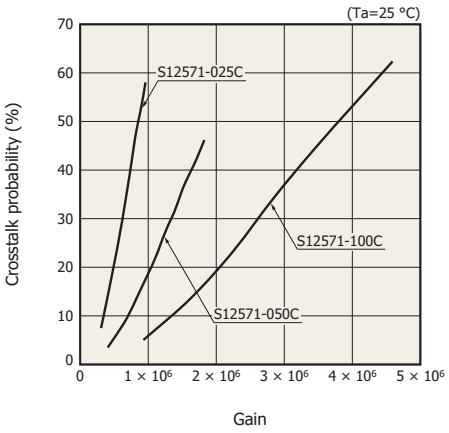
KAPDB0241EA

Photon detection efficiency vs. gain (typical example)



KAPDB0242EA

Crosstalk probability vs. gain (typical example)

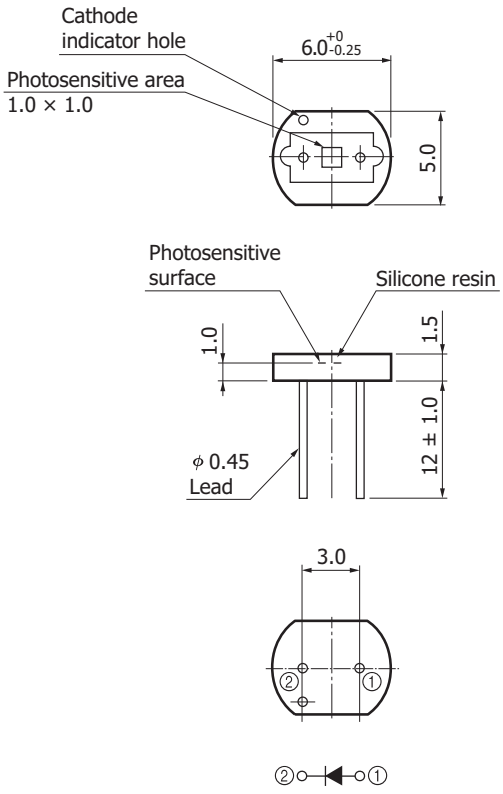


KAPDB0243EA

MPPC characteristics vary with the operating voltage. The 25 µm pixel pitch type is suitable for applications requiring a wide dynamic range, because it has a large number of pixels and provides narrow-width output pulses. The 100 µm pixel pitch type is suitable for applications where high gain is essential. Although increasing the operating voltage improves the photon detection efficiency and time resolution, it also increases the dark count and crosstalk at the same time, so an optimum operating voltage must be selected to match the application.

Dimensional outlines (unit: mm)

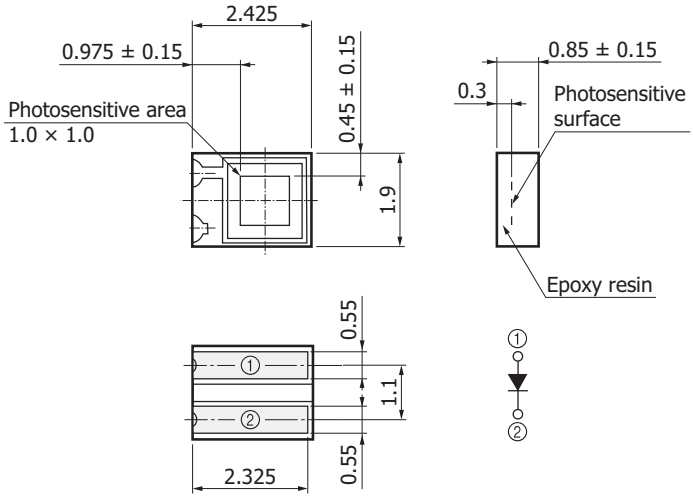
S12571-025C/-050C/-100C



Tolerance unless otherwise noted: ±0.2

KAPDA0141EA

S12571-025P/-050P/-100P



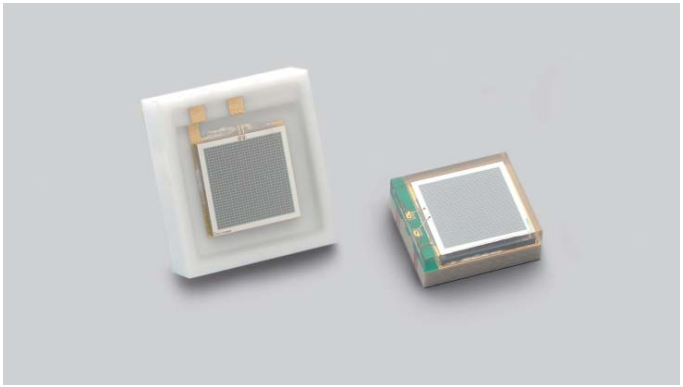
Tolerance unless otherwise noted: ±0.1

KAPDA0142EA

S12572-025, -050, -100C/P

The S12572 series are general-purpose MPPC with drastically reduced afterpulses compared to our previously marketed products. By widening the operating voltage range and improving the time resolution and photon detection efficiency, the S12572 series offer the characteristics needed for a variety of applications. These MPPCs have a photosensitive area of 3 × 3 mm and are available in a ceramic package or surface mount type.

· MPPC modules: C11205-150/-350 (analog output type)



The following characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

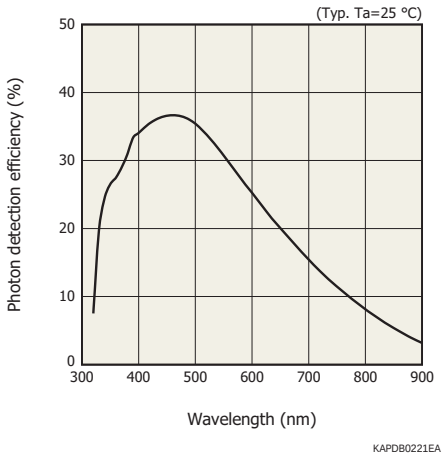
(Typ. Ta=25 °C, unless otherwise noted)

Parameter		Symbol	S12572			Unit
			-025C, -025P	-050C, -050P	-100C, -100P	
Effective photosensitive area		-	3 × 3			mm
Pixel pitch		-	25	50	100	μm
Number of pixels		-	14400	3600	900	-
Spectral response range		λ	320 to 900			nm
Peak sensitivity wavelength		λp	450			nm
Photon detection efficiency (λ=λp)*1		PDE	35			%
Breakdown voltage		V_{BR}	65 ± 10			V
Operating voltage		Vop	V_{BR} + 3.5	V_{BR} + 2.6	V_{BR} + 1.4	V
Dark count*2	Typ.	-	1000			kcps
	Max.		2000			
Terminal capacitance		Ct	320			pF
Time resolution (FWHM)*3		-	300	300	400	ps
Temperature coefficient of operating voltage		-	60			mV/°C
Gain		M	5.15 × 10^5	1.25 × 10^6	2.8 × 10^6	-
Temperature coefficient of gain		-	8.2 × 10^3	2.7 × 10^4	1.2 × 10^5	/°C

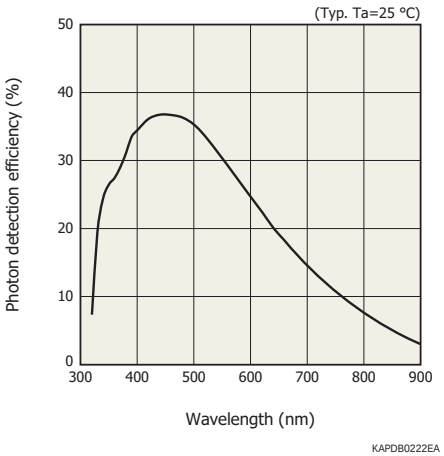
*1: Photon detection efficiency does not include crosstalk and afterpulses.
*2: Threshold=0.5 p.e.
*3: Single photon level
Note: The last letter of each type number indicates the package type (C: ceramic, P: surface mount type).

Photon detection efficiency vs. wavelength

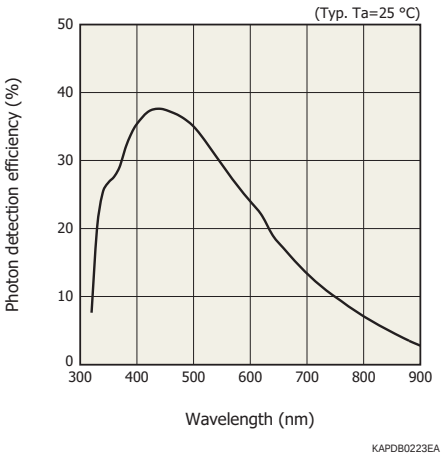
S12572-025C/P (Vop=V_{BR} + 3.5 V)



S12572-050C/P (Vop=V_{BR} + 2.6 V)

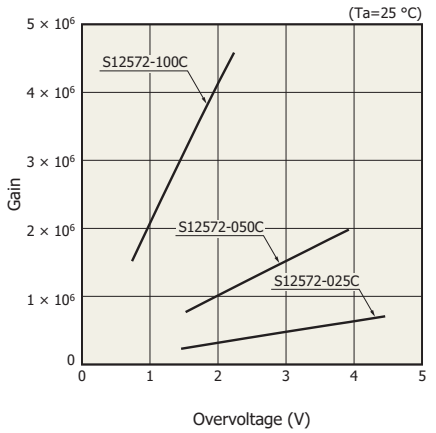


S12572-100C/P (Vop=V_{BR} + 1.4 V)



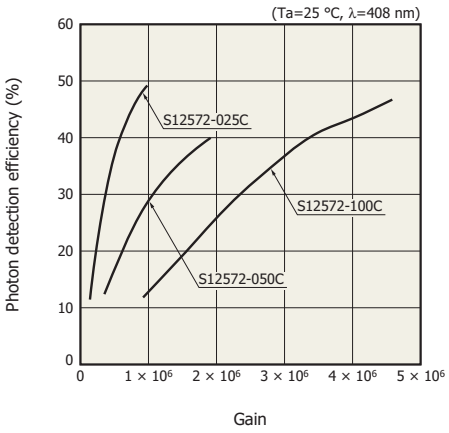
Photon detection efficiency does not include crosstalk and afterpulses.

Gain vs. overvoltage (typical example)



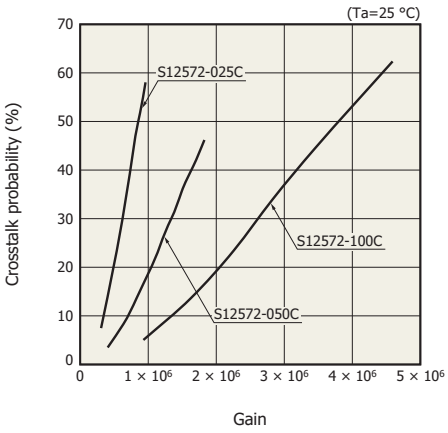
KAPDB0250EA

Photon detection efficiency vs. gain (typical example)



KAPDB0251EA

Crosstalk probability vs. gain (typical example)

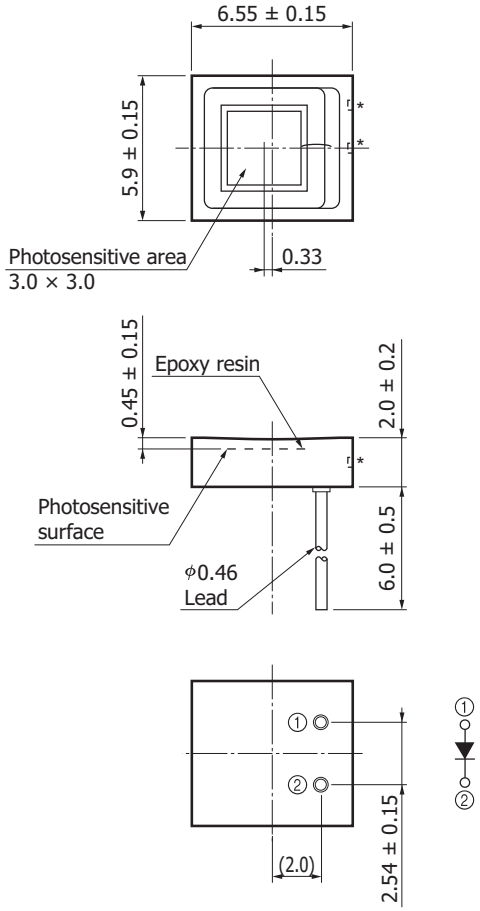


KAPDB0252EA

MPPC characteristics vary with the operating voltage. The 25 µm pixel pitch type is suitable for applications requiring a wide dynamic range, because it has a large number of pixels and provides narrow-width output pulses. The 100 µm pixel pitch type is suitable for applications where high gain is essential. Although increasing the operating voltage improves the photon detection efficiency and time resolution, it also increases the dark count and crosstalk at the same time, so an optimum operating voltage must be selected to match the application.

