

CCD image sensors



S14651/S14661 series

Photosensitive area structure suitable for spectrometers, high-speed/low-noise type available (1-stage TE-cooled)

The S14651/S14661 series are back-thinned CCD image sensors designed for spectrometers. Low-noise type (S14651 series) and high-speed type (S14661 series) are available. The S14650/S14660 series offer nearly flat spectral response characteristics with high quantum efficiency from the UV to near infrared region. A thermoelectric cooler is placed inside the package to keep the chip temperature constant (approx. 5 °C) during operation.

Features

- One-stage TE-cooled type (chip temperature: approx. 5 °C)
- Low etaloning
- High sensitivity over a wide spectral range and nearly flat spectral response characteristics
- High conversion efficiency: 6.5 $\mu\text{V}/\text{e}^-$ (S14651 series)
8 $\mu\text{V}/\text{e}^-$ (S14661 series)
- High full well capacity and wide dynamic range (Horizontal shift register with anti-blooming function)
- Pixel size: 14 × 14 μm

Applications

- Spectrometers and the like

Selection guide

Type no.	Total number of pixels	Number of effective pixels	Image size [mm (H) × mm (V)]	Readout speed max. (MHz)	Suitable driver circuit
S14651-1024	1044 × 198	1024 × 192	14.336 × 2.688	0.5	C11860
S14651-2048	2068 × 198	2048 × 192	28.672 × 2.688		
S14661-1024	1044 × 198	1024 × 192	14.336 × 2.688	10	-
S14661-2048	2068 × 198	2048 × 192	28.672 × 2.688		

Structure

Parameter	S14651 series	S14661 series
Pixel size (H × V)	14 × 14 μm	
Vertical clock	2-phase	
Horizontal clock	4-phase	
Output circuit	One-stage MOSFET source follower	Two-stage MOSFET source follower
Package	28-pin ceramic DIP (refer to dimensional outlines)	
Window material*1	Quartz glass*1	
Cooling	One-stage TE-cooled	

*1: Hermetically sealed

➤ Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating temperature*2	Topr		-50	-	+50	°C
Storage temperature	Tstg		-50	-	+70	°C
Output transistor drain voltage	VOD	S14651 series	-0.5	-	+30	V
		S14661 series	-0.5	-	+25	
Reset drain voltage	VRD		-0.5	-	+18	V
Output amplifier return voltage	Vret		-0.5	-	+18	V
Overflow drain voltage	VOFD		-0.5	-	+18	V
Vertical input source voltage	VISV		-0.5	-	+18	V
Horizontal input source voltage	VISH		-0.5	-	+18	V
Overflow gate voltage	VOFG		-10	-	+15	V
Vertical input gate voltage	VIGV		-10	-	+15	V
Horizontal input gate voltage	VIGH		-10	-	+15	V
Summing gate voltage	VSG		-10	-	+15	V
Output gate voltage	VOG		-10	-	+15	V
Reset gate voltage	VRG		-10	-	+15	V
Transfer gate voltage	VTG		-10	-	+15	V
Vertical shift register clock voltage	VP1V, VP2V		-10	-	+15	V
Maximum current of built-in TE-cooler*3 *4	Imax	Tc*5=Th*6=25 °C	-	-	1.8	A
Maximum voltage of built-in TE-cooler	Vmax	Tc*5=Th*6=25 °C	-	-	3.5	V
Horizontal shift register clock voltage	VP1H, VP2H VP3H, VP4H		-10	-	+15	V
Soldering conditions*7	Tsol		260 °C, within 5 s, at least 2 mm away from lead roots			-

*2: Chip temperature

*3: If the current greater than this value flows into the thermoelectric cooler, the heat absorption begins to decrease due to the Joule heat. It should be noted that this value is not the damage threshold value. To protect the thermoelectric cooler and maintain stable operation, the supply current should be less than 60% of this maximum current.

*4: To ensure stable temperature control, ΔT (temperature difference between Th and Tc) should be less than 30 °C. If ΔT exceeds 30 °C, product characteristics may deteriorate. For example, the dark current uniformity may degrade.

