CMOS linear image sensors

S9227 series

Video data rate: 5 MHz max., simultaneous charge integration

The S9227 series is a small CMOS linear image sensor designed for image input applications. Signal charge is integrated on all pixels simultaneously and then read out of 5 MHz. Two package styles are provided: a DIP type and a surface mount type.

⊟ Features

→ **Pixel pitch: 12.5 μm**
  Pixel height: 250 μm

→ **512 pixels**

→ **5 V single power supply operation**

→ **Video data rate: 5 MHz max.**

→ **Simultaneous charge integration**

→ **Shutter function**

→ **High sensitivity, low dark current, low noise**

→ **Built-in timing generator allows operation with only start and clock pulse inputs.**

→ **Spectral response range: 400 to 1000 nm**

→ **Two package styles are provided:**
  DIP (dual inline package) type: S9227-03
  Surface mount type: S9227-04

⊟ Applications

→ **Position detection**

→ **Image reading**

⊟ Structure

Parameter	Specification	Unit
Number of pixels	512	-
Pixel pitch	12.5	μm
Pixel height	250	μm
Photosensitive area length	6.4	mm
Package	Ceramic	-
Window material	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]	-5 to +85	°C
Storage temperature		Tstg	No dew condensation[1]	-10 to +85	°C
Soldering temperature	S9227-03	Tsol		[2]	-
	S9227-04			240 (twice)[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]: See the recommended soldering conditions (P.7).

[3]: Reflow soldering, IPC/JEDEC J-STD-020 MSL 5, see P.7

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 (Ta=25 °C)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage		Vdd	4.75	5	5.25	V
Clock pulse voltage	High level	V(CLK)	Vdd - 0.25	Vdd	Vdd + 0.25	V
	Low level		-	0	-	V
Start pulse voltage	High level	V(ST)	Vdd - 0.25	Vdd	Vdd + 0.25	V
	Low level		-	0	-	V

Electrical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V]

Parameter	Symbol	Min.	Typ.	Max.	Unit
Clock pulse frequency	f(CLK)	50 k	-	5 M	Hz
Data rate	DR	-	f(CLK)	-	Hz
Current consumption*4	Ic	20	26	32	mA
Conversion efficiency	CE	-	1.6	-	µV/e-
Output impedance	Zo	-	50	200	Ω

*4: f(CLK)=5 MHz

Electrical and optical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V, f(CLK)=5 MHz]

Parameter	Symbol	Min.	Typ.	Max.	Unit
Spectral response range	λ		400 to 1000		nm
Peak sensitivity wavelength	λp	-	650	-	nm
Dark current	I_D	-	10	100	fA
Saturation charge	Qsat	400	430	-	fC
Dark output voltage*5	VD	-	1	10	mV
Saturation output voltage*6	Vsat	4	4.3	-	V
Readout noise	Nread	-	0.45	2	mV rms
Output offset voltage	Voffset	-	0.6	0.9	V
Photoresponse nonuniformity*7 *8	PRNU	-	-	±5	%

*5: Integration time=10 ms
*6: Voltage difference with respect to Voffset
*7: Photoresponse nonuniformity (PRNU) is the output nonuniformity that occurs when the entire photosensitive area is uniformly illuminated by light which is 50% of the saturation exposure level. PRNU is measured using 510 pixels excluding the pixels at both ends, and is defined as follows:
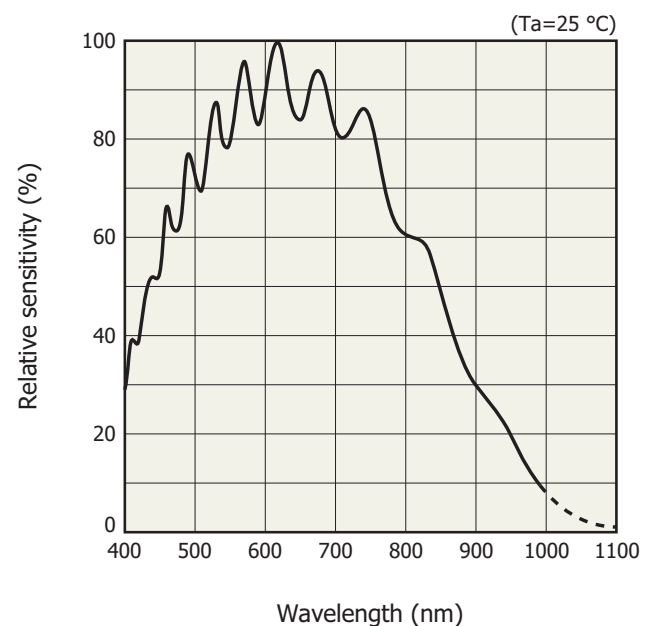PRNU= $\Delta X/X \times 100$ (%)
X: average output of all pixels, ΔX: difference between X and maximum or minimum output
*8: Measured with a tungsten lamp of 2856 K

