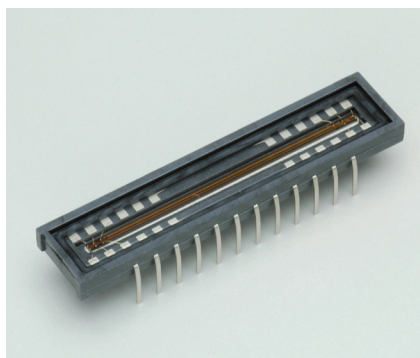


# CMOS linear image sensor



S12706

## High sensitivity, photosensitive area with minute pixels

The S12706 is a high sensitivity CMOS linear image sensor using a photosensitive area with minute pixels. It has a long photosensitive area (effective photosensitive length: 28.672 mm) consisting of 4096 pixels, each with a pixel size of  $7 \times 7 \mu\text{m}$ .

### Features

- Pixel size:  $7 \times 7 \mu\text{m}$
- 4096 pixels
- Effective photosensitive area length: 28.672 mm
- High sensitivity:  $23 \text{ V}/(\text{lx}\cdot\text{s})$
- Simultaneous charge integration for all pixels
- Variable integration time function (electronic shutter function)
- 5 V single power supply operation
- Built-in timing generator allows operation with only start and clock pulse inputs.
- Video data rate: 10 MHz max.

### Applications

- Position detection
- Image reading
- Encoders

### Structure

| Parameter                  | Specification                | Unit          |
|----------------------------|------------------------------|---------------|
| Number of pixels           | 4096                         | -             |
| Pixel size                 | $7 \times 7$                 | $\mu\text{m}$ |
| Photosensitive area length | 28.672                       | mm            |
| Package                    | LCP (liquid crystal polymer) | -             |
| Window material            | Borosilicate glass (Tempax)  | -             |

### 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*1 | Topr   |           | -40 to +85 | °C   |
| Storage temperature*1   | Tstg   |           | -40 to +85 | °C   |

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.

\*1: No condensation

### 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 | 3    | Vdd  | Vdd + 0.25 | V    |
|                     | Low level  | 0    | -    | 0.3        | V    |
| Start pulse voltage | High level | 3    | Vdd  | Vdd + 0.25 | V    |
|                     | Low level  | 0    | -    | 0.3        | V    |

### Input terminal capacitance (Ta=25 °C, Vdd=5 V)

| Parameter                              | Symbol | Min. | Typ. | Max. | Unit |
|--|--------|------|------|------|------|
| Clock pulse input terminal capacitance | C(CLK) | -    | 5    | -    | pF   |
| Start pulse input terminal capacitance | C(ST)  | -    | 5    | -    | pF   |

### 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) | 200 k | 5 M    | 10 M | Hz   |
| Video data rate          | VR     | -     | f(CLK) | -    | Hz   |
| Output impedance         | Zo     | 70    | -      | 260  | Ω    |
| Current consumption*2 *3 | I      | 20    | 40     | 60   | mA   |

\*2: f(CLK)=10 MHz

\*3: Current consumption increases as the clock pulse frequency increases. The current consumption is 10 mA typ. at f(CLK)=200 kHz.

### Electrical and optical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V, f(CLK)=10 MHz]

| Parameter                         | Symbol      | Min.        | Typ.  | Max. | Unit              |
|-----------------------------------|-------------|-------------|-------|------|-------------------|
| Spectral response range           | $\lambda$   | 400 to 1000 |       |      | nm                |
| Peak sensitivity wavelength       | $\lambda_p$ | -           | 600   | -    | nm                |
| Photosensitivity*4                | R           | -           | 23    | -    | V/(lx·s)          |
| Conversion efficiency*5           | CE          | -           | 25    | -    | $\mu\text{V}/e^-$ |
| Dark output voltage*6             | Vd          | 0           | 0.2   | 2    | mV                |
| Saturation output voltage*7       | Vsat        | 1.5         | 2.0   | 2.5  | V                 |
| Readout noise                     | Nr          | 0.5         | 1.0   | 1.8  | mV rms            |
| Dynamic range 1*8                 | DR1         | -           | 2000  | -    | times             |
| Dynamic range 2*9                 | DR2         | -           | 10000 | -    | times             |
| Output offset voltage             | Vo          | 0.3         | 0.5   | 0.9  | V                 |
| Photoresponse nonuniformity*4 *10 | PRNU        | -           | ±2    | ±10  | %                 |
| Image lag*11                      | IL          | -           | -     | 0.1  | %                 |

\*4: Measured with a tungsten lamp of 2856 K

\*5: Output voltage generated per one electron

\*6: Integration time=10 ms

\*7: Difference from Vo

\*8: DR1 = Vsat/Nr

\*9: DR2 = Vsat/Vd

Integration time=10 ms

Dark output voltage is proportional to the integration time and so the shorter the integration time, the wider the dynamic range.

