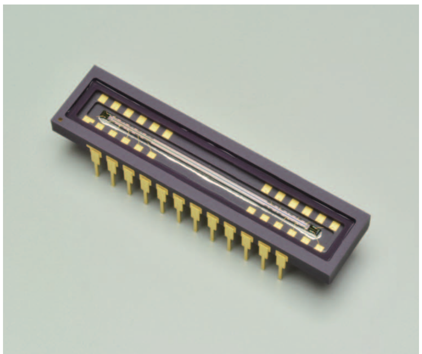
HAMAMATSU

PHOTON IS OUR BUSINESS

NEW

CCD linear image sensor



S15351-2048

Front-illuminated CCD with electronic shutter function

This front-illuminated CCD linear image sensor has a high-speed electronic shutter function. Vertically long pixels required for spectrometers are used. Charge reset is made faster with a structure that moves charges in pixels rapidly.

Features

- **High-speed electronic shutter function**
- **Charge reset time in pixels: 1 µs min.**
- **Image lag: 0.1% typ.**
- **High sensitivity in the UV region (spectral response range: 200 to 1000 nm)**
- **Low dark current**
- **Low price**

Applications

- **Spectrometers**
- **LIBS (Laser-Induced Breakdown Spectroscopy)**

Structure

Parameter	Specification
Pixel size (H × V)	14 × 200 µm
Number of pixels	2092
Number of effective pixels	2048
Fill factor	100%
Image size (H × V)	28.672 × 0.200 mm
Horizontal clock	Two-phase
Output circuit	Two-stage MOSFET source follower
Package	24-pin ceramic DIP (see dimensional outline)
Window material	Quartz glass*1

*1: Resin sealing

Absolute maximum ratings (Ta=25 °C unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating temperature*2 *3	Topr	-50	-	+60	°C
Storage temperature*3	Tstg	-50	-	+70	°C
Output transistor drain voltage	VOD	-0.5	-	+20	V
Reset drain voltage	VRD	-0.5	-	+18	V
Amplifier output return voltage	Vret	-0.5	-	+18	V
All reset drain voltage	VARD	-0.5	-	+18	V
Horizontal input source voltage	VISH	-0.5	-	+18	V
Horizontal input gate voltage	VIGH	-10	-	+15	V
Horizontal shift register clock voltage	VP1H, VP2H	-10	-	+15	V
Summing gate voltage	VSG	-10	-	+15	V
Output gate voltage	VOG	-10	-	+15	V
Reset gate voltage	VRG	-10	-	+15	V
Transfer gate 1 voltage	VTG1	-10	-	+15	V
Transfer gate 2 voltage	VTG2	-10	-	+15	V
All reset gate voltage	VARG	-10	-	+15	V
Soldering conditions*4	Tsol	260 °C, within 5 s, at least 2 mm away from lead roots			-

*2: Package temperature
*3: No dew condensation
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.
*4: Use a soldering iron.
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.

Operating conditions (Ta=25 °C)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Output transistor drain voltage		VOD	13	14	15	V
Reset drain voltage		VRD	12	13	14	V
Amplifier output return voltage		Vret	4	5	6	V
All reset drain voltage		VARD	13.5	14	14.5	V
Substrate voltage		VSS	-	0	-	V
Horizontal input source voltage		VISH	-	VRD	-	V
Horizontal input gate voltage		VIGH	-5	-4	-3	V
Output gate voltage		VOG	2	3	4	V
Horizontal shift register clock voltage	High	VP1HH,VP2HH	2.5	3	3.5	V
	Low	VP1HL,VP2HL	-5	-4	-3	
Summing gate voltage	High	VSGH	2.5	3	3.5	V
	Low	VSGL	-5	-4	-3	
Reset gate voltage	High	VRGH	6	7	8	V
	Low	VRGL	-5	-4	-3	
Transfer gate 1 voltage	High	VTG1H	6.5	7	7.5	V
	Low	VTG1L	-5	-4	-3	
Transfer gate 2 voltage	High	VTG2H	6.5	7	7.5	V
	Low	VTG2L	-5	-4	-3	
All reset gate voltage	High	VARGH	7	7.5	8	V
	Low	VARGL	-5	-4	-3	
External load resistance		RL	2.0	2.2	2.4	kΩ

