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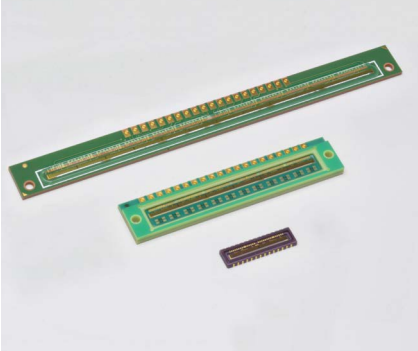
CMOS linear image sensors



S14416/S14417 series

Wide dynamic range and 200 dpi/400 dpi

The S14416/S14417 series are low current consumption CMOS linear image sensors with a 10 MHz data rate. The pixel sizes are 63.5 × 63.5 µm (400 dpi) for the S14416 series, and 127 × 127 µm (200 dpi) for the S14417 series.

Features

- **Pixel size: 63.5 × 63.5 µm (S14416 series)**
  127 × 127 µm (S14417 series)
- **High speed data rate: 10 MHz max.**
- **Single 3 V or 5 V supply voltage operation**
- **Built-in timing generator; requires only a start pulse and clock pulse for operation**
- **Low current consumption**
- **Simultaneous integration capable**

Applications

- **Position detection**
- **Object measurement**
- **Various types of image readout**

Structure

Parameter	S14416-02	S14416-06	S14416-12	S14417-02	S14417-06	Unit
Number of pixels	256	768	1536	128	384	-
Pixel pitch	63.5			127		µm
Pixel height	63.5			127		µm
Effective photosensitive area length	16.256	48.768	97.472	16.256	48.768	mm
Package	Ceramic	Glass epoxy		Ceramic	Glass epoxy	-
Window material	Borosilicate glass		Silicone resin	Borosilicate glass		-

Absolute maximum ratings

Parameter		Symbol	Condition	Value	Unit
Supply voltage		Vdd	Ta=25 °C	-0.3 to +6	V
Clock pulse voltage		V(CLK)	Ta=25 °C	-0.3 to +6	V
Start pulse voltage		V(ST)	Ta=25 °C	-0.3 to +6	V
Operating temperature		Topr	No dew condensation*1	-40 to +85	°C
Storage temperature		Tstg	No dew condensation*1	-40 to +85	°C
Soldering temperature	S14416/S14417-02*2	Tsol		260 (5 s, 3 times)	°C
	S14416/S14417-06*3				
	S14416-12*3				

*1: When there is a temperature difference between a product and the surrounding area in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.
*2: Reflow soldering, IPC/JEDEC J-STD-020 MSL 2a, see P.14
*3: Reflow soldering, IPC/JEDEC J-STD-020 MSL 5a, see P.14
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.

Recommended terminal voltage

Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage		Vdd	3.0	5	5.25	V
Clock pulse voltage	High level	V(CLK)	3.0	Vdd	Vdd + 0.25	V
	Low level		0	-	0.4	
Start pulse voltage	High level	V(ST)	3.0	Vdd	Vdd + 0.25	V
	Low level		0	-	0.4	

Electrical characteristics (Ta=25 °C)

Parameter		Symbol	S14416-02			S14416-06			S14416-12			S14417-02			S14417-06			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Clock pulse frequency		f(CLK)	5 k	-	10 M	5 k	-	10 M	5 k	-	10 M	5 k	-	10 M	5 k	-	10 M	Hz
Data rate		DR	-	f(CLK)	-	-	f(CLK)	-	-	f(CLK)	-	-	f(CLK)	-	-	f(CLK)	-	Hz
Output impedance		Zo	60	-	140	60	-	140	60	-	140	60	-	140	60	-	140	Ω
Current consumption*4	Vdd=3 V	Ic	8	12	16	24	36	48	48	72	96	5	9	13	15	27	39	mA
	Vdd=5 V		14	18	22	42	54	66	84	108	132	9	13	17	27	39	51	

*4: f(CLK)=10 MHz, dark state, V(CLK)=V(ST)=Vdd

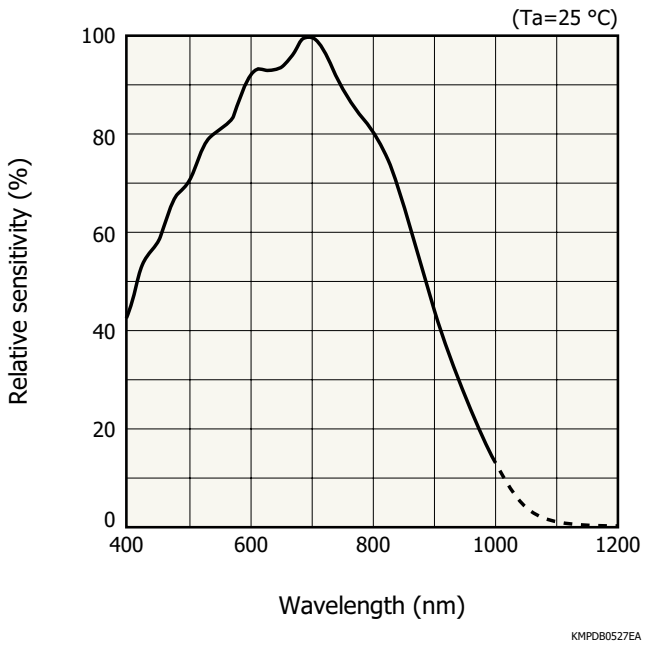
Electrical and optical characteristics [Ta=25 °C, V(CLK)=V(ST)=Vdd, f(CLK)=10 MHz]

Parameter		Symbol	S14416 series			S14417 series			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range		λ	400 to 1000			400 to 1000			nm
Peak sensitivity wavelength		λp	-	700		-	700		nm
Photosensitivity*5		Sw	-	80	-	-	75	-	V/(lx·s)
Conversion efficiency*6		CE	-	0.75	-	-	0.35	-	μV/e⁻
Output offset voltage		Voffset	0.5	0.8	1.1	0.5	0.8	1.1	V
Dark output voltage*7		VD	-	0.02	0.2	-	0.04	0.4	mV
Saturation output voltage*8	Vdd=3 V	Vsat	1.8	2.0	2.2	1.8	2.0	2.2	V
	Vdd=5 V		3.7	4.0	4.3	3.7	4.0	4.3	
Readout noise*9	Vdd=3 V	Nread	-	1.0	1.5	-	0.9	1.4	mV rms
	Vdd=5 V		-	0.7	1.2	-	0.6	1.1	
Dynamic range 1*10	Vdd=3 V	Drange1	-	2000	-	-	2200	-	times
	Vdd=5 V		-	5700	-	-	6600	-	
Dynamic range 2*11	Vdd=3 V	Drange2	-	100000	-	-	50000	-	times
	Vdd=5 V		-	200000	-	-	100000	-	
Photoresponse nonuniformity*4 *12		PRNU	-	±2	±10	-	±2	±10	%