Block diagram

KMPDC0167EB
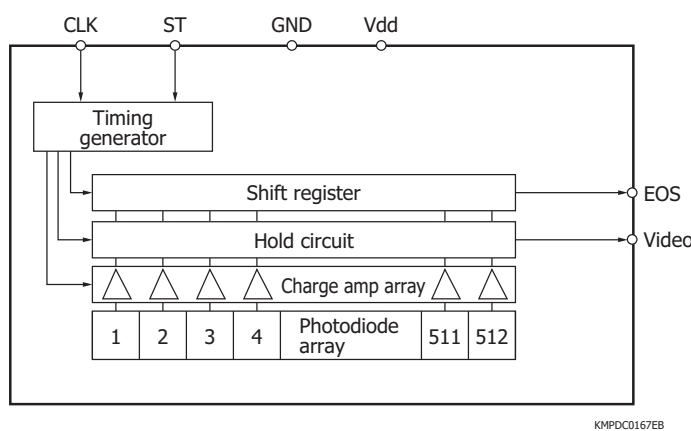
Spectral response (typical example)

KMPDB0230EC

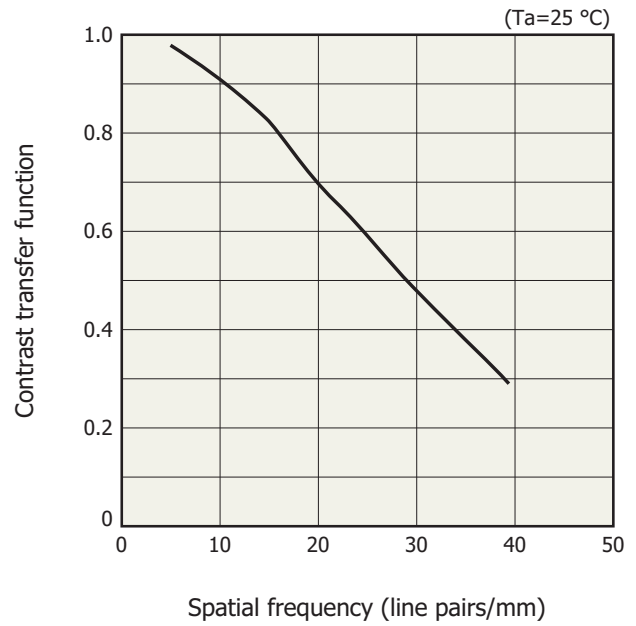## Resolution

CTF: contrast transfer function
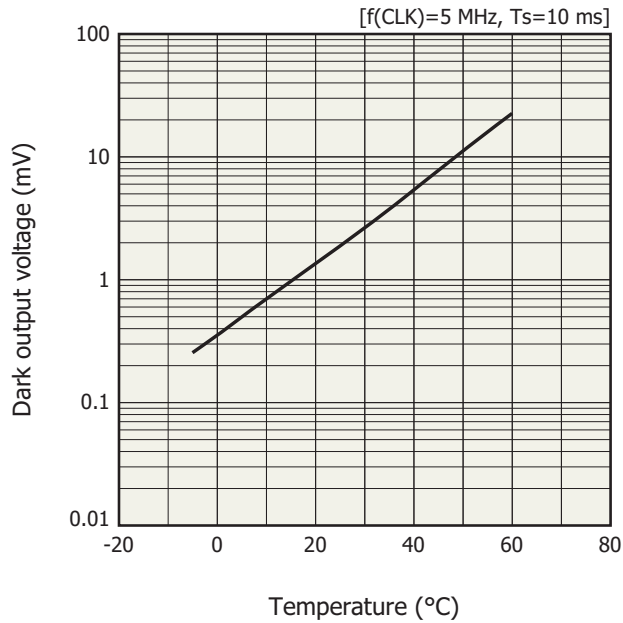
$$CTF = \frac{V_{WO} - V_{BO}}{V_W - V_B}$$

