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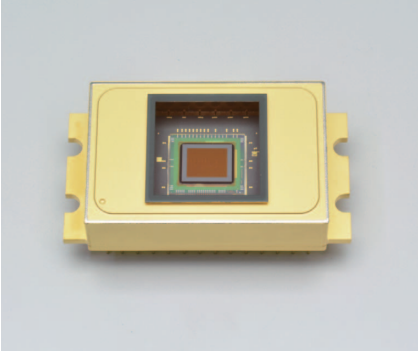
InGaAs area image sensors



G14671 to G14674-0808W

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

The G14671 to G14674-0808W have 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 which is obtained by just supplying digital inputs.
The G14671 to G14674-0808W have 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 G14671 to G14674-0808W are hermetically sealed in a metal package together with a two-stage thermoelectric cooler to deliver stable operation. The frame rate is more than twice that of the previous product, and a partial readout function has been added.

Features

- **High sensitivity: 3.5 µV/e^-**
- **Frame rate: 509 fps max.**
  [4 ports, all pixels (320 × 256) readout, minimum integration time=1 µs]
- **Low dark current**
- **Global shutter mode**
- **Partial readout function**
- **Single operation (built-in timing generator)**
- **Two-stage TE-cooled type**

Applications

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

Selection guide

Type no.	Spectral response range (µm)
G14671-0808W	0.95 to 1.69 (15 °C)
G14672-0808W	1.12 to 1.85 (-20 °C)
G14673-0808W	1.3 to 2.15 (-20 °C)
G14674-0808W	1.7 to 2.55 (-20 °C)

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.

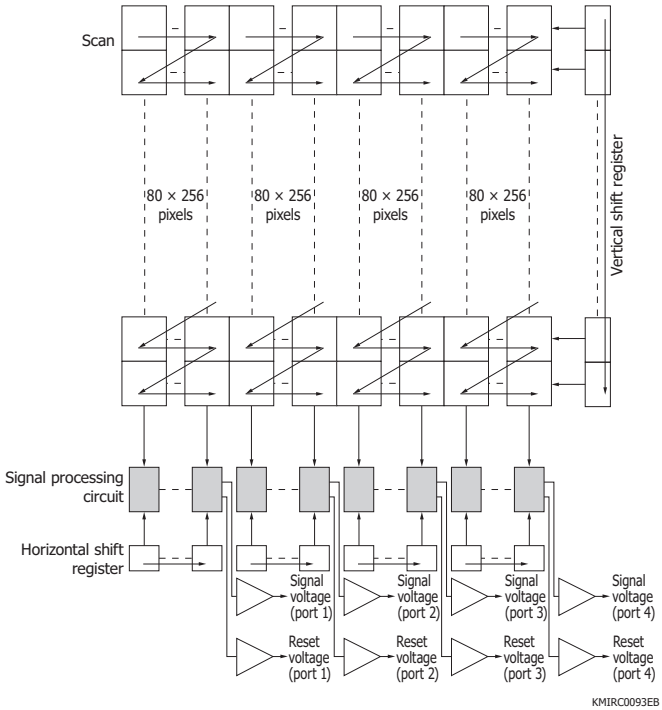
① Transfers the optical signal information sampled and held in each pixel to the signal processing circuit as a signal voltage, and samples and holds the signal voltage.

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	Condition	Value	Unit
Supply voltage (5 V)	Vdd, DVdd V(PD_bias), V(INP) Vb1	Ta=25 °C	-0.3 to +6.0	V
Supply voltage (3.3 V)	Vdd(3.3 V) DVdd (3.3 V)	Ta=25 °C	-0.3 to +4.2	V
Input signal voltage	V(MCLK), V(MSP) V(Vdd), V(En_add) V(Port_sel), V(Mode)	Ta=25 °C	-0.3 to +4.2	V
Operating temperature*1 *2	Topr		-30 to +60	°C
Storage temperature*2	Tstg		-40 to +70	°C
Allowable current of TE-cooler	Ic		2.8	A
Allowable voltage of TE-cooler	Vc		4.0	V
Thermistor power dissipation	Pth		400	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.

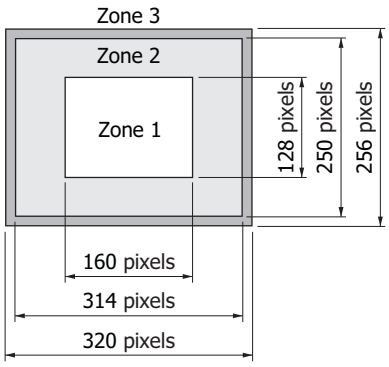
Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

Electrical and optical characteristics [Ta=25 °C, Vdd=5 V, Vdd(3.3 V)=Port_sel=Mode=3.3 V, Vb1=0.83 V, PD_bias=4.28 V, INP=4.2 V]