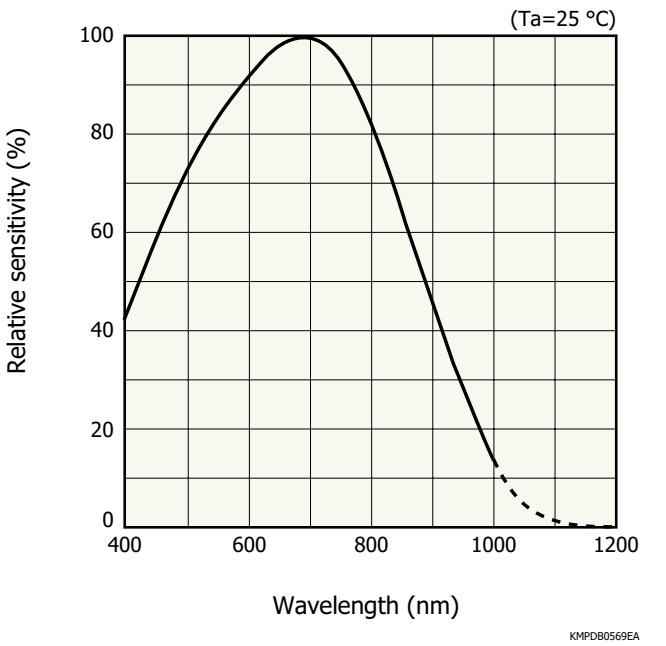
*5: 2856 K, tungsten lamp
*6: Output voltage generated per electron
*7: Integration time=10 ms
*8: Voltage difference from Voffset
*9: Dark state
*10: DR1=Vsat/Nread
*11: DR2=Vsat/VD
*12: Photoresponse nonuniformity is the output non-uniformity when a uniform light with a light exposure that is 50% of saturation output is incident on the entire photosensitive area. It is defined as follows for the 250 pixels (S14416-02), for the 762 pixels (S14416-06), 1530 pixels (S14416-12), for the 122 pixels (S14417-02), for the 378 pixels (S14417-06) excluding the three pixels at each end of the sensor.
PRNU = ΔX/X × 100 [%]
X: Average of the output of all pixels, ΔX: difference between the maximum or minimum output and X

Spectral response (typical example)

S14416-02/-06, S14417-02/-06

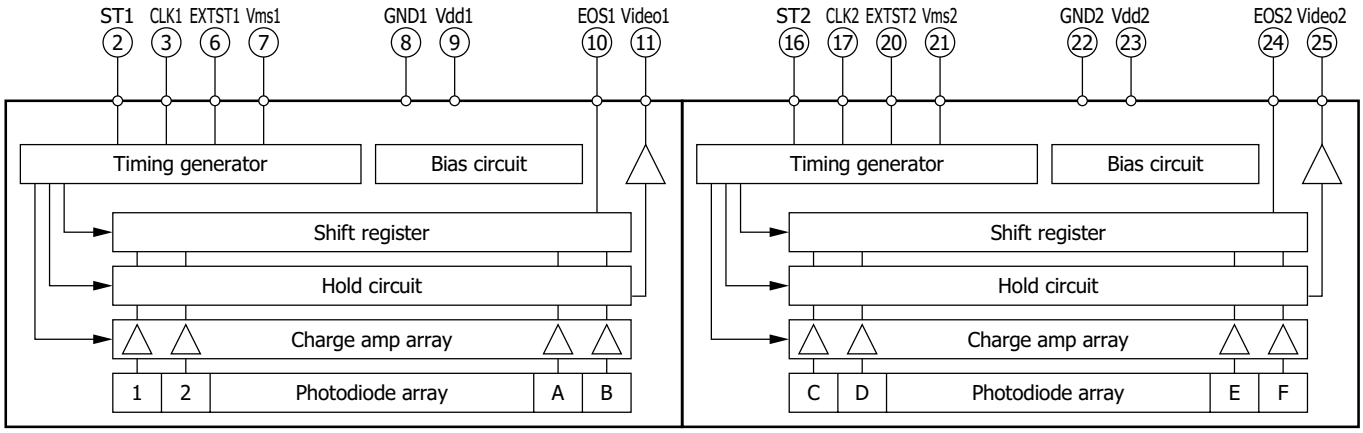


S14416-12



Block diagram

S14416-02, S14417-02



Type no.	A	B	C	D	E	F
S14416-02	127	128	129	130	255	256
S14417-02	63	64	65	66	127	128

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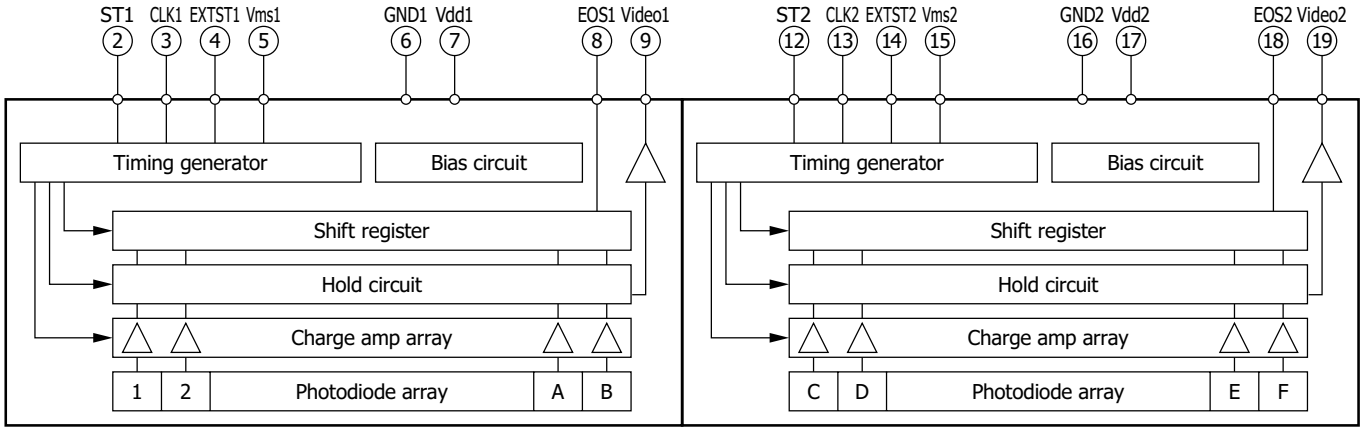
S14416-06/-12, S14417-06



