HAMAMATSU
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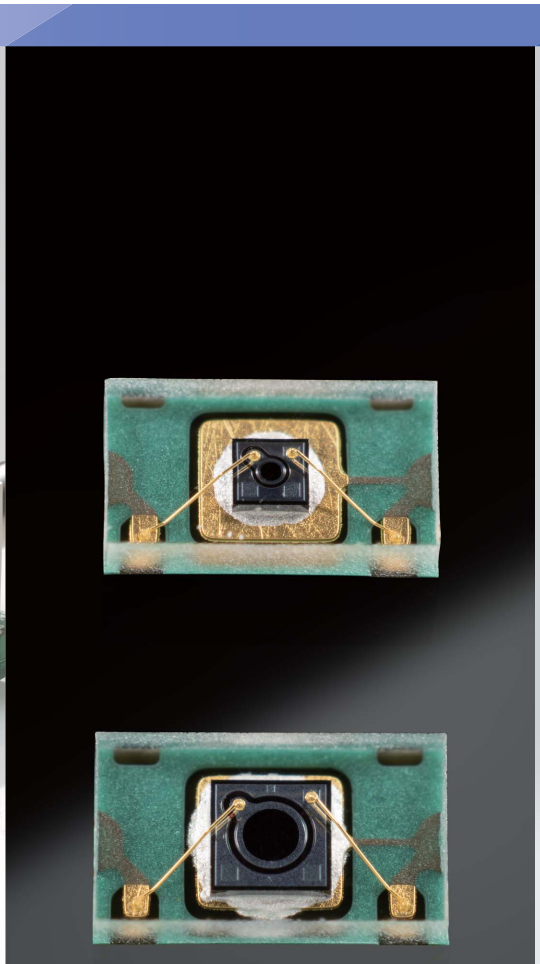
Selection guide - September 2020

Si APD (avalanche photodiode)

High-speed, high sensitivity photodiodes having an internal gain mechanism

■ APD module C10508-01



■ Surface mount type S14645-02, S14645-05

■ Short wavelength type S14124-20

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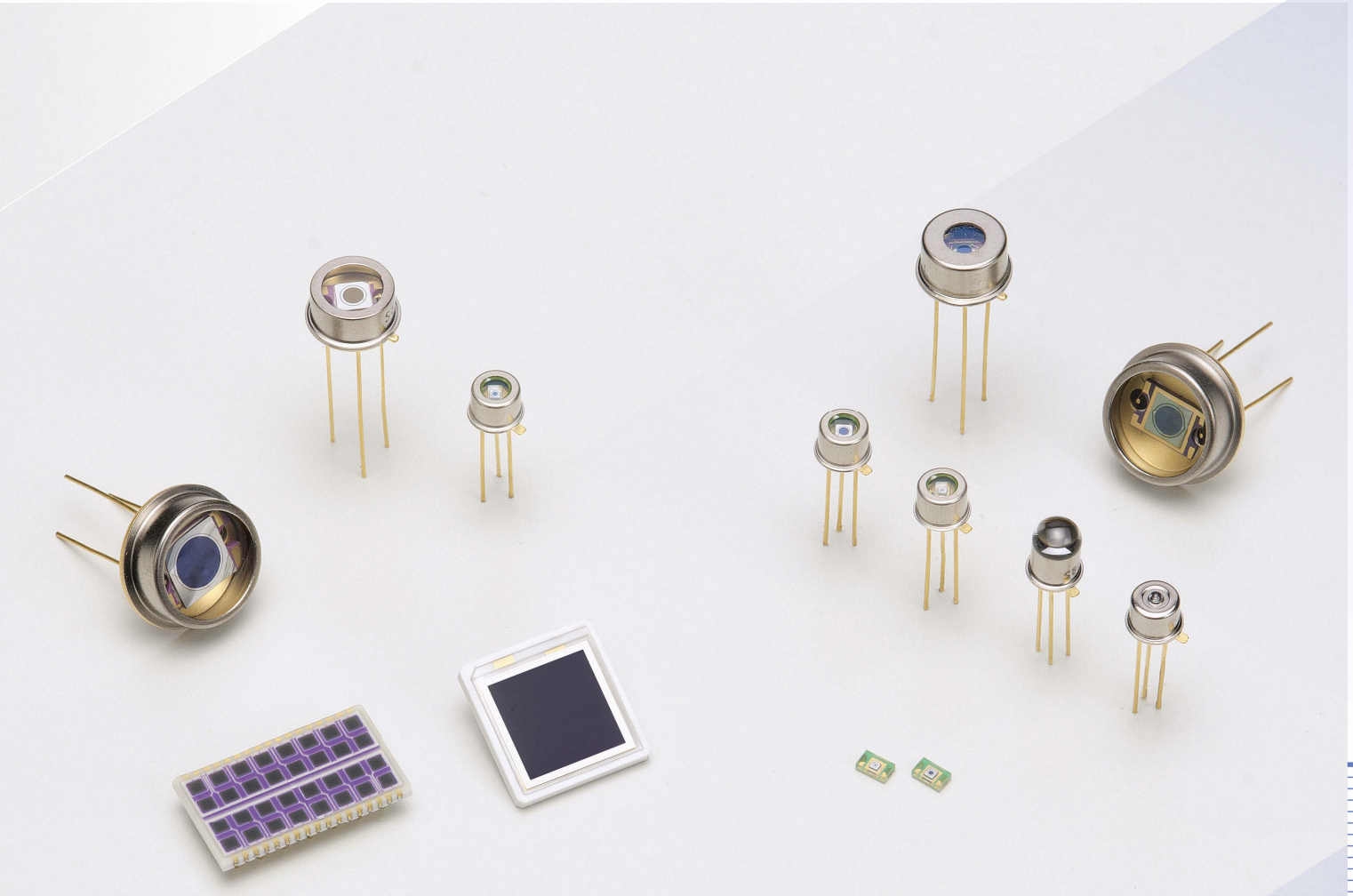
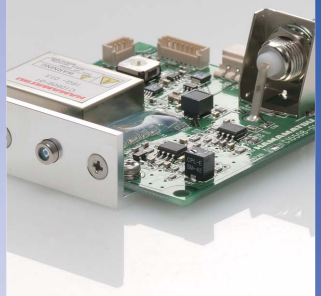
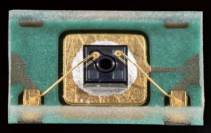
Si APD