Dimensional outlines (unit: mm)

S12572-025C/-050C/-100C

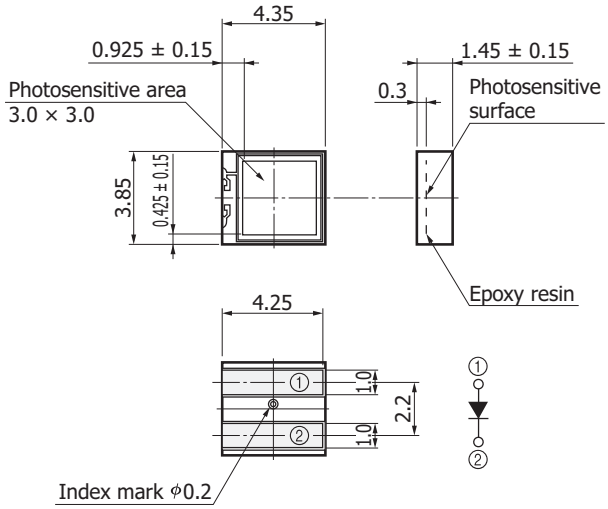


Tolerance unless otherwise noted: ±0.2

* Metal electrodes connecting to the internal electrodes are exposed on the sides of the ceramic package. To avoid short circuits, never allow other conductors to come in contact with these metal electrodes.

KAPDA0143EB

S12572-025P/-050P/-100P



Tolerance unless otherwise noted: ±0.1

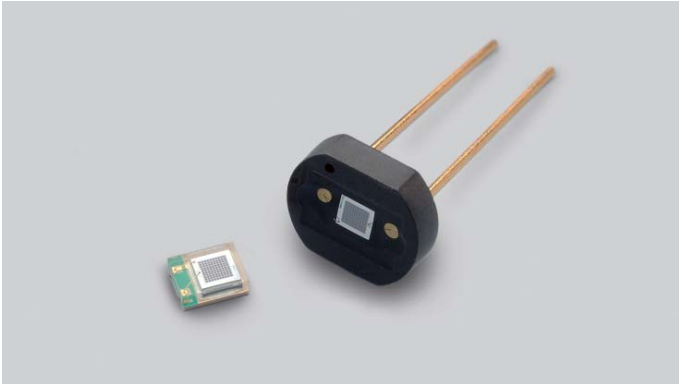
KAPDA0144EA

High-speed, wide dynamic range MPPC

S12571-010, -015C/P

These MPPCs utilize very small pixels arrayed at high densities to achieve a high-speed recovery time and wide dynamic range. Hamamatsu currently produces MPPC with a pixel density up to 10000 pixels/mm^2 (pixel pitch: 10 µm). Utilizing advanced technology to enhance photon detection efficiency minimizes the drop in photon detection efficiency that usually occurs due to shrinking the pixel pitch.

· MPPC module: C11209-110 (analog output type)



The following characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

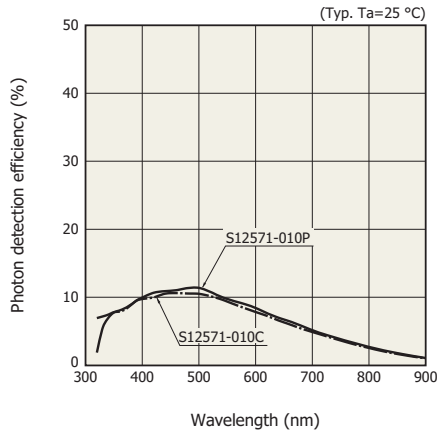
(Typ. Ta=25 °C, unless otherwise noted)

Parameter		Symbol	S12571		Unit
			-010C, -010P	-015C, -015P	
Effective photosensitive area		-	1 × 1		mm
Pixel pitch		-	10	15	µm
Number of pixels		-	10000	4489	-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	470	460	nm
Photon detection efficiency (λ=λp)*1		PDE	10	25	%
Breakdown voltage		VBR	65 ± 10		V
Operating voltage		Vop	VBR + 4.5	VBR + 4.0	V
Dark count*2	Typ.	-	100		kcps
	Max.		200		
Terminal capacitance		Ct	35		pF
Time resolution (FWHM)*3		-	300	250	ps
Temperature coefficient of operating voltage		-	60		mV/°C
Gain		M	1.35 × 10^5	2.3 × 10^5	-
Temperature coefficient of gain		-	1.6 × 10^3	3.5 × 10^3	/°C

*1: Photon detection efficiency does not include crosstalk and afterpulses.
*2: Threshold=0.5 p.e.
*3: Single photon level
Note: The last letter of each type number indicates the package type (C: ceramic, P: surface mount type).

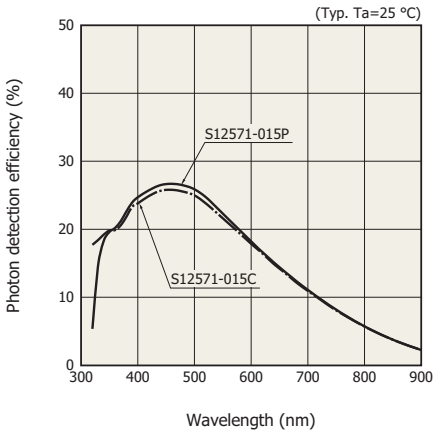
Photon detection efficiency vs. wavelength

S12571-010C/P (Vop=VBR + 4.5 V)



KAPDB0215EA

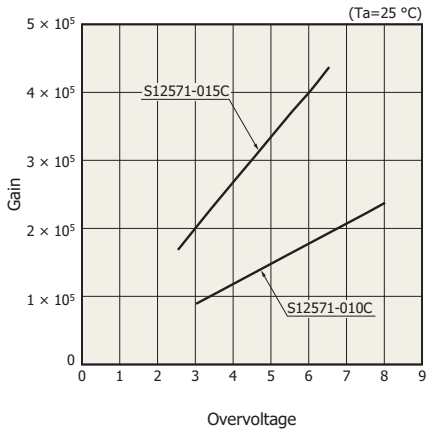
S12571-015C/P (Vop=VBR + 4.0 V)



KAPDB0216EA

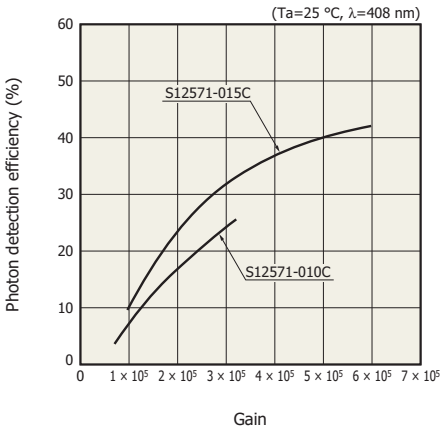
Photon detection efficiency does not include crosstalk and afterpulses.

Gain vs. overvoltage (typical example)



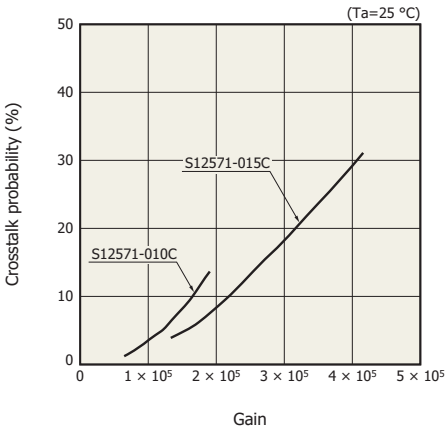
KAPDB0244EA

Photon detection efficiency vs. gain (typical example)



KAPDB0245EA

Crosstalk probability vs. gain (typical example)

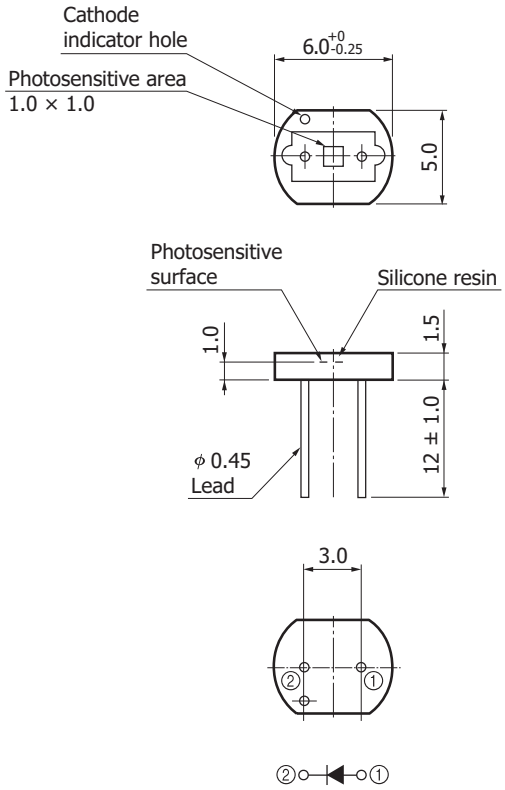


KAPDB0246EA

Because the high-speed, wide dynamic range MPPC has a small pixel capacitance, the gain is smaller than the MPPC for general measurement. The gain and photon detection efficiency are increased by applying the higher operating voltage. Please use it with the appropriate operating voltage because the crosstalk increases at the same time.

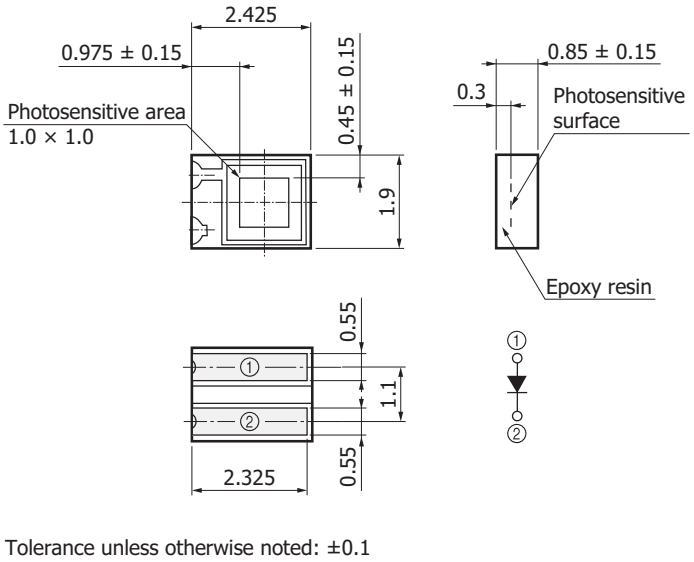
Dimensional outlines (unit: mm)

S12571-010C/-015C



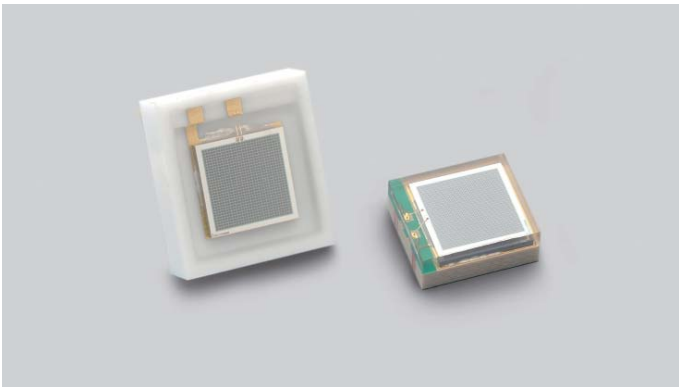
KAPDA0141EA

S12571-010P/-015P



KAPDA0142EA

S12572-010, -015C/P



These MPPCs utilize very small pixels arrayed at high densities to achieve a high-speed recovery time and wide dynamic range. Hamamatsu currently produces MPPC with a pixel density up to 10000 pixels/mm^2 (pixel pitch: 10 µm). Utilizing advanced technology to enhance photon detection efficiency minimizes the drop in photon detection efficiency that usually occurs due to shrinking the pixel pitch.

