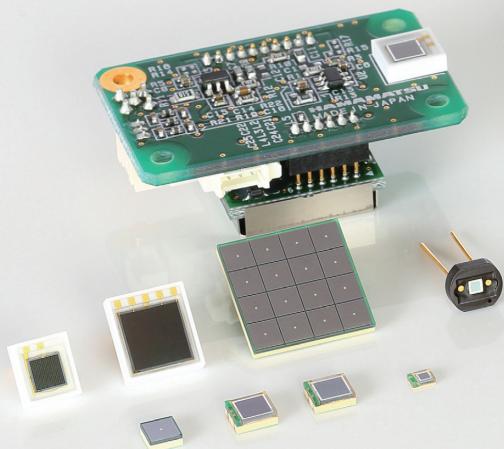


**NEW**

# MPPC® and MPPC® module for precision measurement

## Low-noise MPPC for precision measurement

MPPCs and MPPC modules for precision measurement inherit the high photon detection efficiency of their predecessors and at the same time provide lower crosstalk, lower afterpulse, and lower dark count.



## What is MPPC?

The MPPC (multi-pixel photon counter) is one of the devices called Si-PM (silicon photomultiplier). It is a photon-counting device using multiple APD (avalanche photodiode) pixels operating in Geiger mode. Although the MPPC is essentially an opto-semiconductor device, it has excellent photon-counting capability and can be used in various applications for detecting extremely weak light at the photon counting level.

The MPPC operates on low voltage and features high gain, high photon detection efficiency, high-speed response, excellent time resolution, and wide spectral response range. It achieves the performance that is required in photon-counting at a high level. The MPPC is also immune to magnetic fields, highly resistant to mechanical shocks and the like, which are advantages unique to solid-state devices.

**MPPC®**  
Multi-Pixel Photon Counter

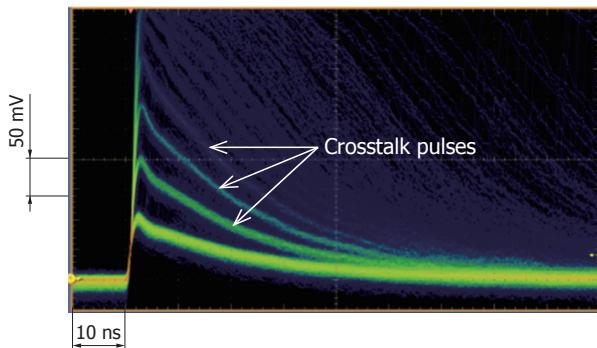
## **NEW Features of MPPC for precision measurement**

When an MPPC detects photons, the output may contain false signals, namely afterpulse and crosstalk, that are separate from the output pulses of the incident photons. The MPPC for precision measurement maintains the high photon detection efficiency while providing low afterpulse, low crosstalk, and low dark count.

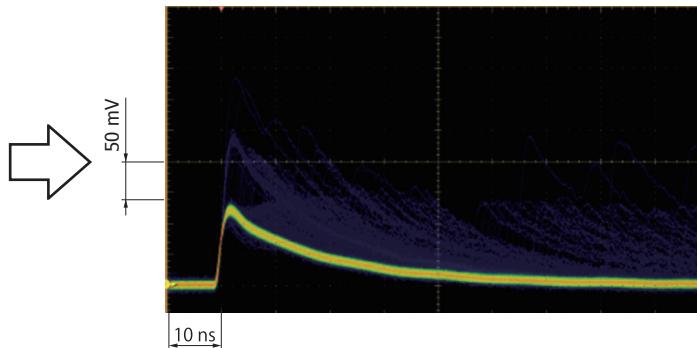
### **Feature 1 Low crosstalk**

The pixel that detects photons may affect other pixels, making them produce pulses separate from output pulses. This phenomenon is called crosstalk. The MPPC for precision measurement employs a structure that suppresses the occurrence of crosstalk. This has drastically reduced crosstalk in comparison with previous products (rate of occurrence reduced from 44% to 3%).

Previous product (3 × 3 mm, 50 µm pitch)



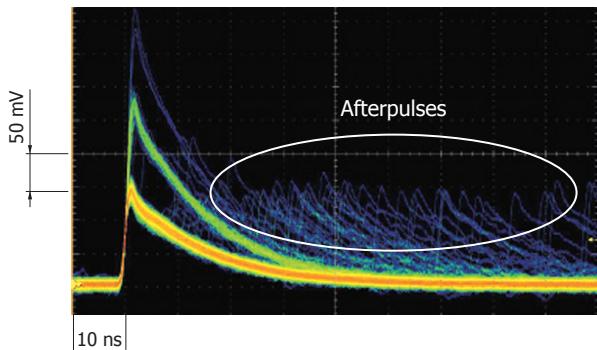
**NEW** S13360-3050CS (3 × 3 mm, 50 µm pitch)



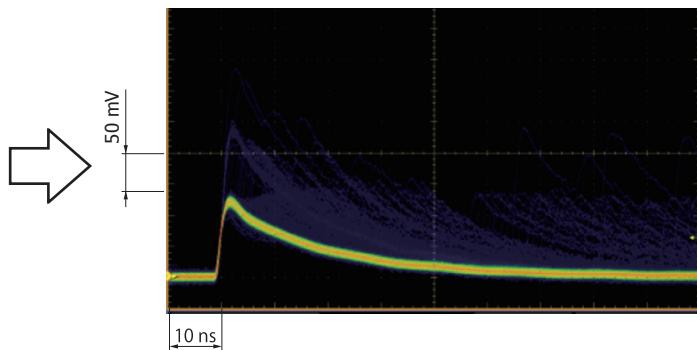
### **Feature 2 Low afterpulses**

While an MPPC detects photons, delayed signals may be output separately from the output pulses. These signals are called afterpulses. The MPPC for precision measurement provides low afterpulses.

Previous product (3 × 3 mm, 50 µm pitch)



**NEW** S13360-3050CS (3 × 3 mm, 50 µm pitch)



### **Feature 3 Low dark count**

Improvement in material and wafer process technology has reduced the dark count down to approximately half that of previous products. See P.3 [Dark count vs. overvoltage].

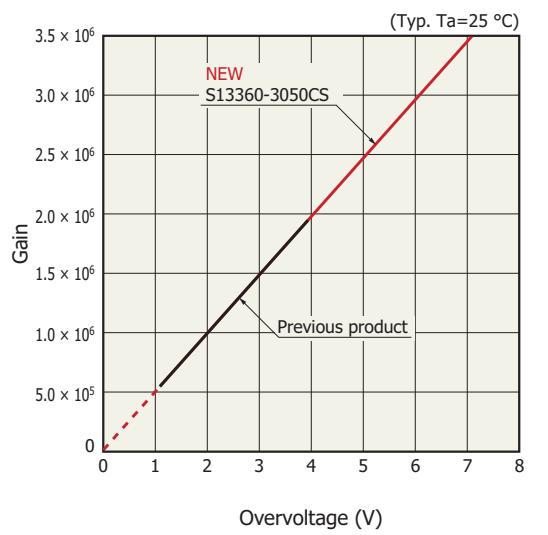
(Typ. Ta=25 °C, 3 × 3mm, V<sub>ov</sub>=3 V)

| Previous product | <b>NEW</b> S13360-3050CS |
|------------------|--------------------------|
| 1 Mcps           | 0.5 Mcps                 |

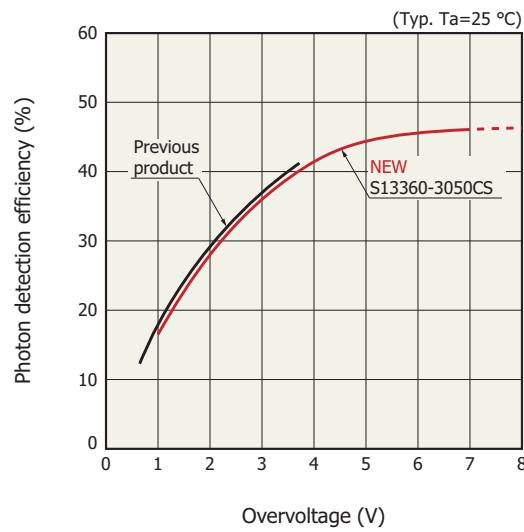
## Feature 4 Widened operating voltage range

The MPPC operation voltage  $V_{op}$  can be expressed as breakdown voltage ( $V_{br}$ ) + overvoltage ( $V_{ov}$ ). As the operating voltage is increased, the gain and photon detection efficiency improve, but at the same time, crosstalk and dark count, which are noise components, also increase. With previous products, the voltage dependency of noise components was high, and increasing the operating voltage caused a significant increase in noise components. On the other hand, with the MPPC for precision measurement, increase in noise components is suppressed even when the operating voltage is increased. Therefore, it can be used with high operating voltage (high gain and high photon detection efficiency).

