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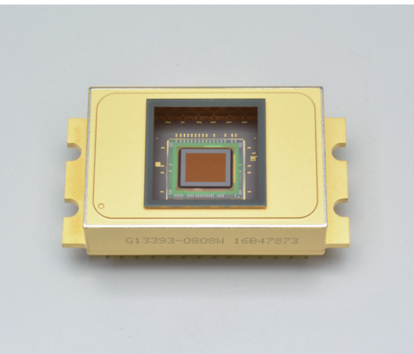


InGaAs area image sensor

G13393-0808W

Image sensor with 320 × 256 pixels developed for two-dimensional infrared imaging

The G13393-0808W has a hybrid structure consisting of a CMOS readout circuit (ROIC: readout integrated circuit) and back-illuminated InGaAs photodiodes. Each pixel is made up of an InGaAs photodiode and a ROIC electrically connected by indium bump. The timing generator in the ROIC provides an analog video output and AD-TRIG output which are obtained by just supplying digital inputs.
The G13393-0808W has 320 × 256 pixels arrayed at a 20 μm pitch. Light incident on the InGaAs photodiodes is converted into electrical signals which are then input to the ROIC through indium bumps. Electrical signals in the ROIC are converted into voltage signals and then sequentially output from the video line by the shift register. The G13393-0808W is hermetically sealed in a metal package together with a two-stage thermoelectric cooler to deliver stable operation.

Features

- **Spectral response range: 0.95 to 1.7 μm**
- **High sensitivity: 1 μV/e-**
- **Frame rate: 228 fps max.**
- **Global shutter mode**
- **Simple operation (built-in timing generator)**
- **Two-stage TE-cooled type**

Applications

- **Near infrared non-destructive inspection (farm produce inspection, semiconductor inspection, fill level inspection)**
- **Hyperspectral imaging**
- **Traffic monitoring**

Structure

Parameter	Specification	Unit
Image size	6.40 × 5.12	mm
Cooling	Two-stage TE-cooled	-
Total number of pixels	320 × 256 (81920)	pixels
Number of effective pixels	320 × 256 (81920)	pixels
Pixel size	20 × 20	μm
Pixel pitch	20	μm
Fill factor	100	%
Package	28-pin metal (refer to dimensional outline)	-
Window material	Sapphire glass with anti-reflective coating	-

Block diagram

The series of operations of the readout circuit are described below.

The integration time is equal to the low period of the master start pulse (MSP), which is a frame scan signal, and the output voltage is sampled and held simultaneously at all pixels. Then, the pixels are scanned, and the video is output.

The vertical shift register scans from top to bottom while sequentially selecting each row. The following operations ① to ③ are performed on each pixel of the selected row.

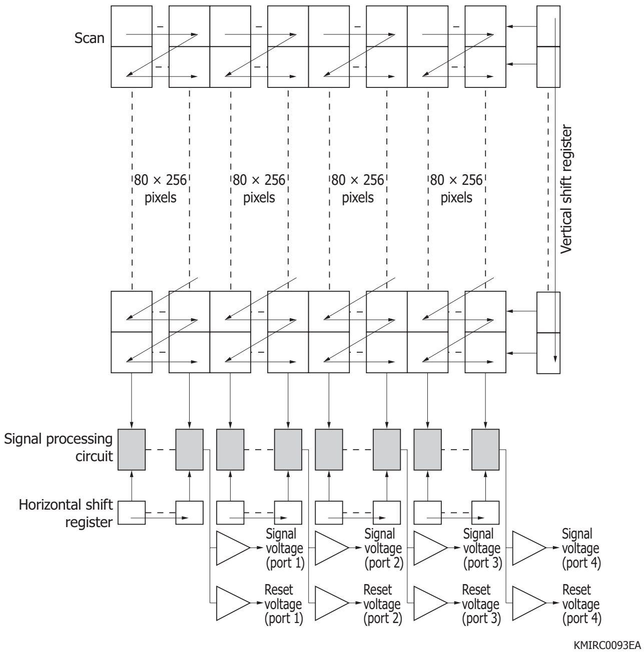
① Transfers the optical signal information sampled and held in each pixel to the signal processing circuit as a signal voltage, and samples and holds the signal voltage.

② Resets each pixel after having transferred the signal, transfers the reset signal voltage to the signal processing circuit, and samples and holds the reset signal voltage.

③ The horizontal shift register performs a sequential scan to output the signal voltage and reset signal voltage as serial data. The offset voltage in each pixel can be eliminated by finding a difference between the signal voltage and the reset signal voltage with a circuit outside the sensor.

