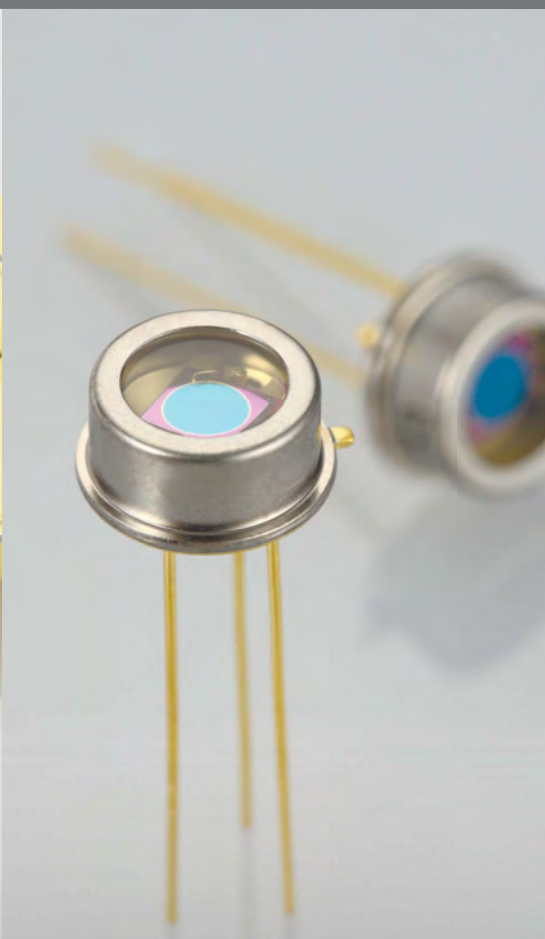


InGaAs Photodiodes

Near infrared detectors with low noise and superb frequency characteristics



InGaAs PHOTODIODES

InGaAs Photodiodes

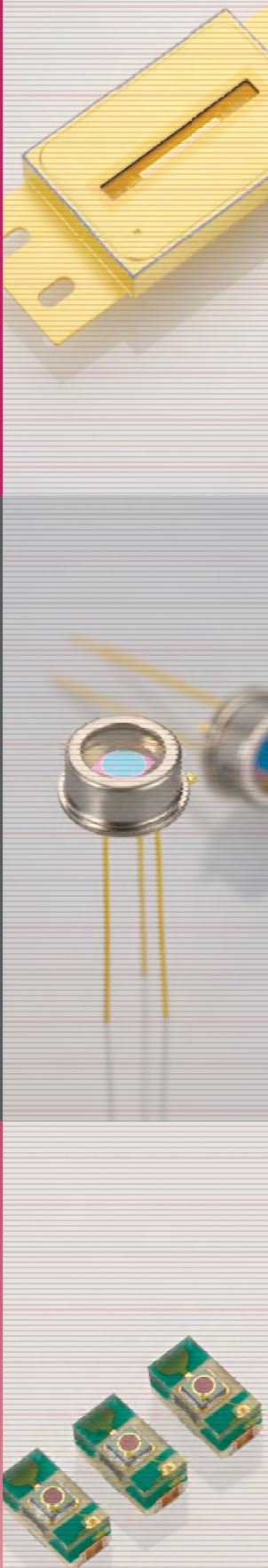
Near infrared detectors with low noise and superb frequency characteristics

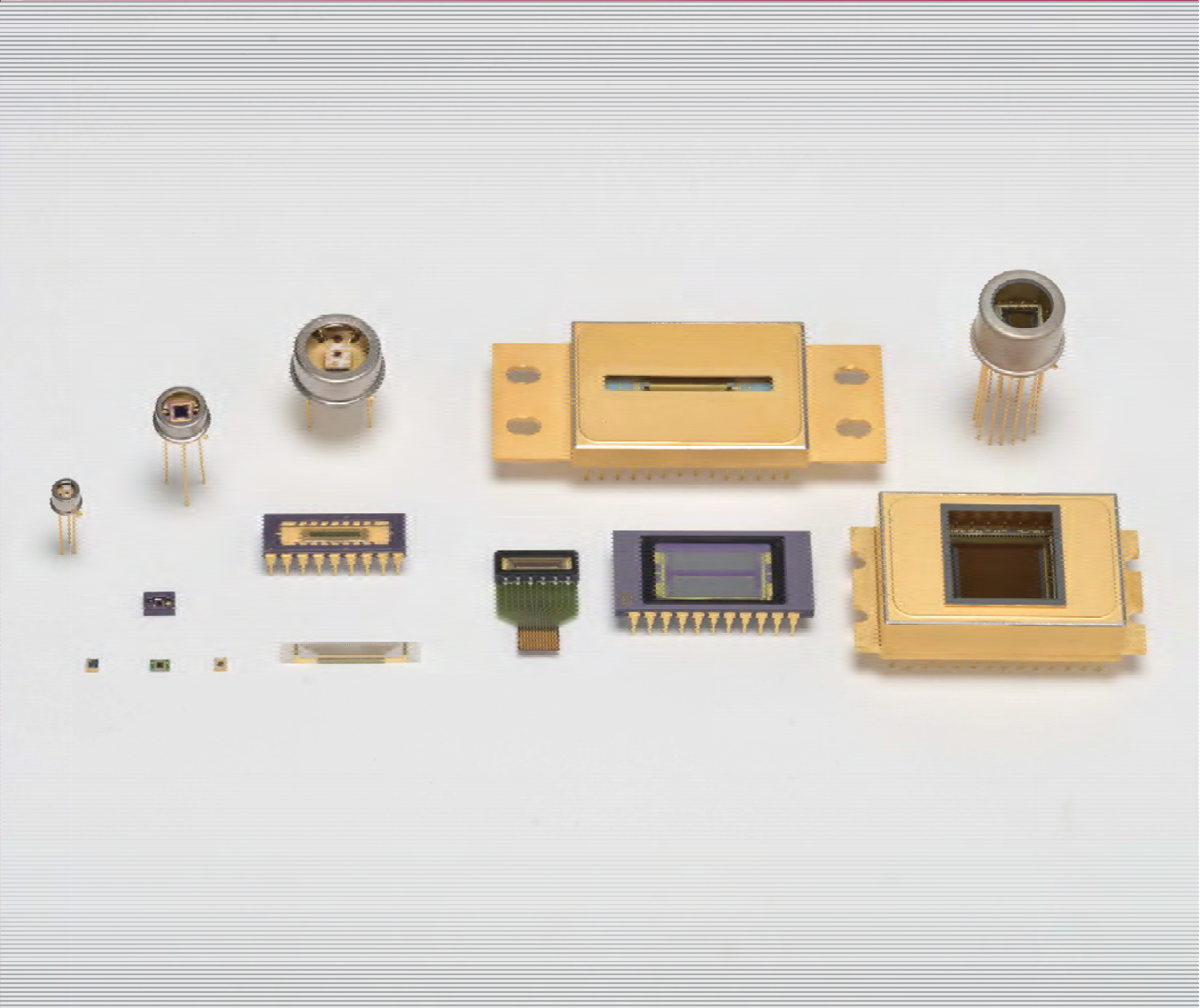
Based on unique, in-house compound semiconductor process technology, Hamamatsu has designed and developed advanced InGaAs photodiodes that feature high speed, high sensitivity, and low noise over a spectral range from 0.5 μm to 2.6 μm . InGaAs photodiodes are used in a wide variety of applications ranging from optical communications to chemical analysis and measurement fields. Hamamatsu provides a wide range of products in different packages including metal, ceramic and surface mount packages as well as linear and area image sensors, and infrared detector modules with built-in preamplifiers.

We also manufacture custom products to meet your specific requirements. Please feel free to contact us.

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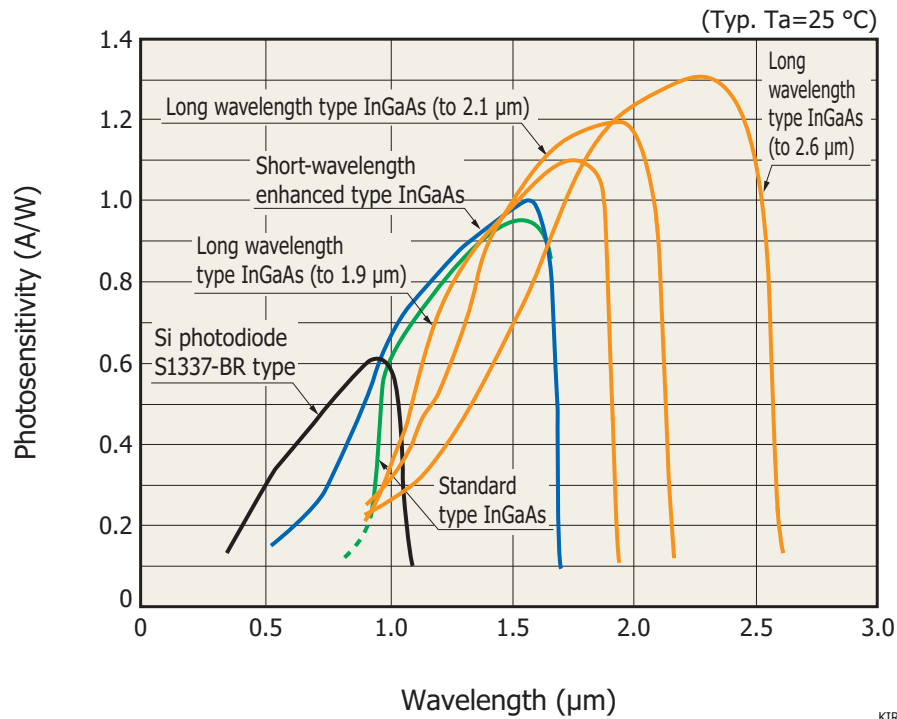
Selection guide