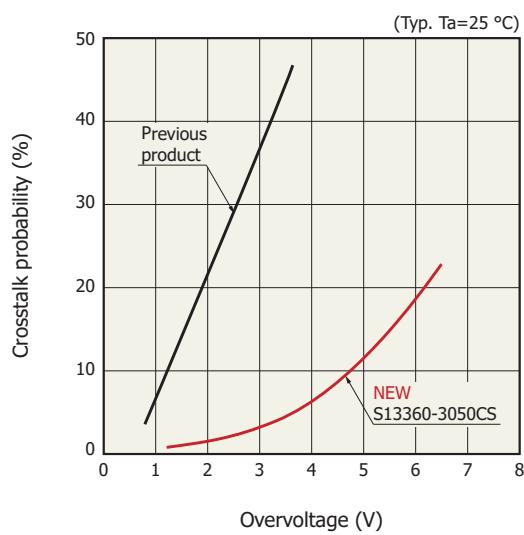
### Gain vs. overvoltage



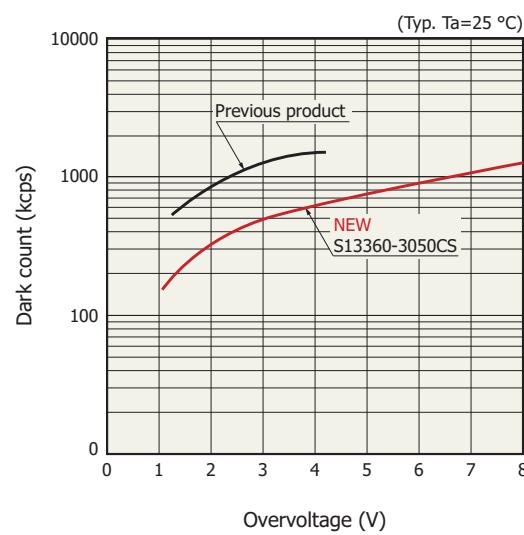
### Photon detection efficiency vs. overvoltage



### Crosstalk probability vs. overvoltage



### Dark count vs. overvoltage



Lineup

**MPPC modules**

| Analog output type       |   |  |                     |             |                           |                            |                                       |                |          |
|--------------------------|---|--|---------------------|-------------|---------------------------|----------------------------|---------------------------------------|----------------|----------|
| Type no.                 | Photo   | Built-in MPPC                                      | Photosensitive area | Pixel pitch | Noise equivalent power    | High-band cutoff frequency | Temperature control                   | Supply voltage | See page |
| <b>NEW</b> C13365-1350SA |  | S13360-1350CS                                      | □1.3 mm             | 50 µm       | 0.7 fW/Hz <sup>1/2</sup>  | 7 MHz                      | Temperature compensation (non-cooled) | ±5 V           | 8        |
| <b>NEW</b> C13365-3050SA |   | S13360-3050CS                                      | □3.0 mm             |             | 1.6 fW/Hz <sup>1/2</sup>  |                            |                                       |                |          |
| <b>NEW</b> C13366-1350GA |  | TE-cooled type<br>(MPPC for precision measurement) | □1.3 mm             | 50 µm       | 0.15 fW/Hz <sup>1/2</sup> | 7 MHz                      | TE-cooled (-20 °C)                    | ±5 V           | 9        |
| <b>NEW</b> C13366-3050GA |   |  | □3.0 mm             |             | 0.3 fW/Hz <sup>1/2</sup>  |                            |                                       |                |          |

| Digital output type      |   |  |                     |             |            |                    |                     |                |          |
|--------------------------|---|--|---------------------|-------------|------------|--------------------|---------------------|----------------|----------|
| Type no.                 | Photo   | Built-in MPPC                                      | Photosensitive area | Pixel pitch | Dark count | Maximum count rate | Temperature control | Supply voltage | See page |
| <b>NEW</b> C13366-1350GD |  | TE-cooled type<br>(MPPC for precision measurement) | □1.3 mm             | 50 µm       | 2.5 kcps   | 10 Mcps            | TE-cooled (-20 °C)  | ±5 V           | 10       |
| <b>NEW</b> C13366-3050GD |   |  | □3.0 mm             |             | 15 kcps    |                    |                     |                |          |

| Starter kit |   |                                       |                |  |  |  |  |  |          |
|-------------|---|---------------------------------------|----------------|--|--|--|--|--|----------|
| Type no.    | Photo   | Temperature control                   | Supply voltage | Features   |  |  |  |  | See page |
| C12332      |  | Temperature compensation (non-cooled) | ±5 V           | <ul style="list-style-type: none"> <li>• Evaluates any non-cooled MPPC (sold separately)</li> <li>• Includes C11204-01 power supply for MPPC</li> <li>• Measurable just by setting MPPC operating voltage from PC</li> </ul> |  |  |  |  | 18       |

**MPPC**

| Type no.                 | Photo   | Effective photosensitive area   | Pixel pitch | Package |  |  | See page |  |
|--------------------------|---|---|-------------|---------|--|--|----------|--|
| <b>NEW</b> S13360-1325CS |  |  | 25 µm       | Ceramic |  |  | 12       |  |
| <b>NEW</b> S13360-1350CS |   |   | 50 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-1325PE |   |   | 25 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-1350PE |   |   | 50 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-3025CS |   |  | 25 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-3050CS |   |   | 50 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-3025PE |   |   | 25 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-3050PE |   |   | 50 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-6025CS |   |  | 25 µm       | Ceramic |  |  |          |  |
| <b>NEW</b> S13360-6050CS |   |   | 50 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-6025PE |   |   | 25 µm       |         |  |  |          |  |
| <b>NEW</b> S13360-6050PE |   |   | 50 µm       |         |  |  |          |  |

