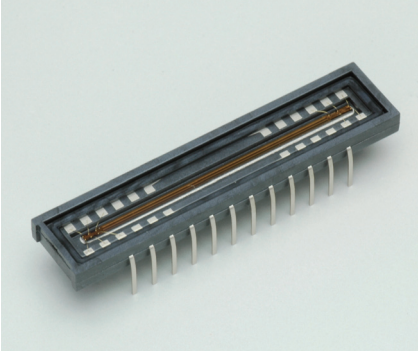
HAMAMATSU
PHOTON IS OUR BUSINESS

CMOS linear image sensor



S13488

RGB color image sensor

The S13488 is a CMOS linear image sensor that is sensitive to red (630 nm), green (540 nm), and blue (460 nm). Filters are attached to the pixels in the following order: R, G, and B.

Features

- **Pixel size: 14 × 42 µm**
- **2048 pixels**
- **Effective photosensitive area length: 28.672 mm**
- **High sensitivity: with a gain switch function [Red: 65 V/(*lx*·s), Green: 85 V/(*lx*·s), Blue: 35 V/(*lx*·s)]**
- **Spectral response range: 400 to 1000 nm**
- **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

- **Image reading**
- **Various color detection**

Structure

Parameter	Specification	Unit
Number of pixels	2048	-
Pixel size	14 × 42	µm
Photosensitive area length	28.672	mm
Package	LCP (liquid crystal polymer)	-
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
Gain selection terminal voltage	Vg	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

*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.

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)	3	Vdd	Vdd + 0.25	V
	Low level		0	-	0.3	V
Start pulse voltage	High level	V(ST)	3	Vdd	Vdd + 0.25	V
	Low level		0	-	0.3	V
Gain selection terminal voltage	High gain	Vg	0	-	0.3	V
	Low gain		3	Vdd	Vdd + 0.25	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
Gain selection terminal capacitance	C(Vg)	-	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
Data rate		DR	-	f(CLK)	-	Hz
Output impedance		Zo	70	-	260	Ω
Current consumption*2 *3	High gain	Ic	60	75	100	mA
	Low gain		20	35	60	

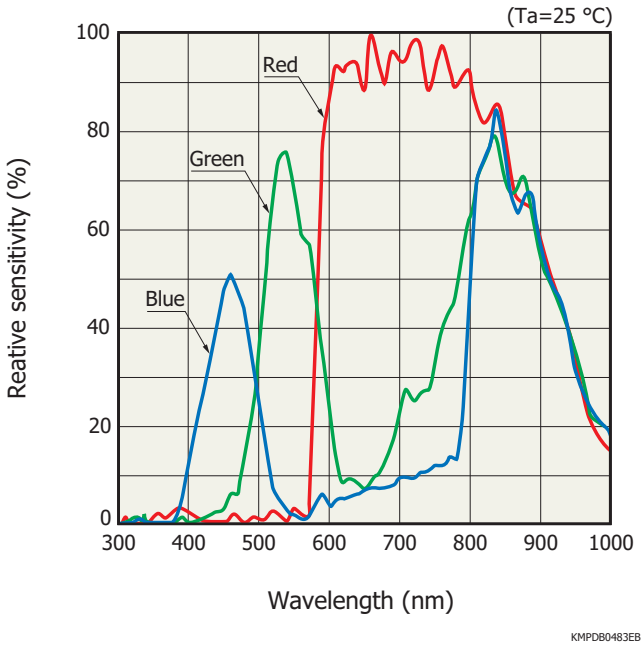
*2: f(CLK)=10 MHz
*3: Current consumption increases as the clock pulse frequency increases. At f(CLK)=200 kHz, the current consumption is 55 mA at high gain and 15 mA at low gain.