Then the vertical shift register shifts by one row to select the next row and the operations ① to ③ are repeated.

When the MSP, which is a frame scan signal, goes low after the vertical shift register advances to the 256th row, the reset switches for all pixels simultaneously turn off and the next frame integration begins.



Absolute maximum ratings

Parameter	Symbol	Value	Unit
Supply voltage	Vdd	-0.3 to +5.5	V
Clock pulse voltage	V(MCLK)	Vdd + 0.5	V
Start pulse voltage	V(MSP)	Vdd + 0.5	V
Operating temperature*1 *2	Topr	0 to +60	°C
Storage temperature*2	Tstg	-20 to +70	°C
Allowable TE cooler current	Ic	2.8	A
Allowable TE cooler voltage	Vc	4.0	V
Thermistor power dissipation	Pth	0.2	mW

*1: Chip temperature

*2: No dew condensation

When there is a temperature difference between a product and the ambient in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause a deterioration of characteristics and reliability.

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.

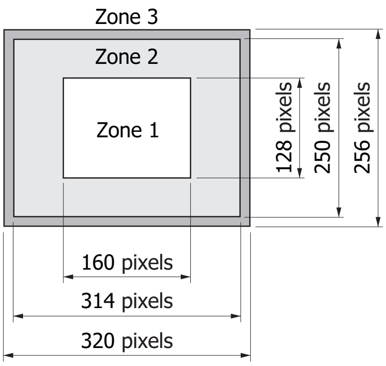
Electrical and optical characteristics (Ta=25 °C, Td=15 °C, Vdd=Port_sel=Mode01=5 V, Mode02=0 V, Vb1=0.5 V, PD_bias=3 V, Vref=3 V)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Spectral response range	λ		-	0.95 to 1.7	-	μm
Peak sensitivity wavelength	λp		-	1.55	-	μm
Photosensitivity	S	λ=λp	0.7	0.8	-	A/W
Conversion efficiency	CE		-	1	-	μV/e^-
Saturation charge	Qsat		-	1100	-	ke^-
Saturation output voltage	Vsat		0.6	1.1	-	V
Photoresponse nonuniformity*3	PRNU	After subtracting dark output, Integration time=5 ms	-	±10	±20	%
Dark output	V_D	Integration time=10 ms	-	0.03	0.15	V
Dark current	I_D		-	0.5	2.5	pA
Dark output nonuniformity	DSNU	Integration time=10 ms	-	±0.1	±0.3	V
Temperature coefficient of dark output	ΔT_{DS}		-	1.1	-	times/°C
Readout noise	Nr	Integration time=10 ms	-	500	1000	μV rms
Dynamic range	DR		-	2200	-	-
Defective pixels*4	-		-	-	0.37	%

*3: Measured at one-half of the saturation, excluding first and last pixels on each row

*4: Pixels with photoresponse nonuniformity (integration time 5 ms), dark output nonuniformity, readout noise, or dark current higher than the maximum value (Zone 1 + 2 + 3)

[Zone definitions]



[Defective pixels in each zone]

Zone	Maximum number of defective pixels	Percentage of defective pixels
1	41	0.2%
2	116	0.2%
3	171	5.0%
1 + 2	157	0.2%
1 + 2 + 3	303	0.37%

[Consecutive defective pixels]
The number of consecutive adjacent defect pixels is less than 16.