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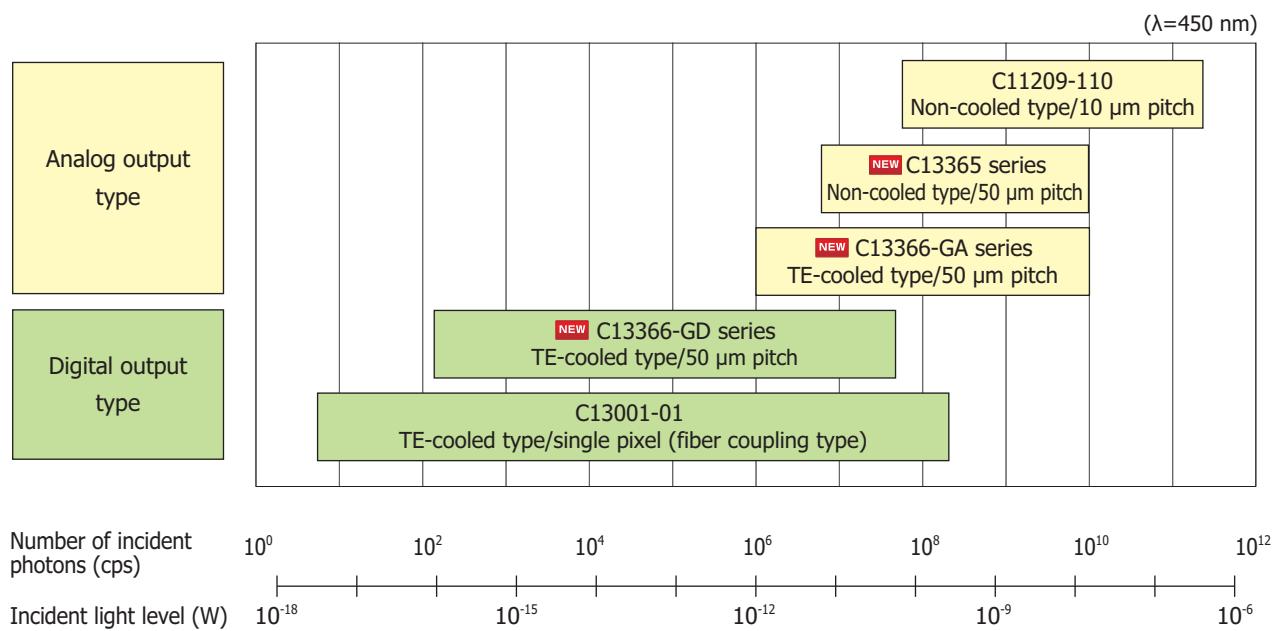
# MPPC® module



Hamamatsu provides a full lineup of MPPC modules capable of measuring light over a wide range (10 orders of magnitude) from the photon counting region to nW (nanowatt) region. The modules contain an amplifier, a temperature-compensation circuit, a high-voltage power supply circuit, and other components needed for MPPC operation. You can use them simply by connecting them to a power supply (e.g.,  $\pm 5$  V). 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. We can also provide custom products that meet customers' specifications.

## ➤ 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.



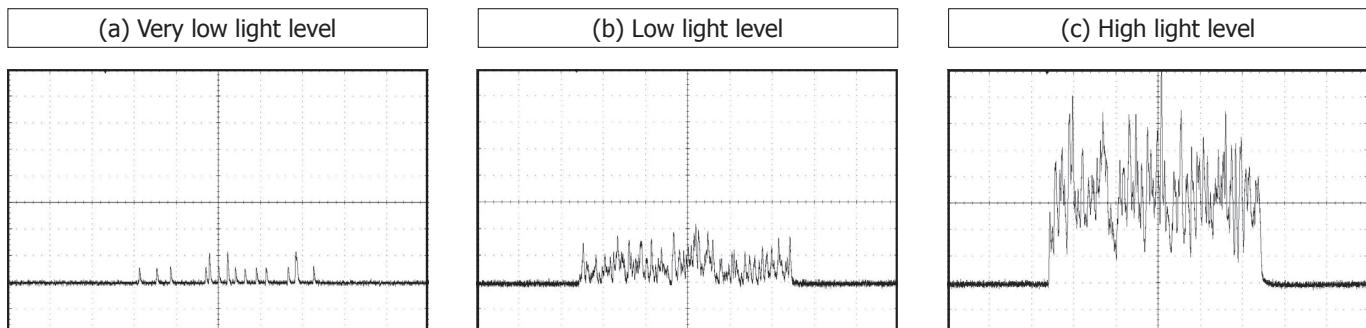
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## ➤ Selecting the digital output type or analog output type

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) 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.

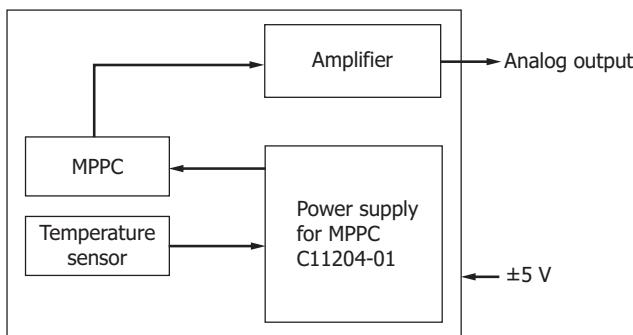
As the light level increases, the output waveform consists of pulses overlapping each other [Figures (b) and (c)]. In this state, the number of pulses cannot be counted and the analog output type should be selected to measure the analog output and find the average value. The detection limit in the analog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

## ➤ Pulse waveform comparison (typical example)



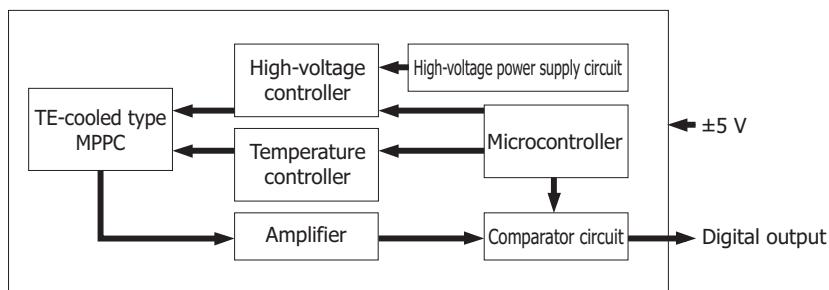
**Block diagram**

Analog output type (C13365-1350SA)



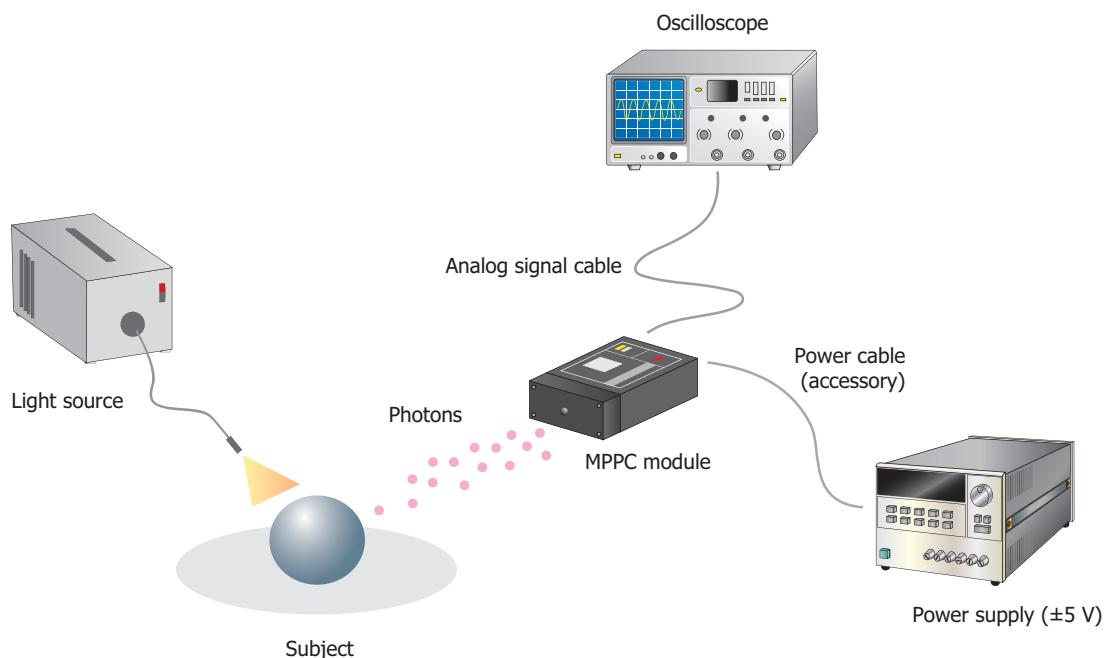
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Digital output type (C13366-1350GD)



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**Connection example (C13366-1350GA)**