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*4			λ		400 to 1000		nm
Peak sensitivity wavelength		Red	λp	-	630	-	nm
		Green		-	540	-	
		Blue		-	460	-	
Photosensitivity*5	High gain	Red	Sw	-	65	-	V/(lx·s)
		Green		-	85	-	
		Blue		-	35	-	
	Low gain	Red		-	13	-	
		Green		-	17	-	
		Blue		-	7	-	
Conversion efficiency*6	High gain		CE	-	125	-	μV/e⁻
	Low gain			-	25	-	
Dark output voltage*7	High gain		VD	0	1.5	15	mV
	Low gain			0	0.1	2	
Saturation output voltage*8	High gain		Vsat	3.5	4	4.5	V
	Low gain			1.5	2	2.5	
Readout noise*9	High gain		Nread	0.1	0.9	2	mV rms
	Low gain			0.1	0.4	1.2	
Dynamic range 1*10	High gain		Drange1	-	4444	-	times
	Low gain			-	5000	-	
Dynamic range 2*11	High gain		Drange2	-	2600	-	times
	Low gain			-	20000	-	
Output offset voltage			Voffset	0.4	0.6	1	V
Photoresponse nonuniformity*12			PRNU	-	±2	±10	%
Image lag*13			Lag	-	-	0.1	%

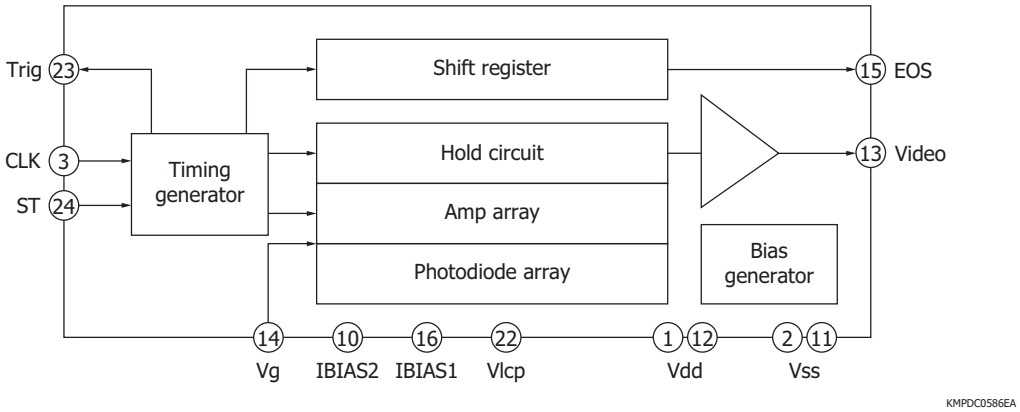
*4: This sensor also has sensitivity in the infrared region, so cut off infrared light as needed.
*5: 2856 K, tungsten lamp, infrared cutoff filter: E-CM500S (t=1.0 mm)
*6: Output voltage generated per electron
*7: Integration time Ts=10 ms
*8: Voltage difference relative to Voffset
*9: Insert a capacitor of about 1 μF between IBIAS1 and GND, and between IBIAS2 and GND.
*10: Drange1=Vsat/Nread
*11: Drange2=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.
*12: Photoresponse nonuniformity is the output nonuniformity 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 each color of the RGB pixels for the 2042 pixels excluding the three pixels at each end of the sensor.
PRNU=(ΔX/X) × 100 [%]
X: average output of each color of RGB pixels, ΔX: difference between the maximum or minimum output of each color of RGB pixels and X
*13: The signal component of the previous data that remains after data is read out under saturation output conditions. The image lag increases if the output exceeds the saturation output voltage.

Spectral response (typical example)



Note: This sensor also has sensitivity in the infrared region, so cut off infrared light as needed.