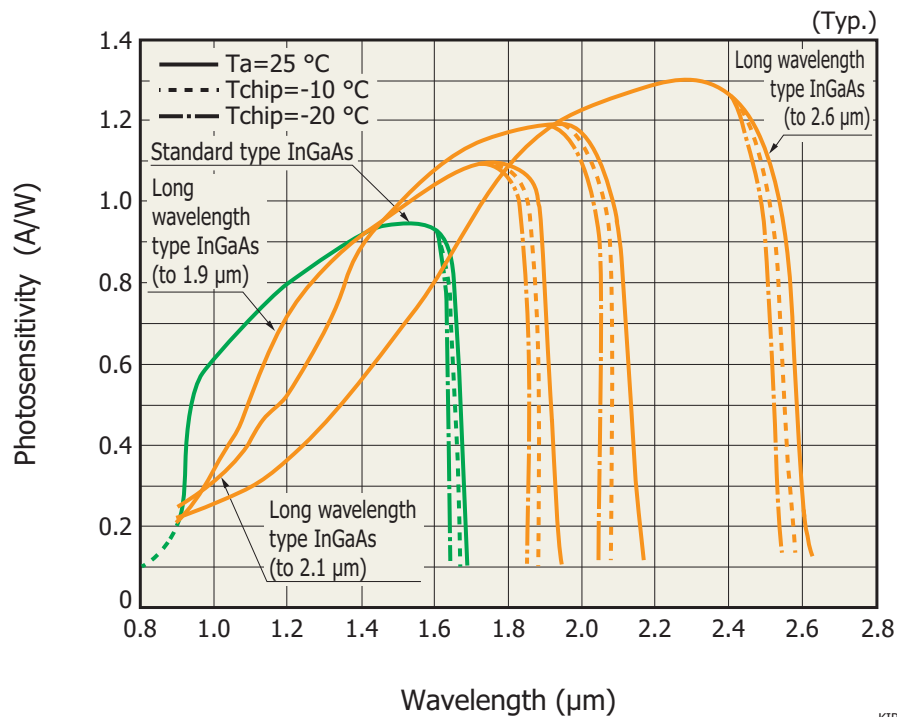
Spectral response range

Hamamatsu provides a wide lineup of InGaAs photodiodes with different spectral response characteristics ranging from 0.5 μm to 2.6 μm .

Spectral response (typical example)



Cutoff wavelength temperature dependence (typical example)



InGaAs PIN photodiodes

Type	Type no.	Page	Spectral response range (μm)												
			0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8
Short-wavelength enhanced type	G10899 series	9	Non-cooled type (0.5 to 1.7 μm)												
	G12180/G8370 series														
	G11193 series		Non-cooled type (0.9 to 1.7 μm)												
	G8941 series														
	Standard type	COB	10	One-stage TE-cooled type (0.9 to 1.67 μm)											
		Array		G6849 series											
				G7150/G7151-16	Two-stage TE-cooled type (0.9 to 1.65 μm)										
				G8909-01											
		G12430 series													
		ROSA	11	(1.31 μm)											
Long wavelength type	to 1.9 μm	11	Non-cooled type (0.9 to 1.9 μm)												
			One-stage TE-cooled type (0.9 to 1.87 μm)												
			Two-stage TE-cooled type (0.9 to 1.85 μm)												
	to 2.1 μm	12	Non-cooled type (0.9 to 2.1 μm)												
			One-stage TE-cooled type (0.9 to 2.07 μm)												
			Two-stage TE-cooled type (0.9 to 2.05 μm)												
	to 2.6 μm	12	Non-cooled type (0.9 to 2.6 μm)												
			One-stage TE-cooled type (0.9 to 2.57 μm)												
			Two-stage TE-cooled type (0.9 to 2.55 μm)												

InGaAs APD

Type	Type no.	Page	Spectral response range (μm)										
			0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
APD	G8931 series	12	Non-cooled type (0.95 to 1.7 μm)										

InGaAs linear image sensors

Type	Type no.	Page	Spectral response range (μm)										
			0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
Standard type	G920X/G9494/G10768 series	13	Non-cooled type (0.9 to 1.7 μm)										
	G11608 series		Non-cooled type (0.5 to 1.7 μm)										
	G11508 series		One-stage TE-cooled type (0.9 to 1.67 μm)										
Back-illuminated type	G11135 series	13	Non-cooled type (0.95 to 1.7 μm)										
	G11620 series	13, 14	One-stage TE-cooled type (0.95 to 1.67 μm)										
	G13913 series	13	Non-cooled type (0.95 to 1.7 μm)										
	G14006-512DE		Non-cooled type (1.12 to 1.9 μm)										
	G12230-512WB		14	Two-stage TE-cooled type (0.95 to 2.15 μm)									
Long wavelength type	to 1.85 μm	14	Two-stage TE-cooled type (0.9 to 1.85 μm)										
	to 2.05 μm		Two-stage TE-cooled type (0.9 to 2.05 μm)										
	to 2.15 μm		Two-stage TE-cooled type (0.9 to 2.15 μm)										
	to 2.55 μm		Two-stage TE-cooled type (0.9 to 2.55 μm)										

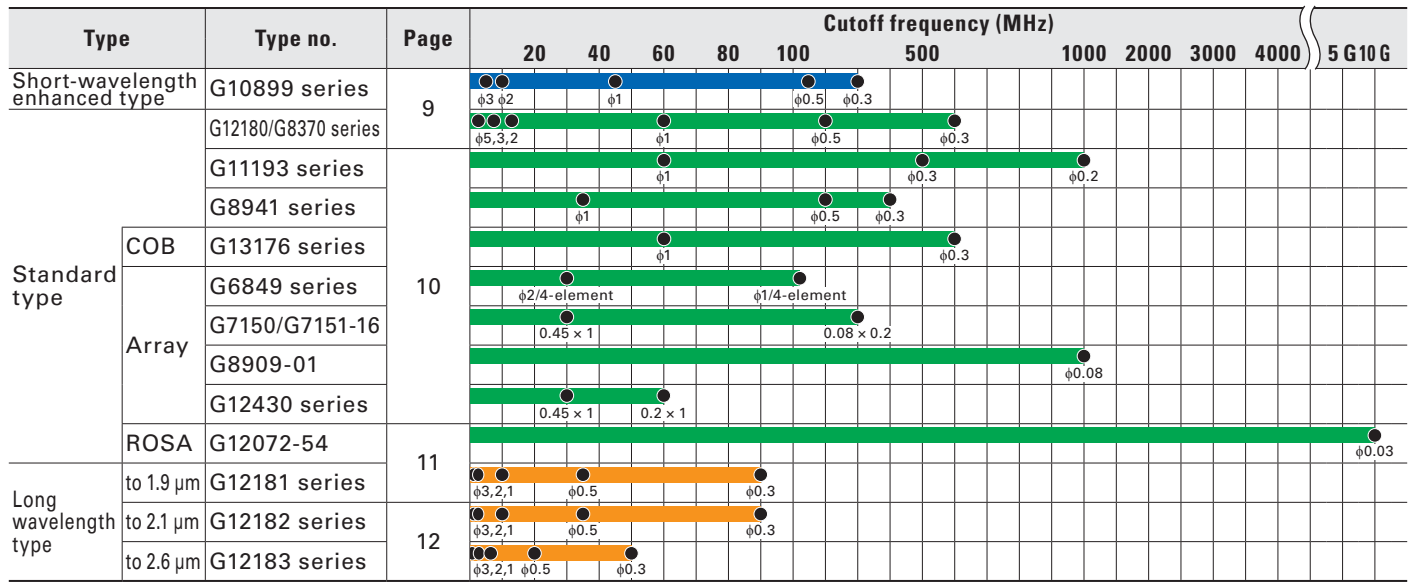
InGaAs area image sensor

Type	Type no.	Page	Spectral response range (μm)										
			0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
Standard type	G11097-0606S	14	One-stage TE-cooled type (0.95 to 1.7 μm)										
	G12460-0606S		One-stage TE-cooled type (1.12 to 1.9 μm)										
	G12242-0707W		Two-stage TE-cooled type (0.95 to 1.7 μm)										
	G13393 series												
	G13441-01		Two-stage TE-cooled type (1.3 to 2.15 μm)										

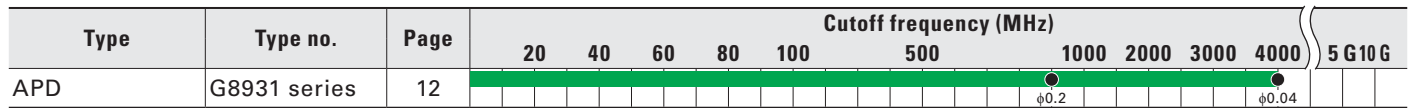


Response speed

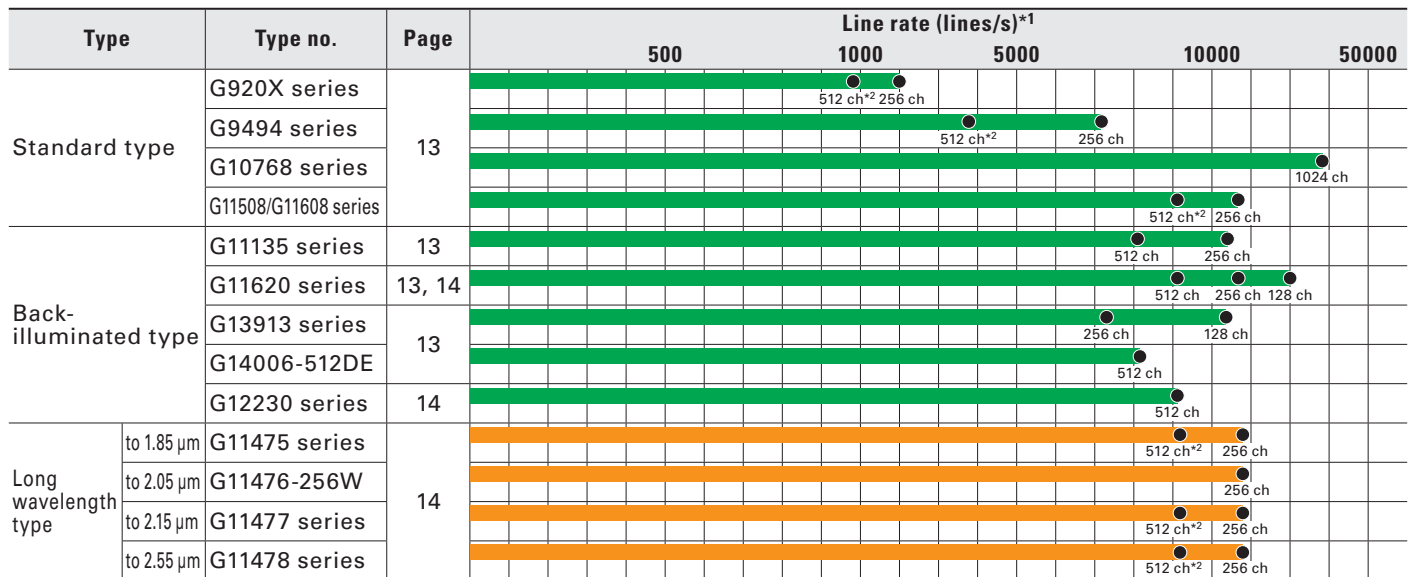
InGaAs PIN photodiodes [Cutoff frequency, Photosensitive area (unit: mm)]