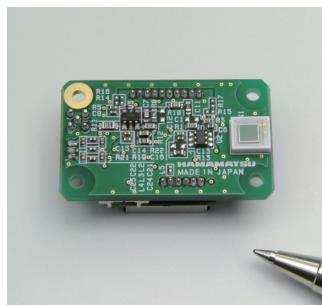


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# MPPC module

**NEW** C13365 series

Analog output



## Features

- **NEW** Built-in MPPC for precision measurement
- High sensitivity in the short wavelength range
- Low noise equivalent power
- Built-in temperature compensation function
- Compact and lightweight

## Applications

- Flow cytometry
- Low-level light measurement
- Fluorescence measurement

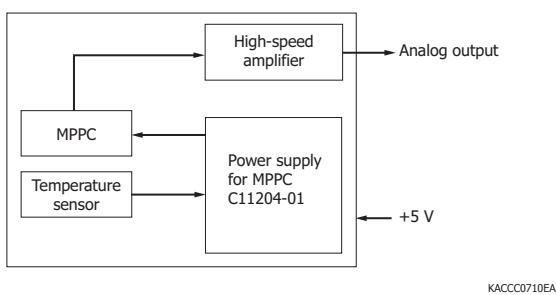
## Absolute maximum ratings

| Parameter             | Symbol           | Condition       | Value      |  |  | Unit |
|-----------------------|------------------|-----------------|------------|--|--|------|
| Supply voltage        | V <sub>s</sub>   |                 | $\pm 6$    |  |  | V    |
| Operating temperature | T <sub>opr</sub> | No condensation | -10 to +40 |  |  | °C   |
| Storage temperature   | T <sub>stg</sub> | No condensation | -20 to +70 |  |  | °C   |

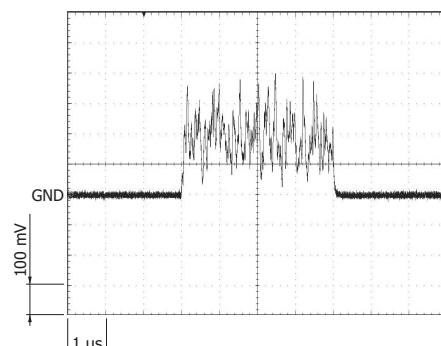
## Specifications (Typ. Ta=25 °C, λ=λ<sub>p</sub>, V<sub>s</sub>=±5 V, unless otherwise noted)

| Parameter   | Symbol         | Condition          | C13365-1350SA  |      |      | C13365-3050SA |      |      | Unit                 |
|---|----------------|--------------------|----------------|------|------|---------------|------|------|----------------------|
|   |                |                    | Min.           | Typ. | Max. | Min.          | Typ. | Max. |                      |
| Spectral response range                           | λ              |                    | 320 to 900     |      |      | 320 to 900    |      |      | nm                   |
| Peak sensitivity wavelength                       | λ <sub>p</sub> |                    | 500            |      |      | 500           |      |      | nm                   |
| Effective photosensitive area                     | -              |                    | 1.3 × 1.3      |      |      | 3.0 × 3.0     |      |      | mm                   |
| Pixel pitch                                       | -              |                    | 50             |      |      | 50            |      |      | μm                   |
| Number of pixels                                  | -              |                    | 667            |      |      | 3600          |      |      | -                    |
| Output voltage stability depending on temperature | -              | Ta=25 ± 10 °C      | -              | -    | ±5   | -             | -    | ±5   | %                    |
| Photoelectric conversion sensitivity              | -              |                    | 0.7            | 1.0  | 1.3  | 0.7           | 1.0  | 1.3  | ×10 <sup>9</sup> V/W |
| Cutoff frequency                                  | fc             | High band<br>-3 dB | 5              | 7    | -    | 5             | 7    | -    | MHz                  |
| Low band  |                |                    | DC             |      |      | DC            |      |      | -                    |
| Noise equivalent power                            | NEP            | Dark state         | -              | 0.7  | 1.4  | -             | 1.6  | 3.2  | fW/Hz <sup>1/2</sup> |
| Minimum detection limit                           | -              | Dark state         | -              | 2    | 4    | -             | 4.5  | 9    | pW.r.m.s.            |
| Maximum output voltage                            | -              |                    | 4.9            |      |      | 4.9           |      |      | V                    |
| Dimensions (W × D × H)                            | -              |                    | 36 × 22 × 12.9 |      |      |               |      |      | mm                   |

## Block diagram



## Analog output waveforms



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# MPPC module

## NEW C13366-GA series

Analog output



### Features

- Built-in TE-cooled MPPC  
(built-in NEW MPPC for precision measurement)
- High sensitivity in the short wavelength range
- Low noise equivalent power
- Built-in temperature control function

### Applications

- Low-level light measurement
- Laser microscope
- Flow cytometry
- Fluorescence measurement

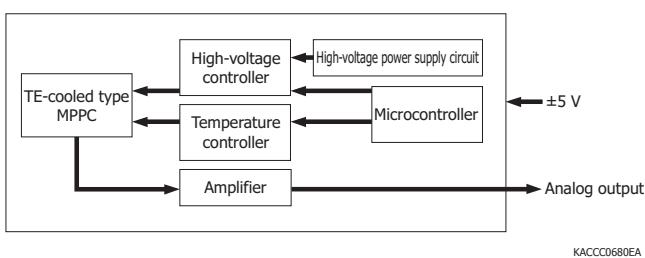
### Absolute maximum ratings

| Parameter             | Symbol           | Condition       | Value      |  |  | Unit |
|-----------------------|------------------|-----------------|------------|--|--|------|
| Supply voltage        | V <sub>s</sub>   |                 | $\pm 6$    |  |  | V    |
| Operating temperature | T <sub>opr</sub> | No condensation | -10 to +40 |  |  | °C   |
| Storage temperature   | T <sub>stg</sub> | No condensation | -20 to +70 |  |  | °C   |

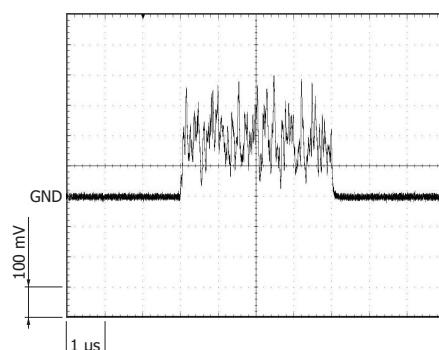
### Specifications (Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

| Parameter                                    | Symbol         | Condition  | C13366-1350GA |      |      | C13366-3050GA |      |      | Unit                 |
|--|----------------|------------|---------------|------|------|---------------|------|------|----------------------|
|  |                |            | Min.          | Typ. | Max. | Min.          | Typ. | Max. |                      |
| Spectral response range                      | λ              |            | 320 to 900    |      |      | 320 to 900    |      |      | nm                   |
| Peak sensitivity wavelength                  | λ <sub>p</sub> |            | 500           |      |      | 500           |      |      | nm                   |
| Effective photosensitive area                | -              |            | 1.3 × 1.3     |      |      | 3.0 × 3.0     |      |      | mm                   |
| Pixel pitch                                  | -              |            | 50            |      |      | 50            |      |      | μm                   |
| Number of pixels                             | -              |            | 667           |      |      | 3600          |      |      | -                    |
| Element temperature<br>(setting temperature) | T <sub>d</sub> |            | -20           |      |      | -20           |      |      | °C                   |
| Photoelectric conversion sensitivity         | -              |            | 0.7           | 1.0  | 1.3  | 0.7           | 1.0  | 1.3  | $\times 10^9$ V/W    |
| Cutoff frequency                             | fc             | -3 dB      | 5             | 7    | -    | 5             | 7    | -    | MHz                  |
| High band<br>Low band                        |                |            | DC            |      |      | DC            |      |      | -                    |
| Noise equivalent power                       | NEP            | Dark state | -             | 0.15 | 0.3  | -             | 0.3  | 0.6  | fW/Hz <sup>1/2</sup> |
| Minimum detection limit                      | -              | Dark state | -             | 0.4  | 0.8  | -             | 0.8  | 1.6  | pW.r.m.s.            |
| Maximum output voltage                       | -              |            | 4.9           |      |      | 4.9           |      |      | V                    |
| Dimensions (W × D × H)                       | -              |            | 98 × 60 × 35  |      |      |               |      |      | mm                   |