\*10: 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 4090 pixels excluding 3 pixels each at both ends, and is defined as follows:

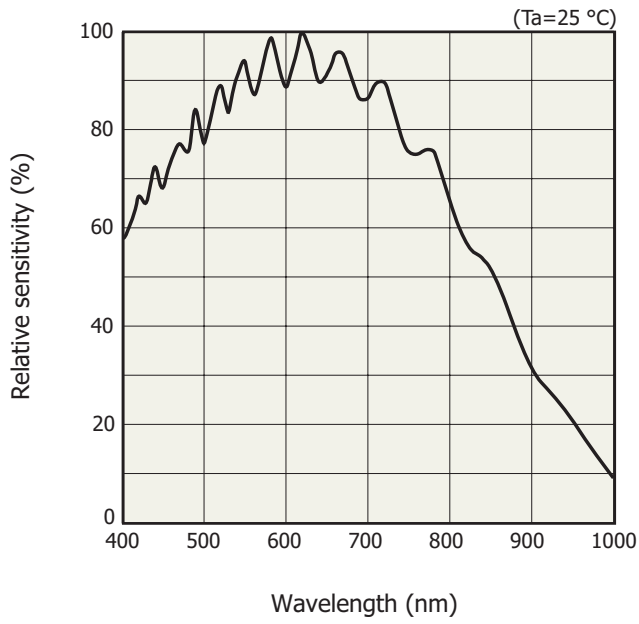
$$\text{PRNU} = \Delta X / X \times 100 (\%)$$

X: average output of all pixels,  $\Delta X$ : difference between X and maximum output or minimum output

\*11: Signal components of the preceding line data that still remain even after the data is read out in a saturation output state.

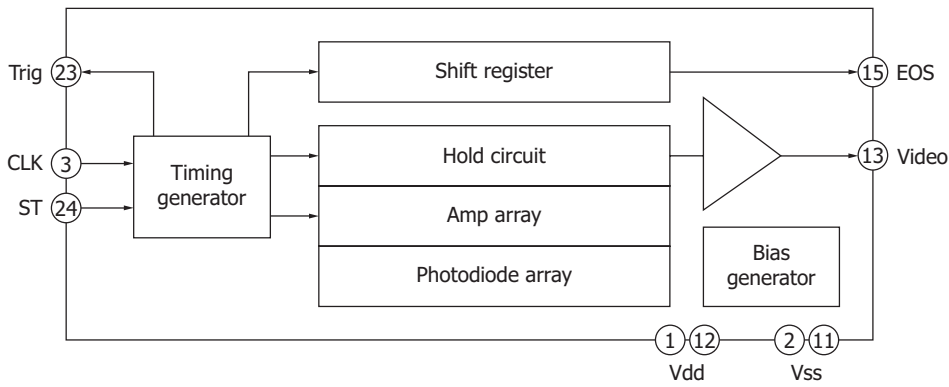
Image lag increases when the output exceeds the saturation output voltage.