Type no.	A	B	C	D	E	F
S14416-06	383	384	385	386	767	768
S14416-12	767	768	769	770	1535	1536
S14417-06	191	192	193	194	383	384

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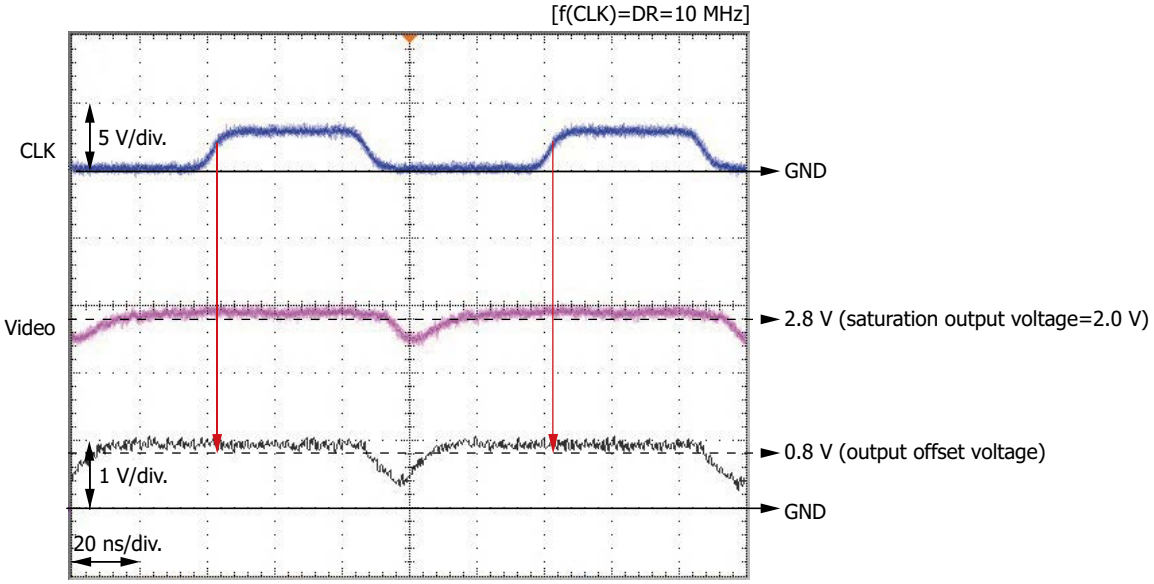
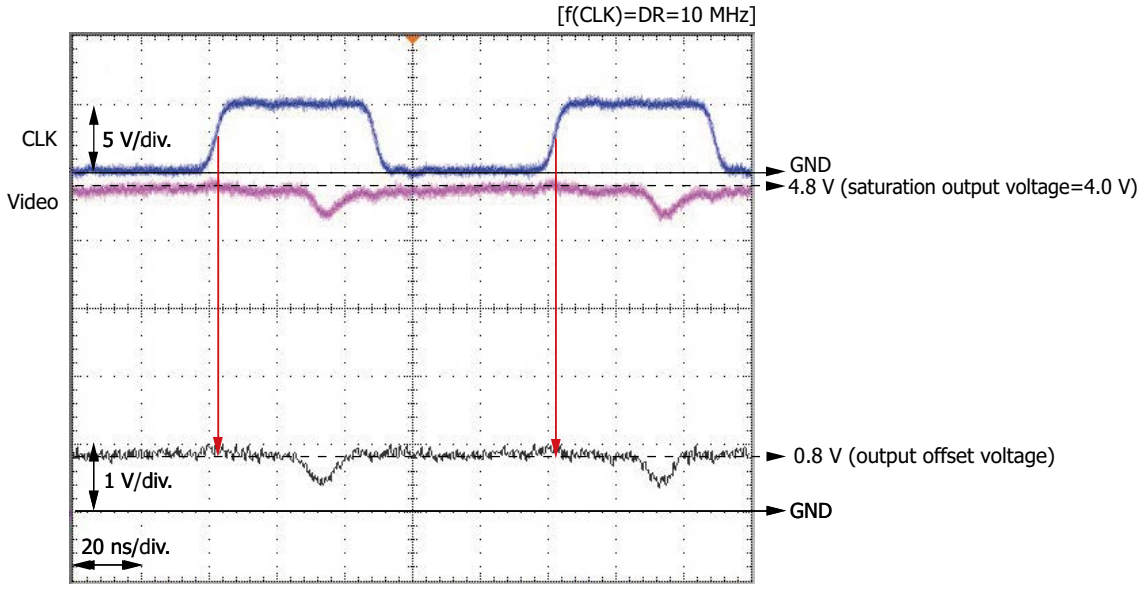
Output waveform of a pixel

The video signal is captured at the rising edge of the CLK signal (see the red arrow).