### Block diagram



### Analog output waveforms



# MPPC module

Digital output

## NEW C13366-GD series



### Features

- Built-in TE-cooled MPPC  
(**NEW** built-in MPPC for precision measurement)
- High sensitivity in the short wavelength range
- Low crosstalk
- Low dark count
- Low afterpulses

### Applications

- Low-level light measurement
- Flow cytometry
- Fluorescence measurement

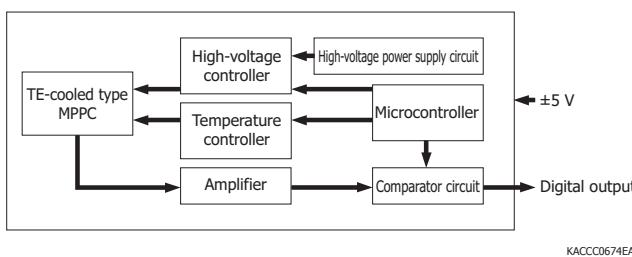
### Absolute maximum ratings

| Parameter             | Symbol           | Condition       | Value      |  |  | Unit |
|-----------------------|------------------|-----------------|------------|--|--|------|
| Supply voltage        | V <sub>s</sub>   |                 | $\pm 6$    |  |  | V    |
| Operating temperature | T <sub>opr</sub> | No condensation | -10 to +40 |  |  | °C   |
| Storage temperature   | T <sub>stg</sub> | No condensation | -20 to +70 |  |  | °C   |

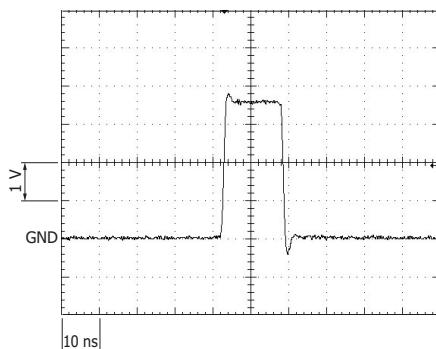
### Specifications (Typ. Ta=25 °C, λ=λ<sub>p</sub>, V<sub>s</sub>=±5 V, unless otherwise noted)

| Parameter                                 | Symbol         | Condition                 | C13366-1350GD                     |      |      | C13366-3050GD |      |      | Unit |
|---|----------------|---------------------------|-----------------------------------|------|------|---------------|------|------|------|
|   |                |                           | Min.                              | Typ. | Max. | Min.          | Typ. | Max. |      |
| Spectral response range                   | λ              |                           | 320 to 900                        |      |      | 320 to 900    |      |      | nm   |
| Peak sensitivity wavelength               | λ <sub>p</sub> |                           | 450                               |      |      | 450           |      |      | nm   |
| Effective photosensitive area             | -              |                           | 1.3 × 1.3                         |      |      | 3.0 × 3.0     |      |      | mm   |
| Pixel pitch                               | -              |                           | 50                                |      |      | 50            |      |      | μm   |
| Number of pixels                          | -              |                           | 667                               |      |      | 3600          |      |      | -    |
| Element temperature (setting temperature) | T <sub>d</sub> |                           | -20                               |      |      | -20           |      |      | °C   |
| Photon detection efficiency               | PDE            | Threshold level: 0.5 p.e. | 40                                |      |      | 40            |      |      | %    |
| Dark count                                | -              | Threshold level: 0.5 p.e. | -                                 | 2.5  | 10   | -             | 15   | 50   | kcps |
| Comparator output                         | -              |                           | TTL compatible                    |      |      |               |      |      | -    |
| Afterpulse probability                    | -              | 100 ns to 500 ns          | -                                 | 0.1  | -    | -             | 0.1  | -    | %    |
| Crosstalk probability                     | -              |                           | -                                 | 1    | -    | -             | 3    | -    | %    |
| Comparator threshold level                | -              |                           | 0.5 to 8.5 (9 levels, adjustable) |      |      |               |      |      | p.e. |
| Dimensions (W × D × H)                    | -              |                           | 98 × 60 × 35                      |      |      |               |      |      | mm   |

### Block diagram



### Digital output waveform



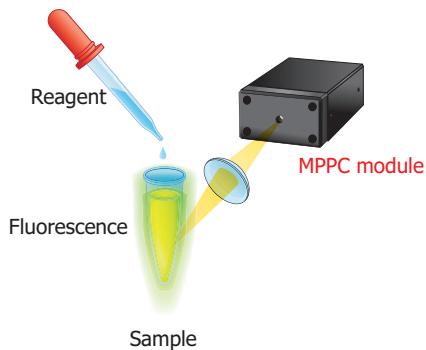
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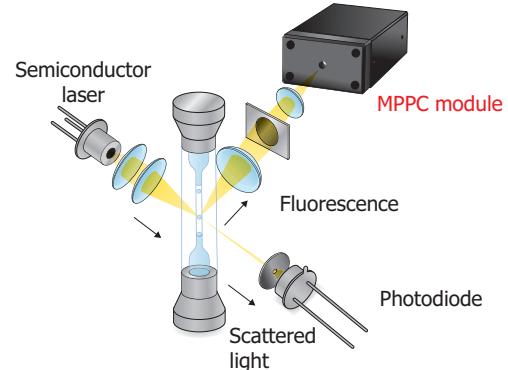
# MPPC® and MPPC® module for precision measurement

## Application examples of MPPC module

### Fluorescence measurement



### Flow cytometry



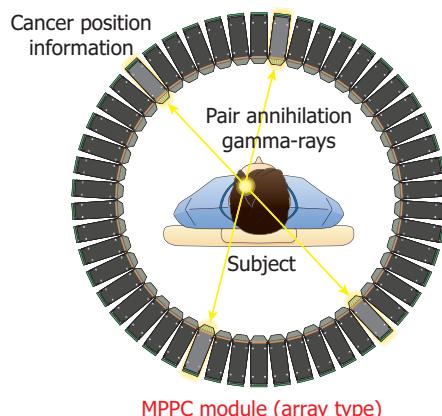
**Major characteristics** High photon detection efficiency, low afterpulse

**Suitable MPPC modules** C13366-1350GA, C13366-3050GA  
C13366-1350GD, C13366-3050GD

**Major characteristics** Wide dynamic range, High photon detection efficiency

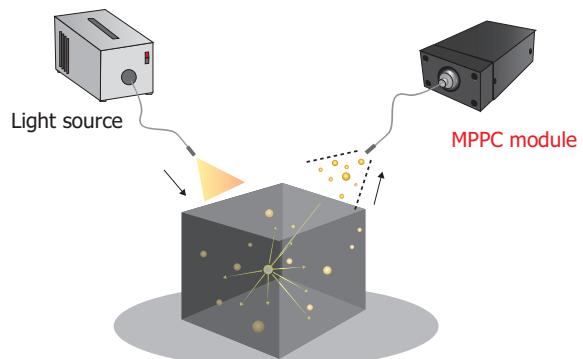
**Suitable MPPC modules** C13365-1350SA, C13365-3050SA  
C13366-1350GA, C13366-3050GA

### Scintillation measurement



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### Particle diameter measurement



KACCC0764EA

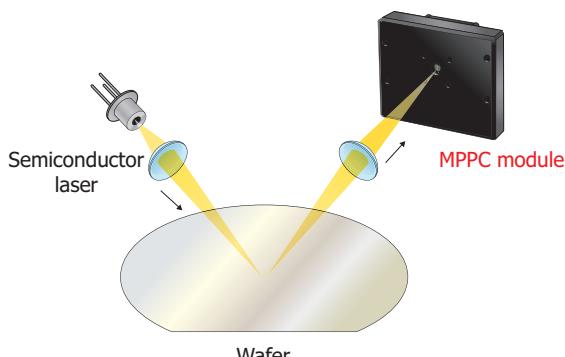
**Major characteristics** Wide dynamic range