V_{WO} : output white level
V_{BO} : output black level
V_W : output white level (when input pattern pulse width is wide)
V_B : output black level (when input pattern pulse width is wide)

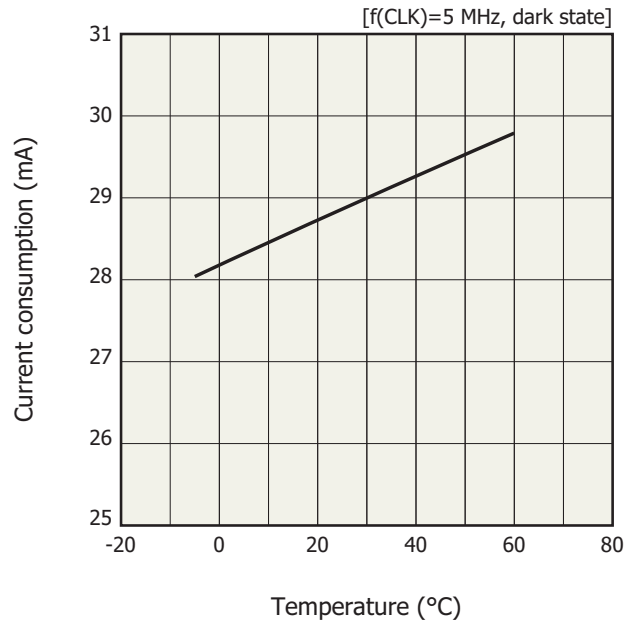## Contrast transfer function vs. spatial frequency (typical example)

KMPDB0321EC

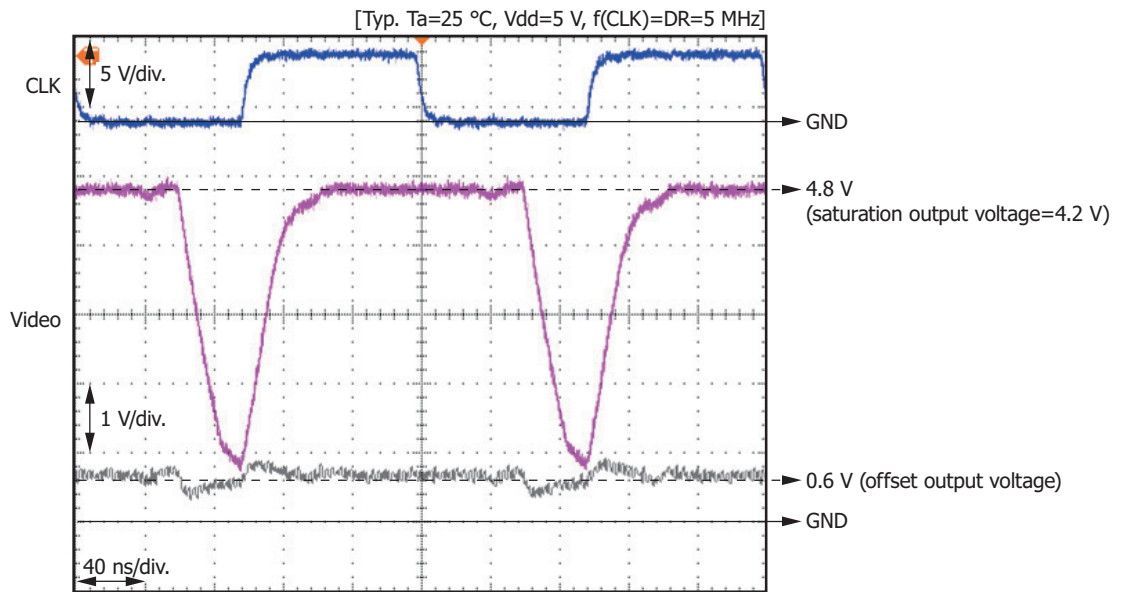## Dark output voltage vs. temperature (typical example)
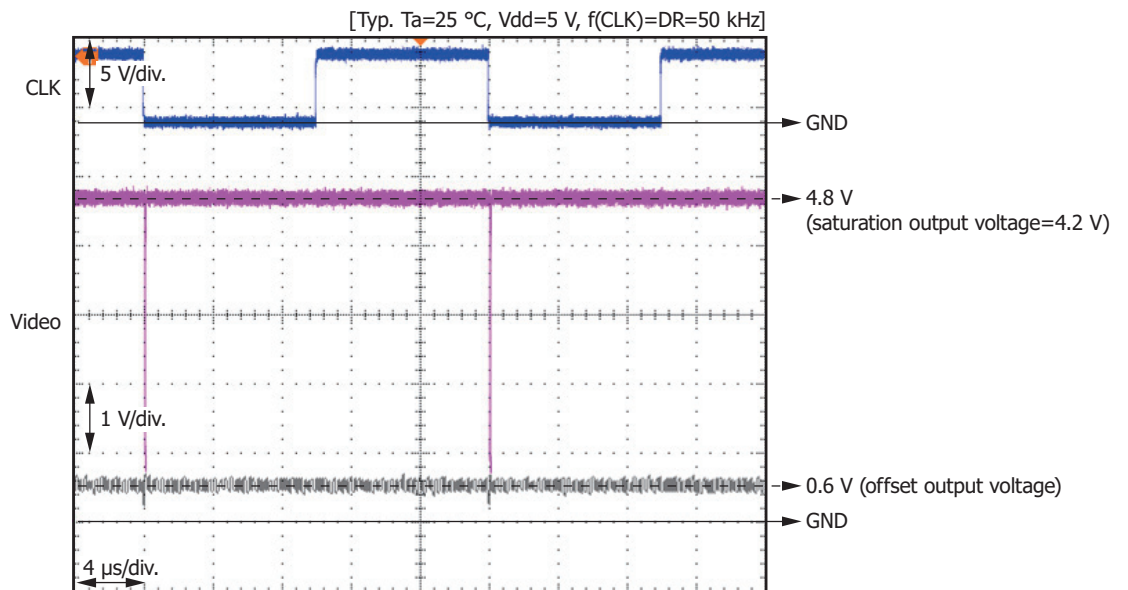