Electrical characteristics (Ta=25 °C, operating conditions: Typ., unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Output signal frequency*5	fc	-	2.5	5	MHz
Line rate	LR	-	1.18	2.33	kHz
Horizontal shift register capacitance	C_{P1H}, C_{P2H}	-	280	-	pF
Summing gate capacitance	C_{SG}	-	10	-	pF
Reset gate capacitance	C_{RG}	-	10	-	pF
Transfer gate 1 capacitance	C_{TG1}	-	170	-	pF
Transfer gate 2 capacitance	C_{TG2}	-	260	-	pF
All reset gate capacitance	C_{ARG}	-	80	-	pF
Charge transfer efficiency*6	CTE	0.99995	0.99999	-	-
DC output level*5	Vout	9	10	11	V
Output impedance*5	Zo	-	280	-	Ω
Output amplifier return current*7	Iret	-	0.1	-	mA
Power consumption*5 *8	P	-	75	-	mW

*5: Varies depending on the load resistance.
*6: Transfer efficiency per CCD shift register pixel measured at half the saturation output
*7: Absolute value. The current flows in the direction of flow out of the sensor.
*8: Power consumption of the on-chip amp plus load resistance

Electrical and optical characteristics (Ta=25 °C, operating conditions: Typ., unless otherwise noted)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Saturation output voltage		Vsat	-	Fw × CE	-	V
Full well capacity*9		Fw	320	400	-	ke^-
Linearity error*10		LE	-	±3	±5	%
Conversion efficiency		CE	6.5	7.5	8.5	$\mu V/e^-$
Dark current*11	Average of all effective pixels	DSave	-	700	3500	e^-/pixel/s
	Maximum among all effective pixels	DSmax	-	3000	15000	
Readout noise		Nread	-	40	60	e^- rms
Dynamic range*12		Drange	5333	10000	-	-
Defective pixels*13		-	-	-	0	-
Spectral response range		λ	200 to 1000			nm
Peak sensitivity wavelength		λp	-	560	-	nm
Photoresponse nonuniformity*14 *15		PRNU	-	±3	±10	%
Image lag*14 *16		L	-	0.1	1	%
Charge reset time during ARG operation*17		Tar	1	-	-	μs

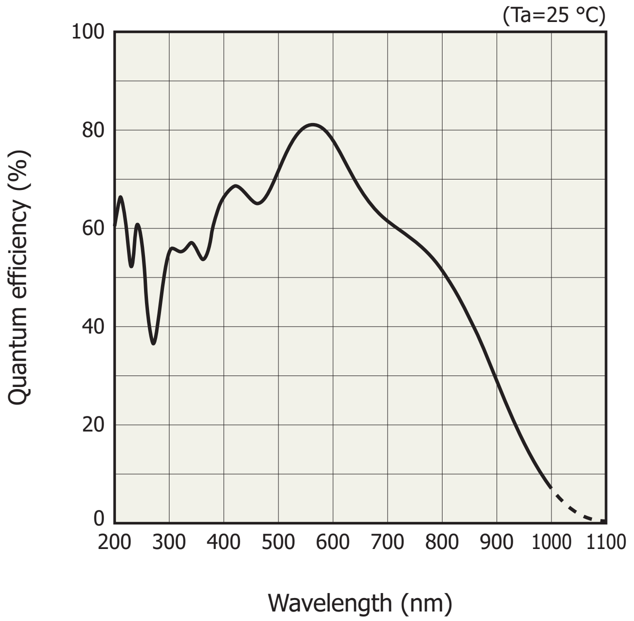
*9: Illuminate the entire photosensitive area with uniform light (in case of light spot, illuminate the center of the photosensitive area).
*10: Output charge=1 ke^- to 320 ke^-. Defined as 0% linearity error when the signal level is half of the full well capacity
*11: Dark current nearly doubles for every 5 to 7 °C increase in temperature.
*12: Dynamic range=Saturation charge/Readout noise
*13: Pixels in which DSmax and PRNU exceed Max.
*14: Measured at half the saturation output using an LED light (peak emission wavelength: 470 nm)

*15: $$\text{Photoresponse nonuniformity} = \frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100\ [\%]$$