**Suitable MPPC modules** C13365-1350SA, C13365-3050SA

**Major characteristics** Low dark count, low afterpulse

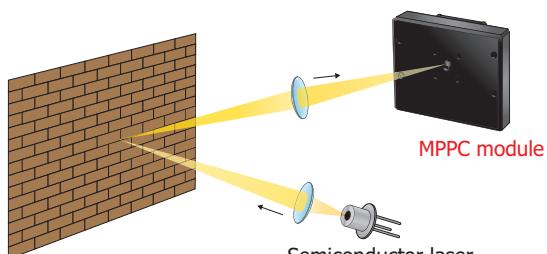
**Suitable MPPC modules** C13001-01

### Wafer surface inspection



KACCC0665EA

### Distance measurement



KACCC0666EA

**Major characteristics** High-speed response, wide dynamic range

**Suitable MPPC modules** C11209-110

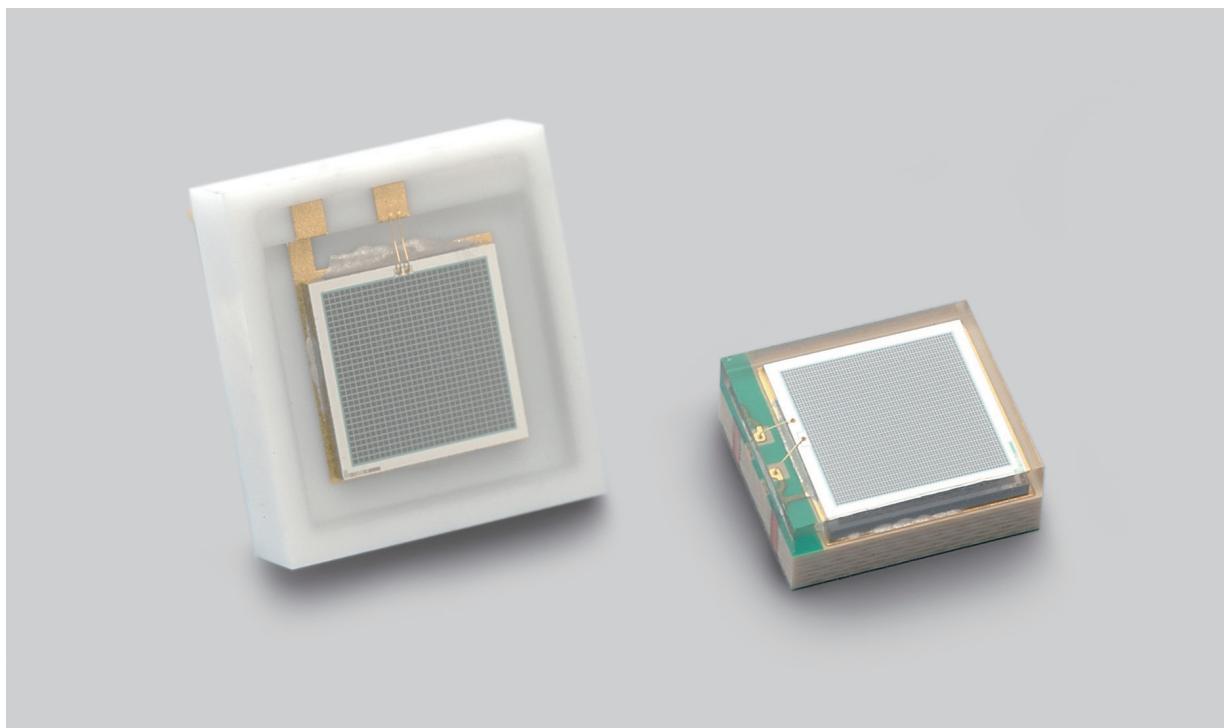
**Major characteristics** High-speed response, wide dynamic range

**Suitable MPPC modules** C11209-110

# MPPC®

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MPPC for precision measurement



# MPPC for precision measurement

## NEW S13360 series

The S13360 series are MPPCs for precision measurement that inherit the high photon detection efficiency of their predecessors and at the same time provide lower crosstalk, lower afterpulse, and lower dark count. They are suitable for precision measurement, such as flow cytometry, DNA sequencer, laser microscope, and fluorescence measurement, that requires low noise characteristics. They are available in two types: ceramic package and surface mount.

### Pixel pitch: 25 µm

**S13360-1325CS, S13360-3025CS, S13360-6025CS**

**S13360-1325PE, S13360-3025PE, S13360-6025PE**

#### Structure

| Parameter                     | S13360         |           |           |               |           |           | Unit |
|-------------------------------|----------------|-----------|-----------|---------------|-----------|-----------|------|
|                               | -1325CS        | -3025CS   | -6025CS   | -1325PE       | -3025PE   | -6025PE   |      |
| Effective photosensitive area | 1.3 × 1.3      | 3.0 × 3.0 | 6.0 × 6.0 | 1.3 × 1.3     | 3.0 × 3.0 | 6.0 × 6.0 | mm   |
| Number of pixels              | 2668           | 14400     | 57600     | 2668          | 14400     | 57600     | -    |
| Package                       | Ceramic        |           |           | Surface mount |           |           | -    |
| Window material               | Silicone resin |           |           | Epoxy resin   |           |           | -    |
| Window refractive index       | 1.41           |           |           | 1.55          |           |           | -    |
| Fill factor                   |                |           | 47        |               |           |           | %    |

#### Absolute maximum ratings

| Parameter               | Symbol | S13360  |         |         |         |         |         | Unit |
|-------------------------|--------|---------|---------|---------|---------|---------|---------|------|
|                         |        | -1325CS | -3025CS | -6025CS | -1325PE | -3025PE | -6025PE |      |
| Operating temperature*1 | Topr   | -20     | to +40  |         |         | -0      | to +40  | °C   |
| Storage temperature*1   | Tstg   |         |         | -20     | to +60  |         |         | °C   |

#### Electrical and optical characteristics (Typ. Ta=25 °C, V=Vop, unless otherwise noted)

| Parameter  | Symbol          | S13360             |                       |                    |              | Unit  |
|--|-----------------|--------------------|-----------------------|--------------------|--------------|-------|
|  |                 | -1325CS<br>-1325PE | -3025CS<br>-3025PE    | -6025CS<br>-6025PE |              |       |
| Spectral response range                                  | λ               |                    | 320 to 900            |                    |              | nm    |
| Peak sensitivity wavelength                              | λp              |                    | 450                   |                    |              | nm    |
| Photon detection efficiency ( $\lambda=\lambda p$ )*2    | PDE             |                    | 25                    |                    |              | %     |
| Dark count*3   | Typ.<br>Max.    | -                  | 70<br>210             | 400<br>1200        | 1600<br>5000 | kcps  |
| Crosstalk probability                                    | -               | 2                  | 5                     | -                  |              | %     |
| Terminal capacitance                                     | Ct              | 60                 | 320                   | 1280               |              | pF    |
| Gain   | M               |                    | 7.0 × 10 <sup>5</sup> |                    |              | -     |
| Breakdown voltage  | V <sub>BR</sub> |                    | 53 ± 5                |                    |              | V     |
| Recommended operating voltage                            | V <sub>op</sub> |                    | V <sub>BR</sub> + 5   |                    |              | V     |
| Temperature coefficient at recommended operating voltage | -               |                    | 54                    |                    |              | mV/°C |

\*1: No condensation \*2: Detection coefficient does not include crosstalk or afterpulses. \*3: Threshold=0.5 p.e.