**Spectral response (typical example)**



KMPDB0397EA

**Block diagram**

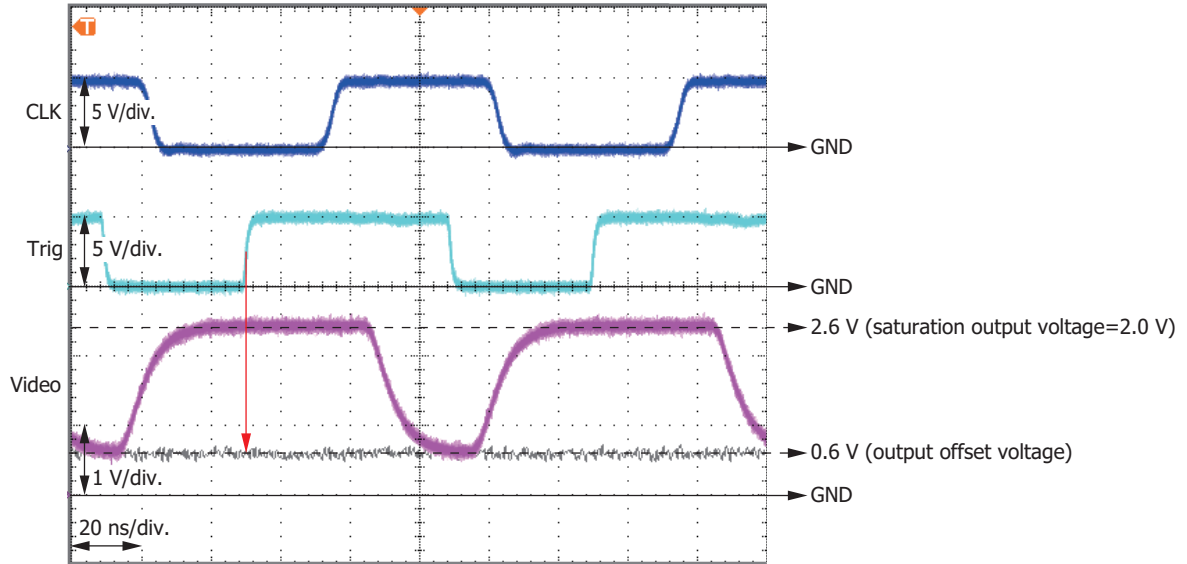


KMPDC0398EA

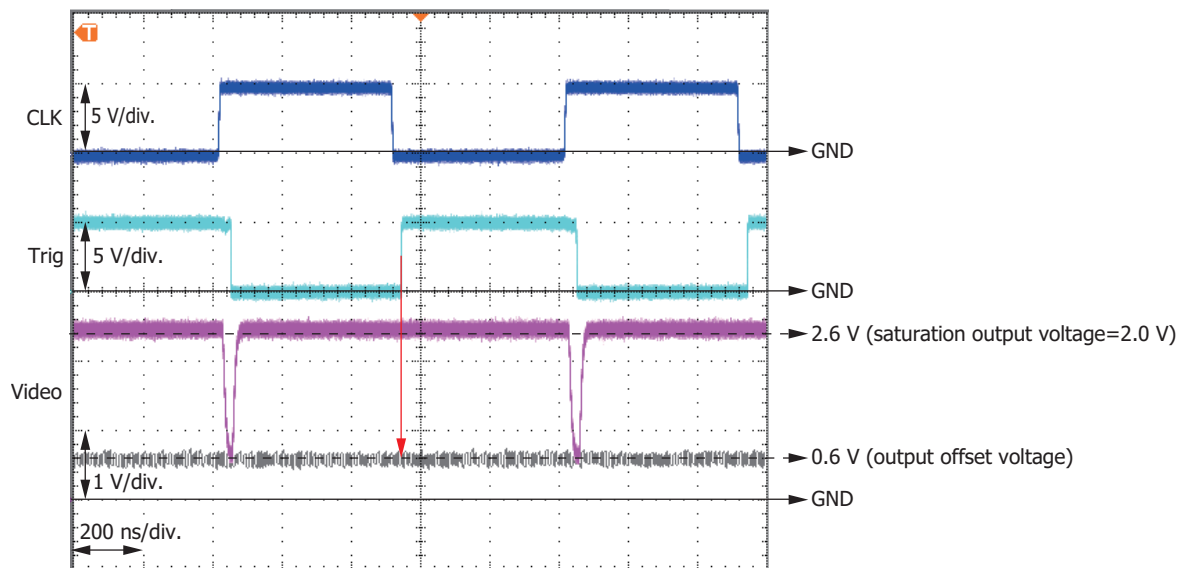
**Output waveforms of one pixel**

The timing for acquiring the Video signal is synchronized with the rising edge of Trig pulse (See red arrow below.).