· MPPC module: C11209-110 (analog output type)

The following characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

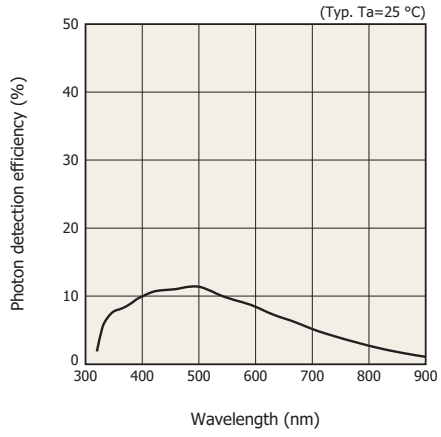
(Typ. Ta=25 °C, unless otherwise noted)

Parameter		Symbol	S12572		Unit
			-010C, -010P	-015C, -015P	
Effective photosensitive area		-	3 × 3		mm
Pixel pitch		-	10	15	µm
Number of pixels		-	90000	40000	-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	470	460	nm
Photon detection efficiency (λ=λp)*1		PDE	10	25	%
Breakdown voltage		VBR	65 ± 10		V
Operating voltage		Vop	VBR + 4.5	VBR + 4.0	V
Dark count*2	Typ.	-	1000		kcps
	Max.		2000		
Terminal capacitance		Ct	320		pF
Time resolution (FWHM)*3		-	500	400	ps
Temperature coefficient of operating voltage		-	60		mV/°C
Gain		M	1.35 × 10^5	2.3 × 10^5	-
Temperature coefficient of gain		-	1.6 × 10^3	3.5 × 10^3	/°C

*1: Photon detection efficiency does not include crosstalk and afterpulses.
*2: Threshold=0.5 p.e.
*3: Single photon level
Note: The last letter of each type number indicates the package type (C: ceramic, P: surface mount type).

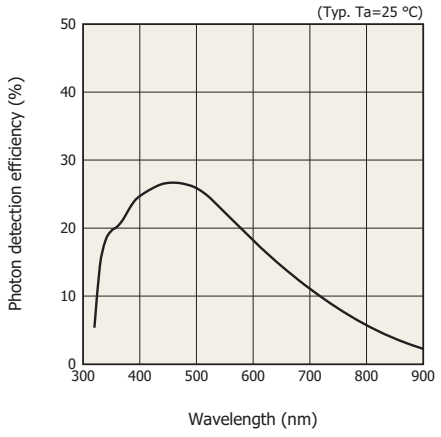
Photon detection efficiency vs. wavelength

S12572-010C/P (Vop=VBR + 4.5 V)



KAPDB0224EA

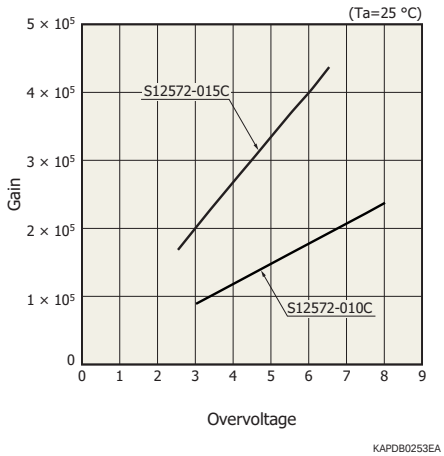
S12572-015C/P (Vop=VBR + 4.0 V)



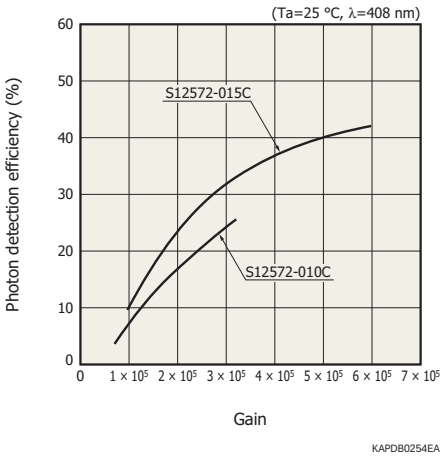
KAPDB0225EA

Photon detection efficiency does not include crosstalk and afterpulses.

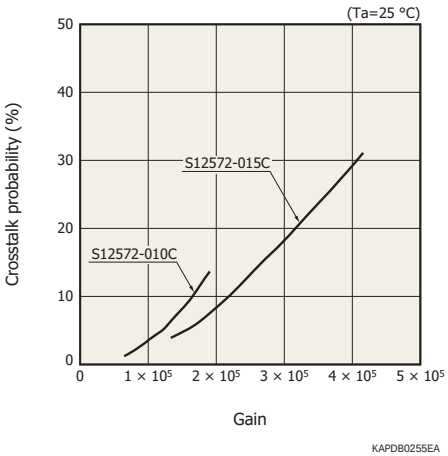
Gain vs. overvoltage (typical example)



Photon detection efficiency vs. gain (typical example)



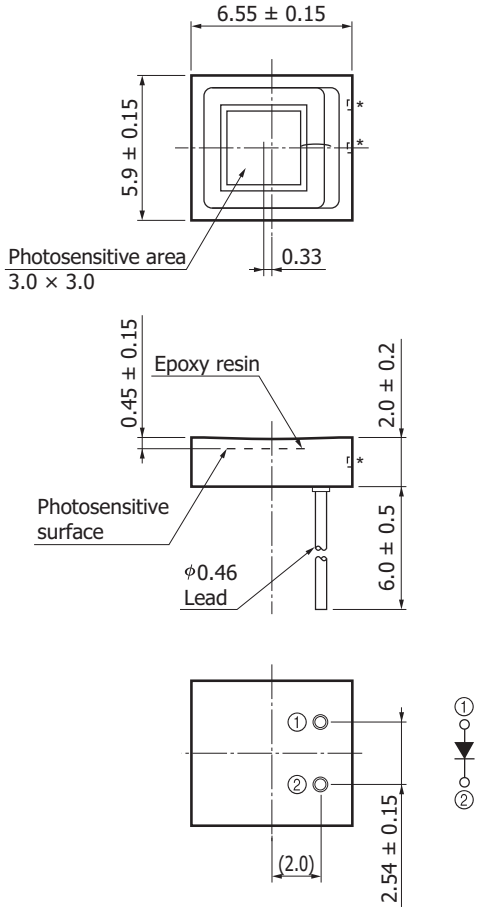
Crosstalk probability vs. gain (typical example)



Because the high-speed, and wide dynamic range MPPC has a small pixel capacitance, the gain is smaller than the MPPC for general measurement. The gain and photon detection efficiency are increased by applying the higher operating voltage. Please use it with the appropriate operating voltage because the crosstalk increases at the same time.

Dimensional outlines (unit: mm)

S12572-010C/-015C

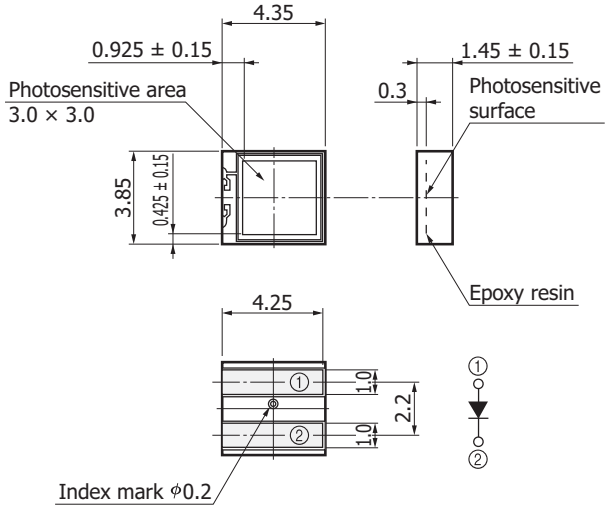


Tolerance unless otherwise noted: ±0.2

* Metal electrodes connecting to the internal electrodes are exposed on the sides of the ceramic package. To avoid short circuits, never allow other conductors to come in contact with these metal electrodes.

KAPDA0143EB

S12572-010P/-015P



Tolerance unless otherwise noted: ±0.1

KAPDA0144EA

MPPC for very low light level measurement

S12576-050, S12577-050

The S12576-050 and S12577-050 are MPPC devices that contain a thermo-electric cooler to avoid the drop in S/N caused by the dark count. The dark count decreases by half for every approx. 8 °C drop in element temperature.

· MPPC modules
C11208-150/-350 (analog/digital output type)
C12661-150/-350 (digital output type)
C12662-150/-350 (analog output type)

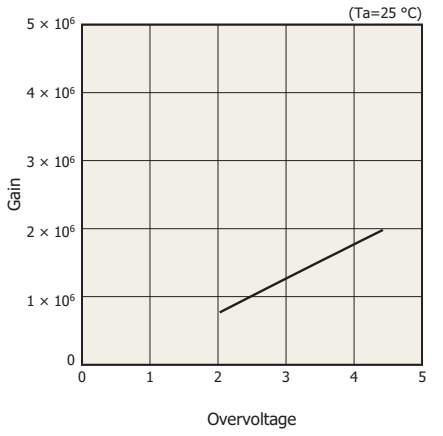
The following characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

(Typ. Td=-10 °C)

Parameter		Symbol	S12576-050	S12577-050	Unit
Effective photosensitive area		-	1 × 1		mm
Pixel pitch		-	50		μm
Number of pixels		-	400	3600	-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	450		nm
Photon detection efficiency (λ=λp)*1		PDE	35		%
Breakdown voltage		V_{BR}	62.9 ± 10		V
Operating voltage		Vop	V_{BR} + 2.6		V
Dark count*2	Typ.	-	5	50	kcps
	Max.		10	100	
Terminal capacitance		Ct	35	320	pF
Time resolution (FWHM)*3		-	250	250	ps
Temperature coefficient of operating voltage		-	60		mV/ °C
Gain		M	1.25×10^6		-
Temperature coefficient of gain		-	2.7×10^4		/°C

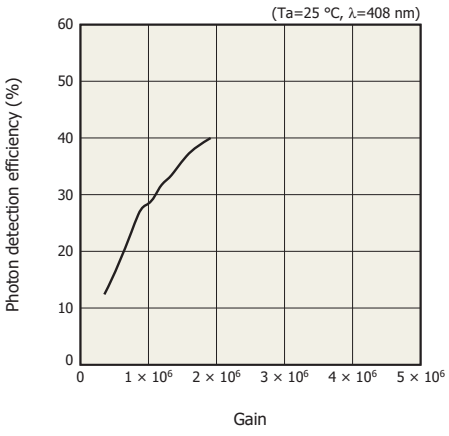
*1: Photon detection efficiency does not include crosstalk and afterpulses.
*2: Threshold=0.5 p.e.
*3: Single photon level

Gain vs. overvoltage (typical example)



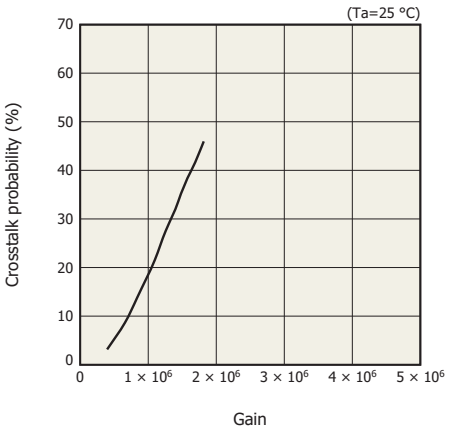
KAPDB0247EA

Photon detection efficiency vs. gain (typical example)



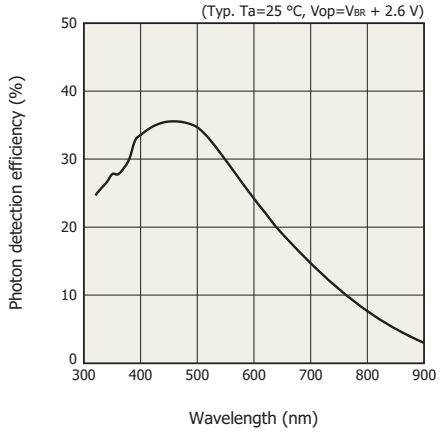
KAPDB0248EA

Crosstalk probability vs. gain (typical example)



KAPDB0249EA

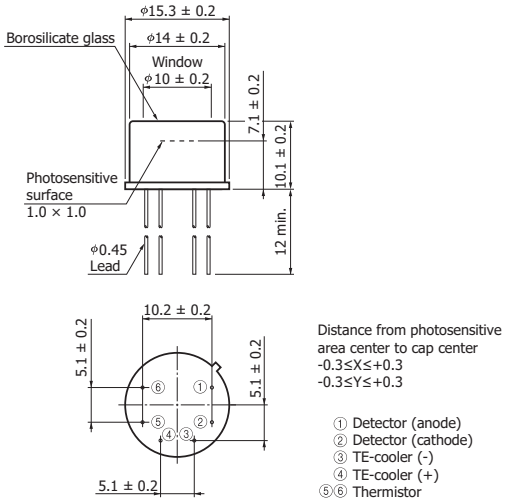
Photon detection efficiency vs. wavelength



KAPDB0220EA

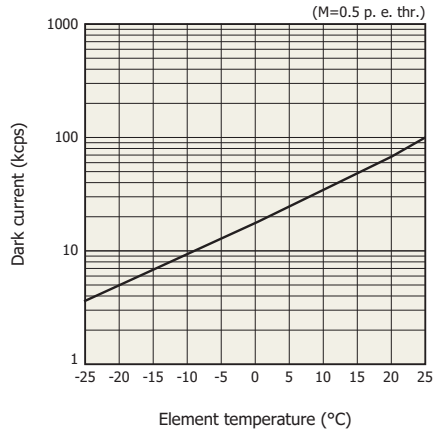
Photon detection efficiency does not include crosstalk and afterpulses.