Parameter	Symbol	G14671-0808W*3			G14672 to G14674-0808W*4				Unit
		Min.	Typ.	Max.	Type no.	Min.	Typ.	Max	
Spectral response range	λ	-	0.95 to 1.69	-	G14672	-	1.12 to 1.85	-	μm
					G14673	-	1.3 to 2.15	-	
					G14674	-	1.7 to 2.55	-	
Peak sensitivity wavelength	λp	-	1.55	-	G14672	-	1.75	-	μm
					G14673	-	1.95	-	
					G14674	-	2.2	-	
Photosensitivity (λ=λp)	S	0.7	0.8	-	G14672	0.9	1.1	-	A/W
					G14673	0.85	1.0	-	
					G14674	0.8	1.0	-	
Conversion efficiency	CE	-	3.5	-		-	3.5	-	μV/e⁻
Saturation charge	Csat	-	370	-		-	370	-	ke⁻
Saturation output voltage	Vsat	0.8	1.3	-		0.8	1.3	-	V
Photoresponse nonuniformity*5	PRNU	-	±10	±20		-	±10	±30	%
Dark current	ID	-	0.03	0.3	G14672	-	0.3	3	pA
					G14673	-	3	30	
					G14674	-	30	300	
Dark output nonuniformity*6	DSNU	-	±0.02	±0.12		-	±0.1	±0.6	V
Readout noise*7	Nread	-	850	1500		-	850	1500	μV rms
		-	242	428		-	242	428	e⁻
Dynamic range	Drange	860	1500	-		860	1500	-	-
Defective pixels*8	-	-	-	0.37		-	-	1	%

*3: Tchip=15 °C
*4: Tchip=-20 °C
*5: Measured at 50% saturation after subtracting the dark output, excluding the first and last pixels of each row
G14671/G14672-0808W: Integration time=5 ms, G14673-0808W: Integration time=500 μs, G14674-0808W: Integration time=50 μs
*6: G14671-0808W: Integration time=10 ms, G14672-0808W: Integration time=5 ms, G14673-0808W: Integration time=1 ms, G14674-0808W: Integration time=100 μs
*7: Integration time=1 μs
*8: Pixels whose saturation output voltage, photoresponse nonuniformity, dark current, dark output nonuniformity, or readout noise is outside the specifications (Zone 1 + 2 + 3)

[Zone definitions]



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

[Defective pixels in each zone]

G14671-0808W

Zone	Maximum number of defective pixels	Percentage of defective pixels
1	41	0.2%
2	116	0.2%
3	171	5%
1 + 2	157	0.2%
1 + 2 + 3	303	0.37%

G14672 to G14674-0808W

Zone	Maximum number of defective pixels	Percentage of defective pixels
1	123	0.6%
2	348	0.6%
3	513	15%
1 + 2	471	0.6%
1 + 2 + 3	819	1%

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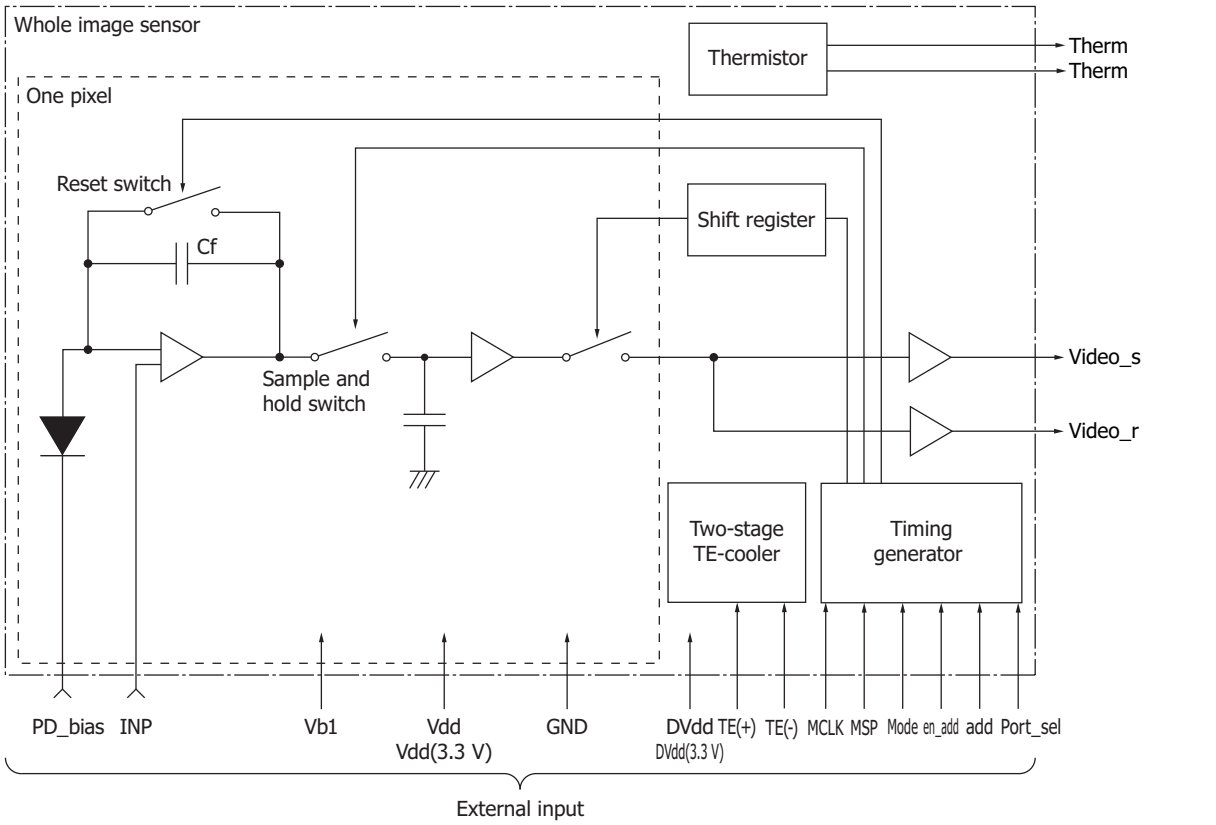
Electrical characteristics (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply current	Idd	-	80	160	mA
Element bias current	I(PD_bias)	-	-	1	mA
	I(INP)	-	-	1	mA
	I(Vb1)	-	-	1	mA