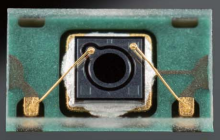
High-speed, high sensitivity photodiodes having an internal gain mechanism

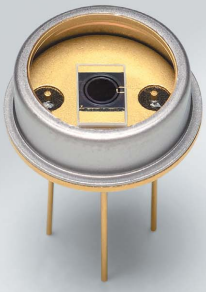


Contents









Si APD (avalanche photodiode)

The APD is a high-speed, high-sensitivity photodiode that internally multiplies photocurrent when reverse voltage is applied. The APD, having a signal multiplication function inside its element, achieves higher S/N than the PIN photodiode and can be used in a wide range of applications such as high-accuracy rangefinders and low-light-level detection that use scintillators. Though the APD can detect lower level light than the PIN photodiode, it does require special care and handling such as the need for higher reverse voltage and more detailed consideration of its temperature-dependent gain characteristics.

Si APD (for general measurement)

Type		Recommended wavelength (nm)	Peak sensitivity wavelength (nm)	Type no.	Package	Features	Applications	Page
Short wavelength type	Low-bias operation	200 to 650	620	S12053 series, etc.	Metal	Enhanced sensitivity in the UV to visible region	· Low-light-level detection · Analytical instruments	5
Short wavelength type	Low terminal capacitance	320 to 650	600	S8664-K series	Metal	Enhanced sensitivity in the UV to visible region	· Low-light-level detection · Analytical instruments	6
Short wavelength type	Low terminal capacitance	320 to 650	600	S8664-55/-1010	Ceramic	Enhanced sensitivity in the UV to visible region	· Low-light-level detection · Analytical instruments	6
Short wavelength type	Low terminal capacitance	320 to 650	600	S8550-02	Ceramic	Enhanced sensitivity in the UV to visible region	· Low-light-level detection · Analytical instruments	6
Near infrared type	Low-bias operation	700 to 900	800	S12023 series, etc.	Metal	Low bias voltage operation	· FSO (free space optics) · Optical fiber communication · Analytical instruments	7
Near infrared type	Low-bias operation	700 to 900	800	S10341-02/-05	Surface mount type	Low bias voltage operation	· FSO (free space optics) · Optical fiber communication · Analytical instruments	7
Near infrared type	Low temperature coefficient	700 to 900	800	S12060 series, etc.	Metal	Low temperature coefficient of the bias voltage, easy gain adjustment	· FSO · Optical fiber communication	8
Near infrared type	800 nm band	700 to 1000	840	S12426-02/-05	Metal	Type with enhanced sensitivity in the 800 nm band (λp=840 nm)	· FSO · Optical fiber communication · Analytical instruments	9
Near infrared type	800 nm band	700 to 1000	840	S12926-02/-05	Surface mount type	Type with enhanced sensitivity in the 800 nm band (λp=840 nm)	· FSO · Optical fiber communication · Analytical instruments	9
Near infrared type	900 nm band	700 to 1000	860	S9251-10/-15 S12092-02/-05	Metal	Type with enhanced sensitivity in the 900 nm band (λp=860 nm)	· FSO · Optical fiber communication · Analytical instruments	10
Near infrared type	900 nm band	800 to 1100	940	S8890-02/-05	Metal	Type with enhanced sensitivity in the 900 nm band (λp=940 nm)	· FSO · Analytical instruments · YAG laser light detection	10
Near infrared type	TE-cooled type	700 to 900	800	S4315 series	Metal	High S/N	· Low-light-level detection	11

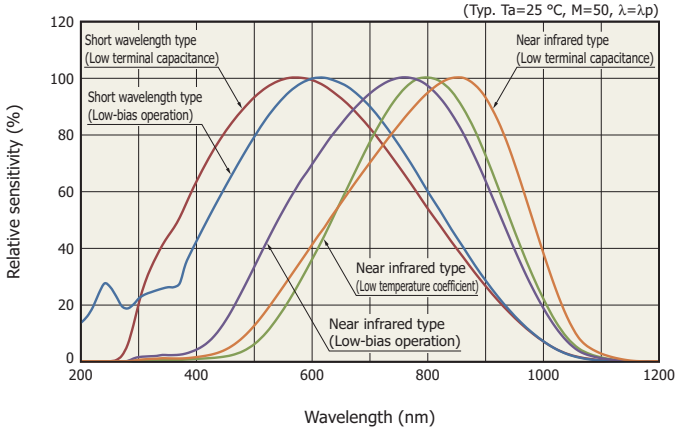
Si APD (for LiDAR)

Type	Recommended wavelength (nm)	Peak sensitivity wavelength (nm)	Type no.	Package	Features	Applications	Page
700 nm band	600 to 800	760	S14643-02	Surface mount type	Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 700 nm band	· LiDAR · Optical rangefinders	12
800 nm band	600 to 800	800	S14644-02/-05	Surface mount type	Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 800 nm band	· LiDAR · Optical rangefinders	12
900 nm band	800 to 1000	840	S14645-02/-05	Surface mount type	Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 900 nm band	· LiDAR · Optical rangefinders	12
900 nm band	810 to 910	900	S14645-02F/-05F	Surface mount type	Type with reduced dark current, expanded operating temperatures, and enhanced sensitivity in the 900 nm band	· LiDAR · Optical rangefinders	12

APD modules

Type	Type no.	Features	Page
Standard type	C12702 series	Contains near infrared type or short wavelength type APD. FC/SMA fiber adapters are also available.	14
High-sensitivity type	C12703 series	High gain type for low-light-level detection	14
High-stability type	C10508-01	Digital temperature compensation type, high stability APD module	15
High-speed type	C5658	Can be used over a wide frequency range (up to 1 GHz)	15

Spectral response (relative values) For the absolute sensitivity values, see the datasheets.