KMPDB0322EC

Current consumption vs. temperature (typical example)

KMPDB0323EC

HAMAMATSU
PHOTON IS OUR BUSINESS

3

Output waveform of one element

■ f(CLK)=DR=5 MHz

[Typ. Ta=25 °C, Vdd=5 V, f(CLK)=DR=5 MHz]

CLK — 5 V/div. — GND
Video — 4.8 V (saturation output voltage=4.2 V)
1 V/div. — 0.6 V (offset output voltage) — GND
40 ns/div.

■ f(CLK)=DR=50 kHz

[Typ. Ta=25 °C, Vdd=5 V, f(CLK)=DR=50 kHz]

CLK — 5 V/div. — GND
Video — 4.8 V (saturation output voltage=4.2 V)
1 V/div. — 0.6 V (offset output voltage) — GND
4 µs/div.

HAMAMATSU
PHOTON IS OUR BUSINESS

Timing chart
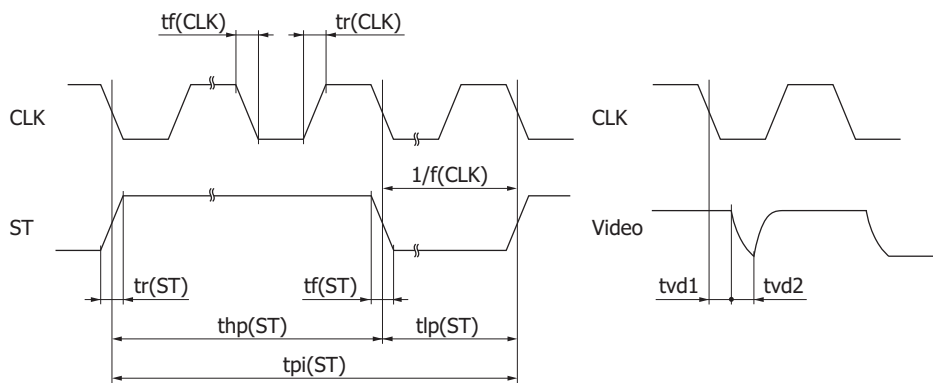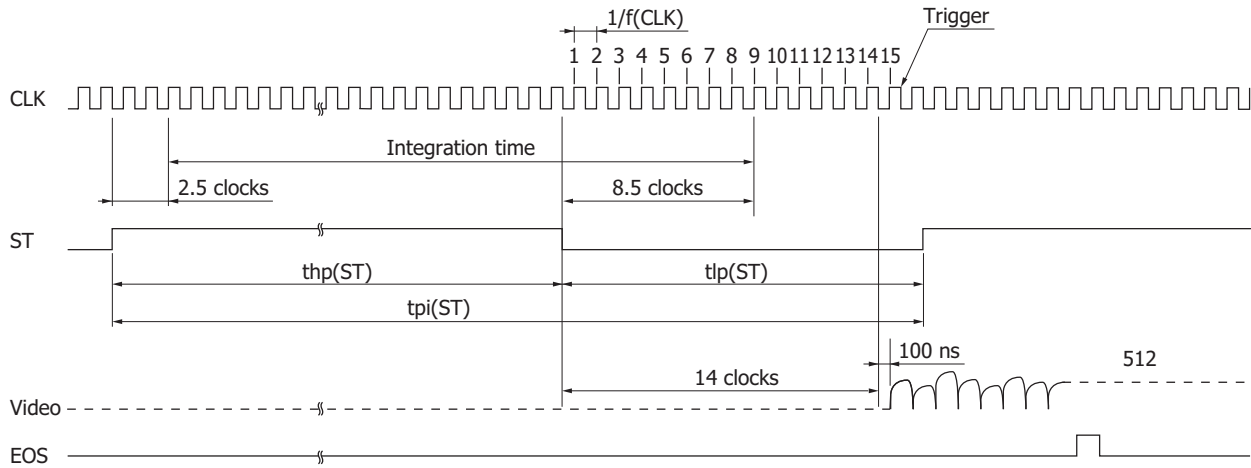
KMPDC0166EF

Parameter	Symbol	Min.	Typ.	Max.	Unit
Start pulse cycle	tpi(ST)	530/f(CLK)	-	1100 m	s
Start pulse high period	thp(ST)	8/f(CLK)	-	1000 m	s
Start pulse low period	tlp(ST)	15/f(CLK)	-	100 m	s
Start pulse rise and fall times	tr(ST), tf(ST)	0	20	30	ns
Clock pulse duty ratio	-	45	50	55	%
Clock pulse rise and fall times	tr(CLK), tf(CLK)	0	20	30	ns
Video delay time 1	tvd1	32	40	48	ns
Video delay time 2	tvd2	40	50	60	ns