InGaAs APD [Cutoff frequency, Photosensitive area (unit: mm)]

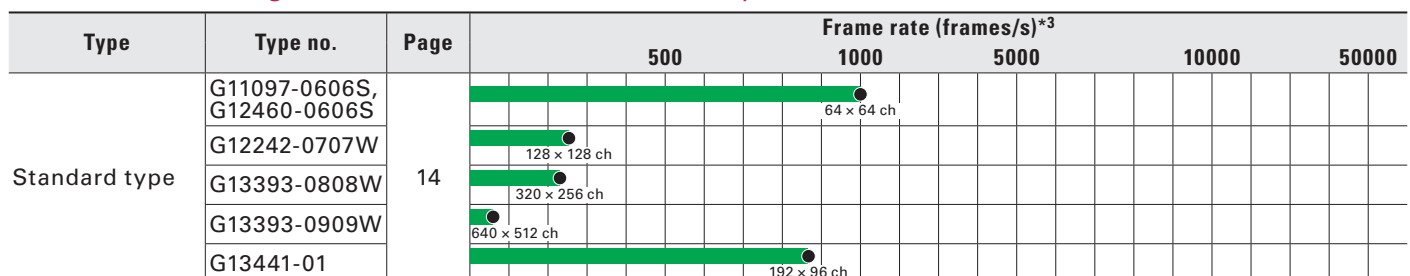


InGaAs linear image sensors [Line rate, Number of pixels]



*1: When the integration time is set to the minimum value. *2: When two video lines are used for readout, the line rate is equal to that for 256 channels.

InGaAs area image sensors [Frame rate, Number of pixels]



*3: Integration time 1 μs

Packages

InGaAs PIN photodiodes

Type	Type no.	Page	Metal			Ceramic	Surface mount type	Receptacle type
			Non-cooled type	One-stage TE-cooled type	Two-stage TE-cooled type			
Short-wavelength enhanced type	G10899 series	9	1 2					
	G12180/G8370 series		1 2	3	3	4		
Standard type	G11193 series	10					5	
	G8941 series						6	
	COB G13176 series						7	
	Array	G6849 series	10	8				
		G7150/G7151-16				9		
		G8909-01					10	
G12430 series				11				
ROSA G12072-54	11						12	
Long wavelength type	to 1.9 μm G12181 series	11	1	3	3			
	to 2.1 μm G12182 series	12	1	3	3			
	to 2.6 μm G12183 series		1	3	3			

InGaAs APD

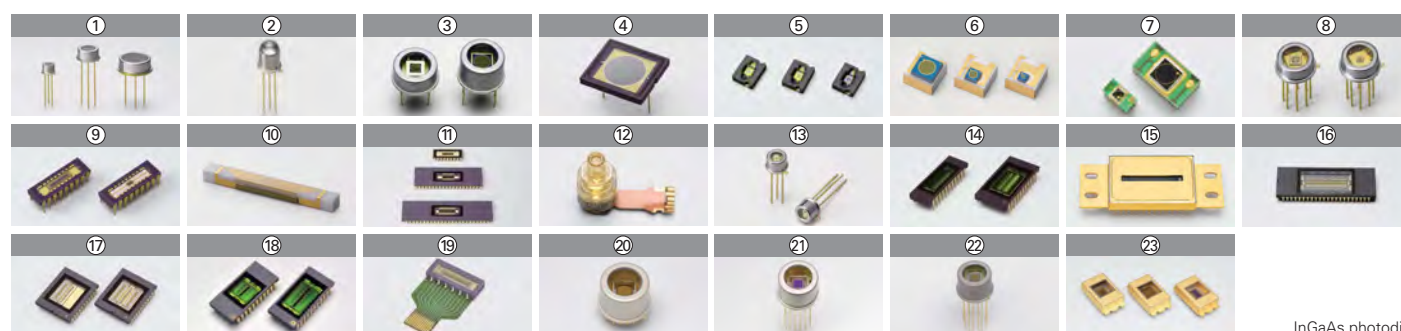
Type	Type no.	Page	Metal			Ceramic	Surface mount type
			Non-cooled type	One-stage TE-cooled type	Two-stage TE-cooled type		
APD	G8931 series	12	13				

InGaAs linear image sensors

Type	Type no.	Page	Metal			Ceramic
			Non-cooled type	One-stage TE-cooled type	Two-stage TE-cooled type	
Standard type	G920X/G9494 series	13				14
	G11508 series			15		
	G10768 series					
	G11608 series					16
Back-illuminated type	G11135 series	13				17
	G11620 series	13, 14		15		18
	G13913 series	13				19
	G14006-512DE	13				18
	G12230-512WB	14			15	
Long wavelength type	to 1.85 μm G11475 series	14			15	
	to 2.05 μm G11476-256W				15	
	to 2.15 μm G11477 series				15	
	to 2.55 μm G11478 series				15	

InGaAs area image sensors

Type	Type no.	Page	Metal			Ceramic
			Non-cooled type	One-stage TE-cooled type	Two-stage TE-cooled type	
Standard type	G11097-0606S	14		20		
	G12460-0606S			21		
	G12242-0707W				22	
	G13393 series				23	
	G13441-01				23	





Application examples

InGaAs PIN photodiodes

Type	Type no.	Page	Radiation thermometer	Moisture meter	Gas analysis	Spectro-photometry	Laser monitor	DWDM monitor	Optical power meter	Optical communication	Distance measurement	
Short-wavelength enhanced type	G10899 series	9				●						
	G12180/G8370 series		●	●		●	●		●	●		
Standard type	G11193 series	10							●			
	G8941 series						●		●			
	COB G13176 series							●	●			
	Array		G6849 series							●		
			G7150/G7151-16				●					
			G8909-01						●			
			G12430 series				●					
ROSA G12072-54	11								●			
Long wavelength type	to 1.9 μm G12181 series	11	●	●	●	●			●			
	to 2.1 μm G12182 series	12	●	●	●	●			●			
	to 2.6 μm G12183 series		●	●	●	●			●			

InGaAs APD

Type	Type no.	Page	Radiation thermometer	Moisture meter	Gas analysis	Spectro-photometry	Laser monitor	DWDM monitor	Optical power meter	Optical communication	Distance measurement
APD	G8931 series	12								●	●

InGaAs linear image sensors

Type	Type no.	Page	Thermo-meter	Multichannel spectrophotometry	Non-destructive inspection	Foreign object screening	DWDM monitor	OCT	Optical spectrum analyzer
Standard type	G920X/G11508 series	13	●	●	●		●		●
	G9494 series				●	●			
	G10768 series				●	●		●	
	G11608 series		●	●	●				
Back-illuminated type	G11135 series	13			●	●			
	G11620 series	13, 14	●	●	●				●
	G13913 series	13	●	●	●				
	G14006-512DE				●	●			
	G12230-512WB	14		●	●				
Long wavelength type	to 1.85 μm G11475 series	14	●	●	●				
	to 2.05 μm G11476-256W		●	●	●				
	to 2.15 μm G11477 series		●	●	●				
	to 2.55 μm G11478 series		●	●	●				

InGaAs area image sensors

Type	Type no.	Page	Hyperspectral imaging	Thermal image monitor	Laser beam profiler	Near infrared image detection	Foreign object screening
Standard type	G11097-0606S	14	●	●	●	●	●
	G11097-0707S		●	●	●	●	●
	G12460-0606S		●	●	●	●	●
	G12242-0707W		●	●	●	●	●
	G13393 series		●	●	●	●	●
	G13441-01		●	●	●	●	●

Application examples of InGaAs photodiodes

Induction heating

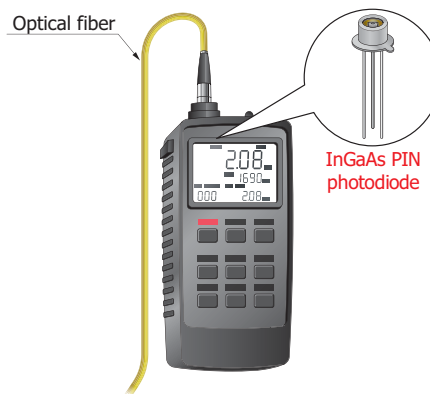


InGaAs PIN photodiode

KIRDC0095EA

InGaAs PIN photodiode detects the temperature at the bottom of a frying pan.

Optical power meter

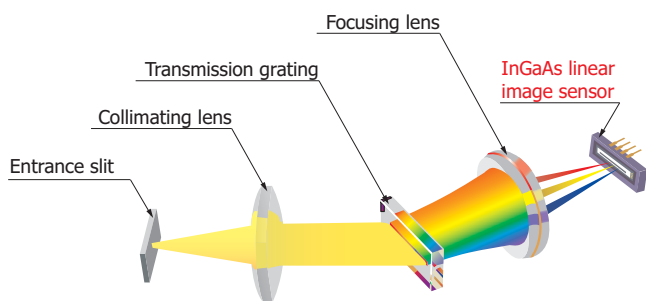


InGaAs PIN photodiode

KIRDC0100EA

InGaAs PIN photodiode is used to detect the level of near infrared light passing through an optical fiber, etc.