Dimensional outline (unit: mm)



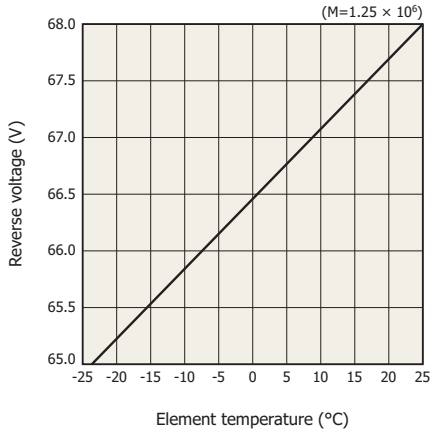
KAPDA0145EA

Dark current vs. element temperature (S12576-050, typical example)



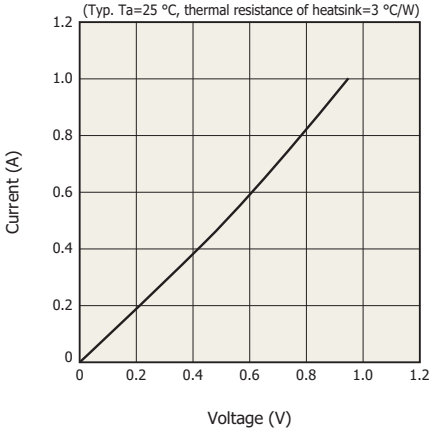
KAPDB0218EA

Reverse voltage vs. element temperature (S12576-050, typical example)



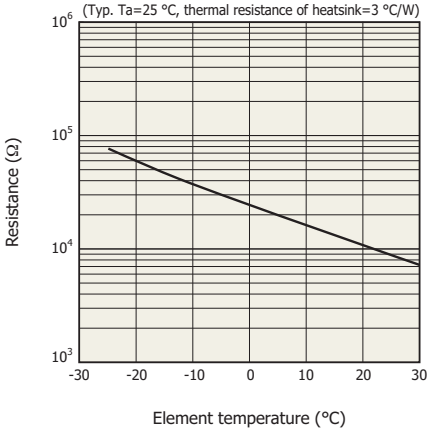
KAPDB0219EA

Current vs. voltage of TE-cooler



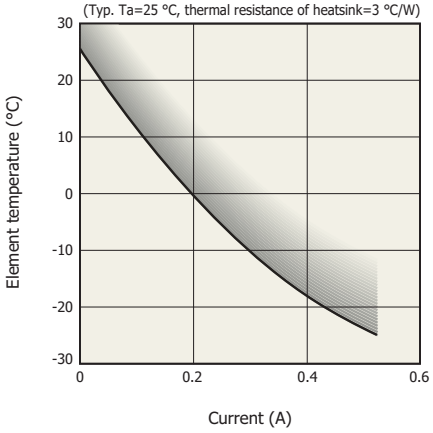
KAPDB0166EA

Thermistor temperature characteristics



KAPDB0167EB

Cooling characteristics of TE-cooler



KAPDB0168ED

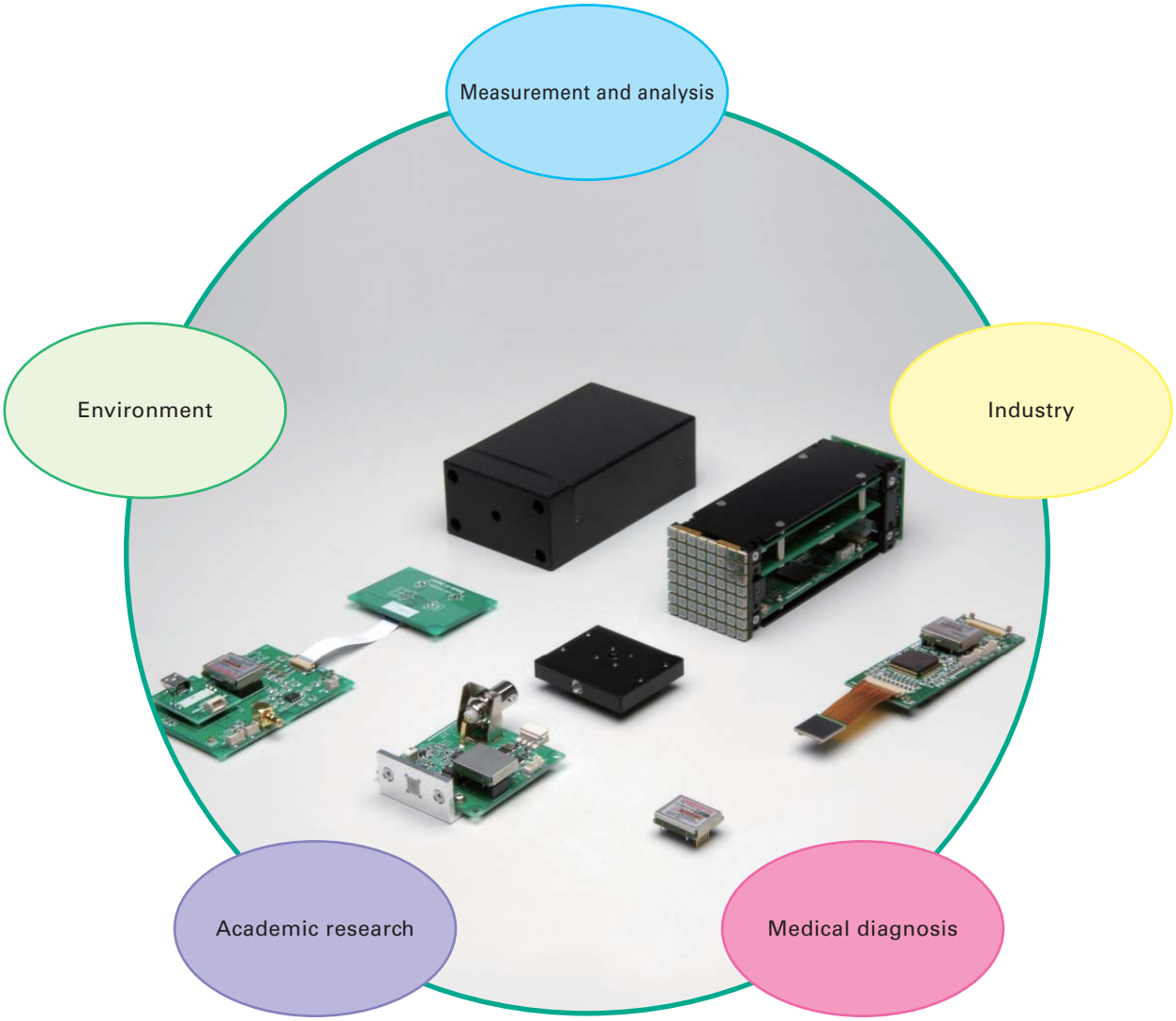
In this data, MPPC is not operated. When MPPC is in operation, the data will vary because the amount of heat generated in MPPC changes depending on the applied reverse voltage and incident light level.

MPPC modules

▶ Optical measurement modules capable of measuring very low light levels

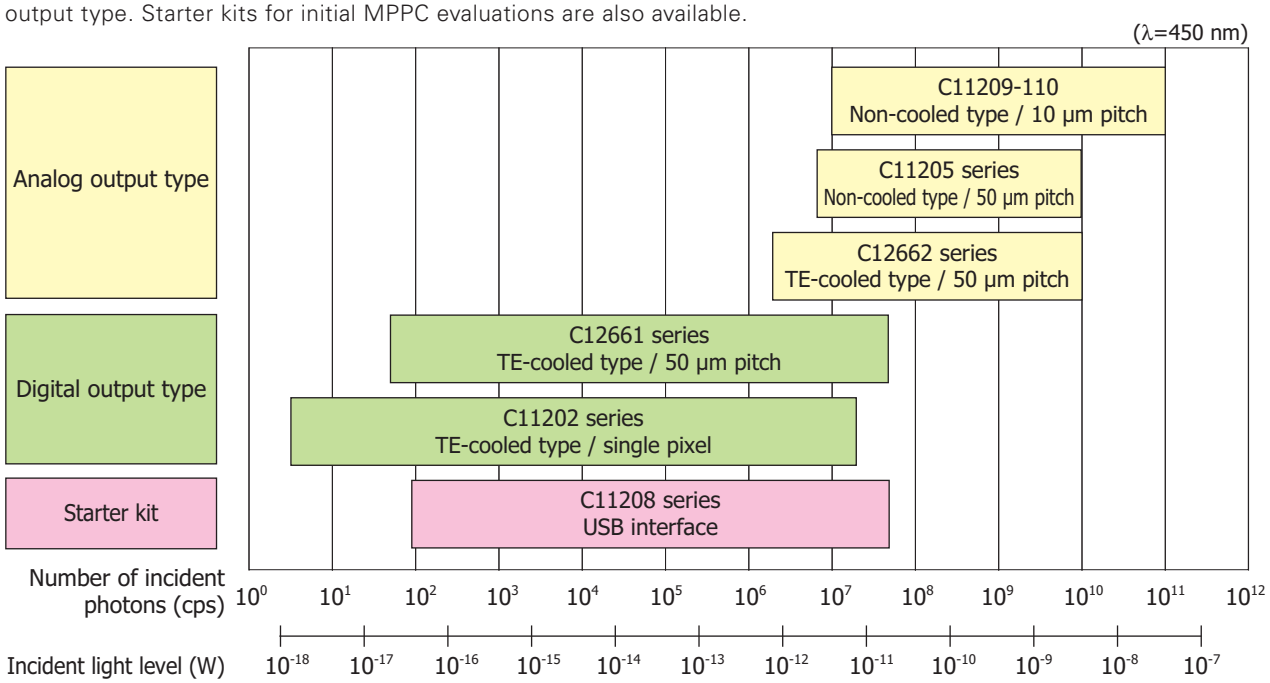
Hamamatsu MPPC modules are optical measurement modules capable of measuring light over a wide range of light levels (10 orders of magnitude) from the photon-counting region up to the nW (nano watt) region. MPPC modules contain a signal amplifier circuit, a high-voltage power supply circuit, and other components needed for MPPC operation. MPPC modules operate just by connecting them to a power supply (±5 V, etc).

Hamamatsu offers a wide lineup of MPPC modules including cooled modules that give a low dark count and non-cooled modules with a temperature compensation function for stable measurement. Hamamatsu also provides starter kits developed for making initial MPPC evaluations and a temperature-compensated high-voltage power supply module designed to operate an MPPC. Besides standard product modules, we also welcome your requests for custom-made designs.