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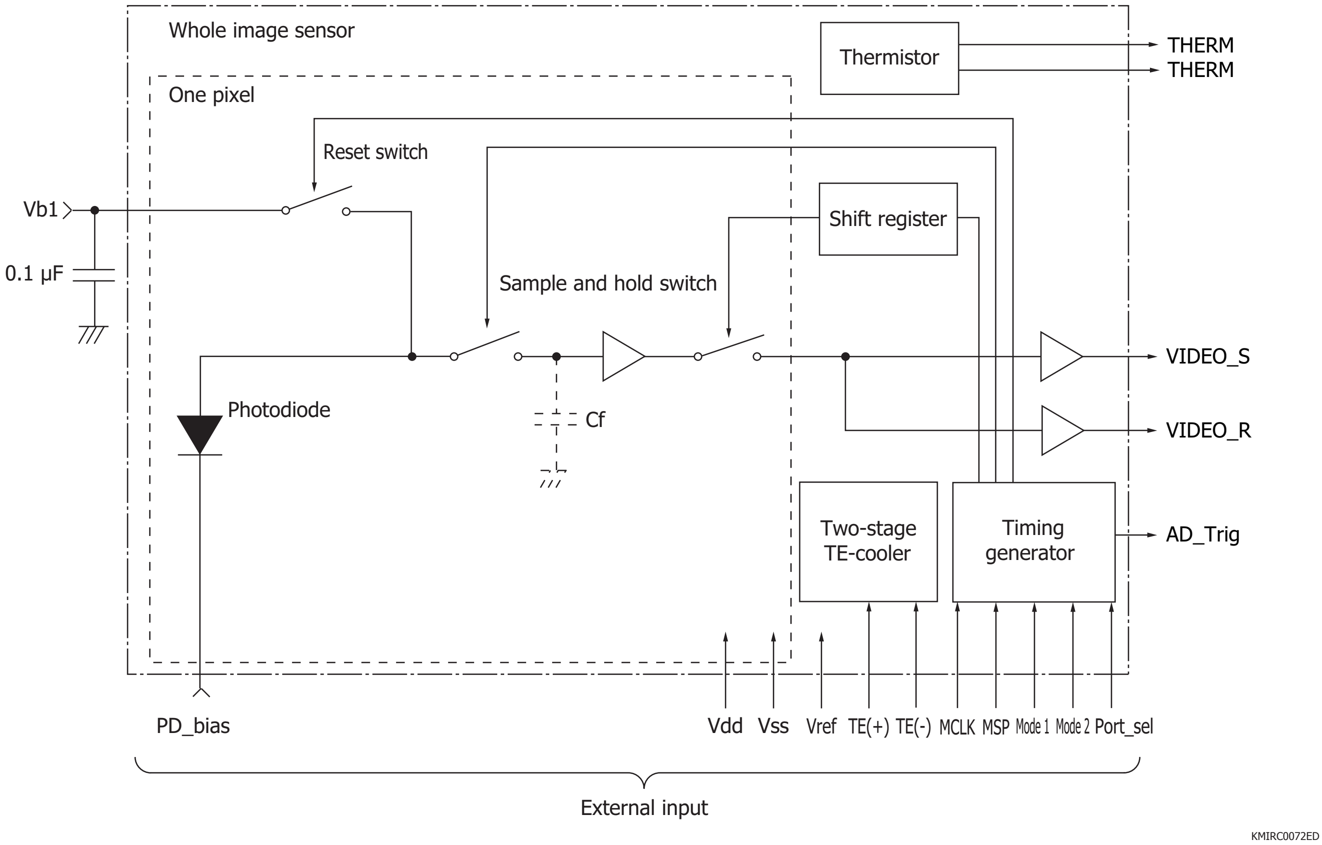
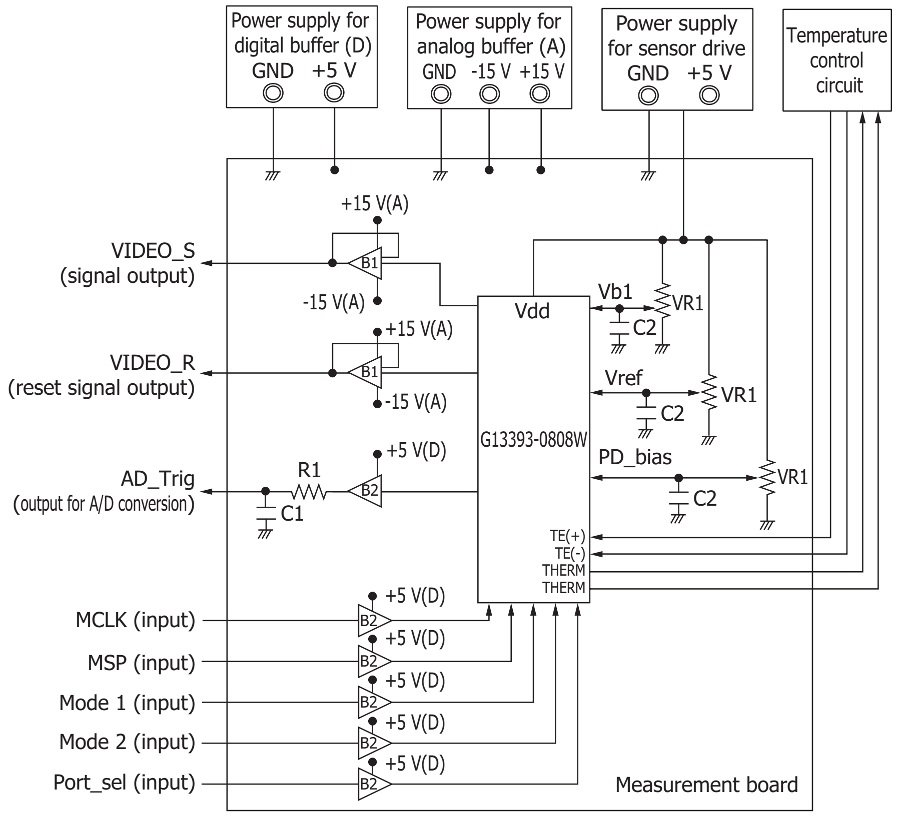
Electrical characteristics (Ta=25 °C, Td=15 °C, Vdd=Port_sel=Mode01=5 V, Mode02=0 V, Vb1=0.5 V, PD_bias=3 V, Vref=3 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply current*5	Idd	-	50	100	mA
Element bias current	I(PD_bias)	-	-	1	mA