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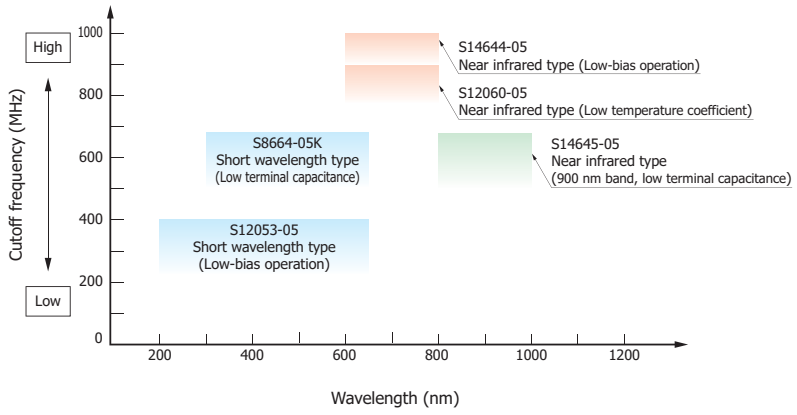
Cutoff frequency vs. recommended wavelength (typical example)



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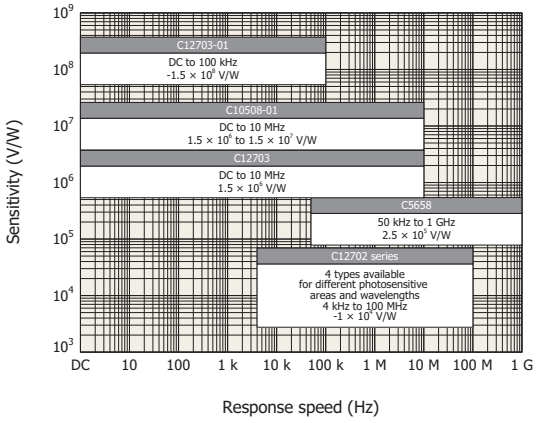
Sensitivity vs. response speed (APD modules)

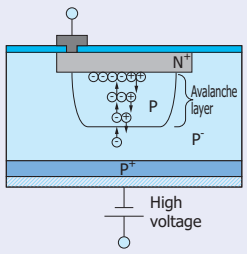


KACCB0355EA

Principle of avalanche multiplication

The photocurrent generation mechanism of the APD is the same as that of a normal photodiode. When light enters a photodiode, electron-hole pairs are generated if the light energy is higher than the band gap energy. The ratio of the number of generated electron-hole pairs to the number of incident photons is defined as the quantum efficiency (QE), expressed in percent (%). The mechanism by which carriers are generated inside an APD is the same as in a photodiode, but the APD is different from a photodiode in that it has a function to multiply the generated carriers. When electron-hole pairs are generated in the depletion layer of an APD with a reverse voltage applied to the PN junction, the electric field causes the electrons to drift toward the N^+ side and the holes to drift toward the P^+ side. The higher the electric field strength, the higher the drift speed of these carriers. However, when the electric field reaches a certain level, the carriers are more likely to collide with the crystal lattice so that the drift speed becomes saturated at a certain speed. If the electric field is increased even further, carriers that escaped the collision with the crystal lattice will have a great deal of energy. When these carriers collide with the crystal lattice, a phenomenon takes place in which new electron-hole pairs are generated. This phenomenon is called ionization. These electron-hole pairs then create additional electron-hole pairs, which generate a chain reaction of ionization.

Principle of APD operation



Generated carriers produce new electron-hole pairs while being accelerated by high electric field. Ionization

Newly generated carriers are also accelerated to produce further electron-hole pairs, and this process repeats itself. Avalanche multiplication

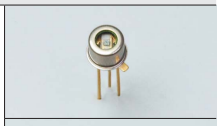
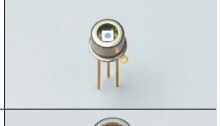
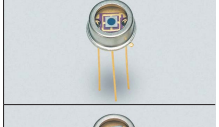
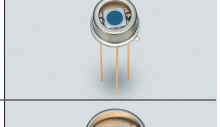
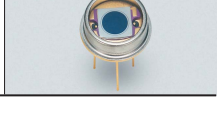
Gain proportional to the applied reverse bias voltage can be obtained.

KAPDC0006ED

Short wavelength type Si APD

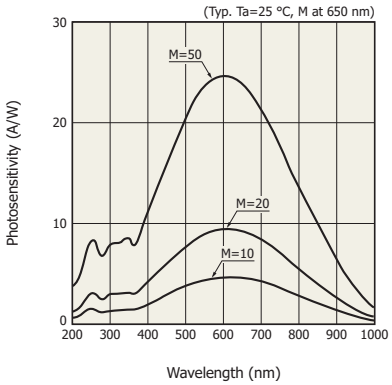
These are short wavelength Si APDs with enhanced sensitivity in the UV to visible region. They offer high gain, high sensitivity, and low noise in the short wavelength region. They are suitable for applications such as low-light-level measurement and analytical instruments.

Low-bias operation

Type no.	Effective photosensitive area*1 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*2 RL=50 Ω (MHz)	Terminal capacitance*2 (pF)	Gain λ=650 nm	Package	
S12053-02	φ0.2	200 to 1000	200	0.14	900	2	50	TO-18	
S12053-05	φ0.5				400	5			
S12053-10	φ1.0				250	15			
S9075	φ1.5				100	30		TO-5	
S5344	φ3.0				25	120			
S5345	φ5.0				8	320		TO-8	

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

Spectral response



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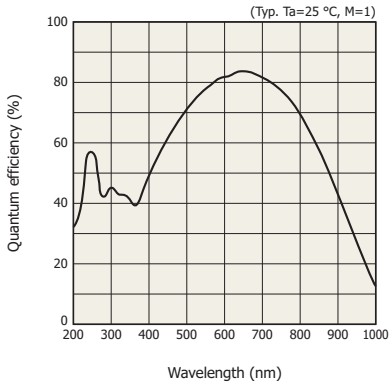
Quantum efficiency vs. wavelength



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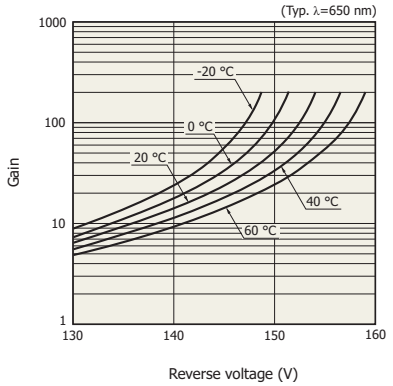
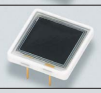
Gain vs. reverse voltage