Note: The internal timing circuit starts operating at the rise of CLK pulse immediately after ST pulse sets to low.
The integration time equals the high period of ST pulse plus 6 CLK cycles.
The output from 1st pixel appears 14 clocks plus 100 ns after the falling edge of ST pulse.
The EOS pulse is output 39 ns after the falling edge of CLK pulse.
The output voltage after reading the last pixel (512 pixels) is indefinite.
The integration time can be changed by changing the high-to-low ratio of ST pulses.

Start pulse setting example (for setting the start pulse cycle to a minimum and the integration time to a maximum)
Start pulse high period=515/f(CLK), Start pulse low period=15/f(CLK)
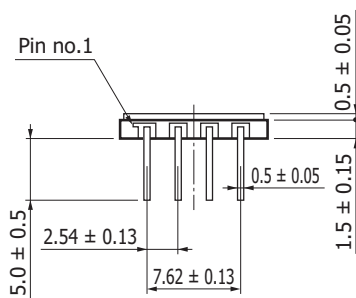
Dimensional outlines (unit: mm)

S9227-03

Photosensitive area
6.4 × 0.25

12.0 ± 0.3
0.763 ± 0.25
7.87 ± 0.25

1st pixel

Direction of scan

1.05 ± 0.15*
0.25 +0.05 -0.03
7.62 ± 0.25

Photosensitive surface

A-A' cross section
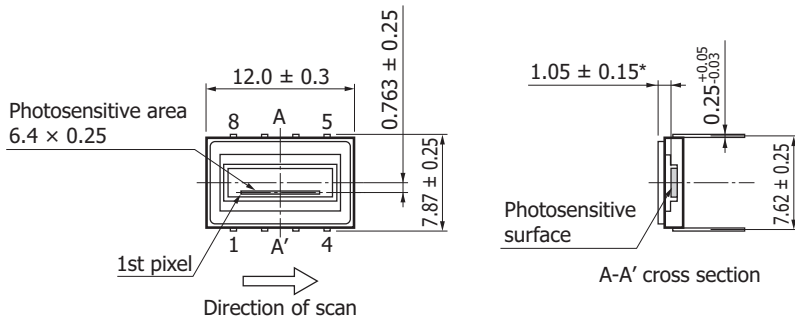
* Distance from upper surface of window to photosensitive surface