*5: Temperature of the cooling side of thermoelectric cooler *6: Temperature of the heat radiating side of thermoelectric cooler

*7: Use a soldering iron.

Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

➤ Operating conditions (MPP mode, Ta=25 °C)

Parameter	Symbol	S14651 series			S14661 series			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Output transistor drain voltage	VOD	23	24	25	12	15	18	V
Reset drain voltage	VRD	11	12	13	14	15	16	V
Overflow drain voltage	VOFD	11	12	13	11	12	13	V
Overflow gate voltage	VOFG	0	12	13	0	13	14	V
Output gate voltage	VOG	4	5	6	4	5	6	V
Substrate voltage	VSS	-	0	-	-	0	-	V
Output amplifier return voltage*8	Vret				-	1	2	V
Test point	Input source	VISV, VISH	-	VRD	-	-	VRD	-
	Vertical input gate	VIGV	-9	-8	-	-9	-8	-
	Horizontal input gate	VIGH	-9	-8	-	-9	-8	-
Vertical shift register clock voltage	High	VP1VH, VP2VH	4	6	8	4	6	8
	Low	VP1VL, VP2VL	-9	-8	-7	-9	-8	-7
Horizontal shift register clock voltage	High	VP1HH, VP2HH VP3HH, VP4HH	4	6	8	4	6	8
	Low	VP1HL, VP2HL VP3HL, VP4HL	-6	-5	-4	-6	-5	-4
Summing gate voltage	High	VSGH	4	6	8	4	6	8
	Low	VSGL	-6	-5	-4	-6	-5	-4
Reset gate voltage	High	VRGH	4	6	8	4	6	8
	Low	VRGL	-6	-5	-4	-6	-5	-4
Transfer gate voltage	High	VTGH	4	6	8	4	6	8
	Low	VTGL	-9	-8	-7	-9	-8	-7
External load resistance	RL	90	100	110	2.0	2.2	2.4	kΩ

*8: Output amplifier return voltage is a positive voltage with respect to substrate voltage, but the current flows out from the sensor.

▣ Electrical characteristics [Ta=25 °C, operating conditions: Typ. value (P.2)]

Parameter	Symbol	S14651 series			S14661 series			Unit	
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Output signal frequency*9	fc	-	0.25	0.5	-	5	10	MHz	
Vertical shift register capacitance	-1024	CP1V, CP2V	-	1800	-	-	1800	-	pF
	-2048		-	3600	-	-	3600	-	
Horizontal shift register capacitance	-1024	CP1H, CP2H	-	80	-	-	80	-	pF
	-2048	CP3H, CP4H	-	160	-	-	160	-	
Summing gate capacitance	CSG	-	10	-	-	10	-	pF	
Reset gate capacitance	CRG	-	10	-	-	10	-	pF	
Transfer gate capacitance	-1024	CTG	-	30	-	-	30	-	pF
	-2048		-	60	-	-	60	-	
Charge transfer efficiency*10	CTE	0.99995	0.99999	-	0.99995	0.99999	-	-	
DC output level**9	Vout	16	17	18	7	8	9	V	
Output impedance*9	Zo	-	10	-	-	0.3	-	kΩ	
Power consumption*9 *11	P	-	4	-	-	75	-	mW	

*9: The values depend on the load resistance (S14651 series: VOD=24 V, RL=100 kΩ, S14661 series: VOD=15 V, RL=2.2 kΩ)

*10: Charge transfer efficiency per pixel, measured at half of the full well capacity

*11: Power consumption of the on-chip amp plus load resistance

▣ Electrical and optical characteristics [Ta=25 °C, operating conditions: Typ. value (P.2), unless otherwise noted]

Parameter	Symbol	S14651 series			S14661 series			Unit	
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Saturation output voltage	Vsat	-	Fw × CE	-	-	Fw × CE	-	V	
Full well capacity	Vertical	Fw	50	60	-	50	60	-	ke ⁻
	Horizontal		250	300	-	150	200	-	
Conversion efficiency*12	CE	5.5	6.5	7.5	7	8	9	μV/e ⁻	
Dark current*13	DS	-	50	500	-	50	500	e ⁻ /pixel/s	
Readout noise*14	Nread	-	6	15	-	30	45	e ⁻ rms	
Dynamic range*15	Line binning	Drange	16600	50000	-	3330	6670	-	
Spectral response range	λ	-	200 to 1100	-	-	200 to 1100	-	nm	
Photoresponse nonuniformity*16	PRNU	-	±3	±10	-	±3	±10	%	