■ Vdd=3 V

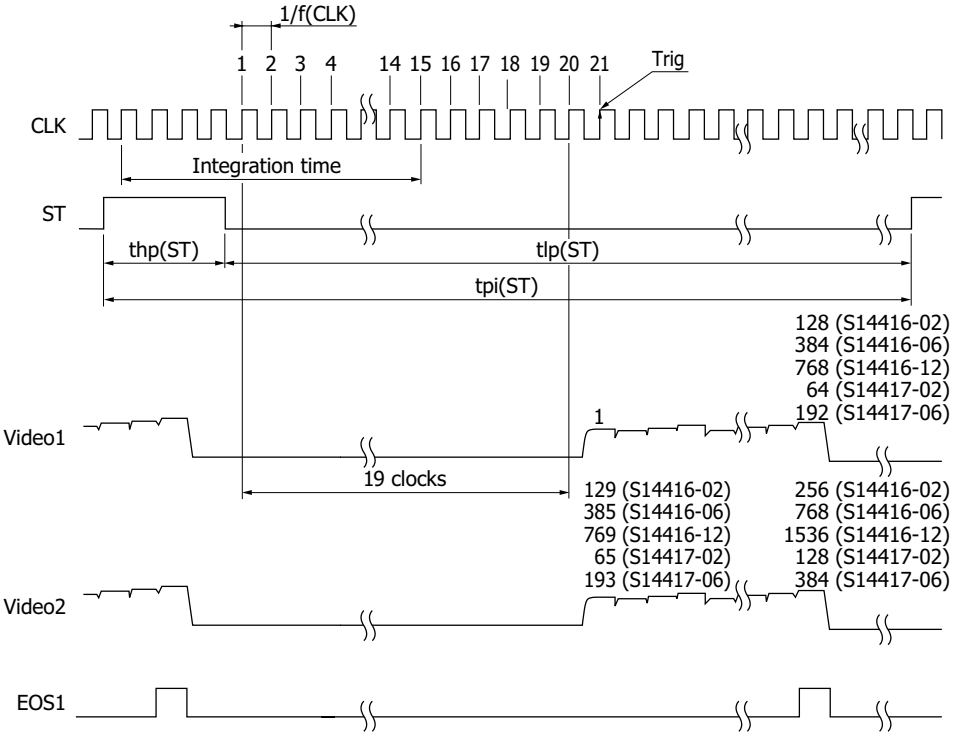


■ Vdd=5 V



Timing chart

Parallel readout



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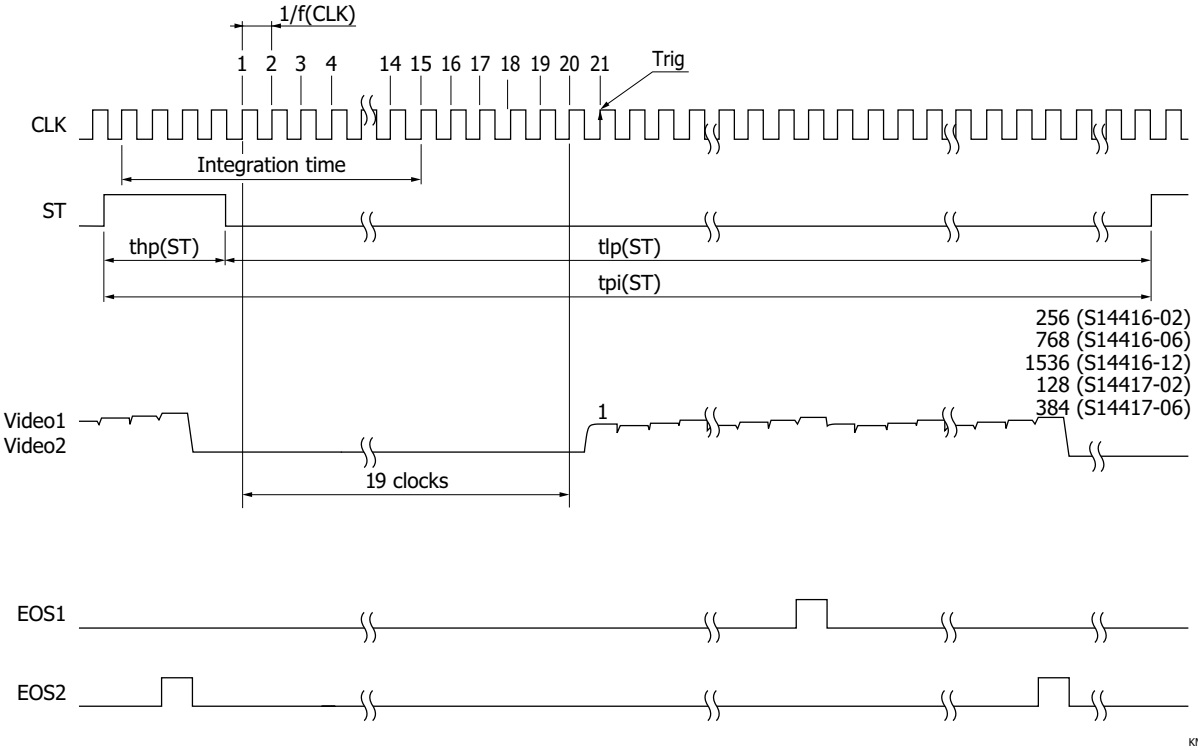
Serial readout



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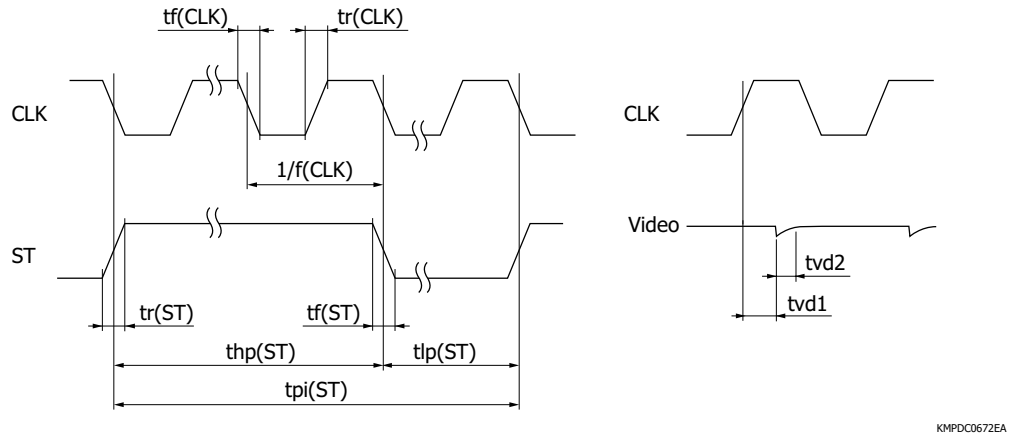


Parameter		Symbol	Min.	Typ.	Max.	Unit
Start pulse period		tpi(ST)	36/f(CLK)	-	-	s
High start pulse period		thp(ST)	4/f(CLK)	-	-	s
Low start pulse period		tlp(ST)	32/f(CLK)	-	-	s
Start pulse rise/fall times		tr(ST), tf(ST)	0	10	15	ns
Clock pulse duty ratio		-	45	50	55	%
Clock pulse rise/fall times		tr(CLK), tf(CLK)	0	10	15	ns
Video delay time 1*13	Vdd=3 V	tvd1	-	60	-	ns
	Vdd=5 V		-	35	-	
Video delay time 2*13	Vdd=3 V	tvd2	-	35	-	ns
	Vdd=5 V		-	30	-	

*13: Ta=25 °C, CLK=10 MHz, V(CLK)=V(ST)=Vdd

Note: If the start pulse period or high start pulse period is increased, the dark output increases.
The internal timing circuit starts operation at the rising edge of CLK immediately after an ST pulse goes low. This rising edge of CLK is considered to be 1.
The integration time corresponds to high ST period + 14 CLK cycles - 100 ns.
If ST is set to low while the shift register is running, the shift register operation is reset and the next operation begins.
The integration time can be changed by changing the ratio of the high and low periods of ST.