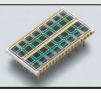


KAPDB0011EC

Low terminal capacitance

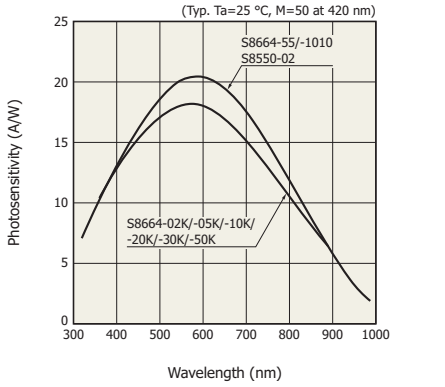
Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain	Package	
S8664-02K	φ0.2	320 to 1000	500	0.78	700	0.8	50 (λ=420 nm)	TO-5	
S8664-05K	φ0.5				680	1.6			
S8664-10K	φ1.0				530	4			
S8664-20K	φ2.0				280	11			
S8664-30K	φ3.0				140	22		TO-8	
S8664-50K	φ5.0				60	55			
S8664-55	5 × 5				40	80		Ceramic	
S8664-1010	10 × 10				11	270			
NEW S14124-20	φ2.0	266			250	11	50 to 400 (λ=266 nm)	TO-8	

4 × 8 element array

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=420 nm	Package	
S8550-02	1.6 × 1.6 (× 32 elements)	320 to 1000	500	0.78	250	9 (per element)	50	Ceramic	

*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

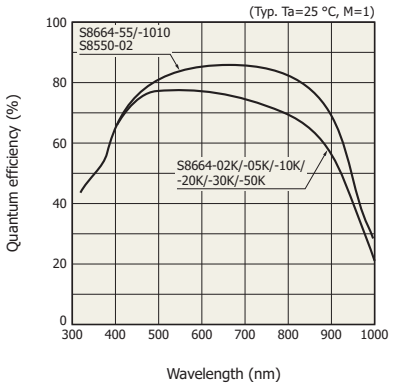
Spectral response



KAPDB0073EE

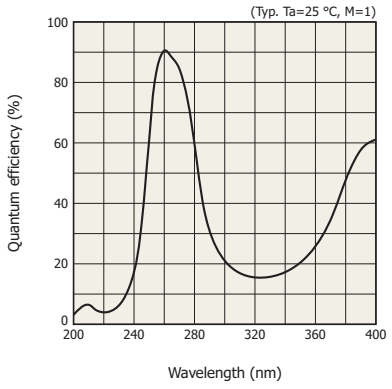
Quantum efficiency vs. wavelength

[S8664 series, S8550-02]



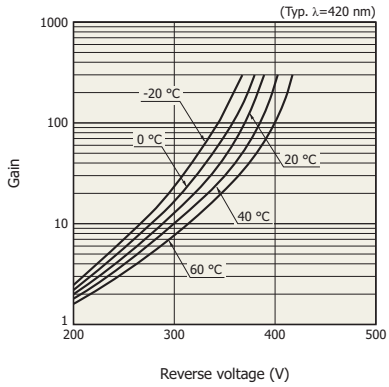
KAPDB0125EC

[S14124-20]



KAPDB0568EB

Gain vs. reverse voltage

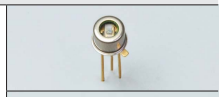
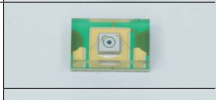
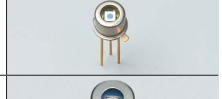
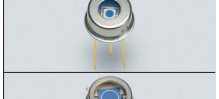
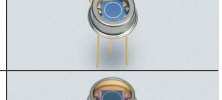
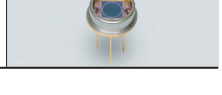


KAPDB0076EB

Near infrared type Si APD

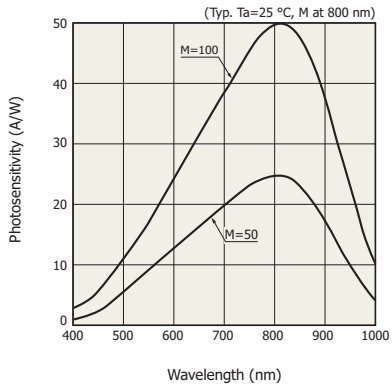
Low-bias operation

These are near infrared Si APDs that operate with low bias voltage. Since high gain can be attained with a bias voltage of 200 V or less, they are suitable for applications such as FSO and optical fiber communication.

Type no.	Effective photosensitive area*1 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*2 RL=50 Ω (MHz)	Terminal capacitance*2 (pF)	Gain λ=800 nm	Package	
S12023-02	φ0.2	400 to 1000	200	0.65	1000	1	100	TO-18	
S12023-05	φ0.5				900	2			
S10341-02	φ0.2				1000	1		Plastic	
S10341-05	φ0.5				900	2			
S12051					900			TO-18	
S12086									
S12023-10	φ1.0				600	6			
S12023-10A									
S3884	φ1.5				400	10	100	TO-5	
S2384	φ3.0				120	40	60		
S2385	φ5.0				40	95	40	TO-8	

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

Spectral response



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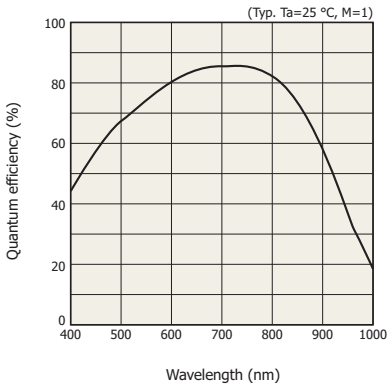
Quantum efficiency vs. wavelength