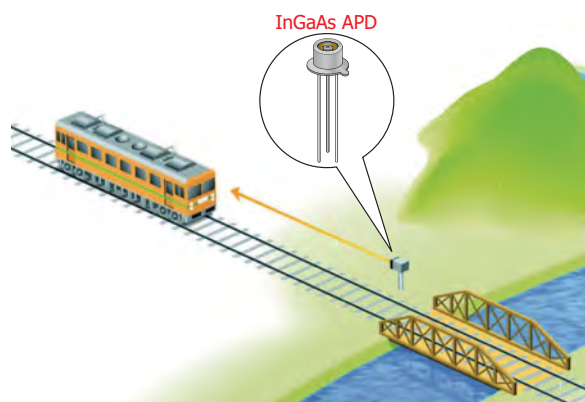
Mini-spectrometer



KIRDC0097EA

InGaAs linear image sensor is used in some of our mini-spectrometers.

Rangefinder

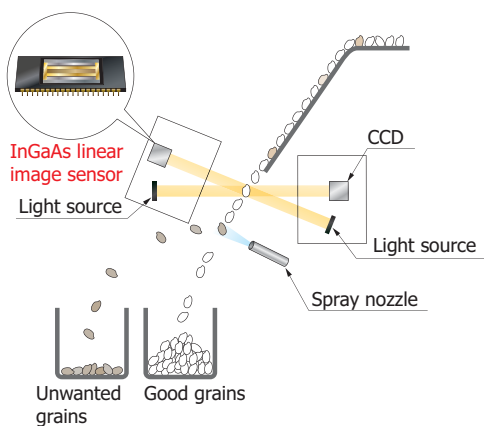


InGaAs APD

KIRDC0098EA

InGaAs APD detects the distance to an object with high speed and accuracy.

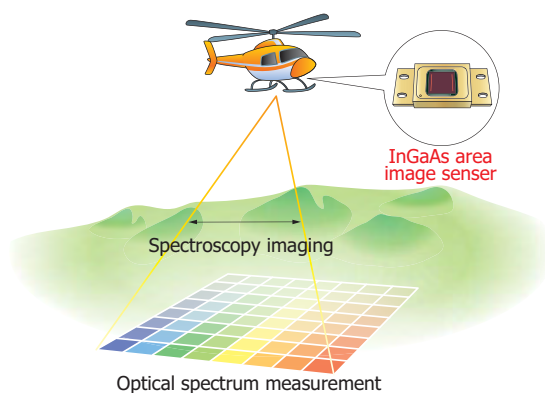
Grain sorter



KIRDC0099EA

Grain sorters irradiate light onto the falling grains and detect the transmitted light to sort out unwanted grains from good ones. (InGaAs linear image sensor detects near infrared light, and CCD detects visible light.)

Hyperspectral imaging



InGaAs area image sensor

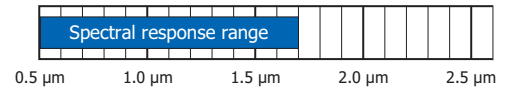
KIRDC0124EA

A hyperspectral image of the ground environment is to be obtained by using an InGaAs area image sensor from a helicopter, etc.

InGaAs PIN photodiodes, InGaAs APD



Short-wavelength enhanced type InGaAs PIN photodiodes



The G10899 series is an InGaAs PIN photodiode that covers a wide spectral response range from 0.5 μm to 1.7 μm. While standard InGaAs PIN photodiodes have spectral response ranging from 0.9 μm to 1.7 μm, the G10899 series has sensitivity extending to 0.5 μm on the shorter wavelength side. A wide spectral range can be detected with a single detector.

Features

- Wide spectral response range
- Low noise, low dark current
- Large photosensitive area available

Applications

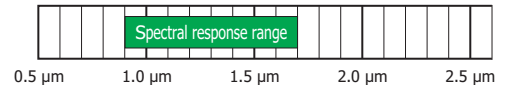
- Spectrophotometry
- Radiation thermometers

(Typ. $T_a=25\text{ }^\circ\text{C}$)

Type no.	Cooling	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity S		Dark current I_D $V_R=1\text{ V}$ (nA)	Cutoff frequency f_c $V_R=1\text{ V}$ (MHz)	Package	Photo	Option (sold separately)
					$\lambda=0.65\text{ }\mu\text{m}$ (A/W)	$\lambda=\lambda_p$ (A/W)					
G10899-003K	Non-cooled	$\phi 0.3$	0.5 to 1.7	1.55	0.22	1	0.3	300	TO-18		C4159-03
G10899-005K		$\phi 0.5$					0.5	150			
G10899-01K		$\phi 1$					1	45			
G10899-02K		$\phi 2$					5	10	TO-5		
G10899-03K		$\phi 3$					15	5			



Standard type InGaAs PIN photodiodes



InGaAs PIN photodiodes have large shunt resistance and low noise. A wide variety of packages are available including highly reliable metal types and surface mount types.

Features

- Low noise, low dark current
- Various photosensitive areas available

Applications

- Laser monitor
- Optical measurement instruments
- Optical communications








(Typ.)

Type no.	Cooling (measurement condition)	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity S $\lambda=\lambda_p$ (A/W)	Dark current I_D $V_R=1\text{ V}$ (nA)	Cutoff frequency f_c (MHz)	Package	Photo	Option (sold separately)
G12180-003A	Non-cooled ($T_a=25\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 1.7	1.55	1.1	0.1*1	600 ($V_R=5\text{ V}$)	TO-18		C4159-03
G12180-005A		$\phi 0.5$				0.15*1	200 ($V_R=5\text{ V}$)			
G12180-010A		$\phi 1$				0.8*1	60 ($V_R=5\text{ V}$)			
G12180-020A		$\phi 2$				1.5	13 ($V_R=1\text{ V}$)	TO-5		
G12180-030A		$\phi 3$				2.5	7 ($V_R=1\text{ V}$)			
G12180-050A		$\phi 5$				5	3 ($V_R=1\text{ V}$)	TO-8		
G8370-81*3	Non-cooled ($T_a=25\text{ }^\circ\text{C}$)	$\phi 1$	0.9 to 1.7	1.55	1.1	1	35 ($V_R=1\text{ V}$)	TO-18		C4159-03
G8370-82*3		$\phi 2$				5	4 ($V_R=1\text{ V}$)	TO-5		
G8370-83*3		$\phi 3$				15	2 ($V_R=1\text{ V}$)	TO-5		
G8370-85*3		$\phi 5$				25*4	0.6 ($V_R=0\text{ V}$)	TO-8		
G12180-110A	One-stage TE-cooled ($T_{chip}=2=-10\text{ }^\circ\text{C}$)	$\phi 1$	0.9 to 1.67	1.55	1.1	0.02	40 ($V_R=1\text{ V}$)	TO-8		C4159-03 A3179 C1103-04
G12180-120A		$\phi 2$				0.1	13 ($V_R=1\text{ V}$)			
G12180-130A		$\phi 3$				0.15	7 ($V_R=1\text{ V}$)			
G12180-150A		$\phi 5$				0.33	3 ($V_R=1\text{ V}$)			
G12180-210A	Two-stage TE-cooled ($T_{chip}=-20\text{ }^\circ\text{C}$)	$\phi 1$	0.9 to 1.65	1.55	1.1	0.01	40 ($V_R=1\text{ V}$)	TO-8		C4159-03 A3179-01 C1103-04
G12180-220A		$\phi 2$				0.04	13 ($V_R=1\text{ V}$)			
G12180-230A		$\phi 3$				0.07	7 ($V_R=1\text{ V}$)			
G12180-250A		$\phi 5$				0.15	3 ($V_R=1\text{ V}$)			
G6854-01	Non-cooled ($T_a=25\text{ }^\circ\text{C}$)	$\phi 0.08$	0.9 to 1.7		0.95	0.08*1	2000 ($V_R=5\text{ V}$)	TO-18 with CD lens		-

*1: $V_R=5\text{ V}$ *2: Element temperature *3: Low PDL (polarization dependence loss) type *4: $V_R=0.1\text{ V}$



■ Ceramic package

(Typ. Ta=25 °C)

Type no.	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity S $\lambda=\lambda_p$ (A/W)	Dark current I_D $V_R=5\text{ V}$ (nA)	Cutoff frequency f_c $V_R=5\text{ V}$ (MHz)	Package	Photo
G8370-10	$\phi 10$	0.9 to 1.7	1.55	0.95	200 ($V_R=10\text{ mV}$)	0.1 ($V_R=0\text{ V}$)	-	
G11193-02R	$\phi 0.2$			1	0.04	1000	Surface mount type	
G11193-03R	$\phi 0.3$				0.1	500		
G11193-10R	$\phi 1$				0.8	60		
G8941-01	$\phi 1$	0.9 to 1.7	1.55	0.95	1	35	Surface mount type (unsealed)	
G8941-02	$\phi 0.5$				0.5	200		
G8941-03	$\phi 0.3$				0.3	400		








■ COB (chip on board) package

(Typ. Ta=25 °C)

Type no.	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity S $\lambda=\lambda_p$ (A/W)	Dark current I_D $V_R=5\text{ V}$ (nA)	Cutoff frequency f_c $V_R=5\text{ V}$ (MHz)	Package	Photo
G13176-003P	$\phi 0.3$	0.9 to 1.7	1.55	1	0.1	600	Surface mount type (Ultra-compact type)	
G13176-010P	$\phi 1$				0.8	60		


■ Photodiode arrays

(Typ. Ta=25 °C)

Type no.	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity S $\lambda=1.55\text{ }\mu\text{m}$ (A/W)	Dark current I_D per element (nA)	Cutoff frequency f_c $V_R=1\text{ V}$ (MHz)	Package	Photo
G6849	$\phi 2$ (quadrant)	0.9 to 1.7	1.55	0.95	0.5 ($V_R=1\text{ V}$)	30	TO-5	
G6849-01	$\phi 1$ (quadrant)				0.15 ($V_R=1\text{ V}$)	120		
G7150-16	0.45 × 1.0 (× 16-element)				2.5 ($V_R=1\text{ V}$)	30	Ceramic	
G7151-16	0.08 × 0.2 (× 16-element)				0.1 ($V_R=1\text{ V}$)	300		
G8909-01	$\phi 0.08$ (× 40-element)				0.02 ($V_R=5\text{ V}$)	1000 ($V_R=5\text{ V}$)	Ceramic (unsealed)	
G12430-016D	0.45 × 1.0 (× 16-element)				0.5 ($V_R=1\text{ V}$)	30		Ceramic
G12430-032D	0.2 × 1.0 (× 32-element)				0.25 ($V_R=1\text{ V}$)	60		
G12430-046D	0.2 × 1.0 (× 46-element)				0.25 ($V_R=1\text{ V}$)	60		