Equivalent circuit



Connection example



(Reference) Parameter values

Symbol	Value
R1	10 Ω
VR1	10 kΩ
C1	330 pF
C2	0.1 µF

(Reference) Buffer

Symbol	IC
B1	AD847
B2	TC74HCT541

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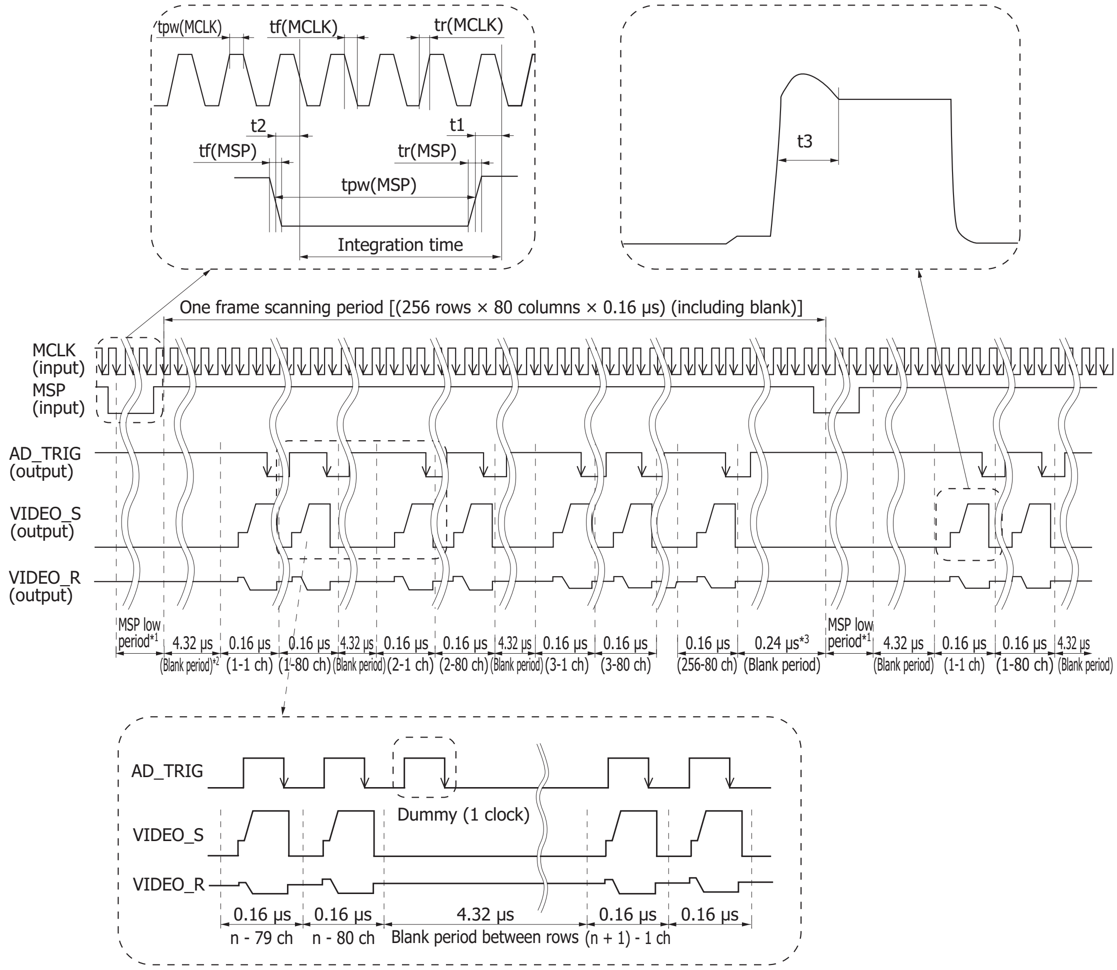
Timing chart

The video output from a single pixel is equal to 4 MCLK (master clock) pulses. The MSP (master start pulse) is a signal for setting the integration time, so making the low (0 V) period of the MSP longer will extend the integration time. The MSP also functions as a signal that triggers each control signal to perform frame scan. When the MSP goes from low (0 V) to high (5 V), each control signal starts on the falling edge of the MCLK and frame scan is performed during the high period of the MSP. The low (0 V) period of the MSP serves as the integration time. The timing charts when operated at a MCLK frequency of 25 MHz are shown below.