Setting for each readout method

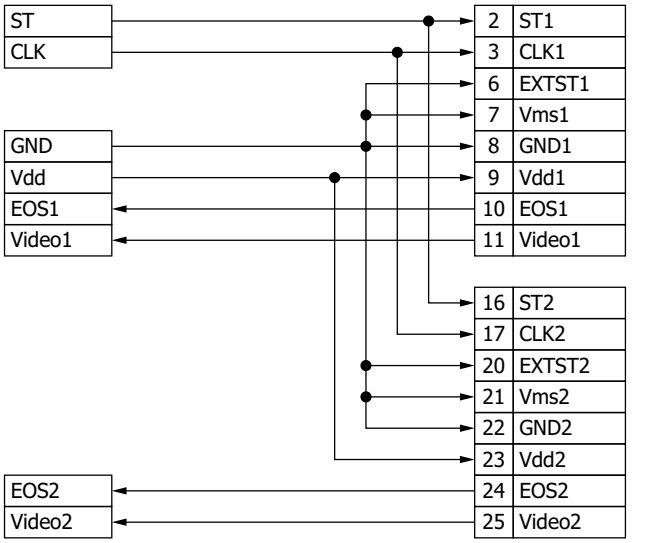
S14416-02, S14417-02

The S14416-02 output terminals are divided into Video1 consisting of 1st pixel to 128th pixel and Video2 consisting of 129th pixel to 256th pixel.
The S14417-02 output terminals are divided into Video1 consisting of 1st pixel to 64th pixel and Video2 consisting of 65th pixel to 128th pixel.
To read Video1 and Video2 in parallel mode, use setting A in the following table.
To read Video1 and Video2 in serial mode, use setting B in the following table for the first stage and setting C for the second stage.

Setting	Readout method	Vms	EXTST
A	All stages of parallel readout	GND	GND
B	First stage of serial readout	GND	Vdd
C	Second stage of serial readout	Vdd	Preceding stage EOS is input.

■ Connection examples

· Parallel readout method



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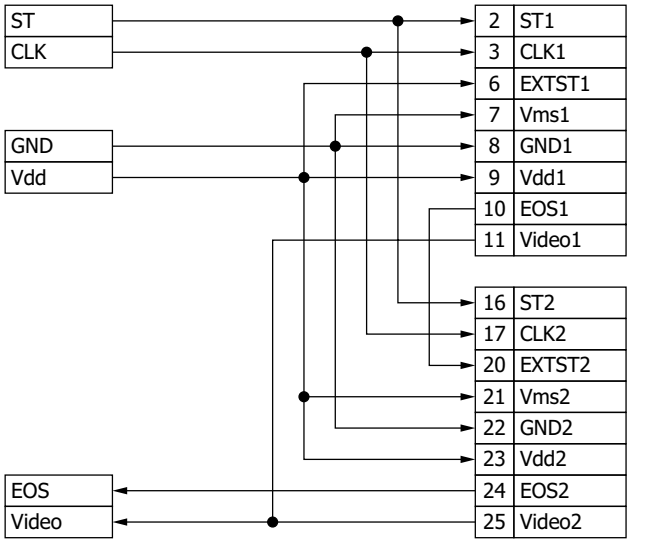
· Serial readout method



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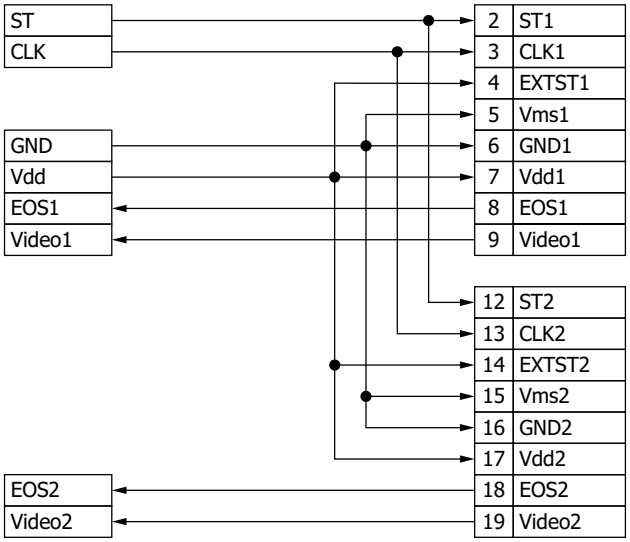
S14416-06/-12, S14417-06

The S14416-06 output terminals are divided into Video1 consisting of 1st pixel to 384th pixel and Video2 consisting of 385th pixel to 768th pixel.
The S14417-06 output terminals are divided into Video1 consisting of 1st pixel to 192nd pixel and Video2 consisting of 193rd pixel to 384th pixel.
The S14416-12 output terminals are divided into Video1 consisting of 1st pixel to 768th pixel and Video2 consisting of 769th pixel to 1536th pixel.
To read Video1 and Video2 in parallel mode, use setting A in the following table.
To read Video1 and Video2 in serial mode, use setting A in the following table for the first stage and setting B for the second stage.

Setting	Readout method	Vms	EXTST
A	All stages of parallel readout, First stage of serial readout	GND	Vdd
B	Second stage of serial readout	Vdd	Preceding stage EOS is input.

■ Connection examples

· Parallel readout method



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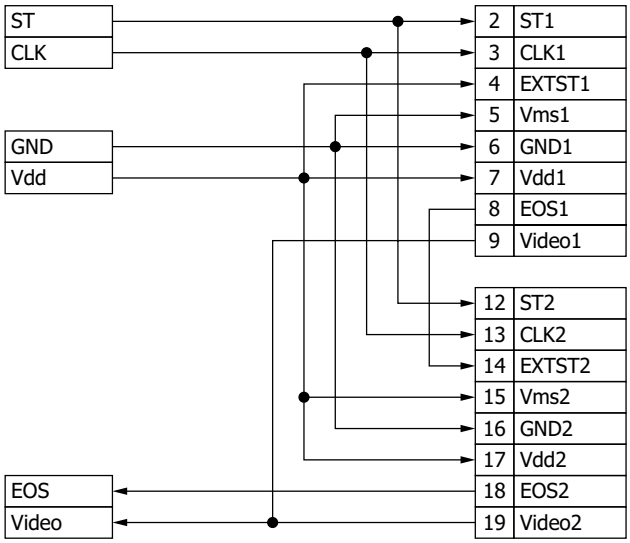
· Serial readout method