■ ROSA

(Typ. Ta=25 °C, Vcc=3.3 V, unless otherwise noted)

Type no.	Wavelength band (μm)	Responsivity R (A/W)	Data rate (Gbps)	Minimum receivable sensitivity Pmin (dBm)	Maximum receivable sensitivity Pmax (dBm)	Trans-impedance Tz (kΩ)	Optical return loss ORL min. (dB)	Photo
G12072-54	1.31	0.8	8.5 to 11.3	-19.5	+5	2.25 (single end)	12	





■ Pigtail/receptacle type (InGaAs PIN photodiodes with preamp)

(Typ. Ta=25 °C, Vcc=3.3 V, unless otherwise noted)

Type no.	Photosensitivity S (V/mW)	Cutoff frequency fc (GHz)	Minimum receivable sensitivity Pmin (dBm)	Maximum receivable sensitivity Pmax (dBm)	Trans-impedance Tz (kΩ)	Optical return loss ORL min. (dB)	Package	Photo
G9821-22	1.5	2.1	-25.5	+1 min.	1.8 (single end)	12	FC board receptacle	
G9821-32							FC panel receptacle	
G9822-11						27	Pigtail coaxial SC	
G9822-12							Pigtail coaxial FC	

■ Pigtail/receptacle type (InGaAs PIN photodiodes)

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

Type no.	Spectral response range λ (μm)	Peak sensitivity wavelength λp (μm)	Photosensitivity S λ=1.55 μm (A/W)	Dark current Id VR=5 V (pA)	Cutoff frequency fc VR=5 V (GHz)	Package	Photo
G8195-11	0.9 to 1.7	1.55	0.95	20	2	Pigtail coaxial SC	
G8195-12						Pigtail coaxial FC	
G9801-22						FC board receptacle	
G9801-32						FC panel receptacle	






Long wavelength type InGaAs PIN photodiodes



These are InGaAs PIN photodiodes whose spectral response range extends up to 2.6 μm. Three groups are available with different peak sensitivity wavelengths of 1.75 μm, 1.95 μm, and 2.3 μm. Thermoelectrically cooled, low noise types are also available.





■ Peak sensitivity wavelength: 1.75 μm

(Typ.)

Type no.	Cooling (measurement condition)	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λp (μm)	Photosensitivity S λ=λp (A/W)	Dark current Id VR=0.5 V (nA)	Cutoff frequency fc VR=0 V (MHz)	Package	Photo	Option (sold separately)
G12181-003K	Non-cooled (Ta=25 °C)	φ0.3	0.9 to 1.9	1.75	1.1	1	90	TO-18		C4159-03
G12181-005K		φ0.5				3	35			
G12181-010K		φ1				10	10			
G12181-020K		φ2				50	2.5	TO-5		
G12181-030K		φ3				100	1.5			
G12181-103K	One-stage TE-cooled (Tchip=-10 °C)	φ0.3	0.9 to 1.87	1.75	1.1	0.1	140	TO-8		C4159-03 A3179 C1103-04
G12181-105K		φ0.5				0.3	50			
G12181-110K		φ1				1	16			
G12181-120K		φ2				5	3.5			
G12181-130K	Two-stage TE-cooled (Tchip=-20 °C)	φ3	0.9 to 1.85	1.75	1.1	10	1.8	TO-8		C4159-03 A3179-01 C1103-04
G12181-203K		φ0.3				0.05	150			
G12181-205K		φ0.5				0.15	53			
G12181-210K		φ1				0.5	17			
G12181-220K		φ2				2.5	3.7			
G12181-230K	φ3	5	1.9							





■ Peak sensitivity wavelength: 1.95 μm

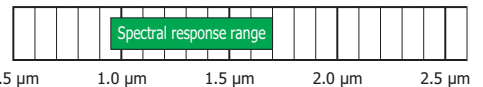
(Typ.)

Type no.	Cooling (measurement condition)	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photo-sensitivity $S_{\lambda=\lambda_p}$ (A/W)	Dark current I_D $V_R=0.5\text{ V}$ (nA)	Cutoff frequency f_c $V_R=0\text{ V}$ (MHz)	Package	Photo	Option (sold separately)
G12182-003K	Non-cooled ($T_a=25\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.1	1.95	1.2	10	90	TO-18		C4159-03
G12182-005K		$\phi 0.5$				20	35			
G12182-010K		$\phi 1$				100	10			
G12182-020K		$\phi 2$				500	2.5	TO-5		
G12182-030K		$\phi 3$				1000	1.5			
G12182-103K	One-stage TE-cooled ($T_{\text{chip}}=-10\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.07	1.95	1.2	1	140	TO-8		C4159-03 A3179 C1103-04
G12182-105K		$\phi 0.5$				3	50			
G12182-110K		$\phi 1$				10	16			
G12182-120K		$\phi 2$				50	3.5			
G12182-130K		$\phi 3$				100	1.8			
G12182-203K	Two-stage TE-cooled ($T_{\text{chip}}=-20\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.05	1.95	1.2	0.5	150	TO-8		C4159-03 A3179-01 C1103-04
G12182-205K		$\phi 0.5$				1.5	53			
G12182-210K		$\phi 1$				5	17			
G12182-220K		$\phi 2$				25	3.7			
G12182-230K		$\phi 3$				50	1.9			

■ Peak sensitivity wavelength: 2.3 μm


(Typ.)

Type no.	Cooling (measurement condition)	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photo-sensitivity $S_{\lambda=\lambda_p}$ (A/W)	Dark current I_D $V_R=0.5\text{ V}$ (μA)	Cutoff frequency f_c $V_R=0\text{ V}$ (MHz)	Package	Photo	Option (sold separately)
G12183-003K	Non-cooled ($T_a=25\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.6	2.3	1.3	0.4	50	TO-18		C4159-03
G12183-005K		$\phi 0.5$				1	20			
G12183-010K		$\phi 1$				3	6			
G12183-020K		$\phi 2$				10	1.5	TO-5		
G12183-030K		$\phi 3$				30	0.8			
G12183-103K	One-stage TE-cooled ($T_{\text{chip}}=-10\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.57	2.3	1.3	0.12	70	TO-8		C4159-03 A3179 C1103-04
G12183-105K		$\phi 0.5$				0.3	25			
G12183-110K		$\phi 1$				0.9	7			
G12183-120K		$\phi 2$				3	2			
G12183-130K		$\phi 3$				9	0.9			
G12183-203K	Two-stage TE-cooled ($T_{\text{chip}}=-20\text{ }^\circ\text{C}$)	$\phi 0.3$	0.9 to 2.55	2.3	1.3	0.085	75	TO-8		C4159-03 A3179-01 C1103-04
G12183-205K		$\phi 0.5$				0.21	28			
G12183-210K		$\phi 1$				0.65	8			
G12183-220K		$\phi 2$				2.1	2.3			
G12183-230K		$\phi 3$				6	1			



These are InGaAs APDs designed for distance measurement, FSO, low-light-detection, and optical communication, etc. The G8931-20 of large photosensitive area $\phi 0.2\text{ mm}$ is also available.

(Typ. $T_a=25\text{ }^\circ\text{C}$)

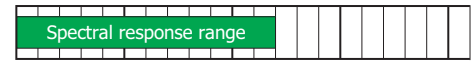
Type no.	Cooling	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photo-sensitivity $S_{\lambda=1.55\text{ }\mu\text{m}}$ $M=1$ (A/W)	Dark current I_D $V_R=V_{BR} \times 0.9$ (nA)	Cutoff frequency f_c $M=10$ (GHz)	Package	Photo
G8931-04	Non-cooled	$\phi 0.04$	0.95 to 1.7	1.55	0.9	40	4	TO-18	
G8931-10		$\phi 0.1$				90	1.5		
G8931-20		$\phi 0.2$				150	0.9		

InGaAs image sensors







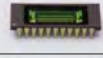




InGaAs linear image sensors

InGaAs linear image sensors are comprised of an InGaAs photodiode array with high sensitivity in the near infrared region, charge amplifier arrays, an offset compensation circuit, a shift register, and a timing generator. The signal from each pixel is read out in charge integration mode. The G11135/G11620/G12230 series use a back-illuminated structure to allow signal readout from a single video line.



0.5 μm 1.0 μm 1.5 μm 2.0 μm 2.5 μm
(Typ. unless otherwise noted)

Standard type

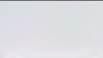

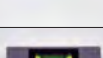





Type no.	Cooling (measurement condition)	Pixel pitch (μm)	Number of pixels	Photosensitive area (mm \times mm)	Spectral response range λ (μm)	Photo-sensitivity S $\lambda=\lambda_p$ (A/W)	Dark current I_D Ta=25 °C (pA)	Defective pixels max. (%)	Photo	Applicable driver circuit (sold separately)
G9203-256D	Non-cooled (Ta=25 °C)	50	256	12.8 \times 0.5	0.9 to 1.7	0.95	4	0		-
G11508-256SA	One-stage TE-cooled (Tchip=-10 °C)				0.9 to 1.67	1.0	± 1			
G9204-512D	Non-cooled (Ta=25 °C)	25	512		0.9 to 1.7	0.95	1			
G11508-512SA	One-stage TE-cooled (Tchip=-10 °C)				0.9 to 1.67	1.0	± 0.5			
G9494-256D	Non-cooled (Ta=25 °C)	50	256	12.8 \times 0.05	0.9 to 1.7	0.95	4	1		C10820
G9494-512D		25	512	12.8 \times 0.025			1			
G10768-1024D	Non-cooled (Ta=25 °C)	25	1024	25.6 \times 0.1	0.9 to 1.7	0.95	± 1	1		C10854
G10768-1024DB				25.6 \times 0.025						
G11608-256DA	Non-cooled (Ta=25 °C)	50	256	12.8 \times 0.5	0.5 to 1.7	1.0	± 1	1		-
G11608-512DA		25	512				± 0.5			



Back-illuminated type

These linear image sensors use a back-illuminated type InGaAs photodiode array that is bump-connected to a CMOS-ROIC with a single output terminal.