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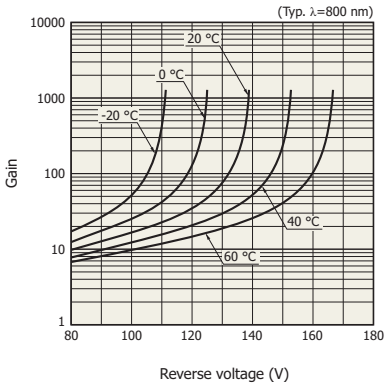
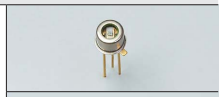
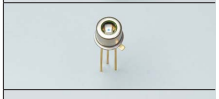
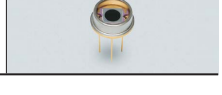
Gain vs. reverse voltage



KAPDB0017EC

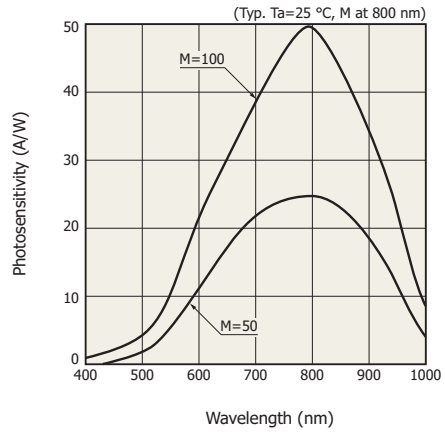
Low temperature coefficient

These are near infrared Si APDs featuring low temperature coefficient of the bias voltage. They produce stable gain over a wide temperature range. They are suitable for applications such as FSO and optical fiber communication.

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=800 nm	Package	
S12060-02	ϕ0.2	400 to 1000	300	0.4	1000	1	100	TO-18	
S12060-05	ϕ0.5				900	2.5			
S12060-10	ϕ1.0				600	6			
S6045-04	ϕ1.5				350	12	100	TO-5	
S6045-05	ϕ3.0				80	50	60		
S6045-06	ϕ5.0				35	120	40	TO-8	

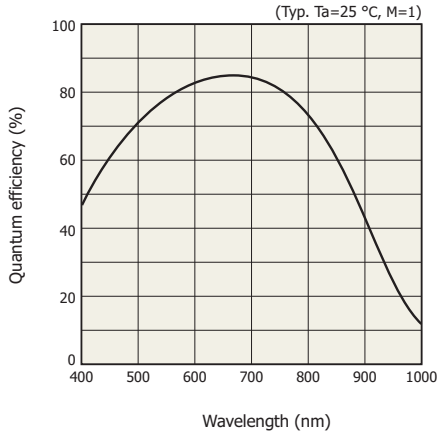
*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

Spectral response



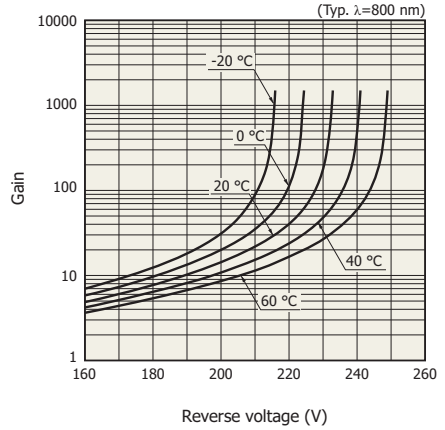
KAPDB0026EB

Quantum efficiency vs. wavelength



KAPDB0027EB

Gain vs. reverse voltage



KAPDB0029ED

800 nm band

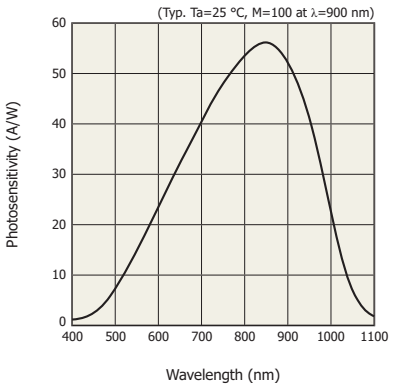
These are Si APDs with enhanced sensitivity in the 800 nm band in near infrared region. They are suitable for applications such as FSO, optical fiber communications, and analytical instruments.

Type no.	Effective photosensitive area*1 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*2 RL=50 Ω (MHz)	Terminal capacitance*2 (pF)	Gain λ=900 nm	Package	
S12426-02	φ0.2	400 to 1100	200	1.1	650	0.5	100	TO-18	
S12426-05	φ0.5				600	1.1			
S12926-02	φ0.2	400 to 1150	160		650	0.6		Plastic	
S12926-05	φ0.5				600	1.3			

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table

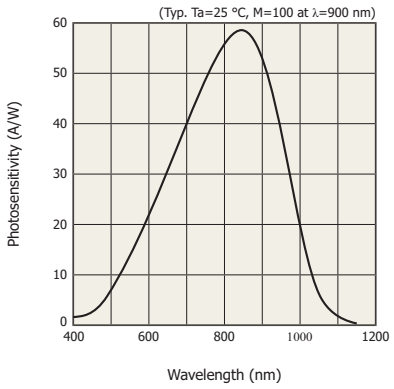
Spectral response

[S12426 series]



KAPDB0297EE

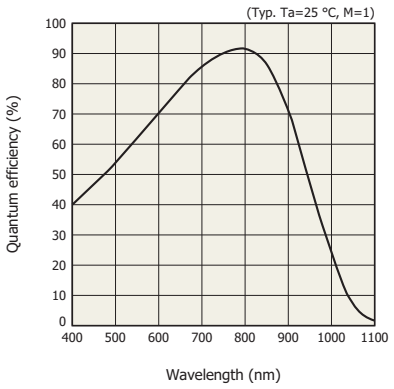
[S12926 series]



KAPDB0267EA

Quantum efficiency vs. wavelength

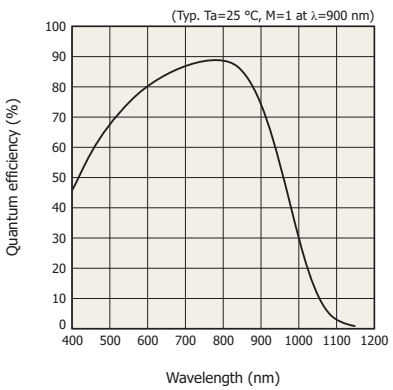
[S12426 series]