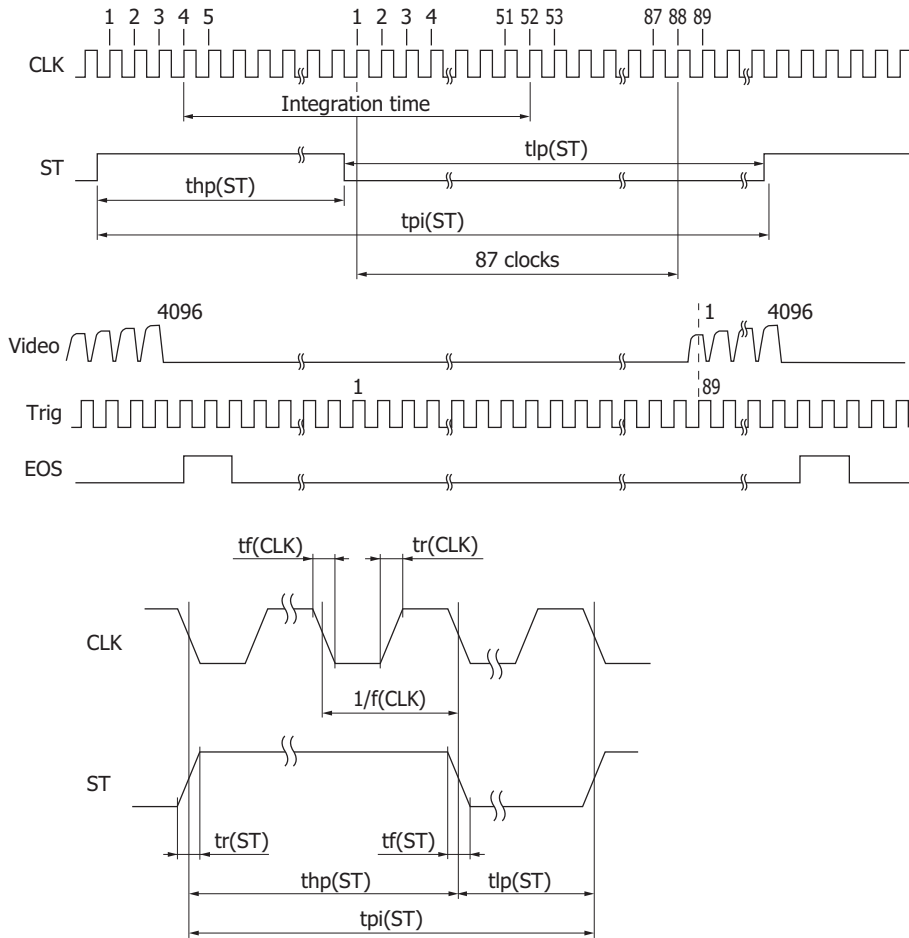
$f(\text{CLK}) = \text{VR} = 10 \text{ MHz}$



$f(\text{CLK}) = \text{VR} = 1 \text{ MHz}$



**Timing chart**



KMPDC0480EA

| Parameter                       | Symbol             | Min.        | Typ. | Max. | Unit |
|---------------------------------|--------------------|-------------|------|------|------|
| Start pulse cycle*12            | $tpi(ST)$          | $98/f(CLK)$ | -    | -    | s    |
| Start pulse high period*12 *13  | $thp(ST)$          | $6/f(CLK)$  | -    | -    | s    |
| Start pulse low period          | $tlp(ST)$          | $92/f(CLK)$ | -    | -    | s    |
| Start pulse rise and fall times | $tr(ST), tf(ST)$   | 0           | 10   | 30   | ns   |
| Clock pulse duty ratio          | -                  | 45          | 50   | 55   | %    |
| Clock pulse rise and fall times | $tr(CLK), tf(CLK)$ | 0           | 10   | 30   | ns   |

\*12: Dark output increases if the start pulse cycle or the start pulse high period is lengthened.

\*13: The integration time equals the high period of ST plus 48 CLK cycles.

The shift register starts operation at the rising edge of CLK immediately after ST goes low.

The integration time can be changed by changing the ratio of the high and low periods of ST.

If the first Trig pulse after ST goes low is counted as the first pulse, the Video signal is acquired at the rising edge of the 89th Trig pulse.