*12: The values depend on the load resistance (S14651 series: VOD=24 V, RL=100 kΩ, S14661 series: VOD=15 V, RL=2.2 kΩ)

*13: Dark current is reduced to half for every 5 to 7 °C decrease in temperature.

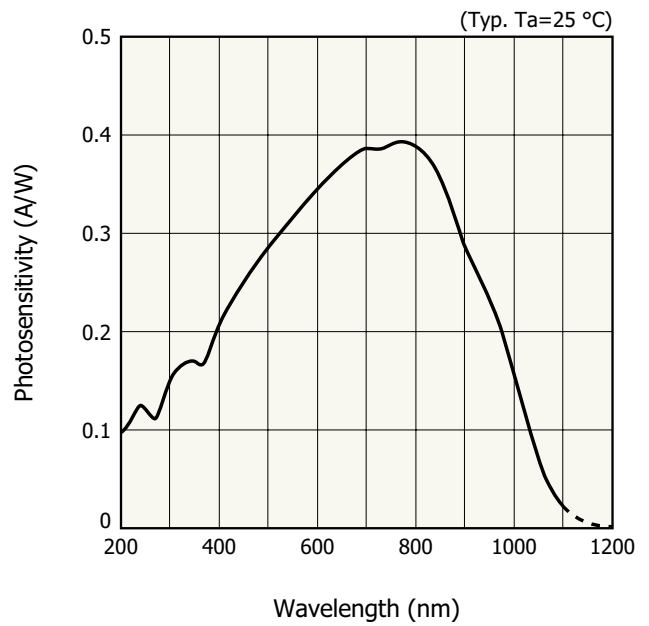
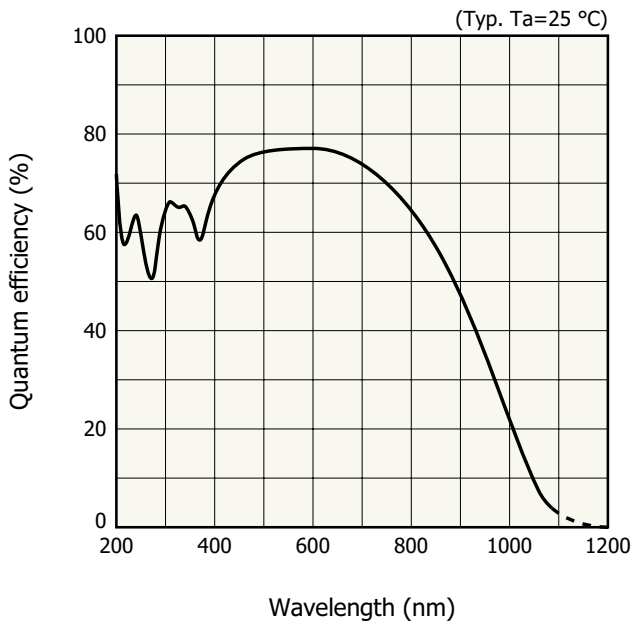
*14: S14651 series (temperature: -40 °C): fc=20 kHz, S14661 series (temperature: 25 °C): fc= 5 MHz

*15: Dynamic range = full well capacity/readout noise

*16: Measured at half the saturation output using an LED light (peak emission wavelength: 660 nm)