KAPDB0277EB

Quantum efficiency vs. wavelength

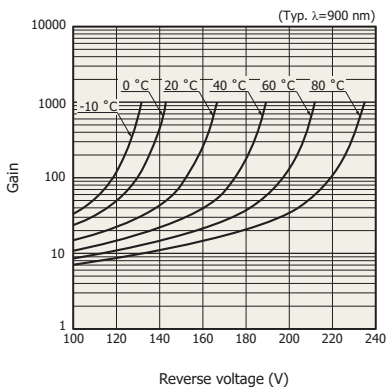
[S12926 series]



KAPDB0605EA

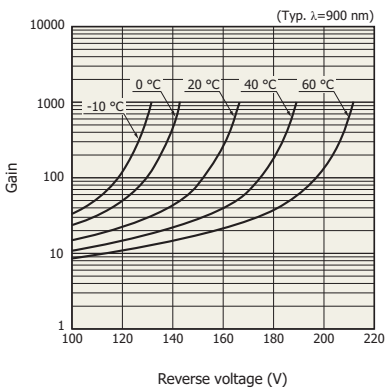
Gain vs. reverse voltage

[S12426 series]



KAPDB0271EA

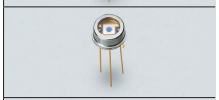
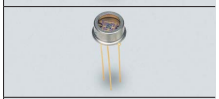
[S12926 series]



KAPDB0311EA

900 nm band

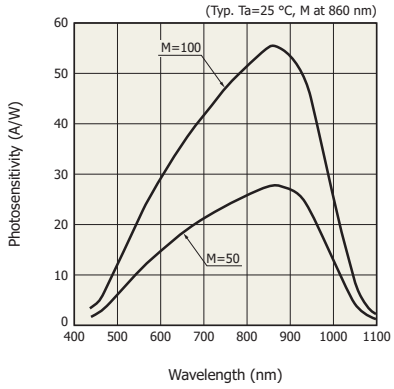
These are Si APDs that offer enhanced 900 nm band near-infrared sensitivity. They are suitable for applications such as FSO, optical fiber communications, and analytical instruments.

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=900 nm	Package	
S12092-02	φ0.2	440 to 1100	250	1.85	400	0.4	100	TO-18	
S12092-05	φ0.5					0.7			
S9251-10	φ1.0				380	1.9		TO-5	
S9251-15	φ1.5				350	3.6			
S8890-02	φ0.2		500	3.5	280	0.2			
S8890-05	φ0.5				240	0.5			

*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

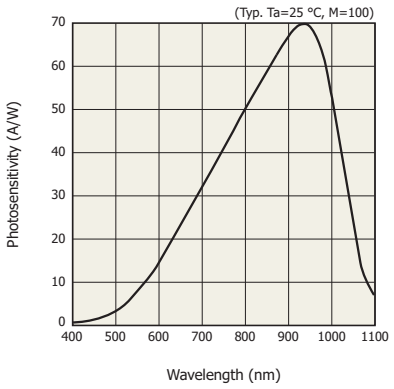
Spectral response

[S12092 series, S9251 series]



KAPDB0606EA

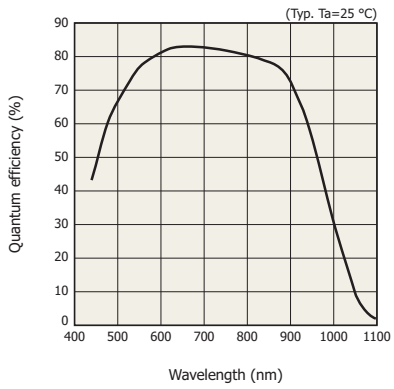
[S8890 series]



KAPDB0064EC

Quantum efficiency vs. wavelength

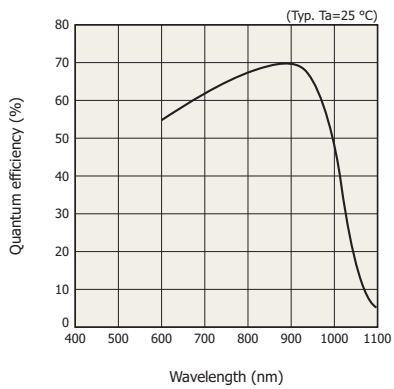
[S12092 series, S9251 series]



KAPDB0607EA

Quantum efficiency vs. wavelength

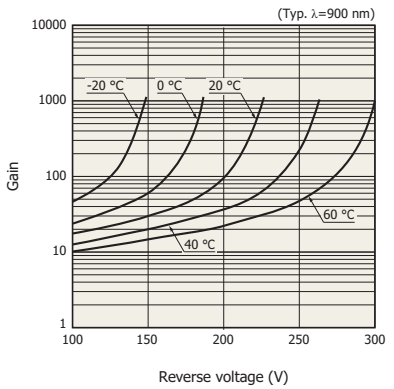
[S8890 series]



KAPDB0608EA

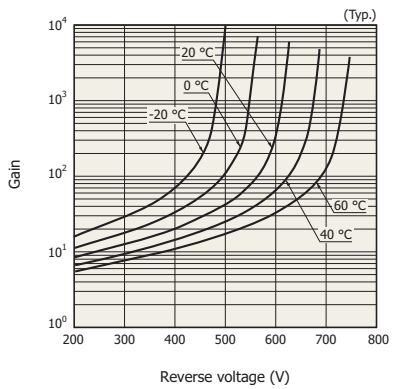
Gain vs. reverse voltage

[S12092 series, S9251 series]



KAPDB0082EA

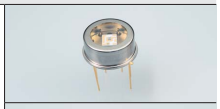
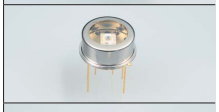
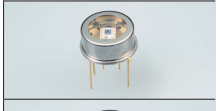
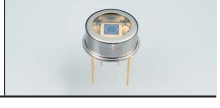
[S8890 series]



KAPDB0066EB

TE-cooled type

The S4315 series is a low-bias operation thermoelectrically-cooled type APD capable of high accuracy detection.