■ Number of readout ports: 4



*1: The minimum number of MCLK pulses during the MSP low period is 25. The integration time can be changed by adjusting the MSP low period.
Integration time = MSP low period
*2: There is a blank of 4.32 μs between each row.
*3: The blank period after scanning the last channel is 0.24 μs.

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Parameter	Symbol	Min.	Typ.	Max.	Unit
Clock pulse rise/fall times	tr(MCLK)	0	10	12	ns
	tf(MCLK)				
Clock pulse width	tpw(MCLK)	10	-	-	ns
Start pulse rise/fall times	tr(MSP)	0	10	12	ns
	tf(MSP)				
Start pulse width	tpw(MSP)	0.001	-	10	ms
Reset (rise) timing*5	t1	10	-	-	ns
Reset (fall) timing*5	t2	10	-	-	ns
Output settling time	t3	-	-	50	ns

*5: Setting these timings shorter than the minimum value may delay the operation by one MCLK pulse and cause malfunction.

Recommended drive conditions (Ta=25 °C)

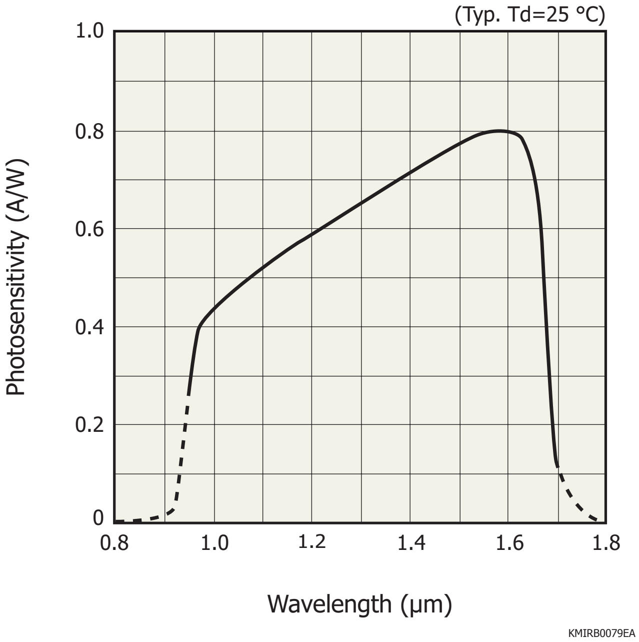
Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage		Vdd	4.9	5	5.1	V
Ground		Vss	-	0	-	V
Element bias current		V(PD_bias)	2.9	3.0	3.1	V
Pixel reset voltage		Vb1	0.4	0.5	0.6	V
Video line reset voltage		Vref	2.9	3.0	3.1	V
Clock frequency		f	-	-	25	MHz
Clock pulse voltage	High level	V(MCLK)	Vdd - 0.5	Vdd	Vdd + 0.5	V
	Low level		0	0	0.5	
Start pulse voltage	High level	V(MSP)	Vdd - 0.5	Vdd	Vdd + 0.5	V
	Low level		0	0	0.5	
Video output voltage (VIDEO_S)	High level	V_{SH}	3.6	4.0	4.1	V
	Low level	V_{SL}	2.8	2.9	3.0	
Video output voltage		VIDEO_R	2.8	2.9	3.0	V
Video data rate		DR	-	f/4	-	MHz
Frame rate*6		FV		-	228	fps

*6: Frame rate=1/(MSP low period + Readout time)
Readout time=(Video data rate × Number of pixels) + (Blank period between rows × Number of rows) + Blank period between frames
MSP low period=1 μs min.
Readout time={0.16 μs × 80 columns × 256 rows)} + (4.32 μs × 256 rows) + 0.24 μs=4382.96 μs
Frame rate=1/(1 μs + 4382.96 μs)=228.1 fps