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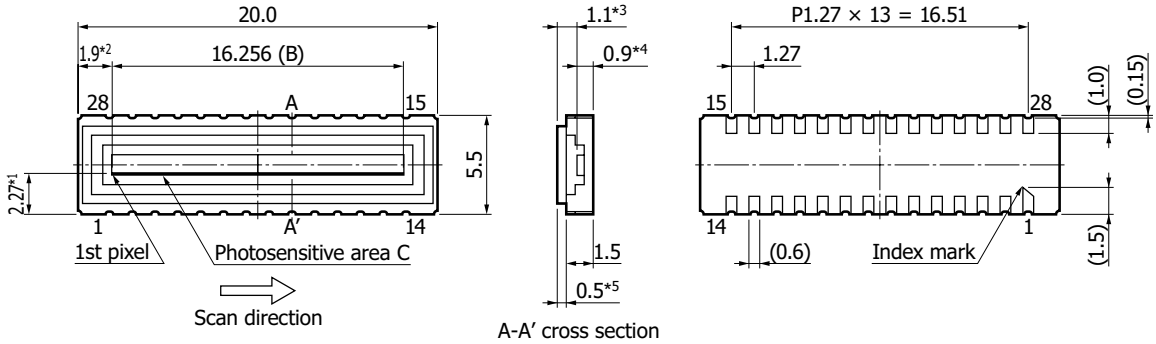
Dimensional outlines (unit: mm)

S14416-02, S14417-02



Tolerance unless otherwise noted: ±0.2
*1: Distance from package end to photosensitive area center
*2: Distance from package end to photosensitive area end
*3: Distance from glass surface to photosensitive area
*4: Distance from substrate bottom to photosensitive area
*5: Glass thickness

Type no.	S14416-02	S14417-02
B	(63.5 µm × 128) × 2 chips	(127 µm × 64) × 2 chips
C	16.12 × 0.0635	16.189 × 0.127

Pin no.	Symbol	I/O	Pin no.	Symbol	I/O
1	NC		15	NC	
2	ST1	I	16	ST2	I
3	CLK1	I	17	CLK2	I
4	NC		18	NC	
5	NC		19	NC	
6	EXTST1	I	20	EXTST2	I
7	Vms1	I	21	Vms2	I
8	GND1	I	22	GND2	I
9	Vdd1	I	23	Vdd2	I
10	EOS1	O	24	EOS2	O
11	Video1	O	25	Video2	O
12	NC		26	NC	
13	NC		27	NC	
14	NC		28	NC	

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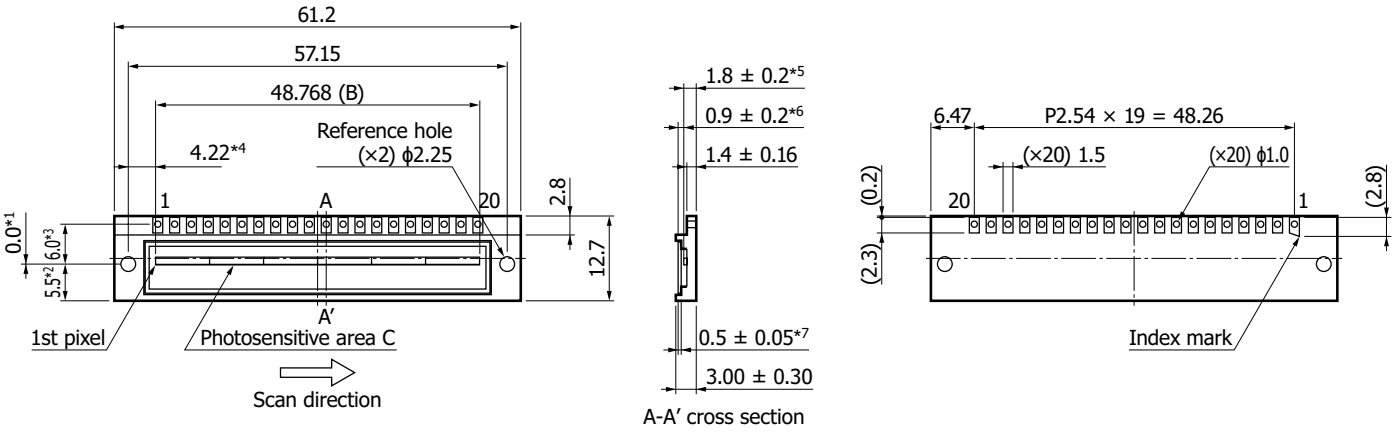
S14416-06, S14417-06



Tolerance unless otherwise noted: ±0.2
*1: Distance from reference hole center to photosensitive area center
*2: Distance from substrate end to reference hole center
*3: Distance from terminal hole center to reference hole center
*4: Distance from reference hole center to photosensitive area end
*5: Distance from substrate bottom to photosensitive area
*6: Distance from glass surface to photosensitive area
*7: Glass thickness

Type no.	S14416-06	S14417-06
B	(63.5 µm × 128) × 6 chips	(127 µm × 64) × 6 chips
C	48.36 × 0.0635	48.701 × 0.127

Pin no.	Symbol	I/O	Pin no.	Symbol	I/O
1	NC		11	NC	
2	ST1	I	12	ST2	I
3	CLK1	I	13	CLK2	I
4	EXTST1	I	14	EXTST2	I
5	Vms1	I	15	Vms2	I
6	GND1	I	16	GND2	I
7	Vdd1	I	17	Vdd2	I
8	EOS1	O	18	EOS2	O
9	Video1	O	19	Video2	O
10	NC		20	NC	

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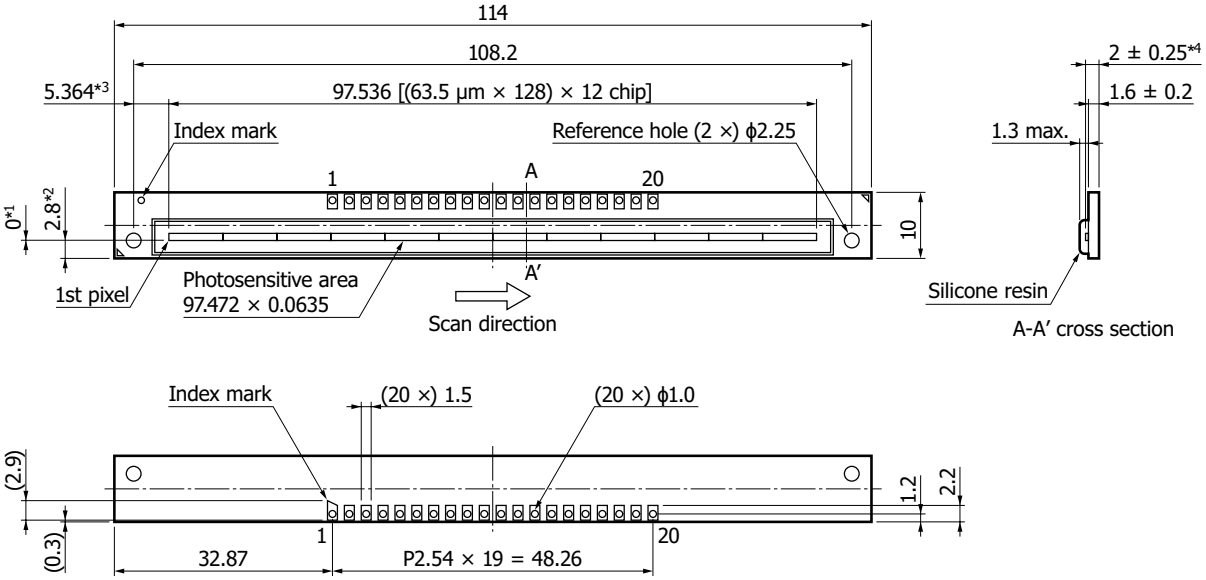
S14416-12