## Pixel pitch: 50 µm

**S13360-1350CS, S13360-3050CS, S13360-6050CS**

**S13360-1350PE, S13360-3050PE, S13360-6050PE**

### Structure

| Parameter                     | S13360         |           |           |               |           |           | Unit |
|-------------------------------|----------------|-----------|-----------|---------------|-----------|-----------|------|
|                               | -1350CS        | -3050CS   | -6050CS   | -1350PE       | -3050PE   | -6050PE   |      |
| Effective photosensitive area | 1.3 × 1.3      | 3.0 × 3.0 | 6.0 × 6.0 | 1.3 × 1.3     | 3.0 × 3.0 | 6.0 × 6.0 | mm   |
| Number of pixels              | 667            | 3600      | 14400     | 667           | 3600      | 14400     | -    |
| Package                       | Ceramic        |           |           | Surface mount |           |           | -    |
| Window material               | Silicone resin |           |           | Epoxy resin   |           |           | -    |
| Window refractive index       | 1.41           |           |           | 1.55          |           |           | -    |
| Fill factor                   |                |           | 74        |               |           |           | %    |

### Absolute maximum ratings

| Parameter               | Symbol | S13360  |         |         |         |         |         | Unit |
|-------------------------|--------|---------|---------|---------|---------|---------|---------|------|
|                         |        | -1350CS | -3050CS | -6050CS | -1350PE | -3050PE | -6050PE |      |
| Operating temperature*1 | Topr   | -20     | to +40  |         |         | -0      | to +40  | °C   |
| Storage temperature*1   | Tstg   |         |         | -20     | to +60  |         |         | °C   |

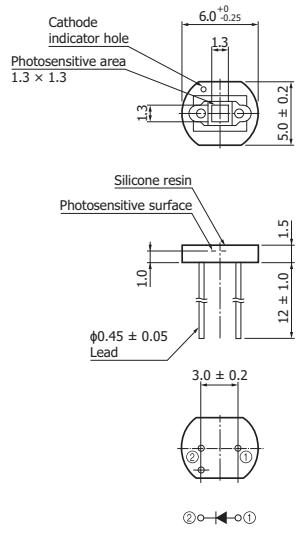
### Electrical and optical characteristics (Typ. Ta=25 °C, V=Vop, unless otherwise noted)

| Parameter  | Symbol          | S13360             |                       |                    |  | Unit  |
|--|-----------------|--------------------|-----------------------|--------------------|--|-------|
|  |                 | -1350CS<br>-1350PE | -3050CS<br>-3050PE    | -6050CS<br>-6050PE |  |       |
| Spectral response range                                  | λ               |                    | 320 to 900            |                    |  | nm    |
| Peak sensitivity wavelength                              | λp              |                    | 450                   |                    |  | nm    |
| Photon detection efficiency ( $\lambda=\lambda p$ )*2    | PDE             |                    | 40                    |                    |  | %     |
| Dark count*3   | Typ.            | 90                 | 500                   | 2000               |  | kcps  |
|  | Max.            | 270                | 1500                  | 6000               |  |       |
| Crosstalk probability                                    | -               | 1                  | 3                     | -                  |  | %     |
| Terminal capacitance                                     | Ct              | 60                 | 320                   | 1280               |  | pF    |
| Gain   | M               |                    | 1.7 × 10 <sup>6</sup> |                    |  | -     |
| Breakdown voltage  | V <sub>BR</sub> |                    | 53 ± 5                |                    |  | V     |
| Recommended operating voltage                            | V <sub>op</sub> |                    | V <sub>BR</sub> + 3   |                    |  | V     |
| Temperature coefficient at recommended operating voltage | -               |                    | 54                    |                    |  | mV/°C |

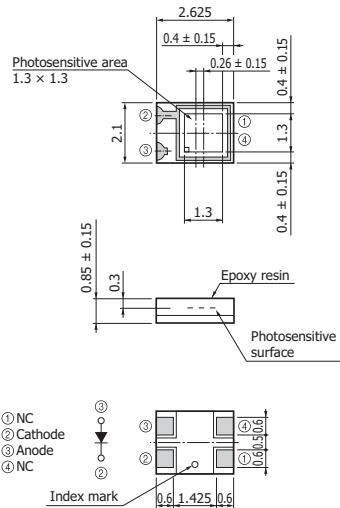
\*1: No condensation \*2: Detection coefficient does not include crosstalk or afterpulses. \*3: Threshold=0.5 p.e.

**Dimensional outline (unit: mm)**

S13360-1325CS/-1350CS

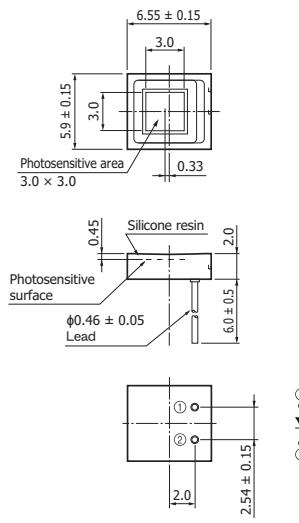


S13360-1325PE/-1350PE

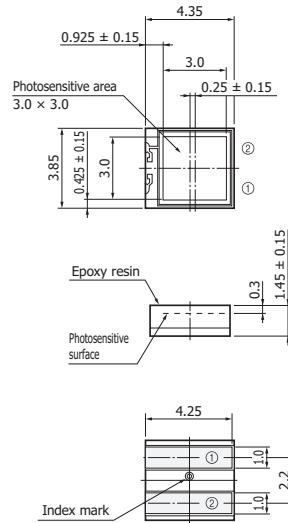


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S13360-3025CS/-3050CS

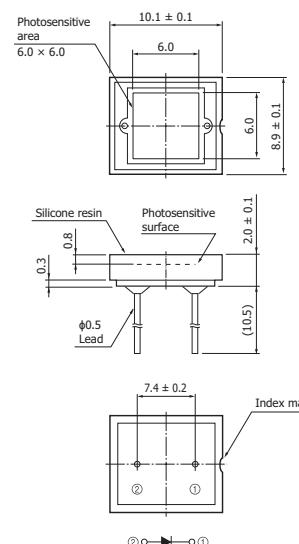


S13360-3025PE/-3050PE

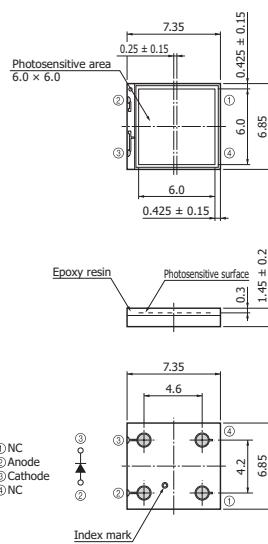


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S13360-6025CS/-6050CS



S13360-6025PE/-6050PE



KAPDA0153EA

# Other MPPC product

## Other MPPC and MPPC module

The product lineup containing MPPCs for general measurement (low afterpulse) is provided below.