**Operation example**

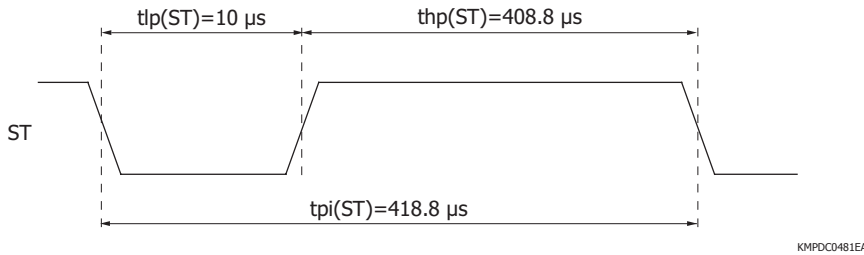
This example assumes that the clock pulse frequency is maximized (video data rate is also maximized), the time of one scan is minimized, and the integration time is maximized

Clock pulse frequency = Video data rate = 10 MHz

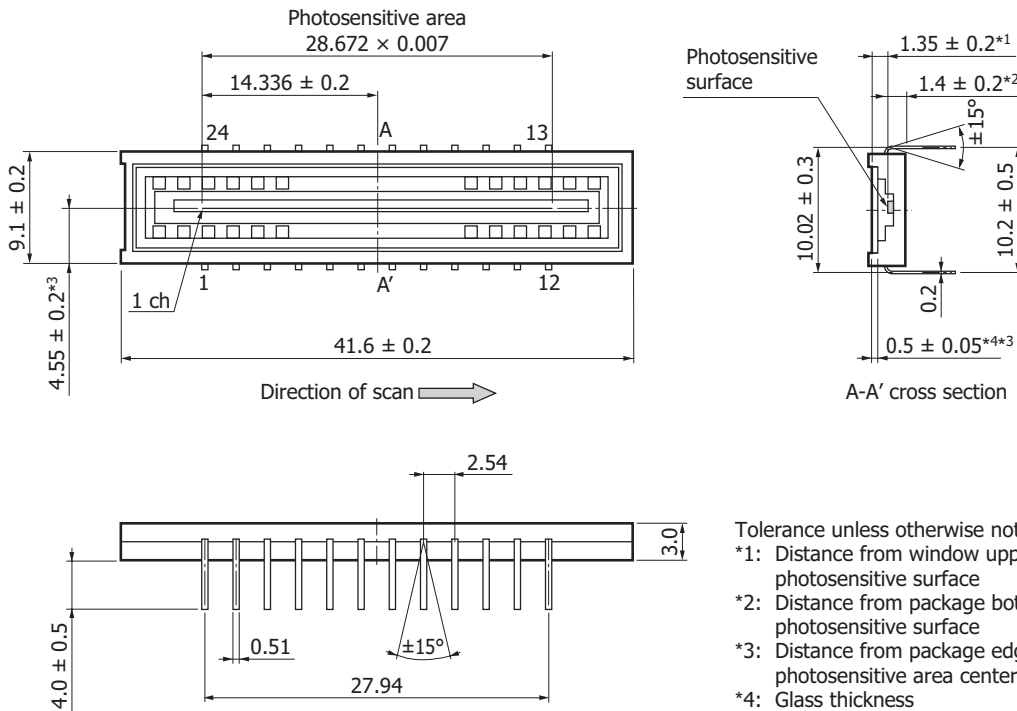
Start pulse cycle =  $4188/f(\text{CLK}) = 4188/10 \text{ MHz} = 418.8 \mu\text{s}$

High period of start pulse = Start pulse cycle - Start pulse's low period min.  
 $= 4188/f(\text{CLK}) - 92/f(\text{CLK}) = 4188/10 \text{ MHz} - 92/10 \text{ MHz} = 409.6 \mu\text{s}$

Integration time is equal to the high period of start pulse + 48 cycles of clock pulses, so it will be  $409.6 + 4.8 = 414.4 \mu\text{s}$ .