Tolerance unless otherwise noted: ±0.1
*1: Distance from reference hole center to photosensitive area center
*2: Distance from substrate end to reference hole center
*3: Distance from reference hole center to photosensitive area end
*4: Distance from substrate bottom to photosensitive area

Pin no.	Symbol	I/O	Pin no.	Symbol	I/O
1	NC		11	NC	
2	ST1	I	12	ST2	I
3	CLK1	I	13	CLK2	I
4	EXTST1	I	14	EXTST2	I
5	Vms1	I	15	Vms2	I
6	GND1	I	16	GND2	I
7	Vdd1	I	17	Vdd2	I
8	EOS1	O	18	EOS2	O
9	Video1	O	19	Video2	O
10	NC		20	NC	

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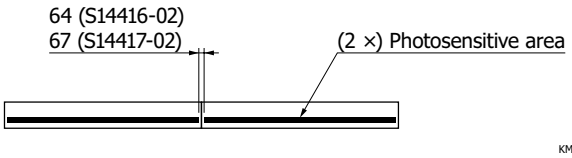
Photosensitive area layout (unit: µm)

S14416-02, S14417-02



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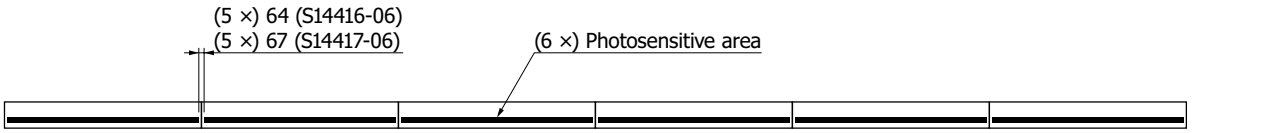
S14416-06, S14417-06



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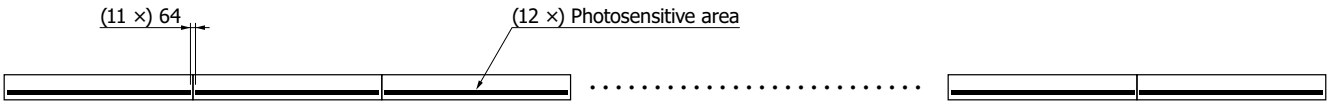
S14416-12



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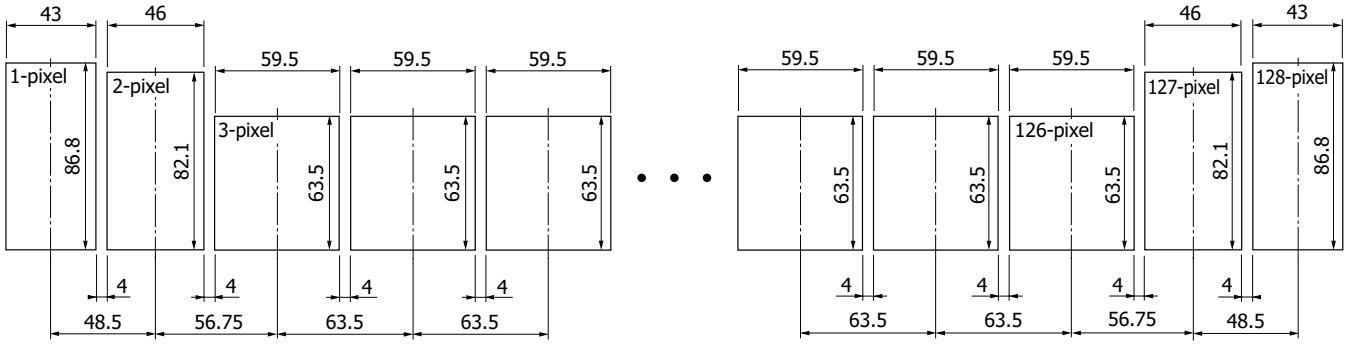
Enlarged view of photosensitive area (unit: µm, per chip)

S14416 series



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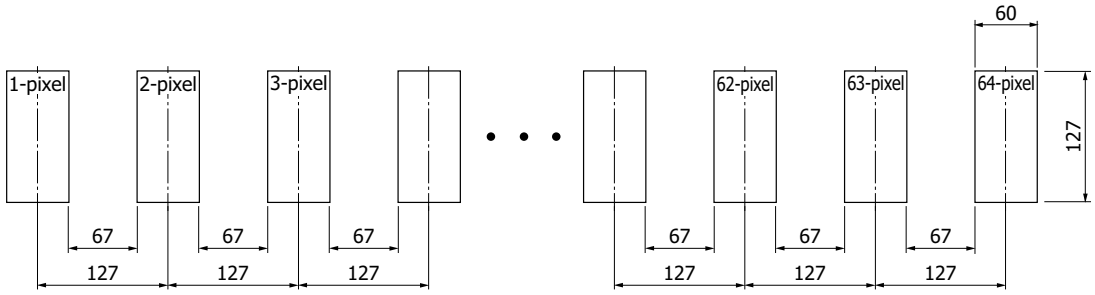
S14417 series