Equivalent circuit



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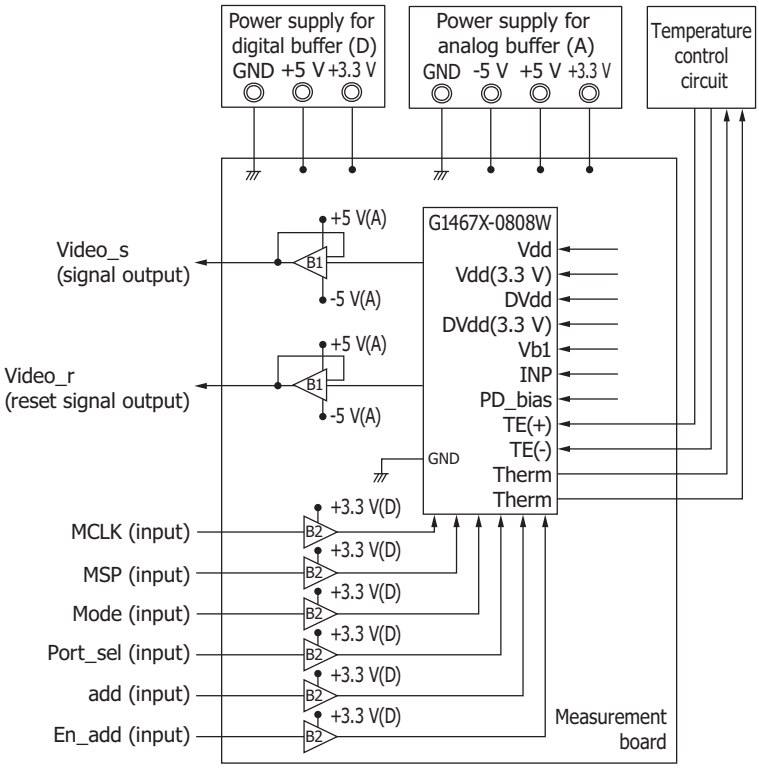
Connection example