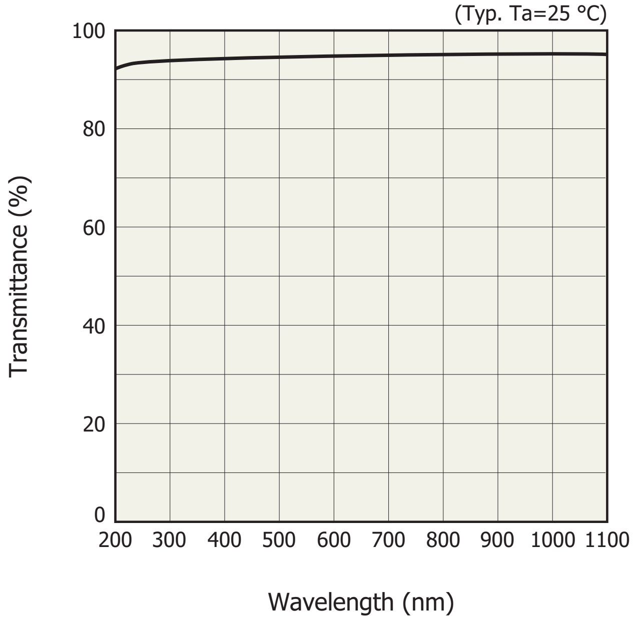
*16: Percentage of unread output charge level when a light pulse is directed so that the output is half the saturation output

*17: The time until the image lag of the in-pixel charge, on average of all pixels, is less than 0.1% with the reset operation using ARG

Spectral response (without window, typical example)*18

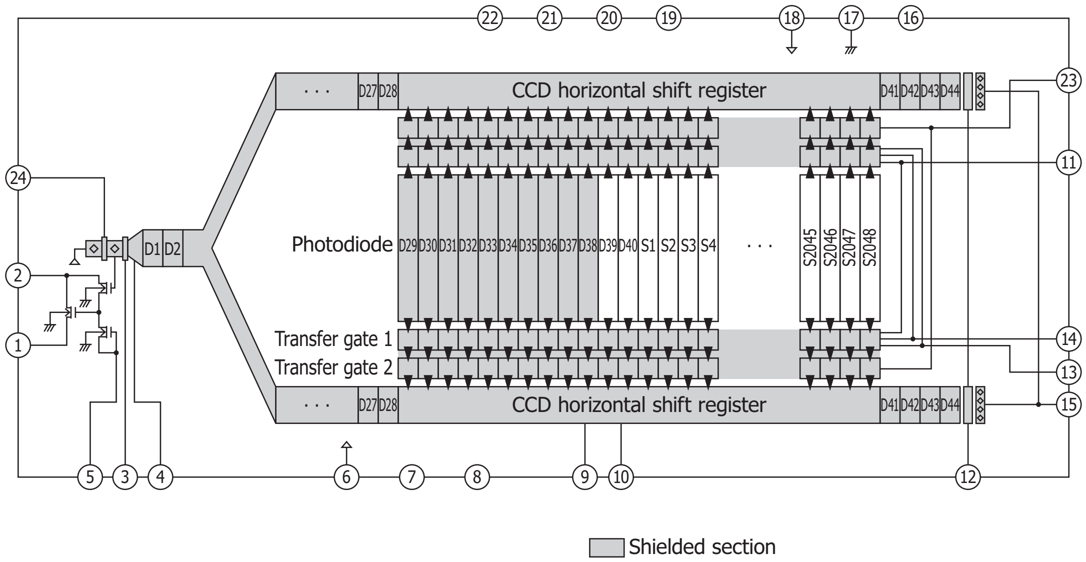


Spectral transmittance of window material



*18: The spectral response will degrade due to the transmittance characteristics of quartz glass.