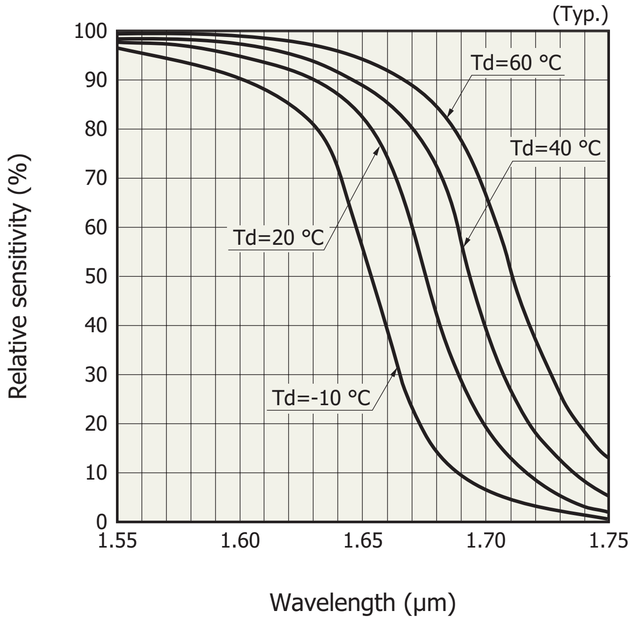
Operation mode selection

Terminal name	Pin no.	Input	Description
Port_sel	24	High=5 V (Vdd)	To enable the setting for reading from all ports, apply a fixed voltage of High=5 V (Vdd).
Mode2	25	Low=0 V (Vss)	To operate the sensor in global shutter mode, apply the fixed voltage indicated on the left.
Mode1	27	High=5 V (Vdd)	

Spectral response



Photosensitivity temperature characteristics



Note: chip temperature

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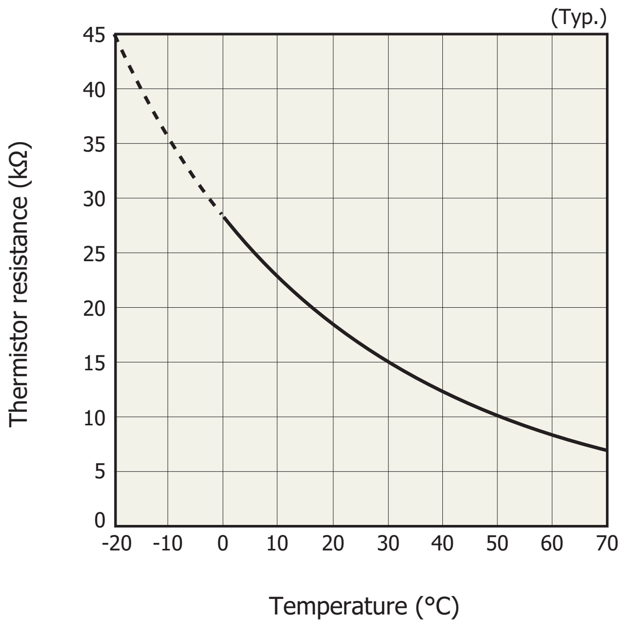
Specifications of built-in TE-cooler and thermistor

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Internal resistance	Rint	Ta=25 °C	0.75	0.9	1.05	Ω
Maximum heat absorption of built-in TE-cooler*7 *8	Qmax		-	8.4	-	W
Thermistor resistance	Rth		8.2	9	9.8	kΩ

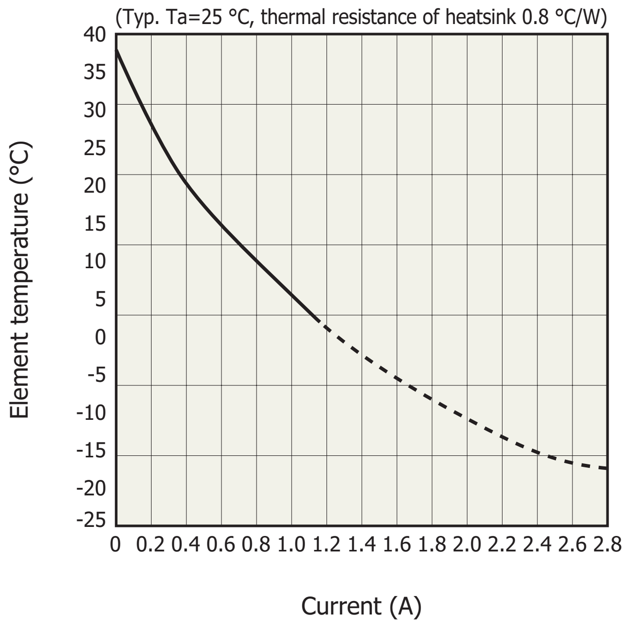
*7: This is a theoretical heat absorption level that offsets the temperature difference in the thermoelectric cooler when the maximum current is supplied to the sensor.