(Reference) Buffer

Symbol	IC
B1	LT1818
B2	SN74LV4T125

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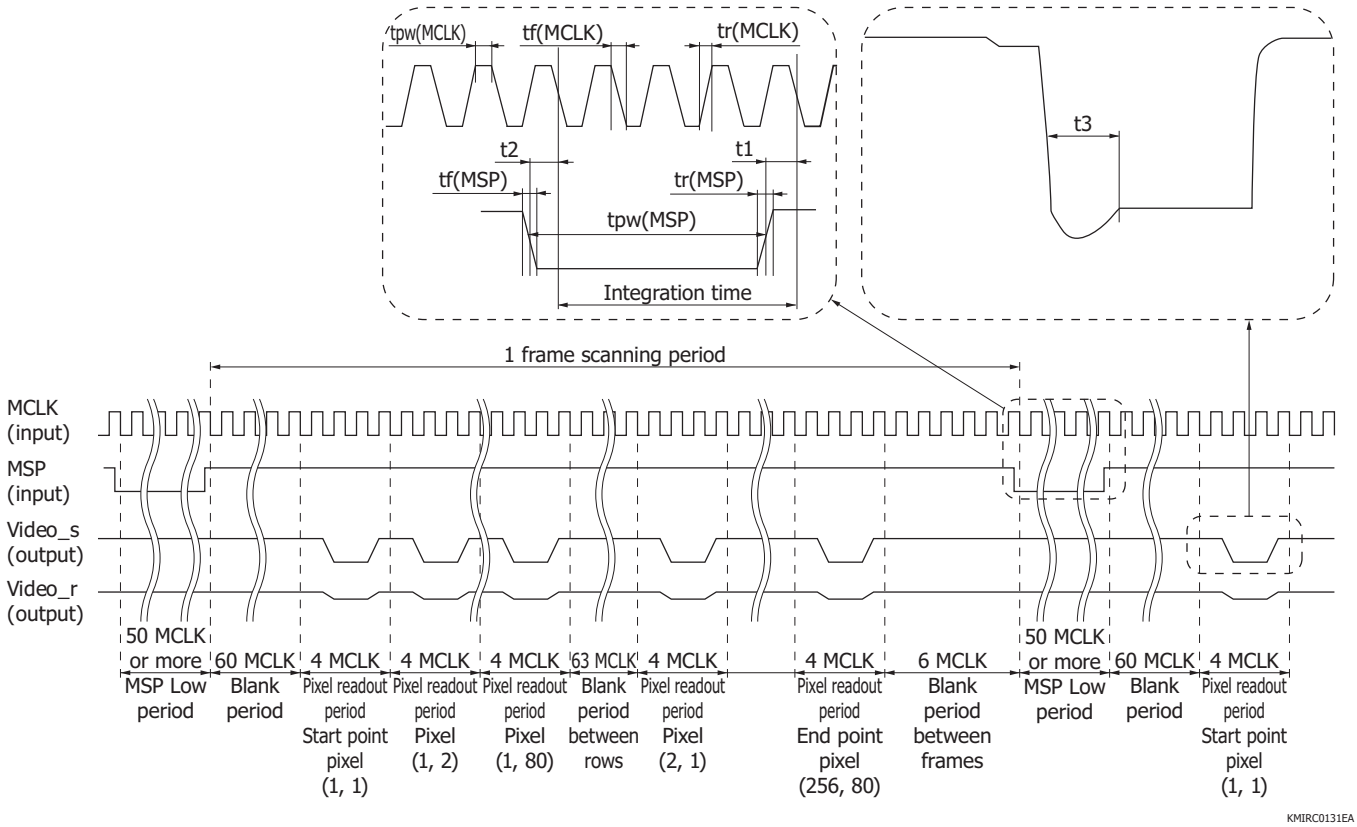
Timing chart

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.

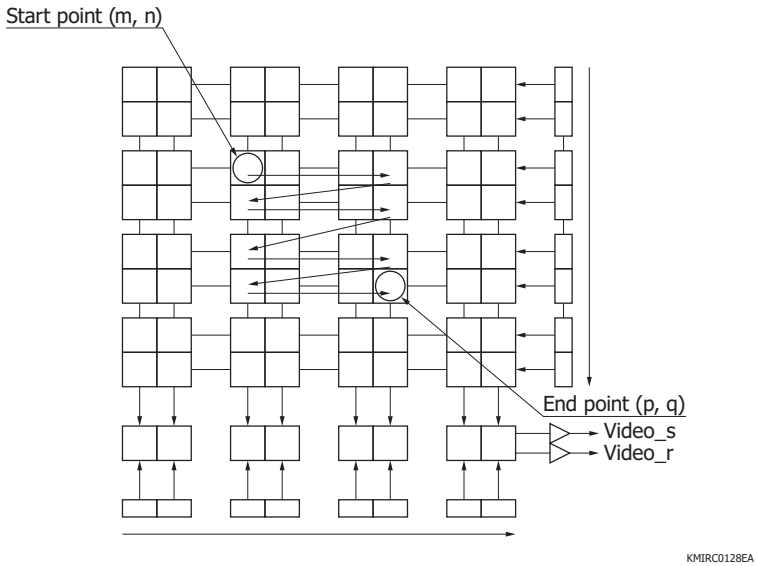
■ Number of readout ports: 4 ports [Port_sel (24-pin): High (3.3 V)]



■ Number of readout ports: 1 port [Port_sel (24-pin): Low (0 V)]
Partial readout

The G14671 to G14674-0808W series have the partial readout function. The number of readout region is one per frame. Specify the readout region in coordinate with a start coordinate (m, n) and end coordinate (p, q). When there is a small number of readout pixels, the frame rate is higher.

· Readout region (m, n) to (p, q)