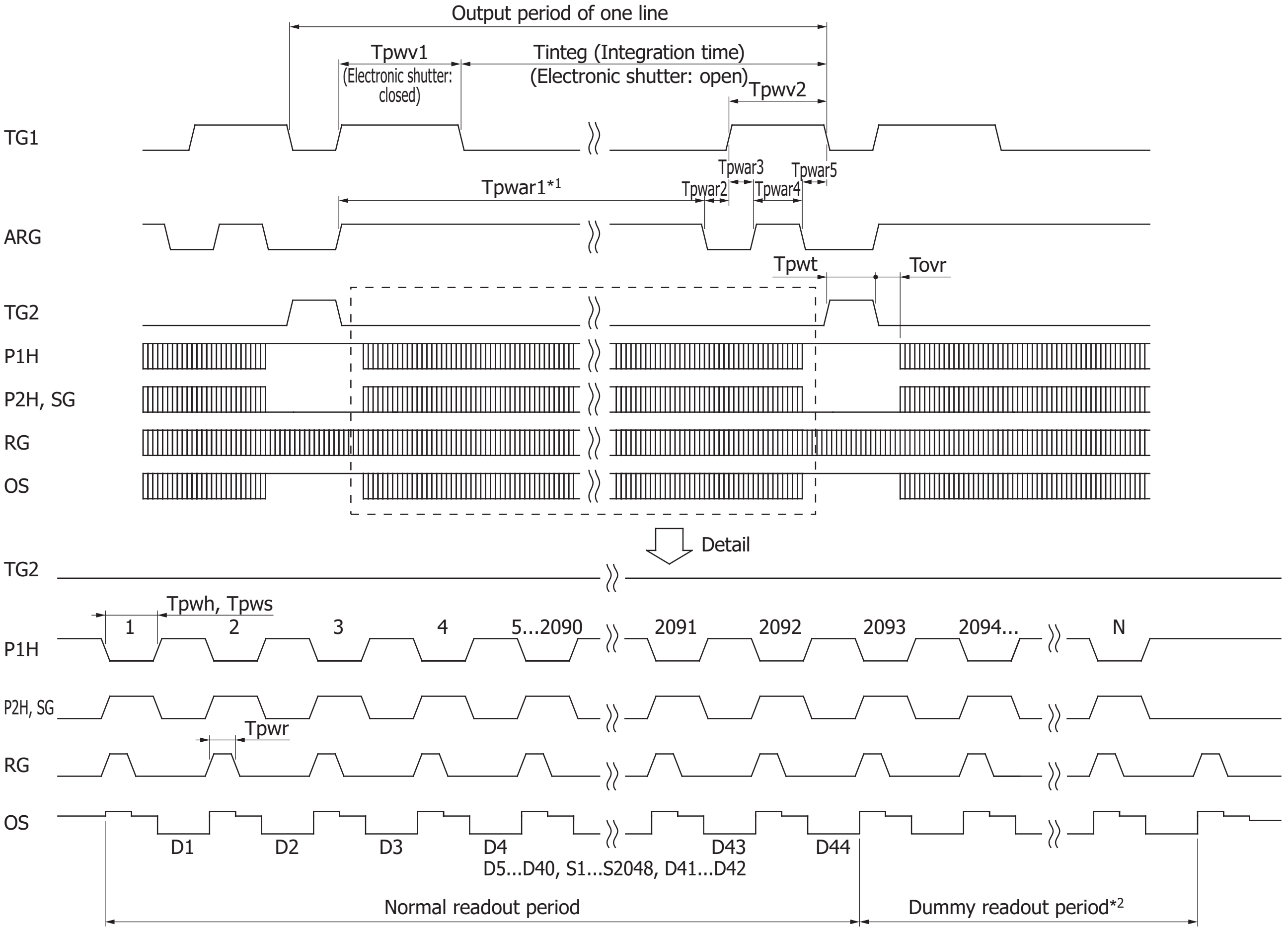
Device structure (schematic of CCD chip as viewed from top of dimensional outline)



The signal charge photoelectrically converted in each pixel of the photosensitive area is separated and transferred vertically from the center of the photosensitive area.
Then, the signal charge is integrated in the CCD horizontal shift registers and readout by the output amplifier.

KMPDC0829EA

Timing chart



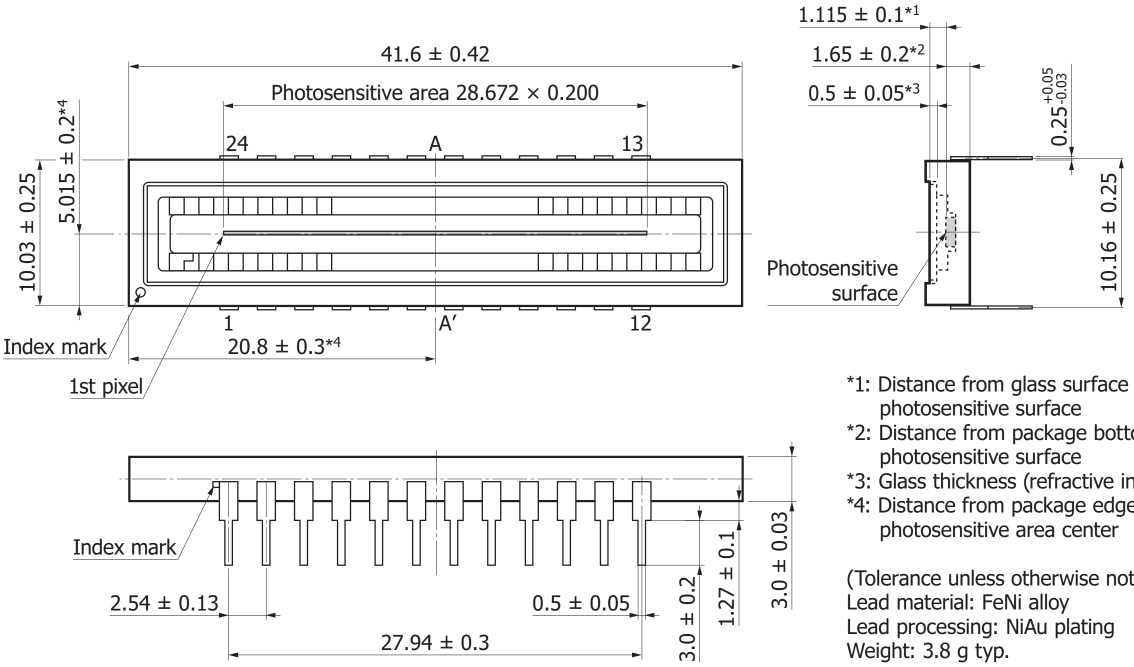
*1: If output period of one line is changed,change the Tpwar1 period.
*2: In order to wipe out the dark current generated in the horizontal shift register when integration time is set longer than normal readout time, do dummy readout after the normal readout period until just before the rising edge of transfer gate 2 pulse.