Block diagram

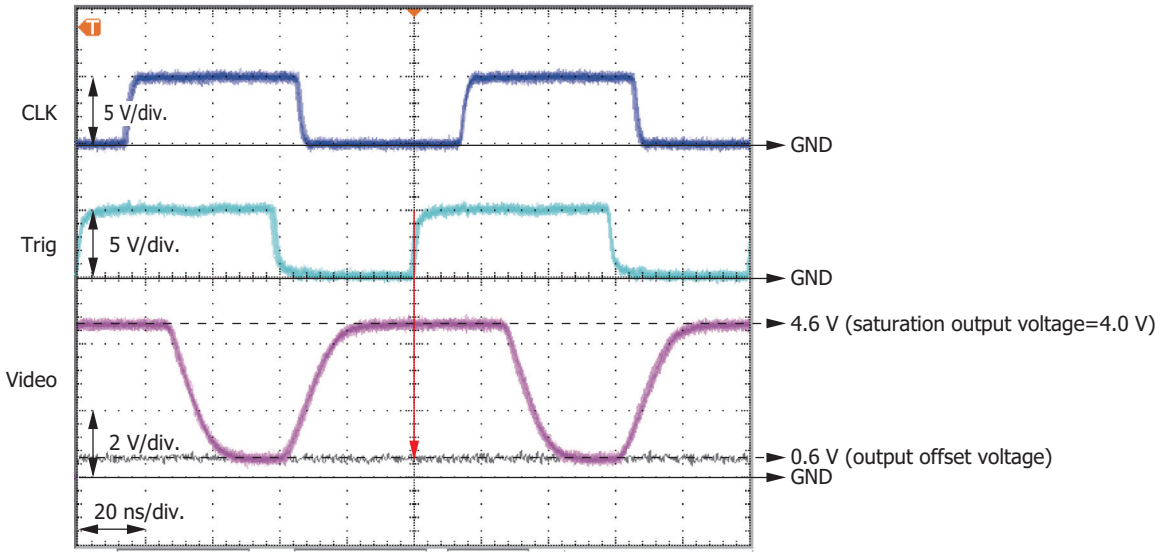


Output waveform of one pixel

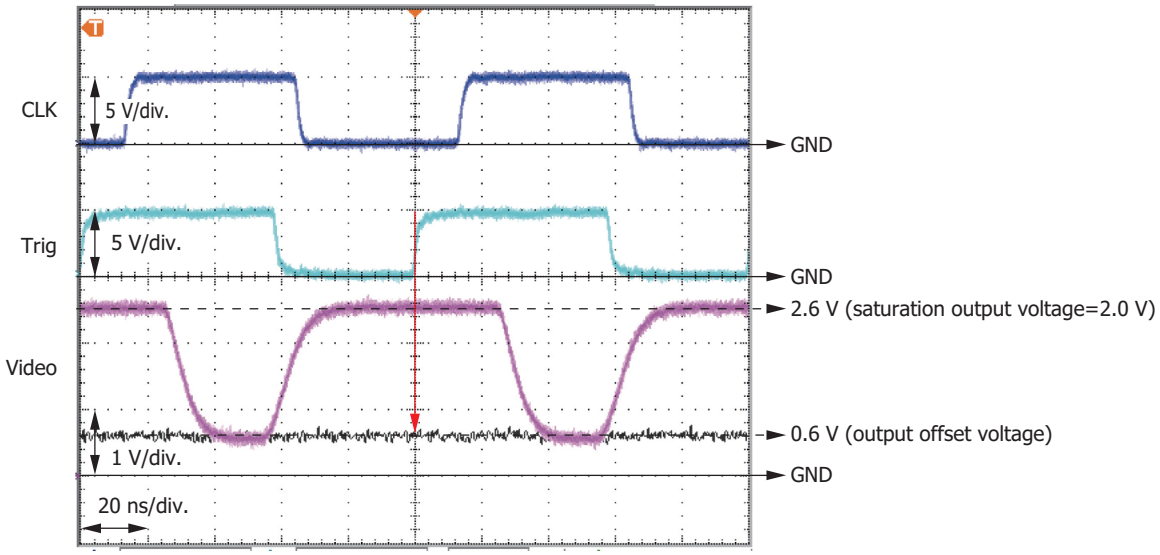
The timing for acquiring the Video signal is synchronized with the rising edge of a trigger pulse.