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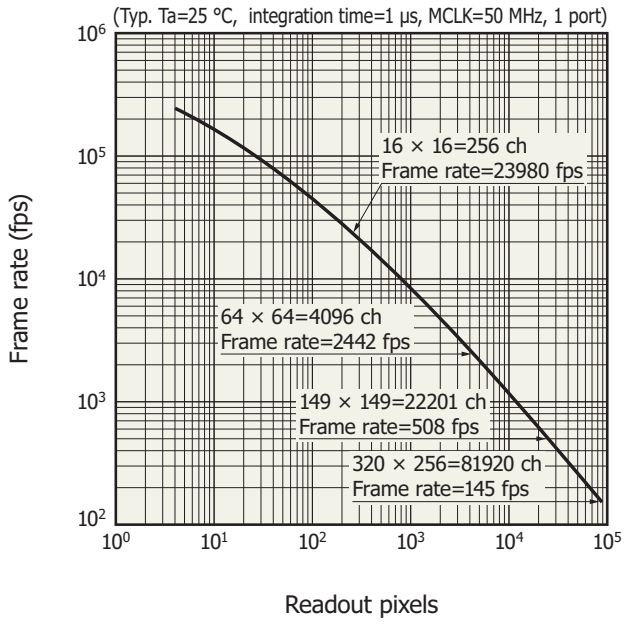
The following figure shows the relationship between the frame rate and the number of readout pixels for 1 port. The frame rate, with 1 port and 149 × 149 pixels readout, corresponds to the frame rate with 4 ports and all-pixel readout.

· Frame rate vs. number of readout pixels



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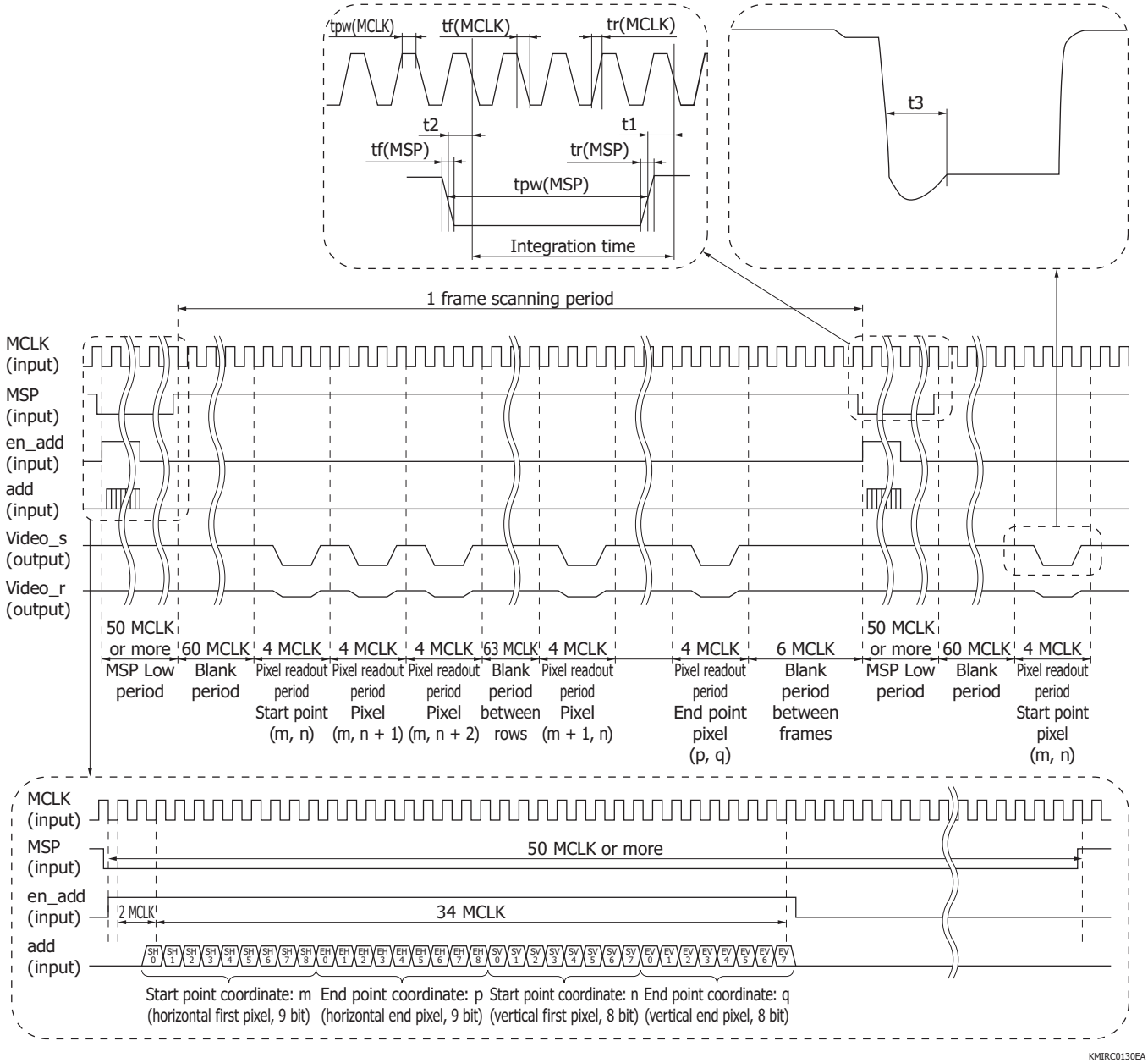