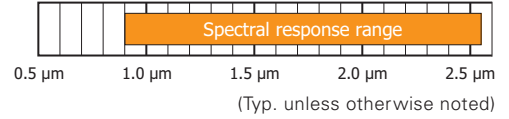


0.5 μm 1.0 μm 1.5 μm 2.0 μm 2.5 μm
(Typ. unless otherwise noted)









Type no.	Cooling	Pixel pitch (μm)	Number of pixels	Photosensitive area (mm \times mm)	Spectral response range λ (μm)	Photo-sensitivity S $\lambda=\lambda_p$ (A/W)	Dark current I_D Ta=25 °C (pA)	Defective pixels max. (%)	Photo	Applicable driver circuit (sold separately)
G11135-256DD	Non-cooled (Ta=25 °C)	50	256	12.8 \times 0.05	0.95 to 1.7	0.82	± 0.2	1		C11514
G11135-512DE		25	512	12.8 \times 0.025						
G11620-256DA		50	256	12.8 \times 0.5			± 0.5			C11513
G11620-512DA		25	512							
G11620-128DA		50	128	6.4 \times 0.5			± 1			-
G11620-256DF		25	256							
 G13913-128FB		50	128	6.4 \times 0.25	1.12 to 1.9	1.05	± 2		-	
 G13913-256FG		25	256							
 G14006-512DE		25	512	12.8 \times 0.025		C11514				

Type no.	Cooling	Pixel pitch (μm)	Number of pixels	Photosensitive area (mm × mm)	Spectral response range λ (μm)	Photo-sensitivity S λ=λp (A/W)	Dark current I _D T _a =25 °C (pA)	Defective pixels max. (%)	Photo	Applicable driver circuit (sold separately)
G11620-256SA	One-stage TE-cooled (T _{chip} =-10 °C)	50	256	12.8 × 0.5	0.95 to 1.67	0.82	±0.5	1		-
G11620-512SA		25	512							
G12230-512WB	Two-stage TE-cooled (T _{chip} =-20 °C)	25	512	12.8 × 0.25	0.95 to 1.65*1	0.82*1	±0.2*1	2		-
					1.4 to 2.15*2	1.0*2	5*2			

*1: 1 to 254 ch (T_{chip}=-20 °C) *2: 259 to 512 ch (T_{chip}=-20 °C)

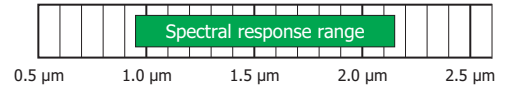


■ Long wavelength type




Type no.	Cooling (measurement condition)	Pixel pitch (μm)	Number of pixels	Photosensitive area (mm × mm)	Spectral response range λ (μm)	Photo-sensitivity S λ=λp (A/W)	Dark current I _D T _{chip} =-20 °C (pA)	Defective pixels max. (%)	Photo	Applicable driver circuit (sold separately)
 G11475-256WB	Two-stage TE-cooled (T _{chip} =-20 °C)	50	256	12.8 × 0.25	0.9 to 1.85	1.1	±2	5		-
 G11475-512WB		25	512					4		
 G11476-256WB		50	256		0.9 to 2.05	1.2	±4	5		
 G11477-256WB		50	256					5		
 G11477-512WB		25	512		0.9 to 2.15	1.3	±5	4		
 G11478-256WB		50	256					5		
 G11478-512WB		25	512		4					



InGaAs area image sensors



InGaAs area image sensors have a hybrid structure consisting of a CMOS readout circuit (ROIC: readout integrated circuit) and a back-illuminated type InGaAs photodiode area array.

Type no.	Cooling (measurement condition)	Pixel pitch (μm)	Number of pixels	Photosensitive area (mm × mm)	Spectral response range λ (μm)	Photo-sensitivity S λ=λp (A/W)	Dark current I _D (pA)	Defective pixels max. (%)	Photo	Applicable driver circuit (sold separately)
G11097-0606S	One-stage TE-cooled (T _{chip} =25 °C)	50	64 × 64	3.2 × 3.2	0.95 to 1.7	0.8	2 (T _{chip} =25 °C)	1		C11512
G12460-0606S	One-stage TE-cooled (T _{chip} =0 °C)				1.12 to 1.9	1.1	8 (T _{chip} =0 °C)			
G12242-0707W	Two-stage TE-cooled (T _{chip} =15 °C)	20	128 × 128	2.56 × 2.56	0.95 to 1.7	0.8	0.5 (T _{chip} =15 °C)	1		C11512-02
G13393-0808W			320 × 256	6.40 × 5.12				0.37		
G13393-0909W		640 × 512	12.8 × 10.24	1		-				
G13441-01		50	192 × 96				9.6 × 4.8	1.3 to 2.15	1	30 (T _{chip} =-20 °C)

Related products



Two-color detectors

Two-color detectors use a combination of two light sensors with different spectral response, in which one sensor is mounted over the other sensor along the same optical axis to provide a broad spectral response range. As the combination of two light sensors, an infrared-transmitting Si photodiode and an InGaAs PIN photodiode (standard type or long wavelength type) or an infrared-transmitting InGaAs PIN photodiode (standard type) and an InGaAs PIN photodiode (long wavelength type) are available. Thermoelectrically cooled two-color detectors are also provided that cool the sensors to maintain their temperatures constant, allowing high precision measurement with an improved S/N.








Features

- Wide spectral response range
- Simultaneously detects light of multiple wavelengths in the same optical path
- High S/N (One-stage TE-cooled type)

Applications

- Spectrophotometers
- Radiation thermometer
- Flame monitor
- Laser monitor

(Typ.)

Type no.	Cooling (measurement condition)	Detector	Photosensitive area (mm)	Spectral response range λ (μm)	Peak sensitivity wavelength λ_p (μm)	Photo-sensitivity S $\lambda=\lambda_p$ (A/W)	Cutoff frequency f_c $V_R=0\text{ V}$ $R_L=1\text{ k}\Omega$ (MHz)	Package	Photo	Option (sold separately)			
K1713-05	Non-cooled (Ta=25 °C)	Si	2.4 × 2.4	0.32 to 1.7	0.94	0.45	1.75	TO-5		C9329 C4159-03			
K1713-08		InGaAs	$\phi 0.5$		1.55	0.55	200						
		Si	2.4 × 2.4	0.32 to 2.6	0.94	0.45	1.75						
K1713-09		InGaAs	$\phi 1$		2.3	0.60	6*1						
		K11908-010K	Si	2.4 × 2.4	0.32 to 1.7	0.94	0.45			1.75			
InGaAs			$\phi 1$	1.55		0.55	50						
K13085-010K		One-stage TE-cooled (Tchip=-10 °C)	InGaAs	2.4 × 2.4	0.9 to 2.55	1.55	0.95			2*1	TO-8		C4159-03
			InGaAs	$\phi 1$		2.1	1.0			6*1			
K3413-05	Non-cooled (Ta=25 °C)	Si	2.4 × 2.4	0.32 to 1.67	0.94	0.45	1.75	Ceramic		-			
		InGaAs	$\phi 0.5$		1.55	0.55	200						
K3413-08	One-stage TE-cooled (Tchip=-10 °C)	Si	2.4 × 2.4	0.32 to 2.57	0.94	0.45	1.75	TO-8		C9329 C4159-03 A3179-03 C1103-04			
		InGaAs	$\phi 1$		2.3	0.60	15						
K3413-09	Non-cooled (Ta=25 °C)	Si	2.4 × 2.4	0.32 to 1.67	0.94	0.45	1.75	Ceramic		-			
		InGaAs	$\phi 1$		1.55	0.55	50						
K12728-010K	Non-cooled (Ta=25 °C)	Si	2.4 × 2.4	0.32 to 1.65	0.96	0.45	2*1	Ceramic		-			
		InGaAs	$\phi 1$		1.55	0.55	10*1						
K12729-010K	Non-cooled (Ta=25 °C)	InGaAs	2.4 × 2.4	0.9 to 2.55	1.55	0.95	2*1	Ceramic		-			
		InGaAs	$\phi 1$		2.1	1.0	6*1						

*1: $V_R=0\text{ V}$, $R_L=50\ \Omega$



Infrared detector modules with preamps

These are infrared detector modules using an InGaAs PIN photodiode and a preamp integrated into a compact case. Thermoelectrically cooled types and liquid nitrogen cooled types are provided for applications requiring low noise. Custom products are also available with different spectral response ranges, time response characteristics, and gains.




Features

- Easy to use
Just connecting it to a DC power supply provides a voltage output that varies with the incident light level.
- Compact size
- Low noise, high sensitivity (TE-cooled type, liquid nitrogen cooled type)

Applications

- Various infrared detections

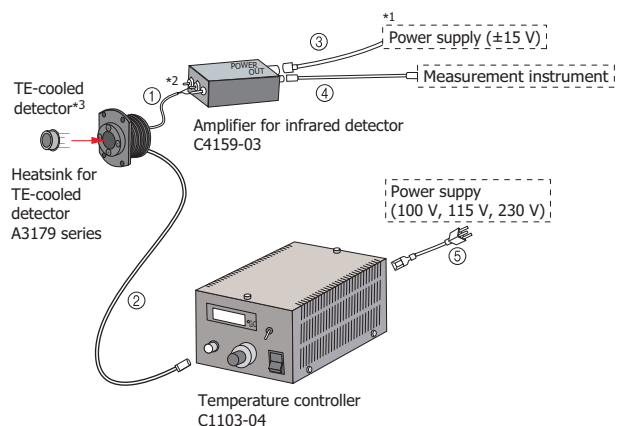
(Typ.)

Type no.	Detector	Cooling (measurement condition)	Photosensitive area (mm)	Cutoff wavelength λ_c (μm)	Peak sensitivity wavelength λ_p (μm)	Photosensitivity $S_{\lambda=\lambda_p}$ (V/W)	Photo
G6121	G8370-05	Non-cooled (Ta=25 °C)	$\phi 5$	1.7	1.55	1×10^6	
C12483-250	G12180-250A	TE-cooled (Tchip=-15 °C)	$\phi 5$	1.66	1.55	5×10^7	
C12485-210	G12182-210K		$\phi 1$	2.05	1.95	1.8×10^8	
C12486-210	G12183-210K		$\phi 1$	2.56	2.3	2×10^8	
G7754-01	G12183-010 (chip)	Liquid nitrogen (Tchip=-196 °C)	$\phi 1$	2.4	2.0	2×10^9	
G7754-03	G12183-030 (chip)		$\phi 3$			5×10^8	

Options

A variety of options are provided to facilitate using InGaAs photodiodes.