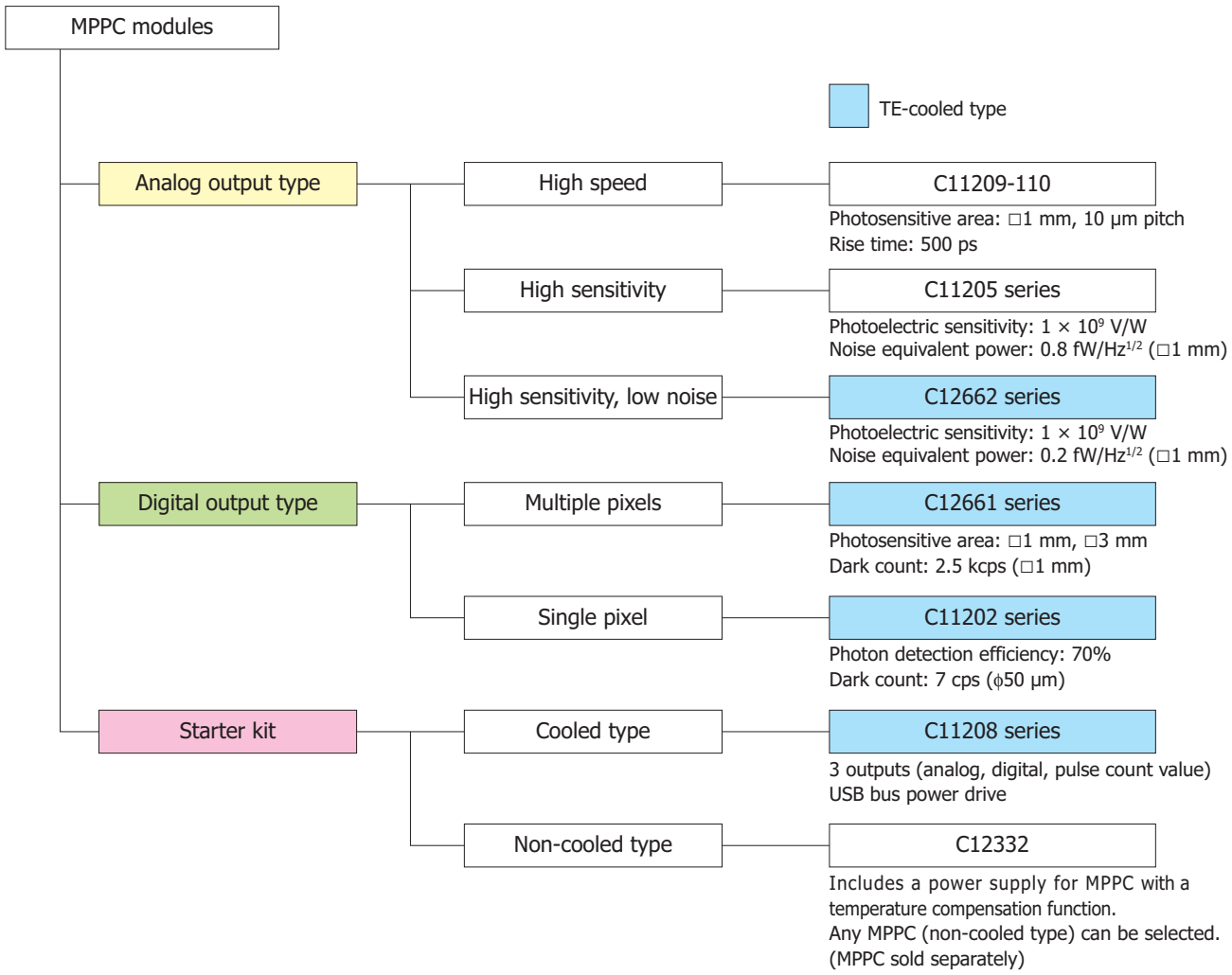


▶ Measurable light level range

MPPC modules include two output types according to the incident light level (number of photons): analog output type and digital output type. Starter kits for initial MPPC evaluations are also available.



▶ Broad product lineup to meet diverse applications



Note: Power supply modules and array modules are also available.

▶ Selecting the digital output type or analog output type

The output type (digital or analog) should be selected according to the light level incident on the MPPC module.

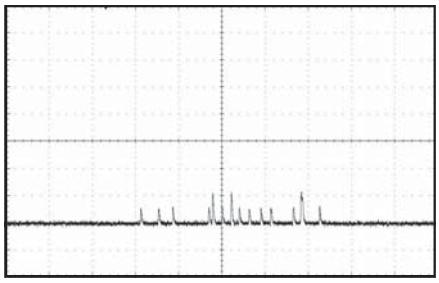
The following output waveforms (a) (b) and (c) show MPPC output waveforms measured at different incident light levels and observed on an oscilloscope. The incident light level was increased in the order of (a) (b) and (c), starting from (a) at very low light levels. The output signal of (a) as seen here consists of discrete pulses. In this state, selecting the digital output type allows measuring at a higher S/N, where the signals are binarized and the number of pulses is digitally counted. Since the digital output type can easily subtract the dark count from the signal, the detection limit is determined by dark count fluctuations.

As the light level increases, the output waveform consists of pulses overlapping each other [Output waveforms (b) (c)]. In this state, the number of pulses cannot be counted and the analog output type should be selected to measure the analog output and find the average value. The detection limit in the analog output type is determined by the dark current shot noise and the cutoff frequency of the readout circuit.

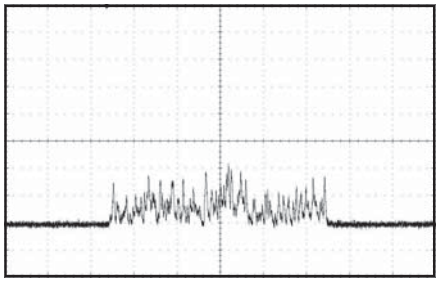
The bottom graphs show dynamic range of analog output type (C12662-350) and digital output type (C12661-350).

Output waveforms

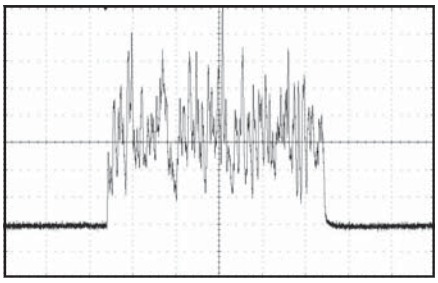
(a) Light level is very low



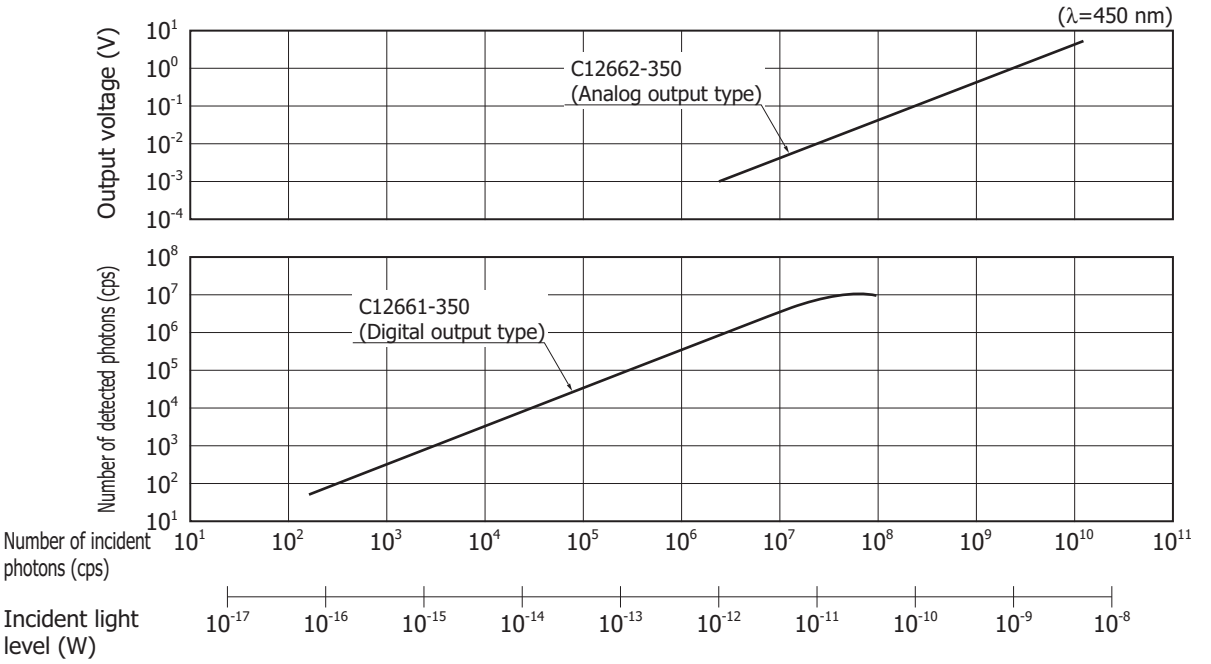
(b) Light level is low



(c) Light level is high

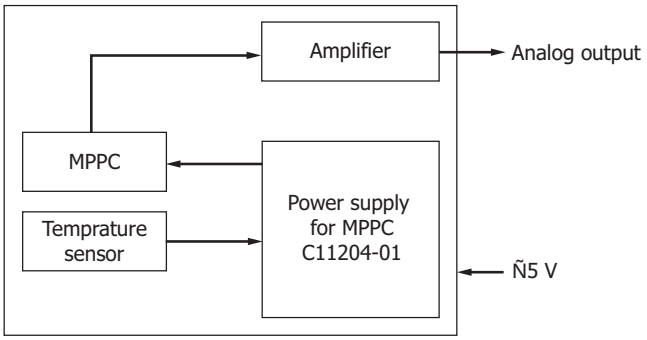


Dynamic range



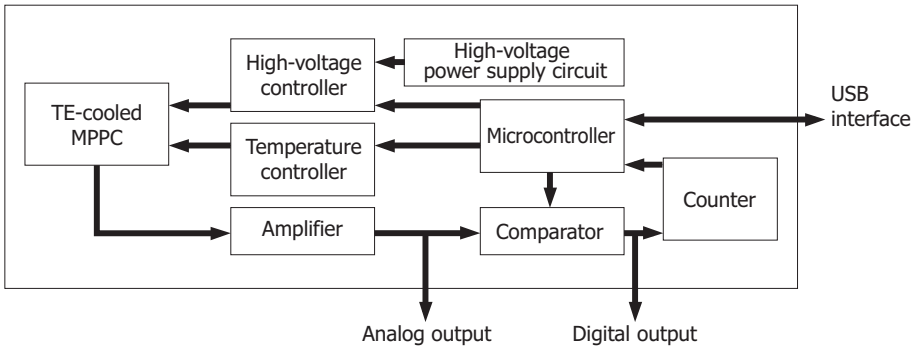
Block diagram

Analog output type (C11205 series)