Parameter	Symbol	Min.	Typ.	Max.	Unit
Clock pulse rise/fall times	tr(MCLK)	0	5.5	6	ns
	tf(MCLK)				
Clock pulse width	tpw(MCLK)	4	-	-	ns
Start pulse rise/fall times	tr(MSP)	0	5.5	6	ns
	tf(MSP)				
Start pulse width	tpw(MSP)	1	-	-	µs
Reset (rise) timing*9	t1	4	-	-	ns
Reset (fall) timing*9	t2	4	-	-	ns
Output settling time	t3	-	-	30	ns

*9: 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)

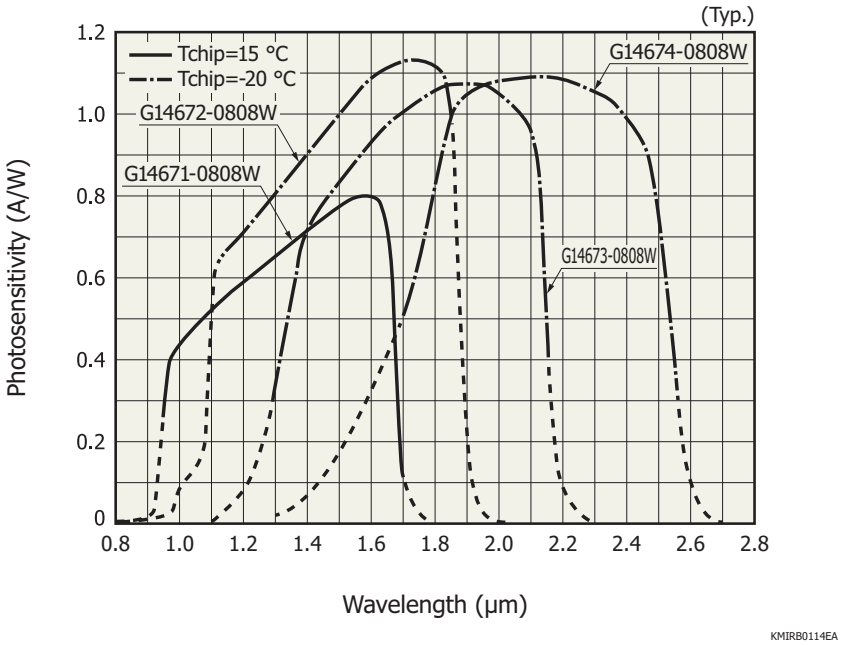
Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage		Vdd	4.9	5.0	5.1	V
		DVdd	4.9	5.0	5.1	V
		Vdd(3.3 V)	3.2	3.3	3.4	V
		DVdd(3.3 V)	3.2	3.3	3.4	V
Ground		GND	-	0	-	V
Element bias voltage		V(PD_bias)	4.1	4.28	4.5	V
Input stage amplifier reference voltage		V(INP)	4.0	4.2	4.4	V
Pixel bias voltage		Vb1	0.7	0.83	0.9	V
Clock frequency		fop	-	-	50	MHz
Clock pulse voltage	High level	V(MCLK)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Start pulse voltage	High level	V(MSP)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Address input signal pulse voltage*10	High level	V(add)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Enable signal voltage of address input signal pulse*10	High level	V(En_add)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Readout port number selection terminal voltage	High level	V(Port_sel)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Operation mode selection terminal voltage	High level	V(Mode)	DVdd(3.3 V) - 0.25	DVdd(3.3 V)	DVdd(3.3 V) + 0.25	V
	Low level		0	0	0.25	
Video output voltage (VIDEO_S)	Dark output	Vs(dark)	-	2.4	2.6	V
	Saturation output	Vs(sat)	-	1.1	1.6	
Video output voltage (VIDEO_R)		VR	2.2	2.4	2.6	V
Video data rate		DR	-	fop/4	-	MHz
Frame rate*11		FR	-	-	507	fps

*10: Partial readout
*11: Number of readout ports=4 ports, all pixels (320 × 256 ch) readout, integration time=1 µs min.
Note: Set the element bias voltage higher than the input stage amplifier reference voltage.

Operation mode selection

Terminal name	Pin no.	Input	Description
Port_sel	24	High=3.3 V [DVdd(3.3 V)]	Number of readout ports: 4 ports (partial readout is impossible)
		Low=0 V (GND)	Number of readout ports: 1 port (partial readout is possible)
Mode	27	High=3.3 V [DVdd(3.3 V)]	To operate the sensor in global shutter mode, apply the fixed voltage indicated on the left.