Connection example



KIRDC0101EC

Cable no.	Cable	Approx. length	Note
①	Coaxial cable (for signal, no connector)	2 m	Supplied with heatsink A3179 series. When using this cable, make it as short as possible (preferably about 10 cm).
②	4-conductor cable (with a connector) A4372-05	3 m	Supplied with temperature controller C1103-04. This cable is also sold separately.
③	4-conductor cable (with a connector) A4372-02	2 m	Supplied with the C4159-03 amplifier for infrared detector, and infrared detector modules with preamps (non-cooled type). This cable is also sold separately. The A4372-03, which is a 6-conductor cable (with connector) supplied with infrared detector module with preamp (non-cooled type), is also sold separately.
④	BNC connector cable E2573	1 m	Option
⑤	Power supply cable (for temperature controller)	1.9 m	Supplied with temperature controller C1103-04

*1: Attach the bare wire end to a 3-pin or 4-pin connector or to a banana plug, and then connect them to the power supply.

*2: Soldering is needed.

*3: No socket is available. Soldering is needed.



Amplifier for infrared detectors

For InGaAs PIN photodiode

The C4159-03 is a low noise amplifier for InGaAs PIN photodiodes.

Features

- Low noise
- 3 ranges switchable

Accessories

- Instruction manual
- Power cable A4372-02 (one end with 4-pin connector for connection to amplifier and the other end unterminated, 2 m)

(Typ.)

Specification

Parameter	Condition	Specification	Unit
Applicable detector*4 *5		InGaAs	-
Conversion impedance		10^7 , 10^6 , 10^5 (3 ranges switchable)	V/A
Frequency response	Amp only, -3 dB	DC to 15 kHz	-
Output impedance		50	Ω
Maximum output voltage	1 k Ω load	+10	V
Output offset voltage		± 5	mV
Equivalent input noise current	f=1 kHz	2.5	pA/Hz ^{1/2}
Reverse voltage		Can be applied from external unit	-
External power supply*6		± 15	V
Current consumption		± 15 max.	mA



Note: A power supply is needed to use this amplifier.

*4: These amplifiers cannot operate multiple detectors.

*5: Consult us before purchasing if you want to use with a detector other than listed here.

*6: Recommended DC power supply (analog power supply): ± 15 V
Current capacity: more than 1.5 times the maximum current consumption
Ripple noise: 5 mVp-p or less



Heatsinks for TE-cooled detectors

For InGaAs PIN photodiode and two-color detector

The A3179 series heatsinks are designed specifically for thermoelectrically cooled infrared detectors. When used at an ambient temperature of 25 °C, the A3179 and A3179-03 provide a temperature difference (ΔT) of about 35 °C and the A3179-01 provides a temperature difference (ΔT) of about 40 °C.

Features

- A3179: for one-stage TE-cooled type
A3179-01: for two-stage TE-cooled type
A3179-03: for two-color detector K3413 series
- Compact size



A3179-01

Accessories

- Instruction manual
- 4-conductor cable (no connector, 2 m): for TE-cooler and thermistor*7 *8
- Coaxial cable (2 m): for signal*7

Note:

*7: When used in combination with the C1103-04 temperature controller, do not use the 4-conductor cable supplied with the A3179 series, but use the 4-conductor cable A4372-05 (sold separately, with a connector).

*8: No socket is supplied for connection to infrared detectors. Connect infrared detectors by soldering. Cover the soldered joints and detector pins with vinyl insulating tubes.



Temperature controller

For InGaAs PIN photodiode

The C1103-04 is a temperature controller designed for TE-cooled infrared detectors. The C1103-04 allows temperature setting for the TE-cooler mounted in an infrared detector.

Accessories

- Instruction manual
- 4-conductor cable A4372-05 (with a connector, 3 m): for TE-cooler and thermistor*9
- Power supply cable

Specifications

Parameter	Specification	Photo
Applicable detector*10	One-stage /two-stage TE-cooled InGaAs PIN photodiode	
Setting element temperature	-30 to +20 °C	
Temperature stability	within ± 0.1 °C	
Output current for temperature control	1.1 A min., 1.2 A typ., 1.3 A max.	
Power supply	100 V \pm 10% · 50/60 Hz*11	
Power consumption	30 W	
Dimensions	107 (W) \times 84 (H) \times 190 (D) mm	
Weight	Approx. 1.9 kg	

*9: When used in combination with the A3179 series heatsink, do not use a 4-conductor cable supplied with the A3179 series, but use the A4372-05 instead.

*10: This temperature controller does not support TE-cooled infrared detector modules with preamps and cannot set temperatures on two or more TE-coolers.

*11: Please specify power supply requirement (AC line voltage) from among 100 V, 115 V and 230 V when ordering.



Multichannel detector head for InGaAs linear image sensor (G10768 series) C10854


The C10854 is a multichannel detector head designed for applications such as sorting machines and SD-OCT (spectral domain-optical coherence tomography) where high-speed response is essential. The C10854 is optimized for use with the G10768 series InGaAs linear image sensors and controllable from a PC by using the supplied application software (DCam-CL) that runs on Windows 7 (32-bit, 64-bit) /10 (32-bit, 64-bit).

Features

- High-speed operation: 5 MHz
- Line rate: 31.25 kHz
- Supports CameraLink

Applications

- Near infrared multichannel spectroscopy
- Foreign object screening
- OCT (optical coherence tomography)

Type no.	Interface	Output	Photo	Applicable sensor (sold separately)
C10854	CameraLink	Digital		G10768-1024D, G10768-1024DB

Multichannel detector heads for InGaAs area image sensors (G11097/G12460-0606S, G12242-0707W) C11512 series


The C11512 series is a multichannel detector head designed for the G11097/G12460-0606S, G12242-0707W InGaAs area image sensors. The C11512 series supports a variety of near infrared imaging applications and is controllable from a PC by using the supplied application software (DCam-CL) that runs on Windows 7 (32-bit, 64-bit) /10 (32-bit, 64-bit).

Features

- Built-in temperature control circuit [Tchip=10 °C typ. (Ta=25 °C)]
- Supports CameraLink
- Compact size
- External trigger input
- Adjustable offset and gain
- Pulse output setting

Applications

- Thermal imaging
- Laser beam profiler
- Foreign object inspection

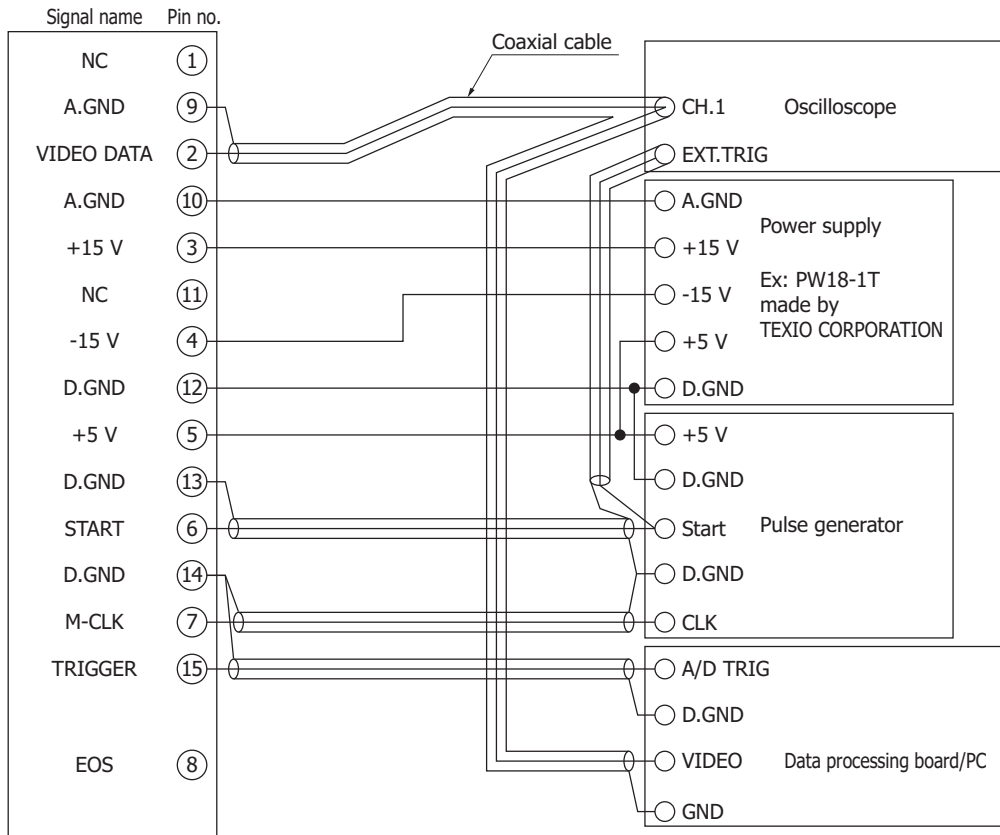
Type no.	Interface	Output	Photo	Applicable sensor (sold separately)
C11512	CameraLink	Digital		G11097-0606S, G12460-0606S
C11512-02				G12242-0707W



Type no.	Features	Photo	Applicable sensor
C10820	High gain setting suitable for low-level-light		G9494-256D G9494-512D
C11513	USB 2.0 interface (USB bus power)		G11620-128DA G11620-256DF G11620-256DA G11620-512DA
C11514	Supports CameraLink		G11135 series G14006-512DE

Connection example (C10820)

I/O connector: D-sub 15-pin type



KACCC0499EB

Description of terms

● Spectral response

The relation (photoelectric sensitivity) between the incident light level and resulting photocurrent differs depending on the wavelength of the incident light. This relation between the photoelectric sensitivity and wavelength is referred to as the spectral response characteristic and is expressed in terms of photosensitivity or quantum efficiency.