KMPDA0173EG

Pin no.1

0.5 ± 0.05
0.5 ± 0.05
1.5 ± 0.15
5.0 ± 0.5
2.54 ± 0.13
7.62 ± 0.13

Pin no.	Symbol	I/O	Pin name
1	GND		Ground
2	NC		No connection
3	NC		No connection
4	Vdd	I	Supply voltage
5	Video	O	Video signal*9
6	EOS	O	End of scan
7	ST	I	Start pulse
8	CLK	I	Clock pulse

*9: Connect a buffer amplifier for impedance conversion to the video output terminal so as to minimize the current flow. As the buffer amplifier, use a high input impedance operational amplifier with JFET or CMOS input.

Note: Leave the "NC" terminals open and do not connect them to GND.

S9227-04

Photosensitive area
6.4 × 0.25

12.5 ± 0.2
7.0 ± 0.2
2.74 ± 0.2

1st pixel

Direction of scan

1.5 ± 0.15
0.5 ± 0.05

Photosensitive surface

1.05 ± 0.2*

A-A' cross section

(16 ×)1.0
(16 ×)0.6
Index mark
(4 ×)R0.2
1.27
8.89
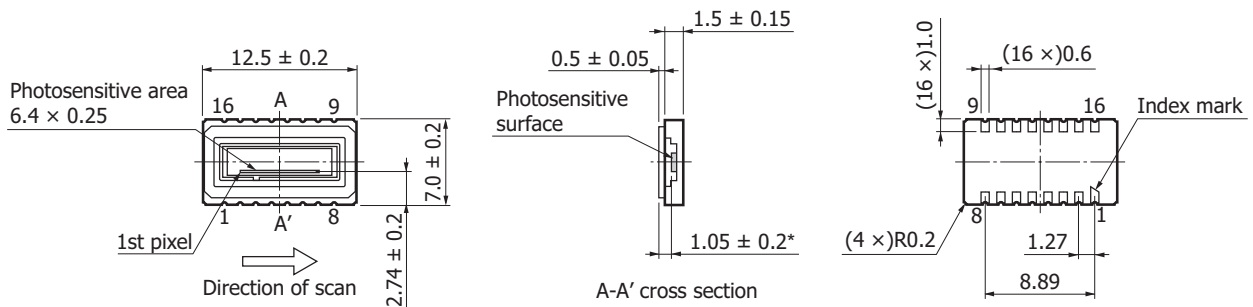
* Distance from upper surface of window to photosensitive surface

KMPDA0281ED

Pin no.	Symbol	I/O	Pin name	Pin no.	Symbol	I/O	Pin name
1	NC		No connection	9	NC		No connection
2	NC		No connection	10	NC		No connection
3	GND		Ground	11	Video	O	Video signal*9
4	NC		No connection	12	EOS	O	End of scan
5	NC		No connection	13	ST	I	Start pulse
6	Vdd	I	Supply voltage	14	CLK	I	Clock pulse
7	NC		No connection	15	NC		No connection
8	NC		No connection	16	NC		No connection

*9: Connect a buffer amplifier for impedance conversion to the video output terminal so as to minimize the current flow. As the buffer amplifier, use a high input impedance operational amplifier with JFET or CMOS input.

Note: Leave the "NC" terminals open and do not connect them to GND.