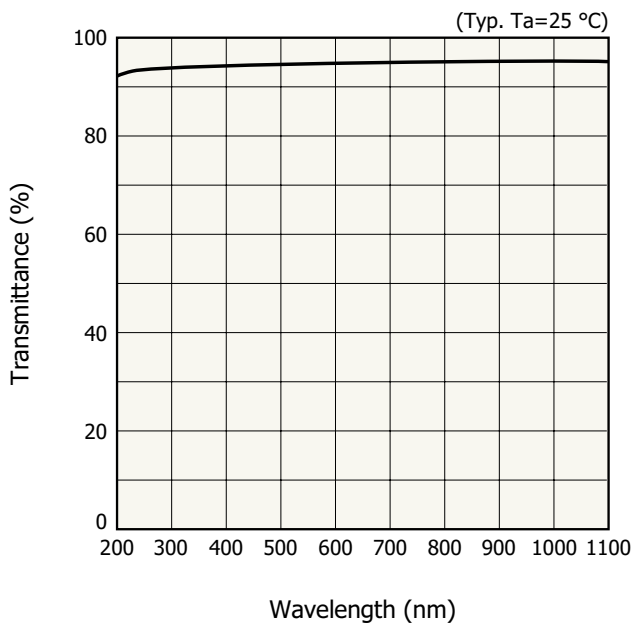
$$\text{Photoresponse nonuniformity} = \frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100 [\%]$$

Spectral response (without window)*17

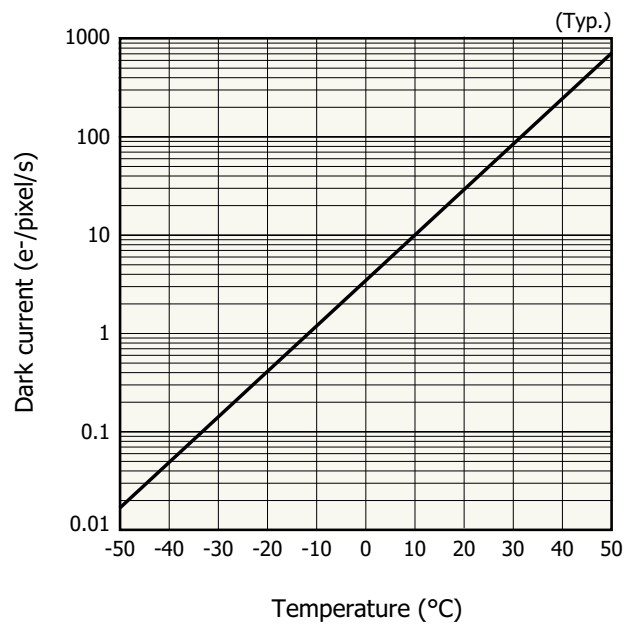


*17: Spectral response will degrade depending on the transmittance characteristics of the quartz glass.

Spectral transmittance characteristics of window material

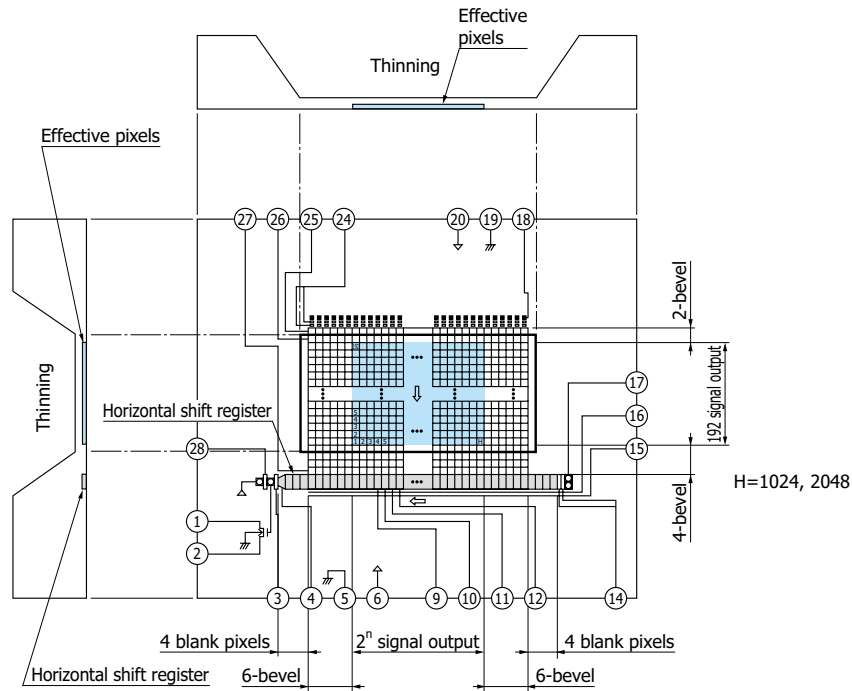


Dark current vs. temperature



Device structure (schematic of CCD chip as viewed from top of dimensional outline)