● Photosensitivity: S

The ratio of photocurrent expressed in amperes (A) or output voltage expressed in volts (V) to the incident light level expressed in watts (W). Photosensitivity is represented as an absolute sensitivity (A/W or V/W) or as a relative sensitivity (%) to the peak wavelength sensitivity normalized to 100. We usually define the spectral response range as the range in which the relative sensitivity is higher than 5% or 10% of the peak sensitivity.

● Quantum efficiency: QE

This is the number of electrons or holes that can be extracted as photocurrent divided by the number of incident photons. It is commonly expressed in percent (%). The quantum efficiency QE and photosensitivity S (unit: A/W) have the following relationship at a given wavelength (unit: nm).

$$QE = \frac{S \times 1240}{\lambda} \times 100 \text{ [%]}$$

● Short circuit current: I_{sc}

This is the output current that flows in a photodiode when load resistance is zero. This is called "white light sensitivity" to differentiate it from the spectral response, and is measured with light from a standard tungsten lamp at 2856 K distribution temperature (color temperature). Our product catalog lists the short circuit current measured under an illuminance of 100 lx.

● Peak sensitivity wavelength: λ_p

This is the wavelength at which the photosensitivity of the detector is at maximum.

● Cutoff wavelength: λ_c

This represents the long wavelength limit of spectral response and in datasheets is listed as the wavelength at which the sensitivity becomes 10% of the value at the peak sensitivity wavelength.

● Dark current: I_d

A small current which flows when a reverse voltage is applied to a photodiode even in a dark state. This current is called the dark current. Noise resulting from dark current becomes dominant when a reverse voltage is applied to photodiodes (PIN photodiodes, etc.).

● Shunt resistance: R_{sh}

This is the voltage/current ratio of a photodiode operated in the vicinity of 0 V. In our product catalog, the shunt resistance is specified by the following equation, where the dark current (I_d) is a value measured at a reverse voltage of 10 mV.

$$R_{sh} [\Omega] = \frac{0.01 \text{ [V]}}{I_d \text{ [A]}}$$

Noise generated from the shunt resistance becomes dominant in applications where a reverse voltage is not applied to the photodiode.

● Terminal capacitance: C_t

In a photodiode, the PN junction can be considered as a type of capacitor. This capacitance is termed the junction capacitance and is an important parameter in determining the response speed. In current-to-voltage conversion circuits using an op amp, the junction capacitance might cause gain peaking. At HAMAMATSU, we specify the terminal capacitance including this junction capacitance plus the package stray capacitance.

● Rise time: t_r

The rise time is the time required for the output to rise from 10% to 90% of the maximum output value (steady-state value) in response to input of step-function light.

● Cutoff frequency: f_c

This is the measure used to evaluate the time response of high-speed PIN photodiodes to a sinewave-modulated light input. It is defined as the frequency at which the photodiode output decreases by 3 dB from the output at 100 kHz. The light source used is a laser diode (1.3 μm or 1.55 μm) and the load resistance is 50 Ω. The rise time t_r has a relation with the cutoff frequency f_c as follows:

$$t_r \text{ [s]} = \frac{0.35}{f_c \text{ [Hz]}}$$

● Noise equivalent power: NEP

NEP is the incident light level equivalent to the noise level of a device. In other words, it is the light level required to obtain a signal-to-noise ratio (S/N) of 1. We define the NEP value at the peak sensitivity wavelength (λ_p). Since the noise level is proportional to the square root of the frequency bandwidth, the bandwidth is normalized to 1 Hz.

$$NEP \text{ [W/Hz}^{1/2}] = \frac{\text{Noise current [A/Hz}^{1/2}]}{\text{Photosensitivity [A/W] at } \lambda_p}$$

● Reverse voltage: V_{R max}

Applying a reverse voltage to a photodiode triggers a breakdown at a certain voltage and causes severe deterioration of the device performance. Therefore the absolute maximum rating is specified for reverse voltage at the voltage somewhat lower than this breakdown voltage. The reverse voltage shall not exceed the maximum rating, even instantaneously.

Reference (Physical constants relating to light and opto-semiconductors)

Constant	Symbol	Numerical value	Unit
Electron charge	q	1.602 × 10 ⁻¹⁹	C
Speed of light in vacuum	c	2.998 × 10 ⁸	m/s
Planck's constant	h	6.626 × 10 ⁻³⁴	J·s
Boltzmann's constant	k	1.381 × 10 ⁻²³	J/K
Thermal energy at room temperature	kT	0.0259 (300 K)	eV
Energy of 1eV	eV	1.602 × 10 ⁻¹⁹	J
Wavelength equivalent to 1 eV in vacuum	-	1240	nm
Permittivity of vacuum	ε ₀	8.854 × 10 ⁻¹²	F/m
Band gap energy of silicon	E _g	Approx. 1.12 (25 °C)	eV

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HAMAMATSU

HAMAMATSU PHOTONICS K.K., Solid State Division

1126-1, Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558, Japan
Telephone: (81)53-434-3311, Fax: (81)53-434-5184

www.hamamatsu.com

Main Products

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Sales Offices

Japan:

HAMAMATSU PHOTONICS K.K.
325-6, Sunayama-cho, Naka-ku,
Hamamatsu City, Shizuoka Pref. 430-8587, Japan
Telephone: (81)53-452-2141, Fax: (81)53-456-7889
E-mail: intl-div@hq.hpkk.co.jp

China:

HAMAMATSU PHOTONICS (CHINA) Co., Ltd.
Main Office
1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu,
Chaoyang District, 100020 Beijing, China
Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866
E-mail: hpc@hamamatsu.com.cn

Shanghai Branch

4905 Wheelock Square, 1717 Nanjing Road West,
Jingan District, 200040 Shanghai, China
Telephone: (86)21-6089-7018, Fax: (86)21-6089-7017

Taiwan:

HAMAMATSU PHOTONICS TAIWAN Co., Ltd.
Main Office
8F-3, No.158, Section2, Gongdao 5th Road,
East District, Hsinchu, 300, Taiwan R.O.C.
Telephone: (886)03-659-0080, Fax: (886)03-659-0081
E-mail: info@tw.hpkk.co.jp

Kaohsiung Office

No.6, Central 6th Road, K.E.P.Z. Kaohsiung 806,
Taiwan R.O.C.
Telephone: (886)07-262-0736, Fax: (886)07-811-7238

U.S.A.:

HAMAMATSU CORPORATION
Main Office
360 Foothill Road, Bridgewater, NJ 08807, U.S.A.
Telephone: (1)908-231-0960, Fax: (1)908-231-1218
E-mail: usa@hamamatsu.com

California Office

2875 Moorpark Ave. San Jose, CA 95128, U.S.A.
Telephone: (1)408-261-2022, Fax: (1)408-261-2522
E-mail: usa@hamamatsu.com

Chicago Office

4711 W.Golf Road, Suite 805, Skokie, IL 60076, U.S.A.
Telephone: (1)847-825-6046, Fax: (1)847-825-2189
E-mail: usa@hamamatsu.com

Boston Office

20 Park Plaza, Suite 312, Boston, MA 02116, U.S.A.
Telephone: (1)617-536-9900, Fax: (1)617-536-9901
E-mail: usa@hamamatsu.com

United Kingdom:

HAMAMATSU PHOTONICS UK Limited
Main Office
2 Howard Court, 10 Tewin Road, Welwyn Garden City,
Hertfordshire AL7 1BW, UK
Telephone: (44)1707-294888, Fax: (44)1707-325777
E-mail: info@hamamatsu.co.uk

South Africa Office:

9 Beukes Avenue, Highway Gardens, Edenvale
1609 South Africa
Telephone/Fax: (27)11-609-0367

France, Portugal, Belgium, Switzerland, Spain:

HAMAMATSU PHOTONICS FRANCE S.A.R.L.
Main Office
19, Rue du Saule Trapu, Parc du Moulin de Massy,
91882 Massy Cedex, France
Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10
E-mail: infos@hamamatsu.fr

Swiss Office

Dornacherplatz 7, 4500 Solothurn, Switzerland
Telephone: (41)32-625-60-60, Fax: (41)32-625-60-61
E-mail: swiss@hamamatsu.ch

Belgian Office

Axisparc Technology, rue Andre Dumont 7
1435 Mont-Saint-Guibert, Belgium
Telephone: (32)10 45 63 34, Fax: (32)10 45 63 67
E-mail: info@hamamatsu.be

Spanish Office

C. Argenters, 4 edif 2 Parque Tecnológico del Vallés
08290 Cerdanyola (Barcelona), Spain
Telephone: (34)93 582 44 30, Fax: (34)93 582 44 31
E-mail: infospain@hamamatsu.es

Germany, Denmark, The Netherlands, Poland:

HAMAMATSU PHOTONICS DEUTSCHLAND GmbH
Main Office
Arzbergerstr. 10, D-82211 Herrsching am Ammersee,
Germany
Telephone: (49)8152-375-0, Fax: (49)8152-265-8
E-mail: info@hamamatsu.de

Danish Office

Lautruphøj 1-3, DK-2750 Ballerup, Denmark
Telephone: (45)70 20 93 69, Fax: (45)44 20 99 10
Email: info@hamamatsu.dk

Netherlands Office

Televisieweg 2, NL-1322 AC Almere, The Netherlands
Telephone: (31)36-5405384, Fax: (31)36-5244948
E-mail: info@hamamatsu.nl

Poland Office

02-525 Warsaw, 8 St. A. Boboli Str., Poland
Telephone: (48)22-646-0016, Fax: (48)22-646-0018
E-mail: poland@hamamatsu.de

North Europe and CIS:

HAMAMATSU PHOTONICS NORDEN AB
Main Office
Torshamnsgatan 35 16440 Kista, Sweden
Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01
E-mail: info@hamamatsu.se

Russian Office

11, Christoprudny Boulevard, Building 1, Office 114,
101000, Moscow, Russia
Telephone: (7)495 258 85 18, Fax: (7)495 258 85 19
E-mail: info@hamamatsu.ru

Italy:

HAMAMATSU PHOTONICS ITALIA S.r.l.
Main Office
Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy
Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41
E-mail: info@hamamatsu.it

Rome Office

Viale Cesare Pavese, 435, 00144 Roma, Italy
Telephone: (39)06-50 51 34 54, Fax: (39)02-93 58 17 41
E-mail: inforoma@hamamatsu.it