Spectral response

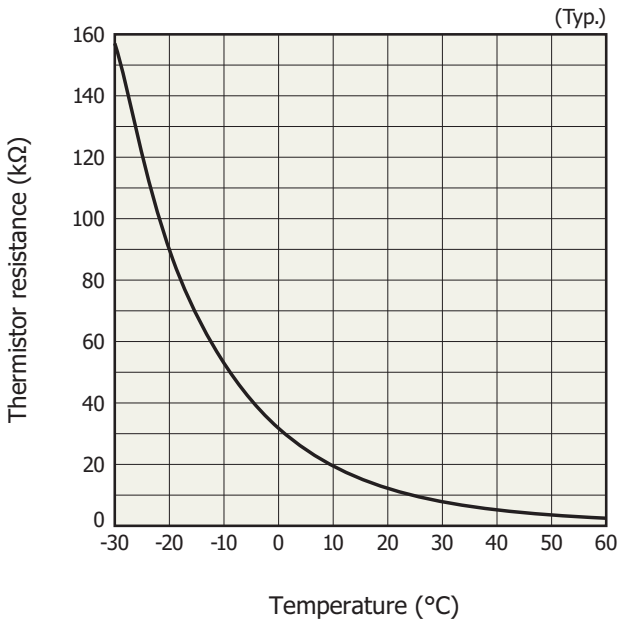


Specifications of built-in TE-cooler and thermistor

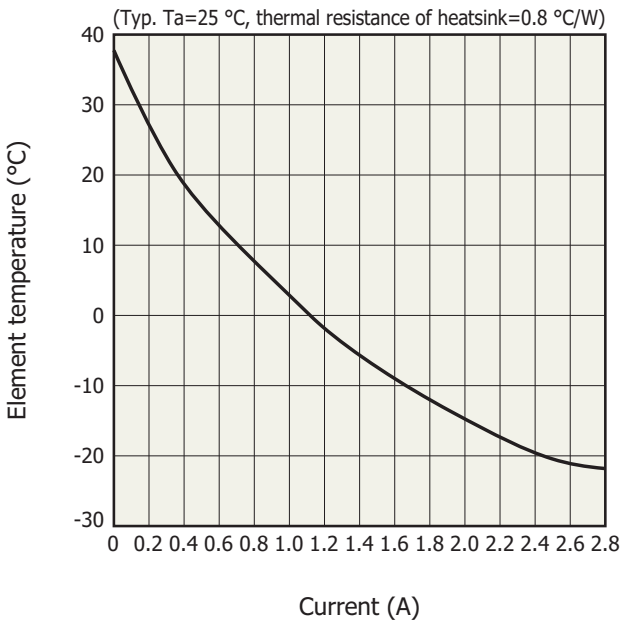
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Internal resistance	Rint	Ta=25 °C	0.75	0.9	1.05	Ω
Maximum heat absorption of built-in TE-cooler*12 *13	Qmax		-	8.4	-	W
Thermistor resistance	Rth		9	10	11	kΩ

*12: 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.
*13: 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



Cooling characteristics of TE-cooler

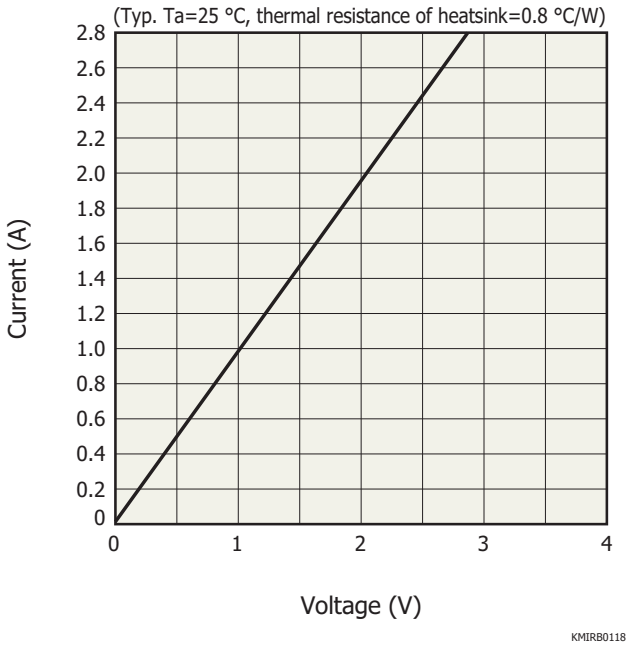


There is the following relation between the thermistor resistance and temperature (°C).