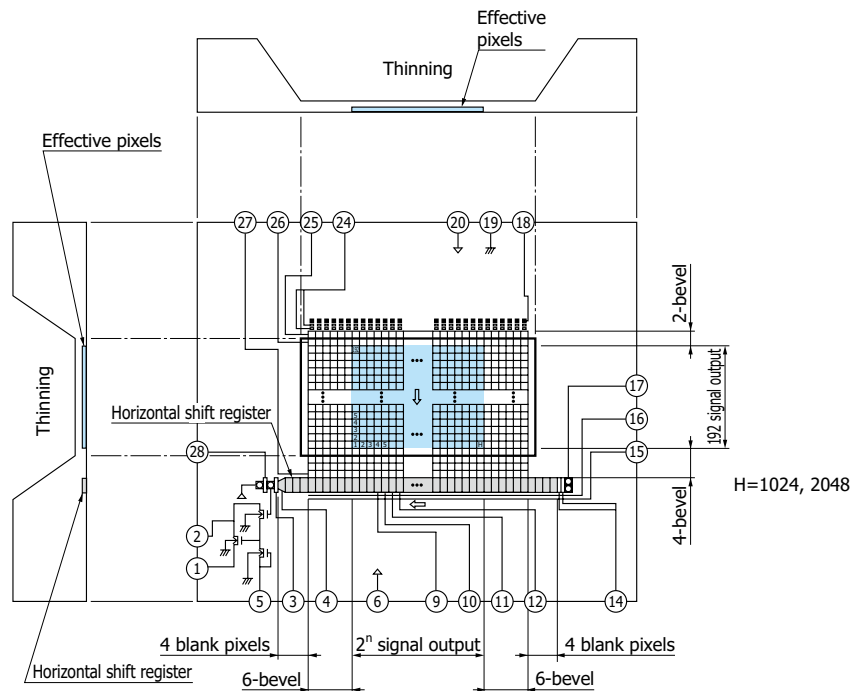
S14651 series



Note: When viewed from the light input side, the horizontal shift register is covered by the thick area of the silicon (insensitive area), but long-wavelength light may pass through the insensitive silicon area. This light may be received by the horizontal shift register. Take measures such as shielding the light.

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S14661 series



Note: When viewed from the light input side, the horizontal shift register is covered by the thick area of the silicon (insensitive area), but long-wavelength light may pass through the insensitive silicon area. This light may be received by the horizontal shift register. Take measures such as shielding the light.