f(CLK)=DR=10 MHz

■ High gain

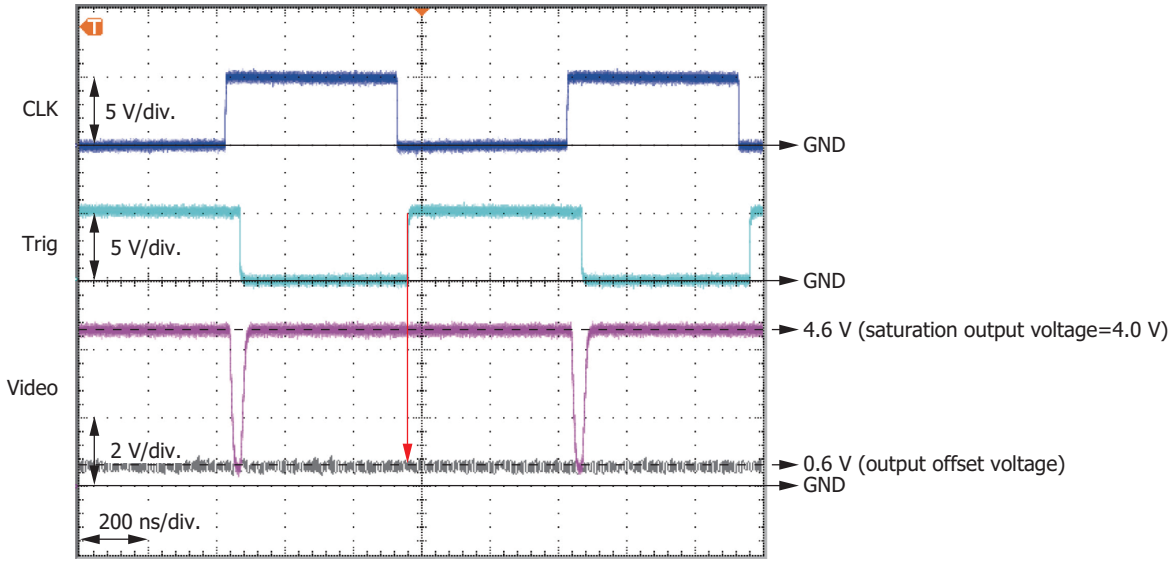


■ Low gain

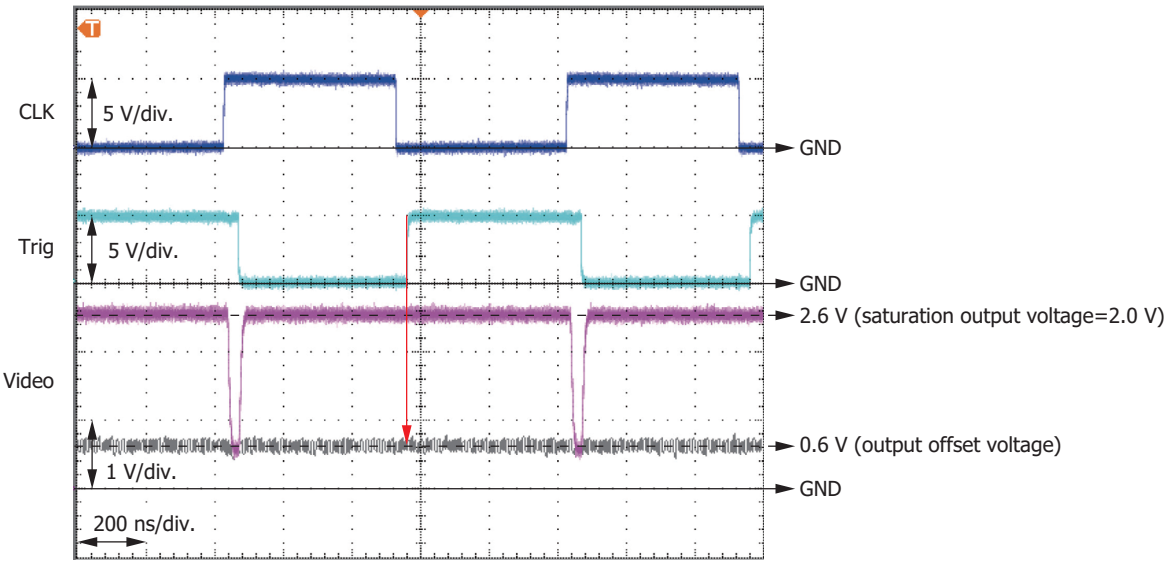


f(CLK)=DR=1 MHz

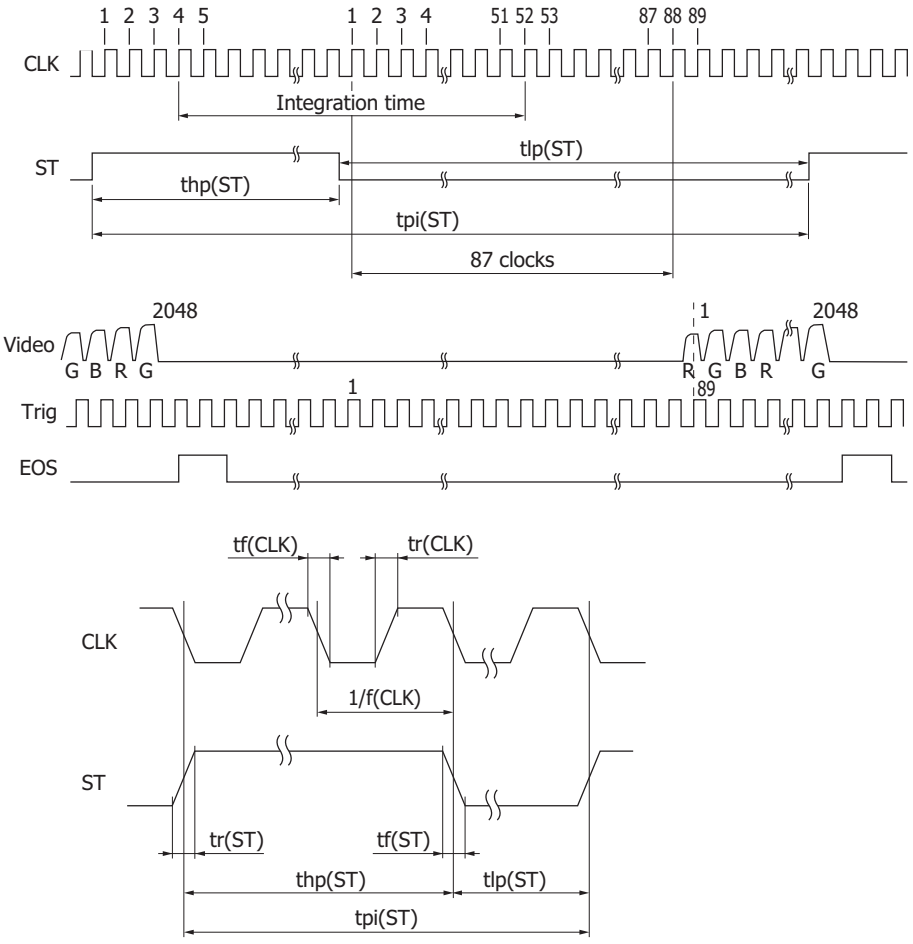
■ High gain



■ Low gain



Timing chart



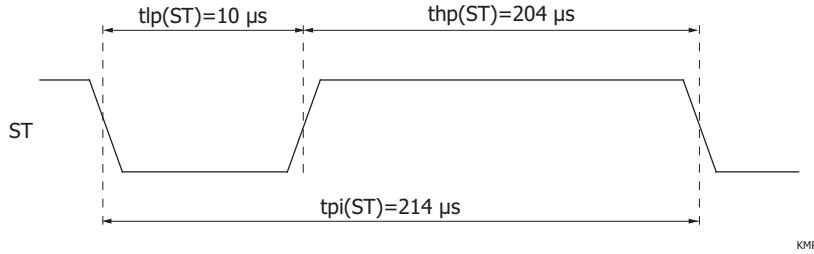
KMPDC0611EA

Parameter	Symbol	Min.	Typ.	Max.	Unit
Start pulse width interval*14	tpi(ST)	106/f(CLK)	-	-	s
Start pulse high period*14 *15	thp(ST)	6/f(CLK)	-	-	s
Start pulse low period	tlp(ST)	100/f(CLK)	-	-	s
Start pulse rise and fall times	tr(ST), tf(ST)	0	10	30	ns
Clock pulse duty	-	45	50	55	%
Clock pulse rise and fall times	tr(CLK), tf(CLK)	0	10	30	ns

*14: Dark output increases if the start pulse period or the start pulse high period is lengthened.
*15: 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.