⊟▪ Recommended soldering conditions

S9227-03		
Parameter	Specification	Remarks
Solder temperature	260 °C max. (less than 5 s)	-

Note: When setting the soldering conditions, check for any problems by testing out the soldering methods in advance.
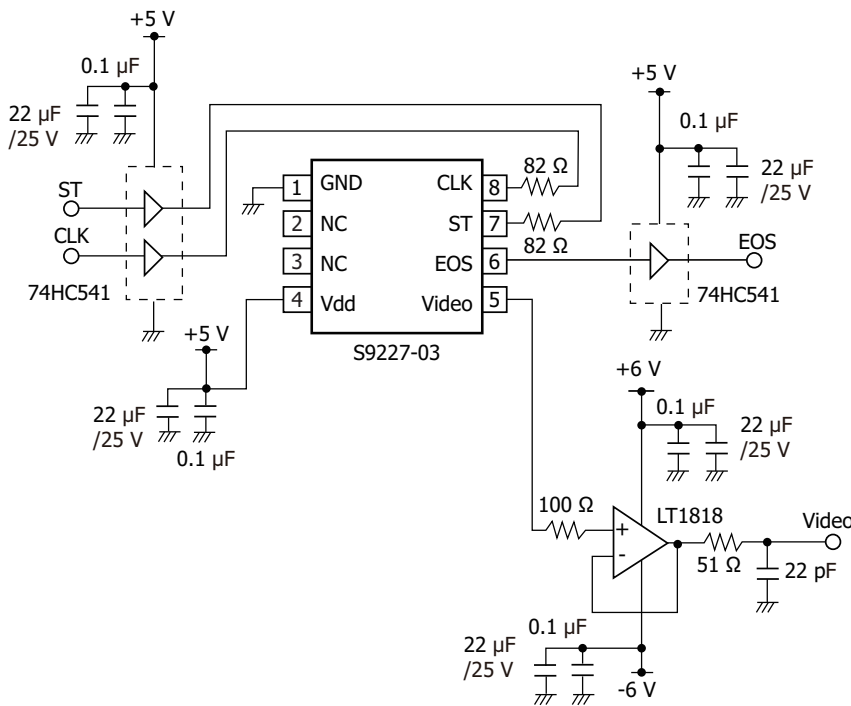
S9227-04
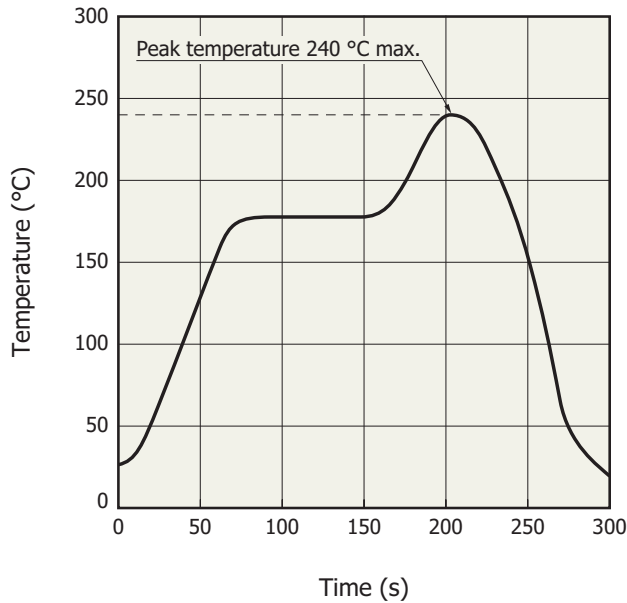
KSPDB0418EA

· This product (S9227-04) 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 48 hours.

· The effect that the product receives during reflow soldering varies depending on the circuit board and reflow oven that are used. Before actual reflow soldering, check for any problems by testing out the reflow soldering methods in advance.

· A sudden temperature rise and cooling may be the cause of trouble, so make sure that the temperature change is within 4 °C per second.

· 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.

HAMAMATSU

PHOTON IS OUR BUSINESS

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 the incident window is contaminated or scratched, the output uniformity will deteriorate considerably, so care should be taken in handling the window. Avoid touching it with bare hands.
The window surface should be cleaned before using the device. If dry cloth or dry cotton swab is used to rub the window surface, static electricity may be generated, and therefore this practice should be avoided. Use soft cloth, cotton swab or soft paper moistened with ethyl alcohol to wipe off dirt and foreign matter on the window surface.

(3) UV exposure
This product is not designed to prevent deterioration of characteristics caused by UV exposure, so do not expose it to UV light.

Application circuit example (S9227-03)*10

KMPDC0415EB

*10: The S9227-04 has a different pin connections, but uses the same circuit.

Related information

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

■ Precautions
· Disclaimer
· Image sensors/Precautions
· Surface mount type products/Precautions