**Dimensional outline (unit: mm)**



KMPDA0309EC

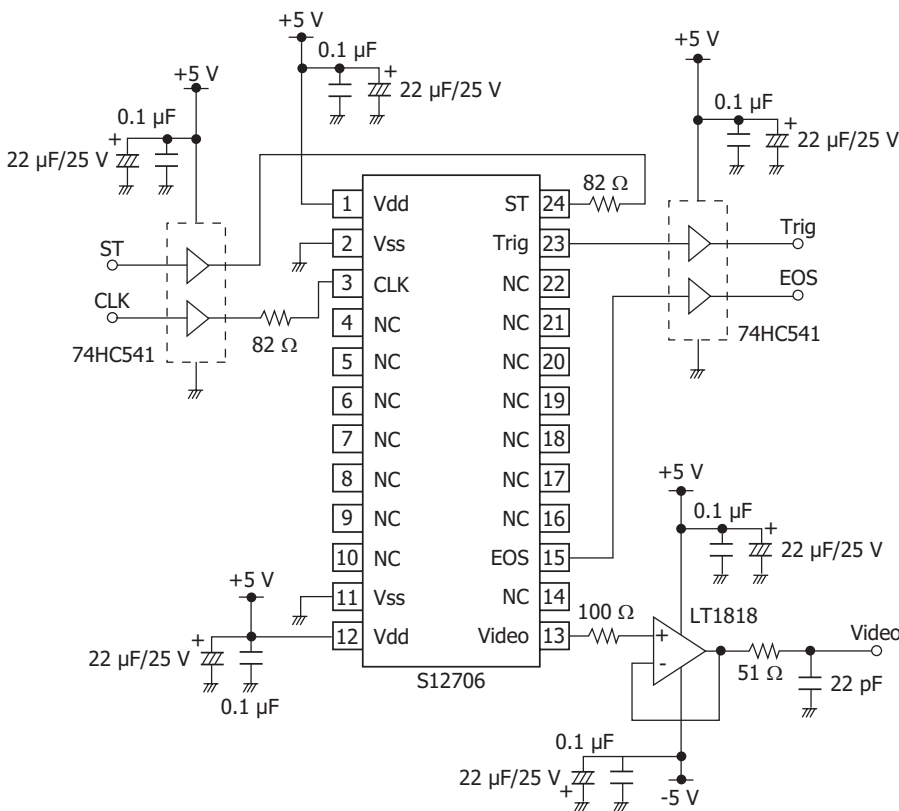
**Pin connections**

| Pin no. | Symbol | I/O | Description    | Pin no. | Symbol | I/O | Description                                |
|---------|--------|-----|----------------|---------|--------|-----|--|
| 1       | Vdd    | I   | Supply voltage | 13      | Video  | O   | Video signal                               |
| 2       | Vss    | -   | GND            | 14      | NC     | -   | No connection                              |
| 3       | CLK    | I   | Clock pulse    | 15      | EOS    | O   | End of scan                                |
| 4       | NC     | -   | No connection  | 16      | NC     | -   | No connection                              |
| 5       | NC     | -   | No connection  | 17      | NC     | -   | No connection                              |
| 6       | NC     | -   | No connection  | 18      | NC     | -   | No connection                              |
| 7       | NC     | -   | No connection  | 19      | NC     | -   | No connection                              |
| 8       | NC     | -   | No connection  | 20      | NC     | -   | No connection                              |
| 9       | NC     | -   | No connection  | 21      | NC     | -   | No connection                              |
| 10      | NC     | -   | No connection  | 22      | NC     | -   | No connection                              |
| 11      | Vss    | -   | GND            | 23      | Trig   | O   | Trigger pulse for video signal acquisition |
| 12      | Vdd    | I   | Supply voltage | 24      | ST     | I   | Start pulse                                |

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

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.

**Application circuit example**



KMPDC0482EA

## 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. Also protect this device from surge voltages which might be caused by peripheral equipment.

### (2) Light input window

If dust or dirt gets on the light input window, it will show up as black blemishes on the image. When cleaning, avoid rubbing the window surface with dry cloth or dry cotton swab, since doing so may generate static electricity. Use soft cloth, paper or a cotton swab moistened with alcohol to wipe dust and dirt 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 5 seconds at a soldering temperature below 260 °C.

### (4) Operating and storage environments

Always observe the rated temperature range when handling the device. Operating or storing the device at an excessively high temperature and humidity may cause variations in performance characteristics and must be avoided.

### (5) UV light irradiation

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

## Related information

[www.hamamatsu.com/sp/ssd/doc\\_en.html](http://www.hamamatsu.com/sp/ssd/doc_en.html)

### ■ Precautions

- Notice
- Image sensor / Precautions

Information described in this material is current as of December 2016.

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