*8: Heat absorption at Tc=Th
Tc: Temperature on the cooling side of TE-cooler
Th: Temperature on the heat dissipating side of TE-cooler.

Thermistor temperature characteristics*9



Cooling characteristics of TE-cooler*9



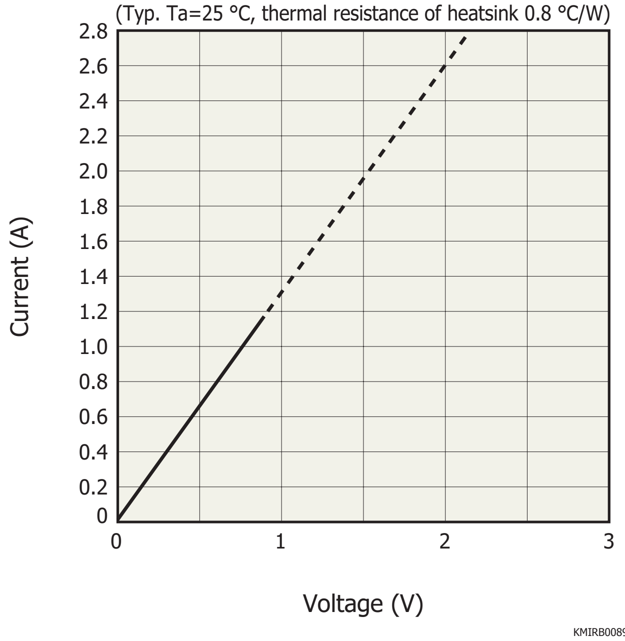
There is the following relation between the thermistor resistance and temperature (°C).

$$R1 = R2 \times \exp B\{1/(T1 + 273.15) - 1/(T2 + 273.15)\}$$

R1: resistance at T1 (°C)
R2: resistance at T2 (°C)
B: B constant (B=3410 K ± 2%)
Thermistor resistance=9 kΩ (at 25 °C)

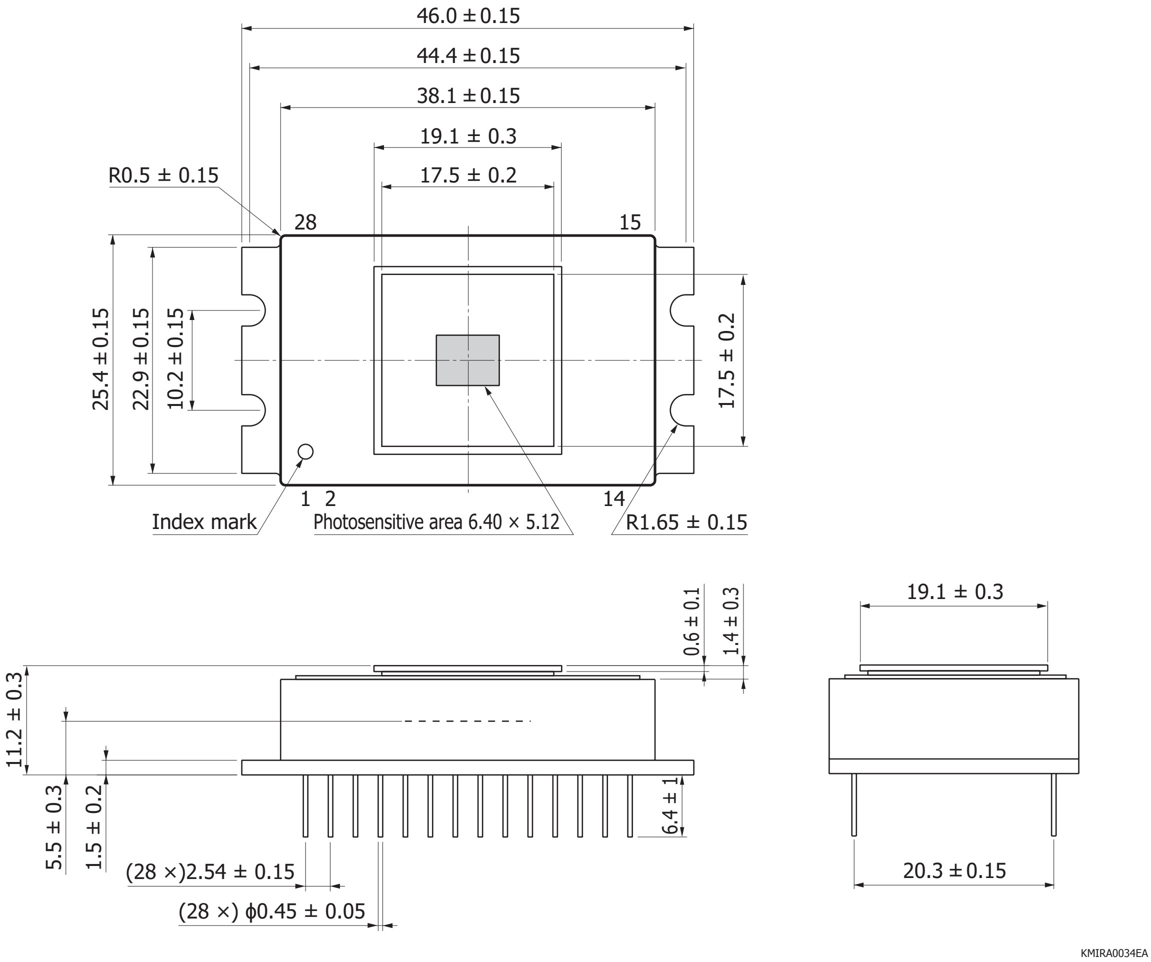
*9: The range outside the operating temperature range (0 to +60 °C) is indicated with a broken line.