Type no.	Cooling temperature ΔT (°C)	Built-in APD	Effective photosensitive area*1 (mm)	Spectral response range (nm)	Breakdown voltage max. ID=100 µA (V)	Cutoff frequency*2 RL=50 Ω (MHz)	Terminal capacitance*2 (pF)	Gain λ=800 nm	Package	
S4315	40	S12023-02	φ0.2	400 to 1000	200	1000	1	100	TO-8	
S4315-01		S12023-05	φ0.5			900	2	100		
S4315-02		S12023-10	φ1.0			600	6	100		
S4315-04		S2384	φ3.0			120	40	60		

*1: Area in which a typical gain can be obtained
*2: Value obtained when operated at the gain indicated in the table
Note: For the graphs of spectral response, quantum efficiency vs. wavelength, gain vs. reverse voltage, see P.7 where the built-in APD is written.

Si APD for LiDAR

These are Si APDs with reduced variation in breakdown voltage, reduced dark current, and expanded operating temperatures compared to the previous products.

700 nm band

This Si APD is suitable for detecting light in the 700 nm band.

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=760 nm	Package	
S14643-02	ϕ0.2	400 to 1000	120	0.42	2000	0.7	100	Plastic	

*3: Area in which a typical gain can be obtained
*4: Value obtained when operated at the gain indicated in the table

800 nm band

These Si APDs are suitable for detecting light in the 800 nm band.

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=800 nm	Package	
S14644-02	ϕ0.2	400 to 1000	180	0.63	1200	0.6	100	Plastic	
S14644-05	ϕ0.5				1000	1.6			

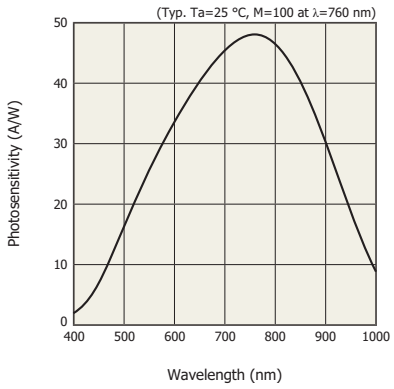
900 nm band

These Si APDs are suitable for detecting light in the 900 nm band.

Type no.	Effective photosensitive area*3 (mm)	Spectral response range (nm)	Breakdown voltage max. (V)	Temp. coefficient of breakdown voltage (V/°C)	Cutoff frequency*4 RL=50 Ω (MHz)	Terminal capacitance*4 (pF)	Gain λ=900 nm	Package	
S14645-02	ϕ0.2	400 to 1100	195	1.1	600	0.5	100	Plastic	
S14645-02F		850 to 950							
S14645-05	ϕ0.5	400 to 1100				1			
S14645-05F		850 to 950							

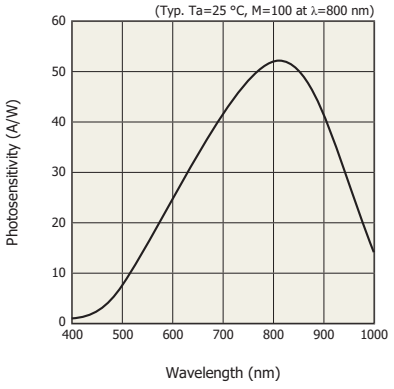
Spectral response

[S14643-02]



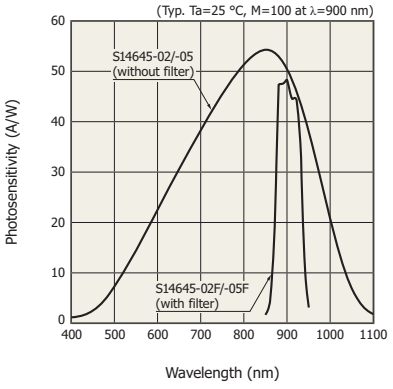
KAPDB0439EA

[S14644 series]



KAPDB0444EA

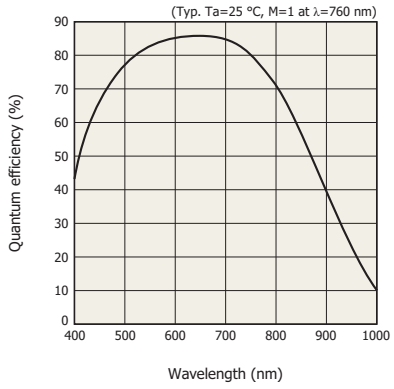
[S14645 series]



KAPDB0436EC

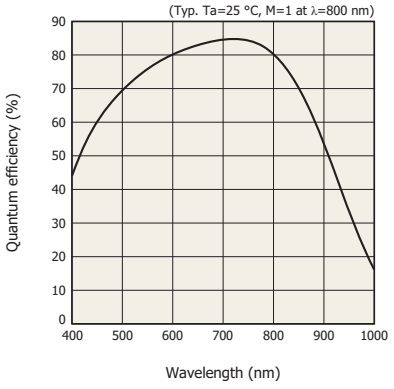
Quantum efficiency vs. wavelength

[S14643-02]



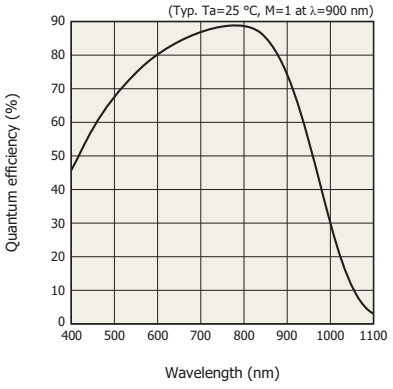
KAPDB0440EA

[S14644 series]



KAPDB0445EA

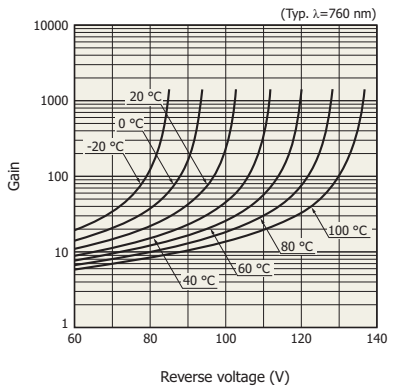
[S14645 series]