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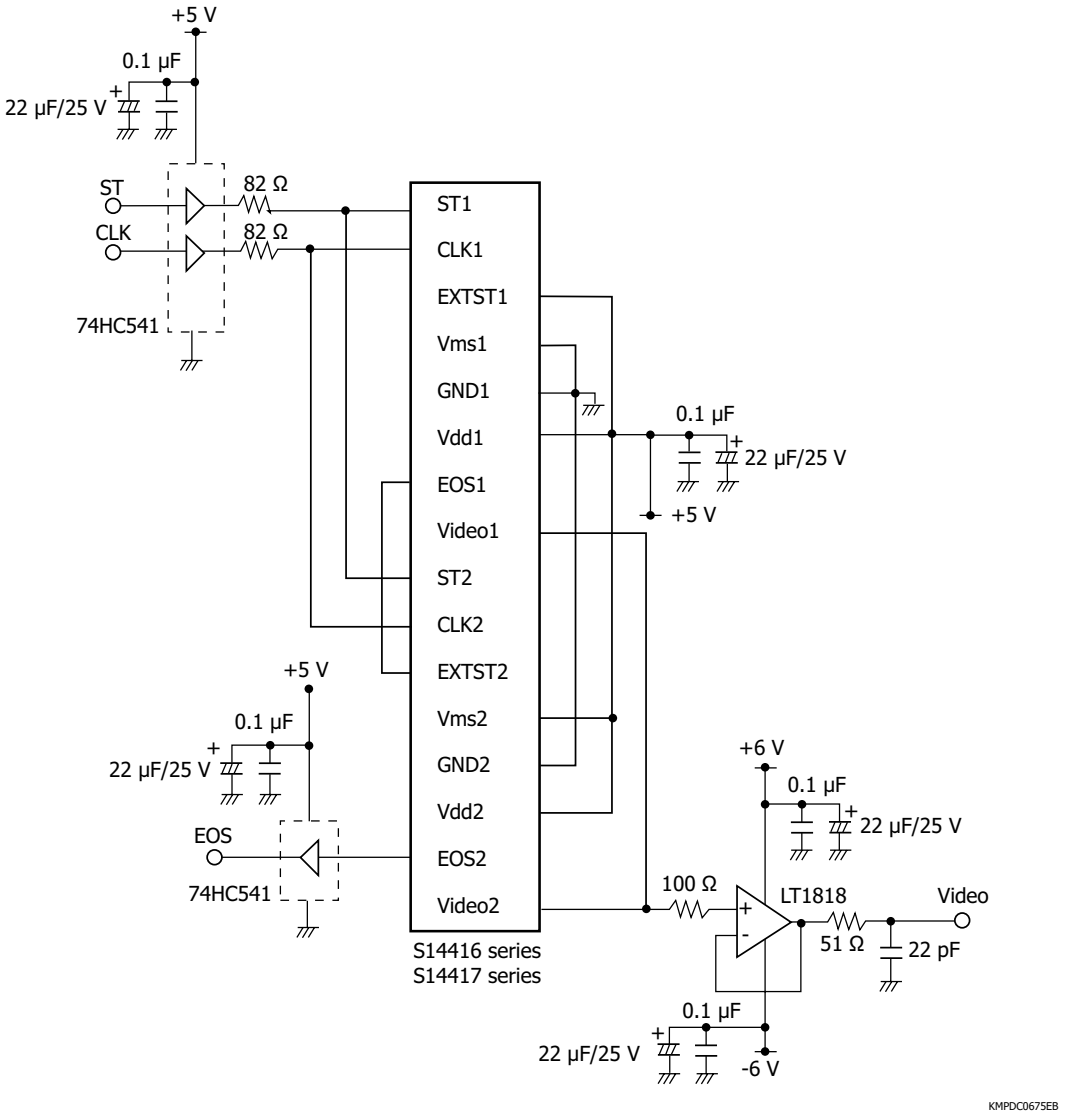
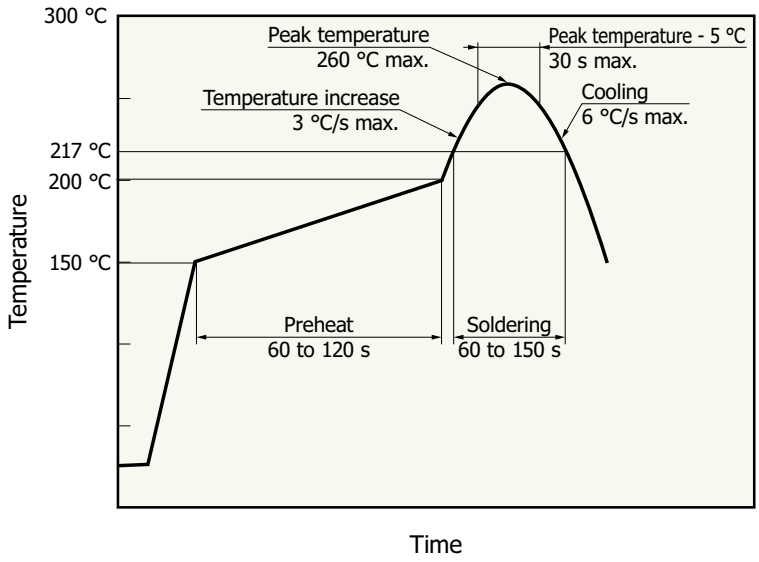
Application circuit example



Recommended reflow soldering conditions (typical example)



· This product supports lead-free soldering. After unpacking, store it in an environment at a temperature of 30 °C or less and a humidity of 60% or less, and perform soldering within 4 weeks (S14416/S14417-02) or 24 hours (S14416/S14417-06, S14416-12).
· The effect that the product is subject to during reflow soldering varies depending on the circuit board and reflow oven that are used. When you set reflow soldering conditions, check that problems do not occur in the product by testing out the conditions in advance. Note that the bonding portion between the ceramic base and the glass may discolor after reflow soldering, but this has no adverse effects on the hermetic sealing of the product.

Baking

When applying reflow soldering after the storage period has passed after opening the package, you need to perform baking to remove moisture.
When you perform baking, be careful of the following points.
· Perform baking according to the recommended baking conditions using a clean drying machine.
· The product package tray is typically not heat tolerant. When baking, transfer the product into a heat tolerant container (metal tray or the like).
· Bake in a dry machine filled with nitrogen gas to prevent the soldering terminal from oxidation.

■ Recommended baking conditions

· Temperature: 120 °C, 3 hours, up to 2 times

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) Light input window

If dust or stain adheres to the surface of the light input window glass, it will appear as black spots 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, a cotton swab, or the like moistened with alcohol to wipe dust and stain off the window surface. Then blow compressed air onto the window surface so that no dust or stain remains.

(3) UV light irradiation

This product is not designed to resist characteristic deterioration under UV light irradiation. Do not apply UV light to it.

Related information

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

■ Precautions

· Disclaimer

· Image sensors

· Surface mount type products

■ Technical Note

· CMOS linear image sensors

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