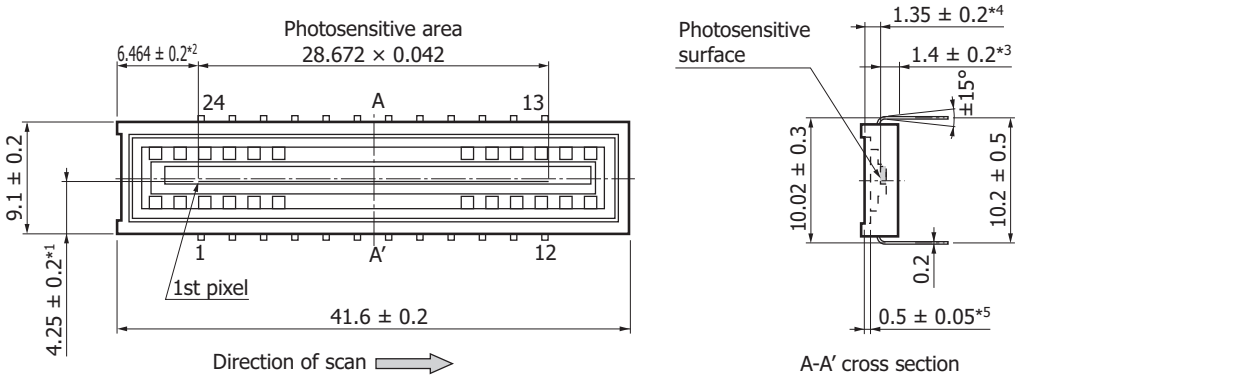
Operation example

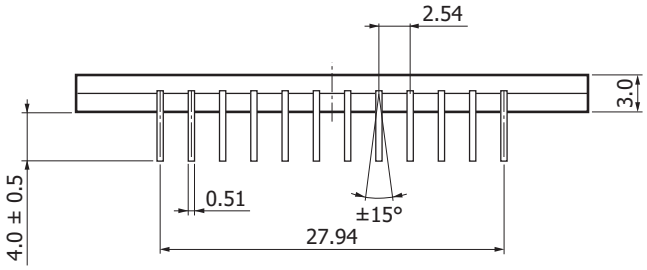
When the clock pulse frequency is maximized (video data rate is also maximized), the time of one scan is minimized, and the integration time is maximized (for outputting signals from all 2048 channels)
Clock pulse frequency = Video data rate = 10 MHz
Start pulse cycle = 2140/f(CLK) = 2140/10 MHz = 214 µs
High period of start pulse = Start pulse cycle - Start pulse's low period min.
= 2140/f(CLK) - 100/f(CLK) = 2140/10 MHz - 100/10 MHz = 204 µs
Integration time is equal to the high period of start pulse + 48 cycles of clock pulses, so it will be 204 + 4.8 = 208.8 µs.



KMPDC0366EB

Dimensional outline (unit: mm)

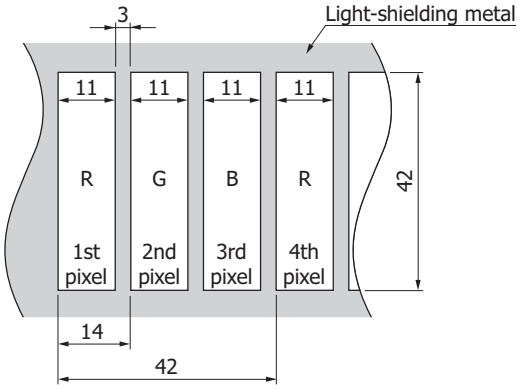




Tolerance unless otherwise noted: ±0.1
*1: Distance from package edge to photosensitive area center
*2: Distance from package edge to photosensitive area edge
*3: Distance from package bottom to photosensitive surface
*4: Distance from window upper surface to photosensitive surface
*5: Glass thickness

KMPDA0327EC

Enlarged view of photosensitive area (unit: µm)