### ▷ MPPC modules

| Type no.   | Photo   | Effective photosensitive area                               | Pixel pitch | Temperature control                   | Output  |
|------------|---|---|-------------|---------------------------------------|---------|
| C11209-110 |  | □1.0 mm   | 10 µm       | Temperature compensation (non-cooled) | Analog  |
| C13001-01  |  | Single pixel $\phi 50 \mu\text{m}$<br>(fiber coupling type) |             | TE-cooled (-20 °C)                    | Digital |

### ▷ MPPC array modules

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

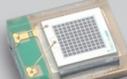
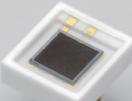
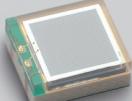
C12677 series: Analog type

C12678 series: Photon counting type

C12679 series: MCA (multi-channel analyzer) type



**▷ MPPC for general measurement**

| Type no.    | Photo   | Photosensitive area | Pixel pitch | Package            |
|-------------|---|---------------------|-------------|--------------------|
| S12571-010C |  | □1.0 mm             | 10 µm       | Ceramic            |
| S12571-015C |   |                     | 15 µm       |                    |
| S12571-010P |  | □1.0 mm             | 10 µm       | Surface mount type |
| S12571-015P |   |                     | 15 µm       |                    |
| S12572-010C |  | □3.0 mm             | 10 µm       | Ceramic            |
| S12572-015C |   |                     | 15 µm       |                    |
| S12572-010P |  | □3.0 mm             | 10 µm       | Surface mount type |
| S12572-015P |   |                     | 15 µm       |                    |

**▷ MPPC arrays (monolithic)**

| Type no.    | Photo   | Photosensitive area per channel | Number of channels | Pixel pitch | Package |
|-------------|---|---------------------------------|--------------------|-------------|---------|
| S12573-025C |  | □3.0 mm                         | 2 × 2 ch           | 25 µm       | Ceramic |
| S12573-050C |   |                                 |                    | 50 µm       |         |

**▷ CSP (chip size package) type**

| Type no.         | Photo   | Photosensitive area per channel | Number of channels | Pixel pitch | Package            | Connector |  |  |
|------------------|---|---------------------------------|--------------------|-------------|--------------------|-----------|--|--|
| S12892PA-50      |  | □2.0 mm                         | 1 ch               | 50 µm       | Surface mount type | -         |  |  |
| S12641PA-50      |  | □3.0 mm                         |                    |             |                    |           |  |  |
| S12894PA-50      |  | □6.0 mm                         |                    |             |                    |           |  |  |
| S12642-0404PA-50 |  | □3.0 mm                         | 4 × 4 ch           |             |                    | -         |  |  |
| S12642-0404PB-50 |   |                                 |                    |             |                    |           |  |  |
| S12642-0808PA-50 |  | □3.0 mm                         | 8 × 8 ch           |             |                    | Yes       |  |  |
| S12642-0808PB-50 |   |                                 |                    |             |                    |           |  |  |

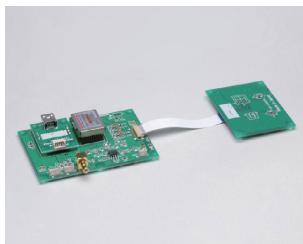
## Related product

### Starter kit for MPPC C12332 series

This is a starter kit for evaluating the MPPC. It consists of a power supply circuit board and a sensor circuit board. The power supply circuit board is equipped with a C11204-01 power supply for MPPC. The sensor circuit board has an MPPC socket with leads, which allows various non-cooled MPPCs to be implemented.

#### Features

- Enables the evaluation of non-cooled MPPCs (sold separately)
- Comes with a socket for an MPPC
- Equipped with a high-accuracy, high-voltage C11204-01 power supply
- Adjustable operating voltage and temperature compensation coefficient
- Selectable amplifier usage
- Load resistance 50 Ω or 1 kΩ selectable
- Analog output



### C11204-01 power supply for MPPC

This is a high voltage power supply that is optimized for driving MPPCs. Since it has a temperature compensation function, MPPCs can be driven stably even in environments subject to temperature changes.

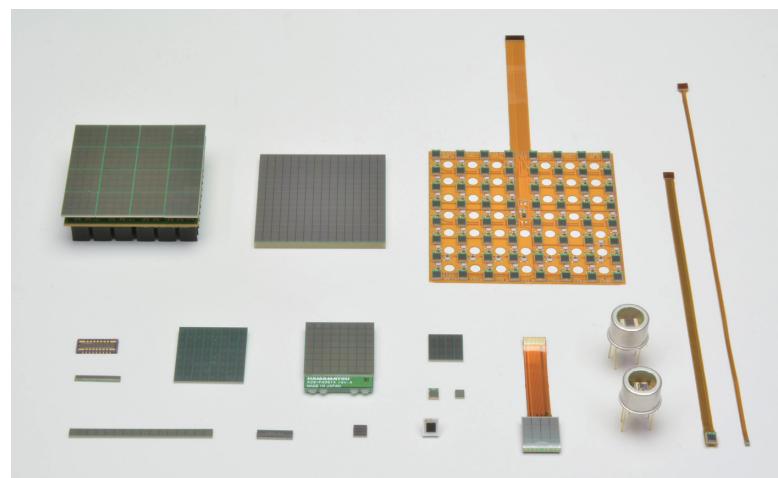
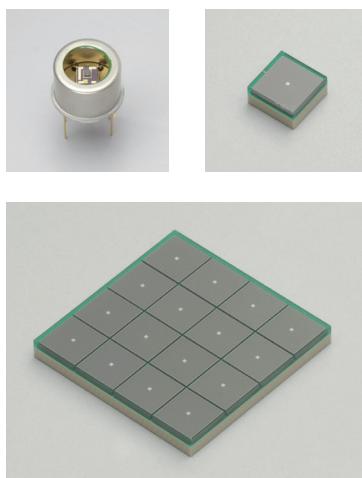
#### Features

- Wide output voltage range: 50 V to 90 V
- Low ripple noise: 0.1 mVp-p typ.
- Superb temperature stability: ±10 ppm/°C typ.
- High resolution settings (1.8 mV resolution)
- Serial interface



### Customized MPPC module

Hamamatsu Photonics can provide the most suitable module product by combining its vast MPPC lineup with optical technologies, circuit technologies, and software technologies. Contact us for detailed information.



## Principle of operation

### 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 an excellent time resolution and a multiplication function having a 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.

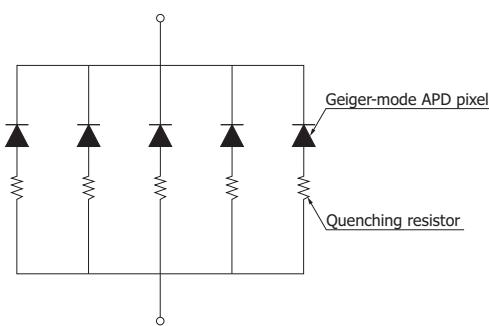
### Geiger mode and quenching resistor

When an APD is operated at a reverse voltage higher than the breakdown voltage, a saturated output inherent to the APD device occurs (Geiger discharge) by input of light regardless of whether the light level is high or low. The condition where an APD operates at this voltage level is called Geiger mode. Geiger mode allows obtaining a large output by way of 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 the 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 [Figure 5].

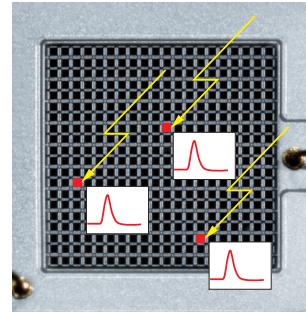
### Structure

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



KAPDC0029EA

### Image of MPPC's photon counting



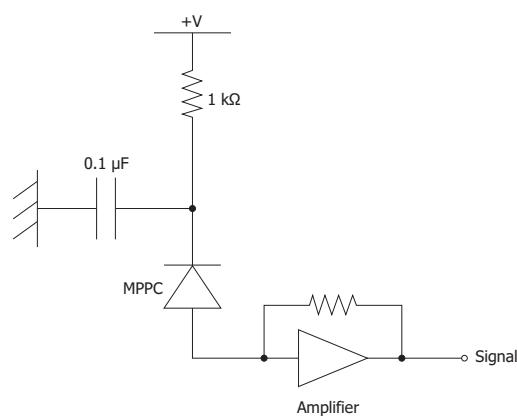
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### Basic operation

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.

### Basic connection diagram



KAPDC0024EB

For the MPPC readout circuit, a current-to-voltage amplifier can be used as with previous semiconductor devices. The MPPC outputs high-speed pulse signals, but because the gain of the MPPC itself is high, there is no need to greatly increase the gain on the circuit side. This has an advantage that there is more freedom in circuit design.

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Information described in this material is current as of March, 2015.

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The product warranty is valid for one year after delivery and is limited to product repair or replacement for defects discovered and reported to us within that one year period. However, even if within the warranty period we accept absolutely no liability for any loss caused by natural disasters or improper product use.

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