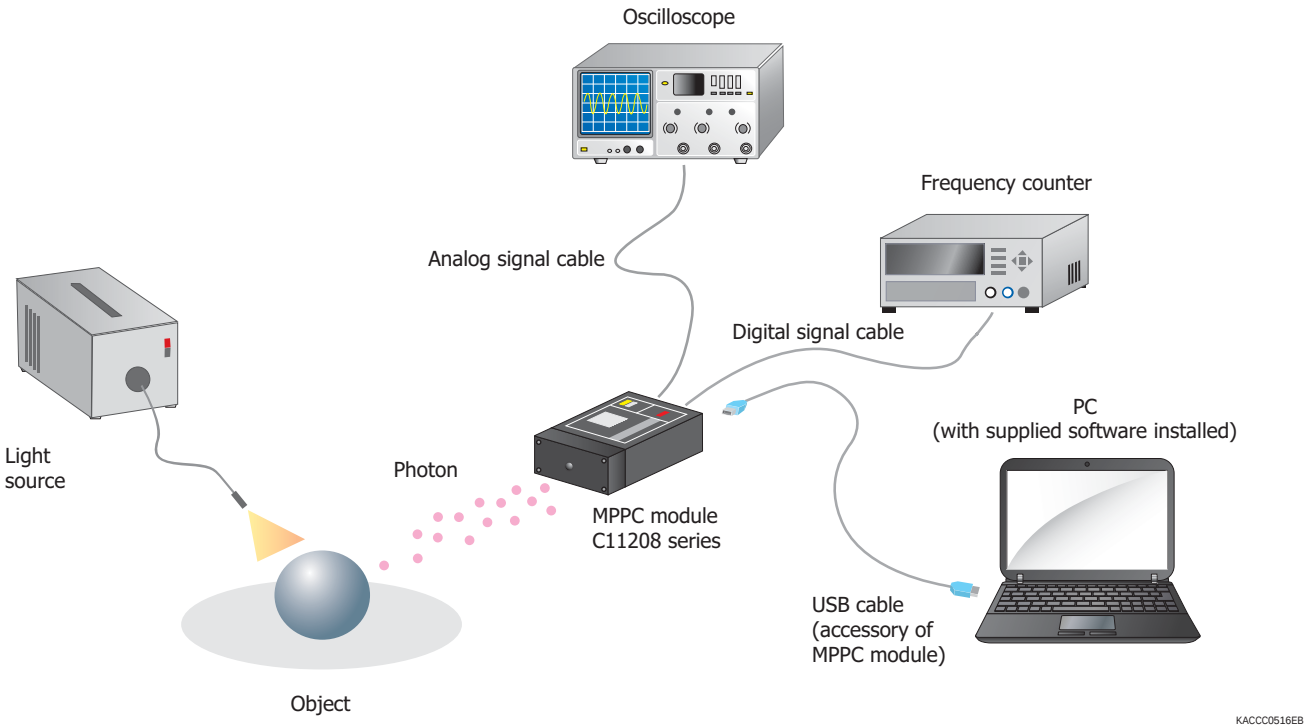
KACCC0675EA

Digital output type (C11208 series)



KACCC0518EA

Connection example



KACCC0516EB

MPPC module lineup

Analog output type NEW

Type no.	Photo W x D x H (mm)	Photosensitive area	Pixel pitch	Internal MPPC	Noise equivalent power	High-band cutoff frequency	Temperature control	Supply voltage	Features
C11209-110	 45 × 38 × 13	□ 1 mm	10 µm	S12571-010C	3 fW/Hz$^{1/2}$	40 MHz (rise time: 500 ps)	Temperature compensation (non-cooled)	+5 V	• High speed • Compact size
C11205-150	 50 × 50 × 19.6	□ 1 mm	50 µm	S12571-050C	0.8 fW/Hz$^{1/2}$	7 MHz	Temperature compensation (non-cooled)	±5 V	• High sensitivity (1 × 10^9 V/W)
C11205-350		□ 3 mm		S12572-050C	2 fW/Hz$^{1/2}$				
C12662-150	 98 × 60 × 35	□ 1 mm	50 µm	S12576-050	0.2 fW/Hz$^{1/2}$	7 MHz	TE-cooled (-20 °C)	±5 V	• High sensitivity (1 × 10^9 V/W) • Low noise
C12662-350		□ 3 mm		S12577-050	0.4 fW/Hz$^{1/2}$				

Digital output type NEW

Type no.	Photo W x D x H (mm)	Photosensitive area	Pixel pitch	Internal MPPC	Dark count	Maximum count rate	Temperature control	Supply voltage	Features
C12661-150	 98 × 60 × 35	□ 1 mm	50 µm	S12576-050	2.5 kcps	10 Mcps	TE-cooled (-20 °C)	±5 V	• High photon detection efficiency (35%) • Low dark count • Low afterpulse
C12661-350		□ 3 mm		S12577-050	25 kcps				
C11202-050	 98 × 60 × 35	ϕ50 µm	–	Single pixel type	7 cps	30 Mcps	TE-cooled (-20 °C)	±5 V	• High photon detection efficiency (70%) • Low dark count • Low afterpulse
C11202-100		ϕ100 µm	–		30 cps	20 Mcps			

Starter kits NEW

Type no.	Photo W x D x H (mm)	Photosensitive area	Pixel pitch	Internal MPPC	Temperature control	Supply voltage	Features
C11208-150	 98 × 60 × 35	□ 1 mm	50 µm	S12576-050	TE-cooled (-10 °C)	USB bus power	• Suitable for initial MPPC evaluations; supports 3 outputs (analog,digital, and pulse count value) • USB bus power drive
C11208-350		□ 3 mm		S12577-050	TE-cooled (0 °C)		
C12332	 70 × 50 × 11.4	Evaluates any non-cooled MPPC (sold separately)			Temperature compensation (non-cooled)	±5 V	• Simple initial MPPC evaluations • Includes C11204-01 power supply for MPPC • Measurable just by setting MPPC operating voltage from PC

Power supply module NEW

Type no.	Photo W x D x H (mm)	Input voltage range	Output voltage range	Ripple noise typ.*1	Temperature stability typ.	Setting resolution	Features
C11204-01	 19.4 × 17 × 6.3	5 V	50 to 90 V	0.1 mVp-p	±10 ppm/°C	1.8 mV	• Includes high-precision temperature compensation function (temperature stability: ±10 ppm/°C typ.) • Various settings possible via serial interface

*1: No load; recommended circuit is used

Array modules

Array modules are available in various types. Contact us for detailed information.

2 × 2 ch MPPC array modules
C11207-0202 series

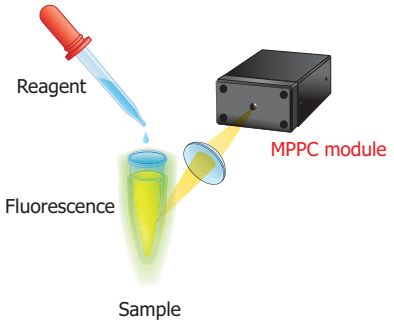
4 × 4 ch MPPC array modules
C11206-0404 series

8 × 8 ch MPPC array modules
C11206-0808 series

Application examples of MPPC modules

Application examples of Hamamatsu MPPC modules are shown below.

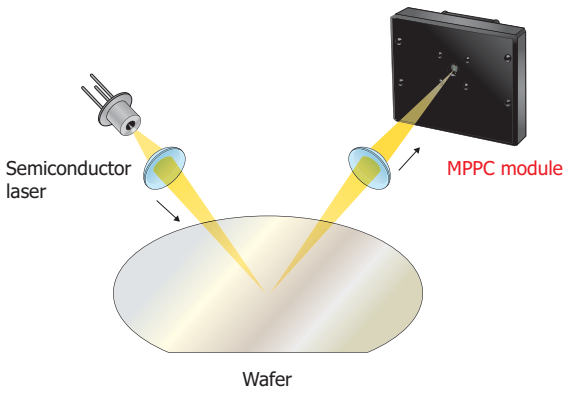
Fluorescence measurement



KACCC0664EA

Major characteristics High photon detection efficiency, low afterpulse
Suitable MPPC modules C12661 series, C12662 series

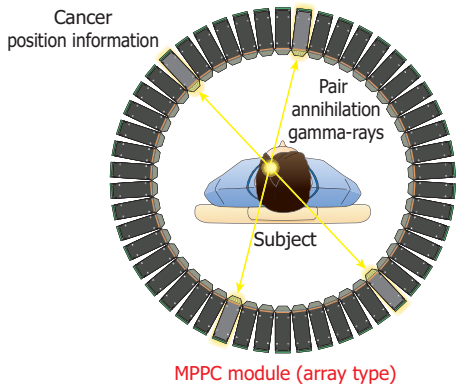
Disc surface inspection



KACCC0665EA

Major characteristics High-speed response, wide dynamic range
Suitable MPPC modules C11209 series

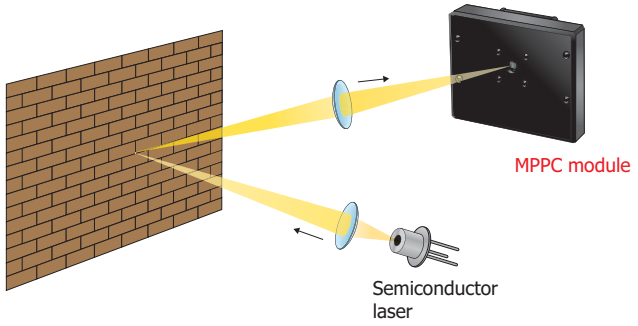
Scintillation measurement



KACCC0598EA

Major characteristics Wide dynamic range
Suitable MPPC modules C11205 series

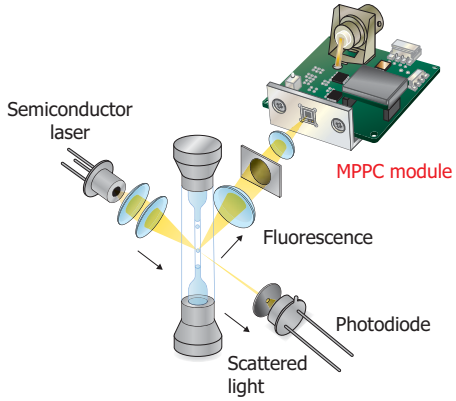
Distance measurement



KACCC0666EA

Major characteristics High-speed response, wide dynamic range
Suitable MPPC modules C11209 series

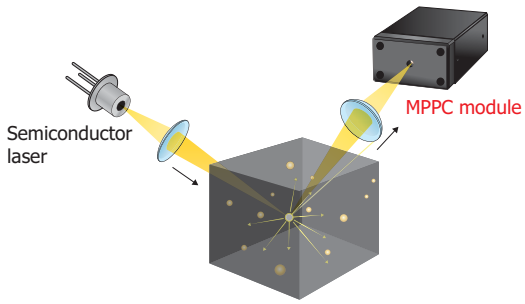
Flow cytometry



KACCC0668EA

Major characteristics High photon detection efficiency
Suitable MPPC modules C11205 series, C12662 series

Particle measurement



KACCC0667EA

Major characteristics High photon detection efficiency, low afterpulse
Suitable MPPC modules C11202 series

Analog output type MPPC modules

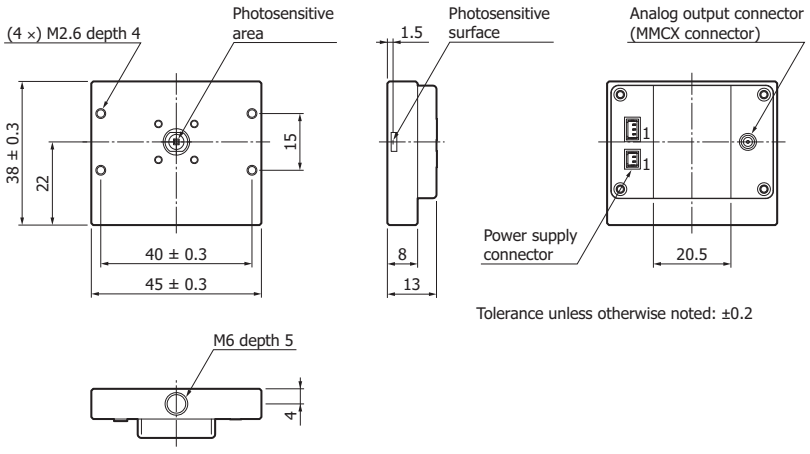
C11209-110

The C11209-110 is an optical measurement module capable of detecting low level light. It consists of an MPPC, a high-speed amplifier circuit, a high-voltage circuit, and a temperature compensation circuit. Utilizing a small pixel pitch (10 µm) MPPC allows high-speed measurement over a wide dynamic range, making the C11209-110 suitable for high-speed signal measurement such as distance measurement. The C11209-110 operate just by connecting it to an external single power supply (+5 V).