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Pin connections

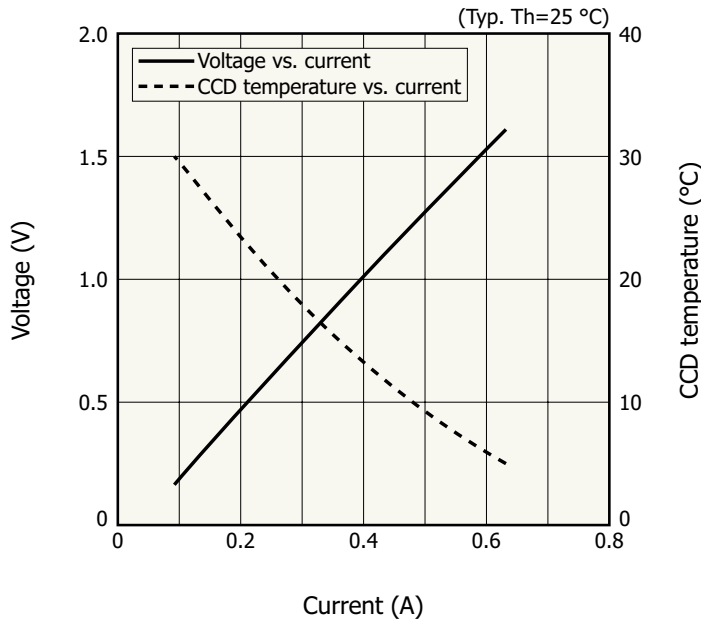
S14651 series			
Pin no.	Symbol	Function	Remark (standard operation)
1	OS	Output transistor source	RL=100 kΩ
2	OD	Output transistor drain	+24 V
3	OG	Output gate	+5 V
4	SG	Summing gate	Same pulse as P4H
5	SS	Substrate	GND
6	RD	Reset drain	+12 V
7	Th1	Thermistor	
8	P-	TE-cooler-	
9	P4H	CCD horizontal register clock-4	
10	P3H	CCD horizontal register clock-3	
11	P2H	CCD horizontal register clock-2	
12	P1H	CCD horizontal register clock-1	
13	-		
14	IGH	Test point (horizontal input gate)	-8 V
15	OFG	Overflow gate	+12 V
16	OFD	Overflow drain	+12 V
17	ISH	Test point (horizontal input source)	Connect to RD
18	ISV	Test point (vertical input source)	Connect to RD
19	SS	Substrate	GND
20	RD	Reset drain	+12 V
21	P+	TE-cooler+	
22	Th2	Thermistor	
23	-		
24	IGV	Test point (vertical input gate)	-8 V
25	P2V	CCD vertical register clock-2	
26	P1V	CCD vertical register clock-1	
27	TG	Transfer gate	Same pulse as P2V
28	RG	Reset gate	

S14661 series			
Pin no.	Symbol	Function	Remark (standard operation)
1	OS	Output transistor source	RL=2.2 kΩ
2	OD	Output transistor drain	+15 V
3	OG	Output gate	+5 V
4	SG	Summing gate	Same pulse as P4H
5	Vret	Output amplifier return	+1 V
6	RD	Reset drain	+15 V
7	Th1	Thermistor	
8	P-	TE-cooler-	
9	P4H	CCD horizontal register clock-4	
10	P3H	CCD horizontal register clock-3	
11	P2H	CCD horizontal register clock-2	
12	P1H	CCD horizontal register clock-1	
13	-		
14	IGH	Test point (horizontal input gate)	-8 V
15	OFG	Overflow gate	+13 V
16	OFD	Overflow drain	+12 V
17	ISH	Test point (horizontal input source)	Connect to RD
18	ISV	Test point (vertical input source)	Connect to RD
19	SS	Substrate	GND
20	RD	Reset drain	+15 V
21	P+	TE-cooler+	
22	Th2	Thermistor	
23	-		
24	IGV	Test point (vertical input gate)	-8 V
25	P2V	CCD vertical register clock-2	
26	P1V	CCD vertical register clock-1	
27	TG	Transfer gate	Same pulse as P2V
28	RG	Reset gate	

Specifications of built-in TE-cooler (Typ., vacuum condition)

Parameter	Symbol	Condition	Specification	Unit
Internal resistance	R _{int}	T _a =25 °C	1.6	Ω
Maximum heat absorption*19	Q _{max}		4.0	W

*19: This is a theoretical heat absorption level that offsets the temperature difference in the thermoelectric cooler when the maximum current is supplied to the unit.



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Specifications of built-in temperature sensor

A thermistor chip is built in the same package with a CCD chip, and the CCD chip temperature can be monitored with it. A relation between the thermistor resistance and absolute temperature is expressed by the following equation.

$$R_{T1} = R_{T2} \times \exp \left(B_{T1/T2} \left(\frac{1}{T1} - \frac{1}{T2} \right) \right)$$

R_{T1}: Resistance at absolute temperature T₁ [K]