KAPDB0294EA

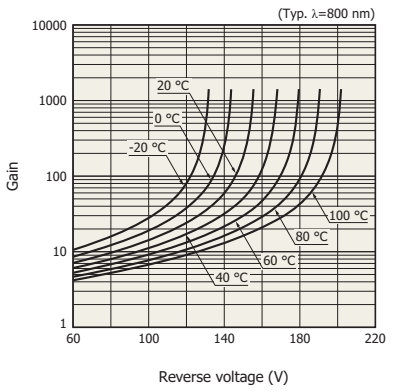
Gain vs. reverse voltage

[S14643-02]



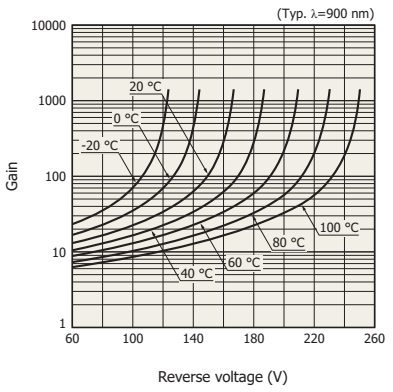
KAPDB0451EA

[S14644 series]



KAPDB0452EA

[S14645 series]



KAPDB0449EA

APD modules

Standard type

The APD module consists of an amplifier and bias power supply assembled in a compact form to facilitate the use of the Si APD. Running on a +5 V power supply, it can be used for a variety of light detection applications up to 100 MHz of frequency bandwidth.

Near infrared type

Features

- Peak sensitivity wavelength: 800 nm
- Wide bandwidth
- Optical fiber adapters are also available. (sold separately).

Applications

- Si APD evaluation
- FSO
- Barcode readers
- LiDAR
- Optical rangefinders
- Optical communication

Type no.	Effective photosensitive area* (mm)	Built-in APD	Cutoff frequency		Photoelectric conversion sensitivity M=30, λ=800 nm (V/W)	Minimum detection limit M=30, λ=800 nm (nW rms)	Temperature stability of gain 25 ± 10 °C (%)	Supply voltage (V)
			Low	High				
C12702-03	ϕ1.0	S12023-10	4 kHz	100 MHz	-6.8×10^4	3	±5 max.	+5
C12702-04	ϕ3.0	S2384		80 MHz	-2.3×10^4	3.6		

Short wavelength type

Features

- Peak sensitivity wavelength: 620 nm
- Wide bandwidth
- Optical fiber adapters are also available (sold separately).

Applications

- Si APD evaluation
- Film scanners
- Laser monitoring

Type no.	Effective photosensitive area* (mm)	Built-in APD	Cutoff frequency		Photoelectric conversion sensitivity M=30, λ=620 nm (V/W)	Minimum detection limit M=30, λ=620 nm (nW rms)	Temperature stability of gain 25 ± 10 °C (%)	Supply voltage (V)
			Low	High				
C12702-11	ϕ1.0	S12053-10	4 kHz	100 MHz	-2.5×10^4	5	±5 max.	+5
C12702-12	ϕ3.0	S5344		40 MHz	-1.9×10^4	6.3		

High-sensitivity type

These are high-gain APD modules suitable for low-light-level detection. They can be used for DC light detection.

Features

- Low-light-level detection
- DC light detection
- High gain

Applications

- Si APD evaluation
- Fluorescence measurement
- Barcode readers
- Particle counters
- Film scanners

Type no.	Effective photosensitive area* (mm)	Internal APD	Cutoff frequency		Photoelectric conversion sensitivity M=30, λ=800 nm (V/W)	Minimum detection limit M=30, λ=800 nm (nW rms)	Temperature stability of gain 25 ± 10 °C (%)	Supply voltage (V)
			Low	High				
C12703	ϕ1.5	S3884	DC	10 MHz	1.5×10^6	0.63	±5 max.	±12
C12703-01	ϕ3.0	S2384		100 kHz	-1.5×10^8	0.0063		

* Area in which a typical gain can be obtained

High-stability type

The C10508-01 consists of an APD, current-voltage converter, high-voltage power supply circuit as well as a microcontroller for adjusting the APD gain and controlling temperature compensation with high accuracy. This makes it easy to adjust the APD gain and even at high gain, stable detection is possible even under temperature fluctuating conditions.

Features

- Gain: adjustable by switch or PC command
- Gain temperature stability: ±5% or less (Gain=250, Ta=0 °C to +40 °C)
- Easy handling: only ±5 V power supply

Applications

- Si APD evaluation
- Power meters
- Low-light-level detection

Type no.	Effective photosensitive area* (mm)	Internal APD	Cutoff frequency		Photoelectric conversion sensitivity M=250, λ=800 nm (V/W)	Minimum detection limit M=250, λ=800 nm (pW rms)	Temperature stability of gain 0 to 40 °C (%)	Supply voltage (V)
			Low	High				
C10508-01	φ1.0	S12023-10A	DC	10 MHz	1.25×10^7	63	±5 max.	±5

FC/SMA fiber adapter (sold separately)

FC or SMA fiber adapters can be attached to the following APD modules to allow FC or SMA optical fiber cables to be connected to the modules.

APD module	FC fiber adapter	SMA fiber adapter
C12702-03	A8407-18	A8424-18
C12702-04	A8407-05A	A8424-05A
C12702-11	A8407-18	A8424-18
C12702-12	A8407-05A	A8424-05A
C12703	A8407-05	A8424-05
C12703-01	A8407-05A	A8424-05A
C10508-01	A12855-01	A12855-02

High-speed type

This device can be used in a wide frequency range (up to 1 GHz).

Features

- High-speed light detection
- Flat frequency characteristics
- Compact and lightweight
- Single power supply operation

Applications

- OTDR
- Optical communication
- LiDAR
- FSO
- Optical rangefinders

Type no.	Effective photosensitive area* (mm)	Internal APD	Cutoff frequency		Photoelectric conversion sensitivity M=100, λ=800 nm (V/W)	Minimum detection limit M=100, λ=800 nm (nW rms)	Temperature stability of gain 25 ± 10 °C (%)	Supply voltage (V)
			Low	High				
C5658	φ0.5	S12023-05	50 kHz	1 GHz	2.50×10^5	16	±5	+12

* Area in which a typical gain can be obtained

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