Current vs. voltage characteristics of TE-cooler*9



*9: The range outside the operating temperature range (0 to +60 °C) is indicated with a broken line.

Dimensional outline (unit: mm)



Pin connections

Pin no.	Name	Input/output	Function	Remarks
1	PD_bias	Input	Photodiode bias voltage	3.0 V
2	Vb1	Input	Pixel bias voltage	0.5 V
3	TE(+)	Input	Thermoelectric cooler (+)	
4	NC	-	-	
5	Vref	Input	Video reference voltage	3.0 V
6	VIDEO-S1	Output	Video output after integration (port 1)	2.9 to 4.0 V typ.
7	VIDEO-R1	Output	Video output after reset (port 1)	2.9 V typ.
8	Vss	Input	0 V ground	0 V
9	VIDEO-S2	Output	Video output after integration (port 2)	2.9 to 4.0 V typ.
10	VIDEO-R2	Output	Video output after reset (port 2)	2.9 V typ.
11	VIDEO-S3	Output	Video output after integration (port 3)	2.9 to 4.0 V typ.
12	VIDEO-R3	Output	Video output after reset (port 3)	2.9 V typ.
13	VIDEO-S4	Output	Video output after integration (port 4)	2.9 to 4.0 V typ.
14	VIDEO-R4	Output	Video output after reset (port 4)	2.9 V typ.
15	Vdd	Input	+5 V power supply	5 V
16	THERM	Output	Thermistor	
17	THERM	Output	Thermistor	
18	D_Vdd	Input	+5 V power supply (digital)	5 V
19	NC	-	-	
20	AD_Trig	Output	A/D sampling signal	Synchronized with falling edge
21	MSP	Input	Frame scan start pule	
22	MCLK	Input	Control pulse for timing generator	Synchronized with falling edge
23	D_Vdd	Input	+5 V power supply (digital)	5 V
24	Port_sel	Input	Readout port	Fixed at 5 V
25	Mode2	Input	Operation mode 2	Fixed at 0 V
26	TE(-)	Input	Thermoelectric cooler (-)	
27	Mode1	Input	Operation mode 1	Fixed at 5 V
28	NC	-	-	Do not ground.

Precautions

(1) Electrostatic countermeasures
This device has a built-in protection circuit against static electrical charges. However, to prevent destroying the device with electrostatic charges, take countermeasures such as grounding yourself, the workbench and tools to prevent static discharges. Also protect this device from surge voltages which might be caused by peripheral equipment.

(2) Incident window
If there is dust or stain on the light incident window, it will show up as black blemishes on the image. When cleaning, avoid rubbing the window surface with dry cloth, dry cotton swab or the like, since doing so may generate static electricity. Use soft cloth, paper or a cotton swab moistened with alcohol to wipe dust and stain off the window surface. Then blow compressed air onto the window surface so that no spot or stain remains.

(3) Soldering
To prevent damaging the device during soldering, take precautions to prevent excessive soldering temperatures and times. Soldering should be performed within 10 seconds at a soldering temperature below 260 °C.

(4) Operating and storage environments
Handle the device within the temperature range specified in the absolute maximum ratings. Operating or storing the device at an excessively high temperature and humidity may cause variations in performance characteristics and must be avoided.

Related information

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

■ Precautions
· Disclaimer
· Image sensors

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