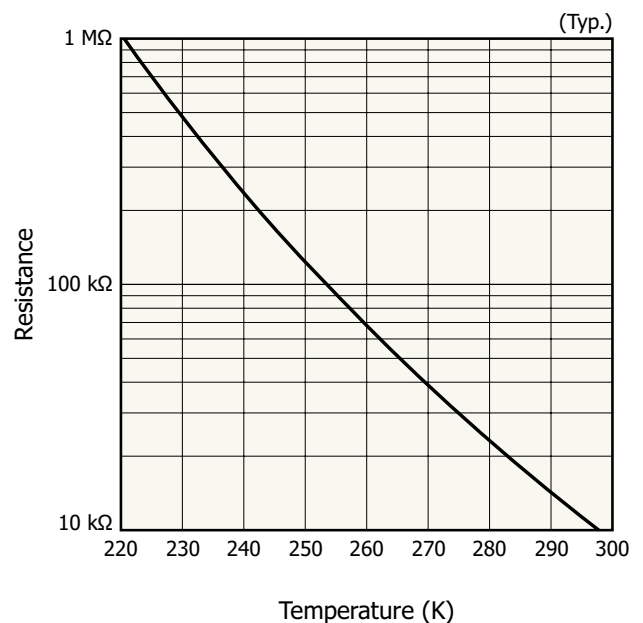
R_{T2}: Resistance at absolute temperature T₂ [K]

B_{T1/T2}: B constant [K]

The characteristics of the thermistor used are as follows.

R₂₉₈=10 kΩ

B_{298/323}=3900 K



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Precautions (electrostatic countermeasures)

- If the thermoelectric cooler does not radiate away sufficient heat, then the product temperature will rise and cause physical damage or deterioration to the product. Make sure there is sufficient heat dissipation during cooling. As a heat dissipation measure, we recommend applying a high heat-conductivity material (silicone grease, etc.) over the entire area between the product and the heat-sink (metallic block, etc.), and screwing and securing the product to a heatsink.
- Handle these sensors with bare hands or wearing cotton gloves. In addition, wear anti-static clothing or use a wrist band with an earth ring, in order to prevent electrostatic damage due to electrical charges from friction.
- Do not place the sensor directly on workbenches or floors that may become charged with static electricity.
- Connect a ground wire to workbenches or floors in order to discharge static electricity.
- Ground tools, such as tweezers and soldering irons, that are used to handle the sensor.

It is not always necessary to provide all the electrostatic countermeasures stated above. Implement these countermeasures according to the extent of deterioration or damage that may occur.

Related information

www.hamamatsu.com/sp/ssd/doc_en.html

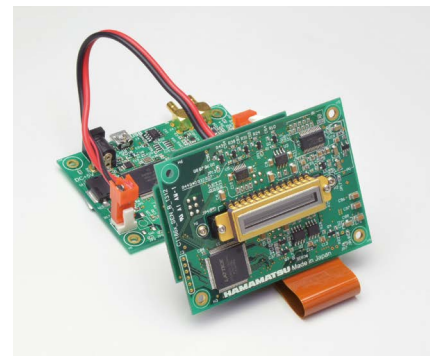
- Precautions
 - Disclaimer
 - Image sensors
- Technical information
 - FFT-CCD area image sensor

Driver circuit C11860 (sold separately) for CCD image sensor (S14651 series, S11850-1106)

The C11860 is a driver circuit developed for the Hamamatsu CCD image sensor S14651 series, S11850-1106.

Features

- Built-in 16-bit A/D converter
- The sensor circuit board and interface circuit board are connected using a flexible cable.
- Interface: USB 2.0
- External synchronization capable
- Single power supply: +5 VDC
- Sensor cooling control (approx. +5 °C)



Information described in this material is current as of February 2023.

Product specifications are subject to change without prior notice due to improvements or other reasons. This document has been carefully prepared and the information contained is believed to be accurate. In rare cases, however, there may be inaccuracies such as text errors. Before using these products, always contact us for the delivery specification sheet to check the latest specifications.

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HAMAMATSU

www.hamamatsu.com

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

U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218

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

France: HAMAMATSU PHOTONICS FRANCE S.A.R.L.: 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

United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 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

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

Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: info@hamamatsu.it

China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201, Tower B, Jianning Center, 27 Dongsanhuan Bellu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn

Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 8F-3, No.158, Section 2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: info@hamamatsu.com.tw