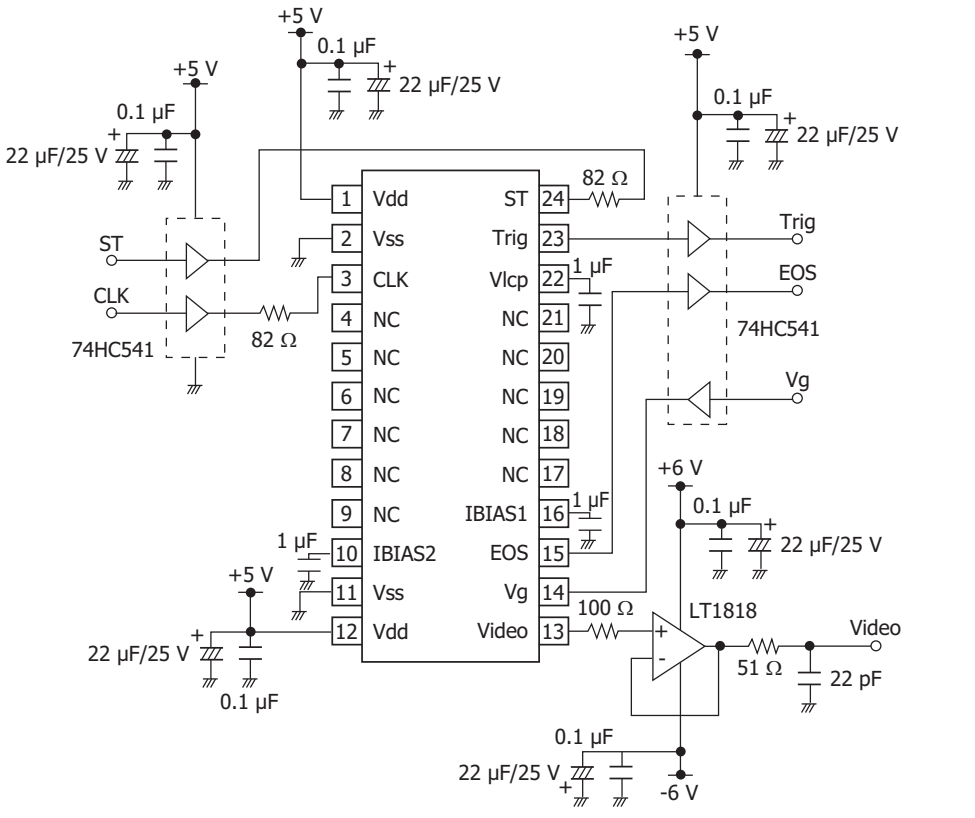
KMPDA0355EC

Pin connections

Pin no.	Symbol	I/O	Description	Pin no.	Symbol	I/O	Description
1	Vdd	I	Supply voltage	13	Video	O	Video signal*16
2	Vss		GND	14	Vg	I	Gain selection terminal*17
3	CLK	I	Clock pulse	15	EOS	O	End of scan
4	NC		No connection	16	IBIAS1	O	No connection*18
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	IBIAS2	O	No connection*18	22	Vlcp	O	Bias voltage for negative voltage circuit*19
11	Vss		GND	23	Trig	O	Trigger pulse for video signal acquisition
12	Vdd	I	Supply voltage	24	ST	I	Start pulse

*16: 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.
*17: Select NC or Vdd for low gain and GND for high gain.
*18: Approximately 1.1 V generated by the voltage circuit inside the chip is output to these terminals. In addition, inserting a capacitor of about 1 µF between IBIAS1 and GND and between IBIAS2 and GND. If you are not going to insert these capacitors, be sure to leave these terminals open and the readout noise is increased to 1.5 mVrms (High gain).
*19: Approximately -1.5 V generated by the negative voltage circuit inside the chip is output to the terminal. To maintain the voltage, insert a capacitor around 1 µF between Vlcp and GND.
Note: Leave the "NC" terminals open and do not connect them to GND.

Application circuit example



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 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 exposure
This product 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

■ Precautions
· Disclaimer
· Image sensors

Information described in this material is current as of May 2019.
Product specifications are subject to change without prior notice due to improvements or other reasons. This document has been carefully prepared and the information contained is believed to be accurate. In rare cases, however, there may be inaccuracies such as text errors. Before using these products, always contact us for the delivery specification sheet to check the latest specifications.
The product warranty is valid for one year after delivery and is limited to product repair or replacement for defects discovered and reported to us within that one year period. However, even if within the warranty period we accept absolutely no liability for any loss caused by natural disasters or improper product use.
Copying or reprinting the contents described in this material in whole or in part is prohibited without our prior permission.

HAMAMATSU www.hamamatsu.com

HAMAMATSU PHOTONICS K.K., Solid State Division
1126-1 Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81)53-434-3311, Fax: (81)53-434-5184
U.S.A.: Hamamatsu Corporation: 360 Foothill Road, Bridgewater, N.J. 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218, E-mail: usa@hamamatsu.com
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8, E-mail: info@hamamatsu.de
France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10, E-mail: infos@hamamatsu.fr
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, United Kingdom, Telephone: (44)1707-294888, Fax: (44)1707-325777, E-mail: info@hamamatsu.co.uk
North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01, E-mail: info@hamamatsu.se
Italy: Hamamatsu Photonics Italia S.r.l.: Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41, E-mail: info@hamamatsu.it
China: Hamamatsu Photonics (China) Co., Ltd.: B1201, Jiaming Center, No.27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R.China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866, E-mail: hpc@hamamatsu.com.cn
Taiwan: Hamamatsu Photonics Taiwan Co., Ltd.: 8F-3, No. 158, Section2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081, E-mail: info@hamamatsu.com.tw

Cat. No. KMPD1180E03 May 2019 DN