(Typ. Ta=25 °C, λ=λp, Vs=+5 V, unless otherwise noted)

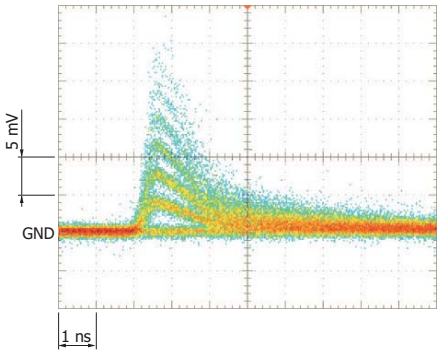
Parameter		Symbol	C11209-110	Unit
Internal MPPC		-	S12571-010C	-
Effective photosensitive area		-	1 × 1	mm
Pixel pitch		-	10	µm
Number of pixels		-	10000	-
Spectral response range		λ	320 to 900	nm
Peak sensitivity wavelength		λp	520	nm
Temperature stability of output voltage		-	±5 max.	%
Photoelectric sensitivity		-	2.6×10^6	V/W
Rise time		tr	500	ps
Cutoff frequency	High band	fc	40	MHz
	Low band		10	kHz
Noise equivalent power		NEP	3	$fW/Hz^{1/2}$
Minimum detection limit		-	20	pW rms
Saturation input light level		-	100	nW
Dimensions		-	45 × 38 × 13	mm

Dimensional outline (unit: mm)

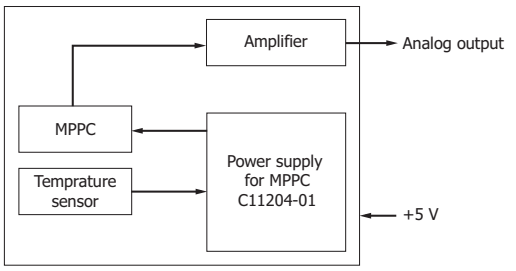


KACCA0312EA

Analog output waveforms



Block diagram



KACCC0675EA

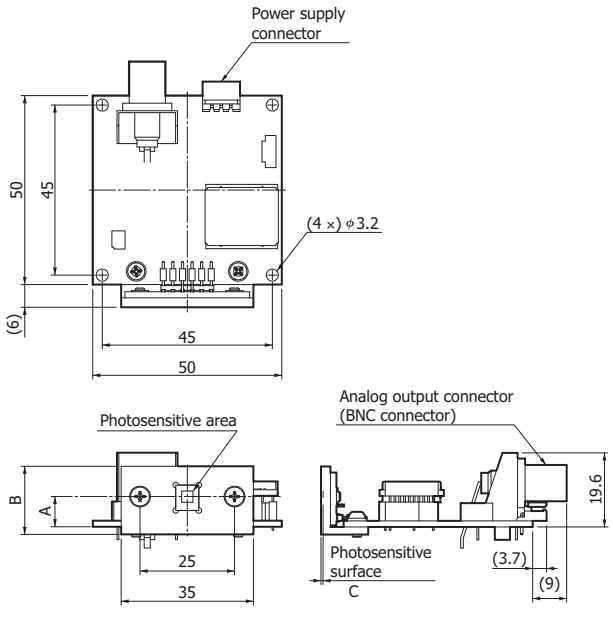
C11205 series

The C11205 series are optical measurement modules capable of detecting low level light. These modules consist of an MPPC, a signal amplifier circuit, a high-voltage power supply circuit, and a temperature compensation circuit. The photosensitive area is available in two sizes of 1 × 1 mm and 3 × 3 mm, and the signal output is analog. Modules operate just by connecting them to an external power supply (±5 V).

(Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	C11205-150	C11205-350	Unit
Internal MPPC		-	S12571-050C	S12572-050C	-
Effective photosensitive area		-	1 × 1	3 × 3	mm
Pixel pitch		-	50		μm
Number of pixels		-	400	3600	-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	500		nm
Temperature stability of output voltage		-	±5 max.		%
Photoelectric sensitivity		-	1.0×10^9		V/W
Cutoff frequency	High band	fc	7		MHz
	Low band		DC		-
Noise equivalent power		NEP	0.8	2	$fW/Hz^{1/2}$
Minimum detection limit		-	2.5	5.5	pW rms
Maximum output voltage		-	4.9		V
Dimensions		-	50 × 50 × 19.6		mm

Dimensional outline (unit: mm)

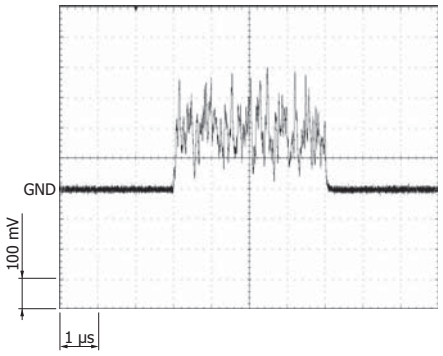


Type no.	A	B	C
C11205-150	6	16	0.6
C11205-350	8	18	0.55

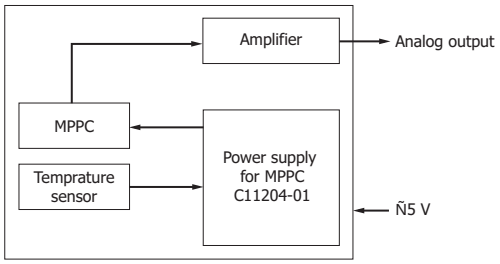
Tolerance unless otherwise noted: ±0.3

KACCA0310EA

Analog output waveform



Block diagram



KACCC0675EA

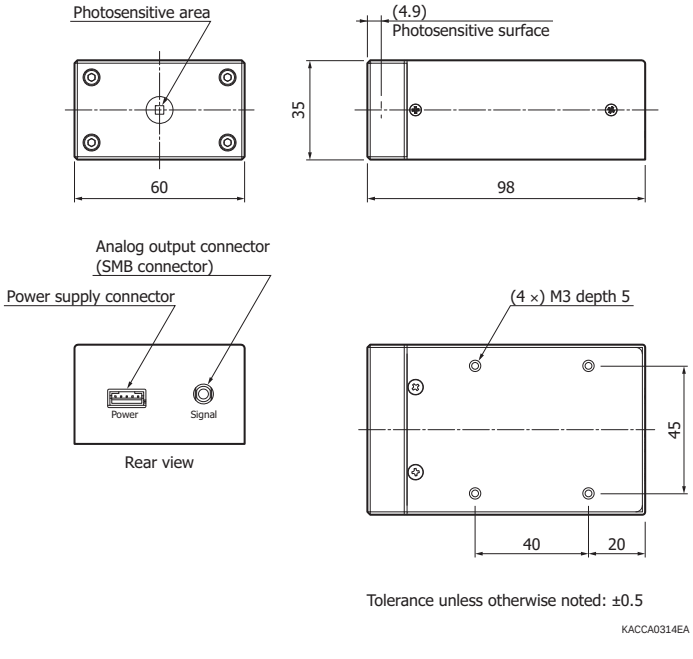
C12662 series

The C12662 series are optical measurement modules capable of detecting low light levels. These modules consist of a thermoelectrically cooled MPPC, a signal amplifier circuit, a high-voltage power supply circuit, and a temperature control circuit. The photosensitive area is available in two sizes of 1 × 1 mm and 3 × 3 mm, and the signal output is analog. Modules operate just by connecting them to an external power supply (±5 V).

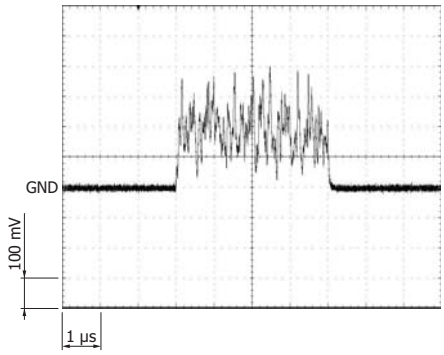
(Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	C12662-150	C12662-350	Unit
Internal MPPC		-	S12576-050	S12577-050	-
Effective photosensitive area		-	1 × 1	3 × 3	mm
Pixel pitch		-	50		μm
Number of pixels		-	400	3600	-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	500		nm
Element temperature (setting temperature)		Td	-20		°C
Photoelectric sensitivity		-	1.0×10^9		V/W
Cutoff frequency	High band	fc	7		MHz
	Low band		DC		-
Noise equivalent power		NEP	0.2	0.4	$fW/Hz^{1/2}$
Minimum detection limit		-	0.55	1.1	pW rms
Maximum output voltage		-	4.9		V
Dimensions		-	98 × 60 × 35		mm

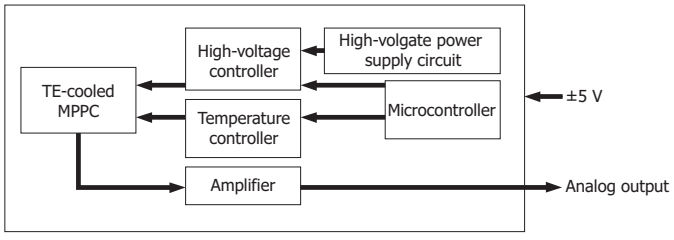
Dimensional outline (unit: mm)



Analog output waveform



Block diagram



Digital output type MPPC modules

C12661 series

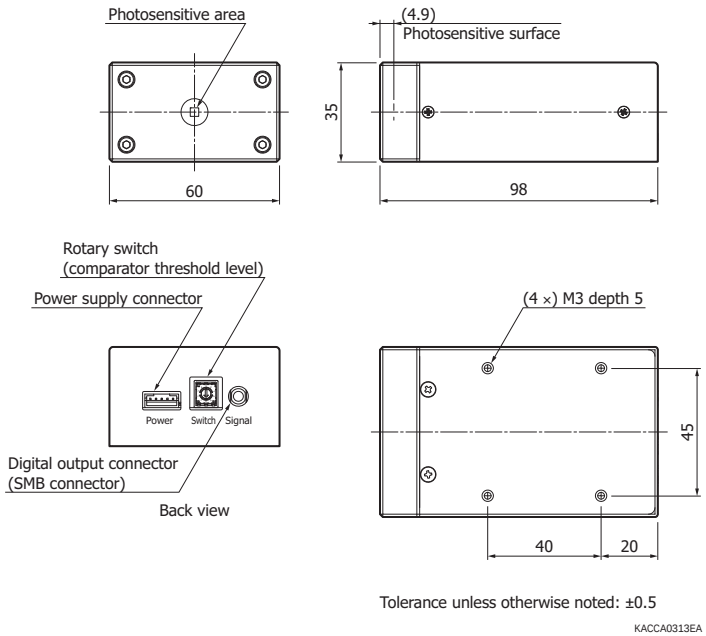
The C12661 series are photon counting modules capable of detecting low light levels. These modules consist of a thermoelectrically cooled MPPC, a signal amplifier circuit, a comparator circuit, a high-voltage power supply circuit, and a temperature control circuit. The photosensitive area is available in two sizes of 1 × 1 mm and 3 × 3 mm, and the signal output is digital. Modules operate just by connecting them to an external power supply (±5 V).

(Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter	Symbol	C12661-150	C12661-350	Unit
Internal MPPC	-	S12576-050	S12577-050	-
Effective photosensitive area	-	1 × 1	3 × 3	mm
Pixel pitch	-	50		μm
Number of pixels	-	400	3600	-
Spectral response range	λ	320 to 900		nm
Peak sensitivity wavelength	λp	450		nm
Element temperature (setting temperature)	Td	-20		°C
Photon detection efficiency*	PDE	35		%
Dark count*	-	2.5	25	kcps
Afterpulse probability	-	1		%
Comparator output	-	TTL compatible		-
Comparator threshold level	-	Can be set in 10 steps from 0.5 to 8.5 and "disable"		p.e.
Maximum count rate	-	10		Mcps
Dimensions	-	98 × 60 × 35		mm

*0.5 p.e. (threshold level)

Dimensional outline (unit: mm)



Tolerance unless otherwise noted: ±0.5

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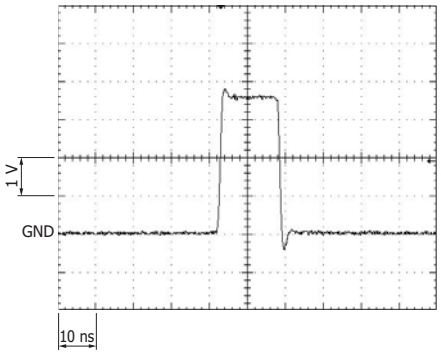
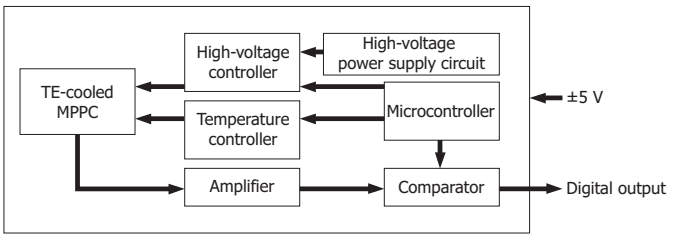
Digital output waveform



Block diagram



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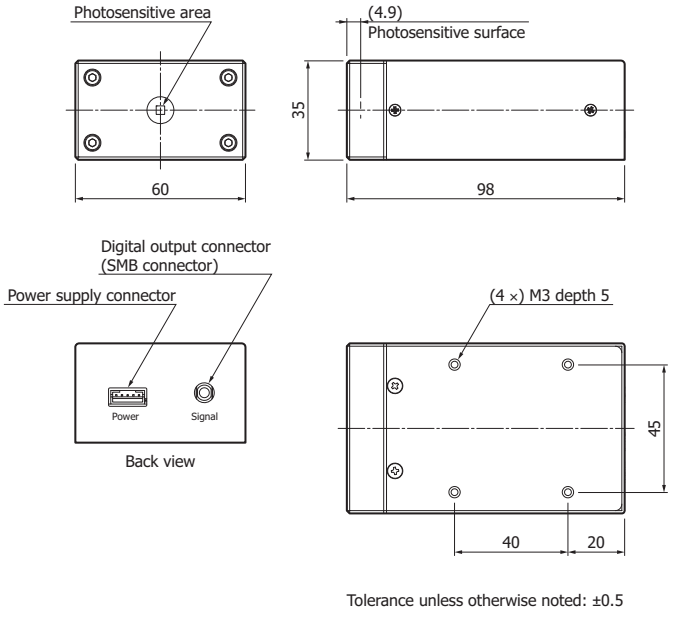
C11202 series

The C11202 series is a single-photon counting module capable of detecting low light levels. The C11202 series is made up of a single-pixel thermoelectrically cooled MPPC, a signal amplifier circuit, a comparator circuit, a high-voltage power supply circuit, and a temperature control circuit. The photosensitive area is available in two sizes of ϕ50 µm and ϕ100 µm, and such small photosensitive areas offer a low dark count. Modules operate just by connecting them to an external power supply (±5 V).

(Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	C11202-050	C11202-100	Unit
Internal MPPC		-	Single pixel type		-
Effective photosensitive area		-	ϕ50	ϕ100	µm
Number of pixels		-	1		-
Spectral response range		λ	320 to 900		nm
Peak sensitivity wavelength		λp	450		nm
Element temperature (setting temperature)		Td	-20		°C
Photon detection efficiency		PDE	70		%
Dark count		-	7	30	cps
Afterpulse probability	to 100 ns	-	1	1.5	%
	from 100 ns		0.01		
Comparator output		-	TTL compatible		-
Maximum count rate		-	30	20	Mcps
Dimensions		-	98 × 60 × 35		mm

Dimensional outline (unit: mm)



Tolerance unless otherwise noted: ±0.5

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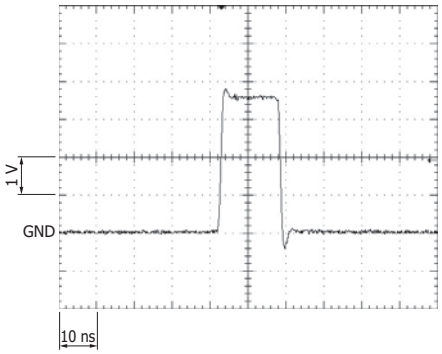
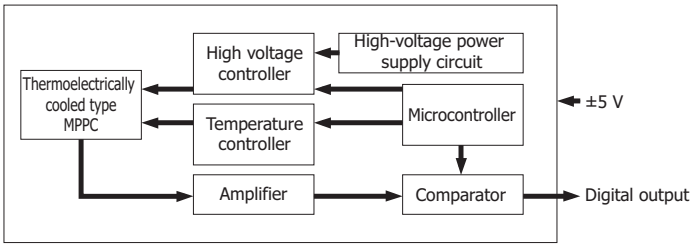
Digital output waveform



Block diagram



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Starter kits

C11208 series

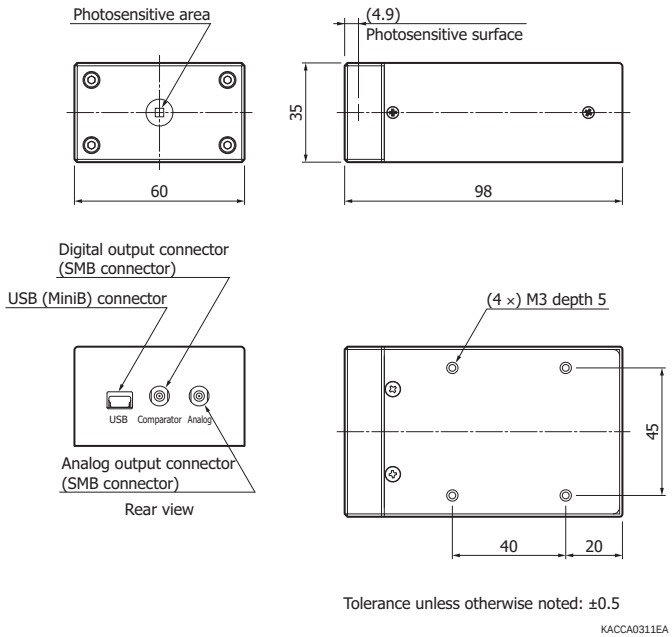
The C11208 series are starter kits designed for evaluating thermoelectrically cooled MPPC. These starter kits have a USB interface that allows you to change the threshold level and acquire data from a PC. No external power supply is needed since they operate on USB bus power. Three signal output formats of analog, digital, and pulse count (USB) are provided.

(Typ. Ta=25 °C, λ=λp, unless otherwise noted)

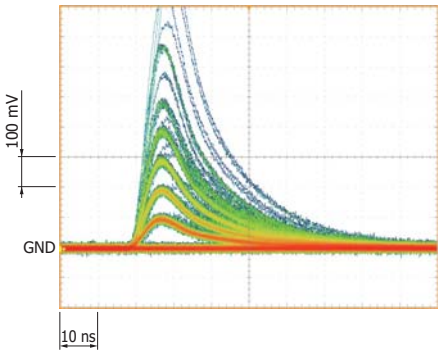
Parameter	Symbol	C11208-150	C11208-350	Unit
Internal MPPC	-	S12576-050	S12577-050	-
Effective photosensitive area	-	1 × 1	3 × 3	mm
Pixel pitch	-	50		μm
Number of pixels	-	400	3600	-
Spectral response range	λ	320 to 900		nm
Peak sensitivity wavelength	λp	450		nm
Element temperature (setting temperature)	Td	-10	0	°C
Photon detection efficiency*	PDE	35		%
Dark count*	-	5	120	kcps
Comparator output	-	TTL compatible		-
Comparator threshold level	-	9 adjustable levels: 0.5 to 7.5 and disable		p.e.
Interface	-	USB 1.1		-
Dimensions	-	98 × 60 × 35		mm

*0.5 p.e. (threshold level)

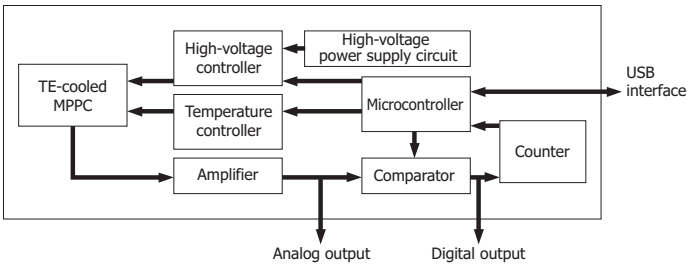
Dimensional outline (unit: mm)



Analog output waveform

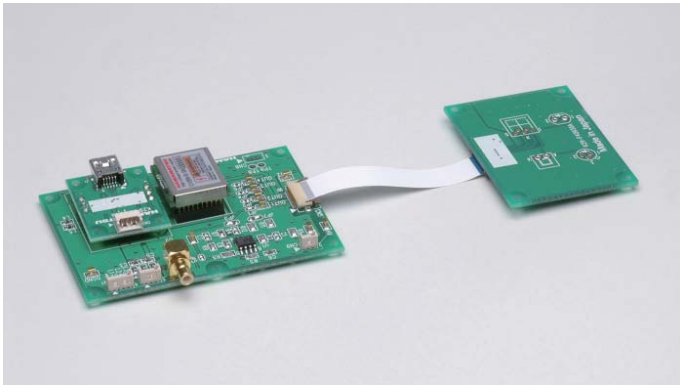


Block diagram



C12332

The C12332 is a starter kit designed for simple non-cooled MPPC evaluations. It consists of a sensor board and a power supply board. The sensor board includes an MPPC socket and a temperature sensor. The power supply board includes a C11204-01 power supply module for MPPC, a signal amplifier circuit, and a USB interface board. The USB interface allows you to change the bias voltage and set the temperature compensation coefficient from a PC. The C12332 operates just by connecting it to an external power supply (±5 V).

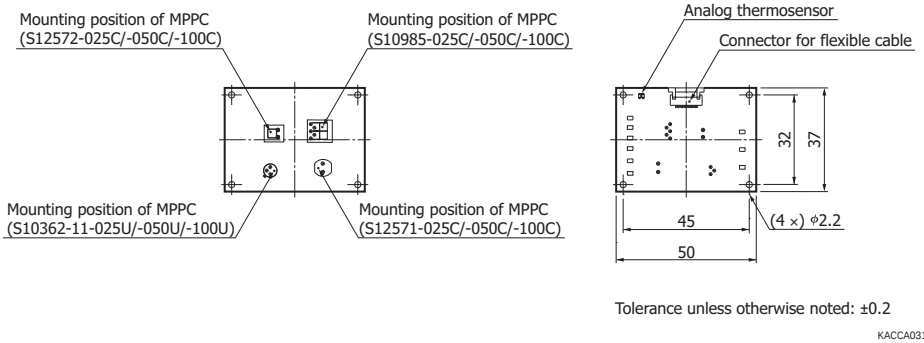


(Typ. Ta=25 °C, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	C12332	Unit
Supply voltage		Vs	±5	V
Supply voltage range		Vo	50 to 90	V
Setting voltage error		-	±10	mV
Setting voltage resolution*		-	10	mV
Voltage monitoring error		-	±10	mV
Current monitoring error		-	±0.05	mA
Load resistance		RL	50 or 1k	Ω
Cutoff frequency	High band	fc	40	MHz
	Low band		DC	
Integrated thermosensor		-	LM94021BIMG (by Texas Instruments)	-
Interface		-	USB 2.0 (Full speed)	-

*When using sample software

Dimensional outline (unit: mm)



Tolerance unless otherwise noted: ±0.2

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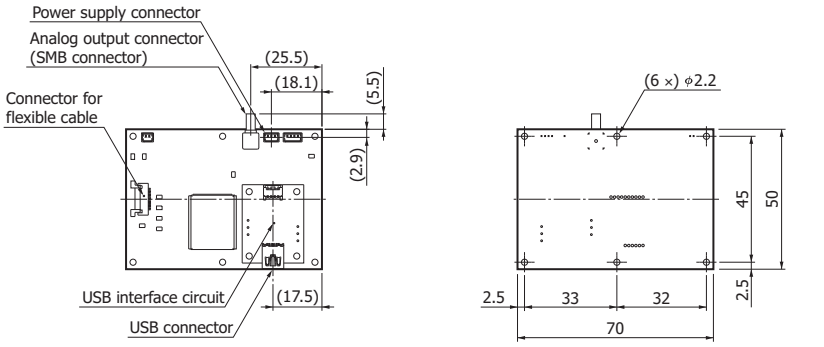

Tolerance unless otherwise noted: ±0.2

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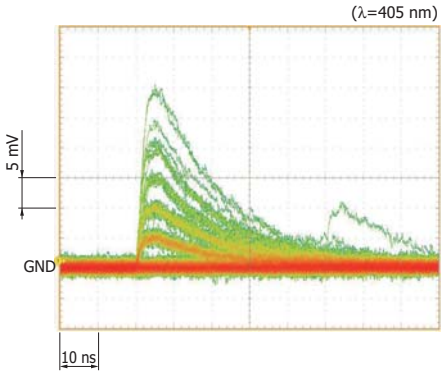
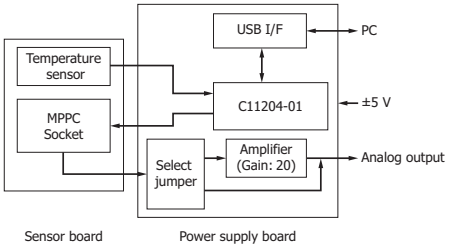
Analog output waveforms (impulse light)



Block diagram



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