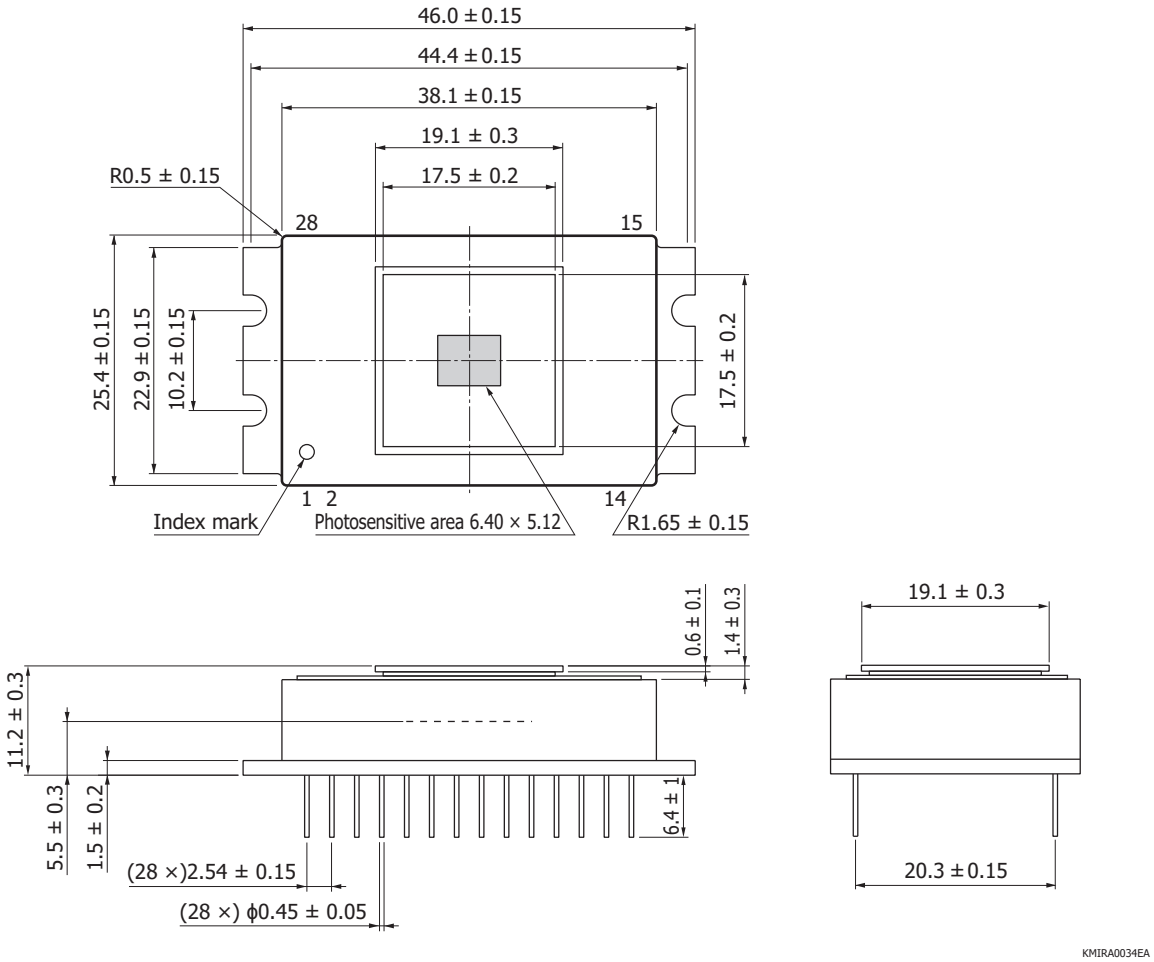
$R1 = R2 \times \exp B \{1/(T1 + 273.15) - 1/(T2 + 273.15)\}$

R1: resistance at T1 (°C)
R2: resistance at T2 (°C)
B: B constant (B=3950 K ± 2%)
Thermistor resistance=10 kΩ (at 25 °C)

Current vs. voltage characteristics of TE-cooler



Dimensional outline (unit: mm)



Pin connections

Pin no.	Symbol	I/O	Content	Remark
1	PD_bias	Input	Photodiode bias voltage	4.28 V typ.
2	Vb1	Input	Pixel bias voltage	(0.7 to 0.9 V)
3	TE(+)	Input	TE-cooler (+)	
4	INP	Input	Input stage amplifier reference voltage	4.2 V typ.
5	NC	-		
6	Video_s1	Output	Video output after integration (port 1)	1.1 to 2.4 V typ.
7	Video_r1	Output	Video output after reset (port 1)	2.4 V typ.
8	GND	Input	0 V Ground	0 V
9	Video_s2	Output	Video output after integration (port 2)	1.1 to 2.4 V typ.
10	Video_r2	Output	Video output after reset (port 2)	2.4 V typ.
11	Video_s3	Output	Video output after integration (port 3)	1.1 to 2.4 V typ.
12	Video_r3	Output	Video output after reset (port 3)	2.4 V typ.
13	Video_s4	Output	Video output after integration (port 4)	1.1 to 2.4 V typ.
14	Video_r4	Output	Video output after reset (port 4)	2.4 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	add	Input	Address input signal pulse	Used when reading 1-port
20	NC	-		
21	MSP	Input	Frame scan start pulse	
22	MCLK	Input	Control pulse for timing generator	Falling synchronization
23	D_Vdd(3.3 V)	Input	+3.3 V power supply (digital)	3.3 V
24	Port_sel	Input	Readout port	High (3.3 V): 4-port readout Low (0 V): 1-port readout
25	en_add	Input	Enable signal voltage of address input signal pulse	Used when reading 1-port
26	TE(-)	Input	TE-cooler (-)	
27	Mode	Input	Operation mode	High (3.3 V)
28	Vdd(3.3 V)	Input	+3.3 V power supply	3.3 V

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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