KMPDC0830EA

Parameter		Symbol	Min.	Typ.	Max.	Unit
TG1	Pulse width	Tpwv1	1	-	-	μs
		Tpwv2	4	8	-	
	Rise and fall times	Tprv, Tpfv	30	200	-	ns
ARG	Pulse width	Tpwar1	2	-	-	μs
		Tpwar2	1	1	-	
		Tpwar3	1	2	-	
		Tpwar4	2	5	-	
		Tpwar5	1	1	-	
	Rise and fall times	Tprar, Tpfar	30	200	-	ns
TG2	Pulse width	Tpwt	1	2	-	μs
	Rise and fall times	Tprt, Tpft	30	-	-	ns
P1H, P2H*19	Pulse width	Tpwh	100	200	-	ns
	Rise and fall times	Tprh, Tpfh	20	-	-	ns
	Duty ratio	-	40	50	60	%
SG	Pulse width	Tpws	100	200	-	ns
	Rise and fall times	Tprs, Tpfs	20	-	-	ns
	Duty ratio	-	40	50	60	%
RG	Pulse width	Tpwr	30	60	-	ns
	Rise and fall times	Tprr, Tpfr	10	-	-	ns
TG2-P1H	Overlap time	Tovr	1	2	-	μs
Integration time*20		Tinteg	6	10	-	μs

*19: Symmetrical clock pulses should be overlapped at 50% of maximum pulse amplitude.
*20: Tinteg = Tpwar1 - Tpwv1 + Tpwar2 + Tpwv2

Dimensional outline (unit: mm)



*1: Distance from glass surface to photosensitive surface
*2: Distance from package bottom to photosensitive surface
*3: Glass thickness (refractive index≈1.5)
*4: Distance from package edge to photosensitive area center

(Tolerance unless otherwise noted: ±0.1)
Lead material: FeNi alloy
Lead processing: NiAu plating
Weight: 3.8 g typ.

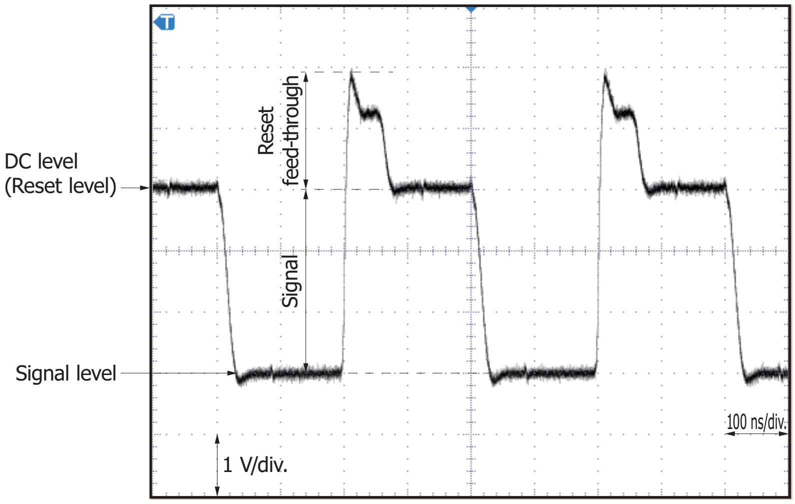
Note: This product is not hermetically sealed, and therefore moisture may penetrate into the package. Storing or using the product in a place with sudden temperature or humidity changes may cause condensation to form inside the package, so avoid such locations.

KMPDA0629EA

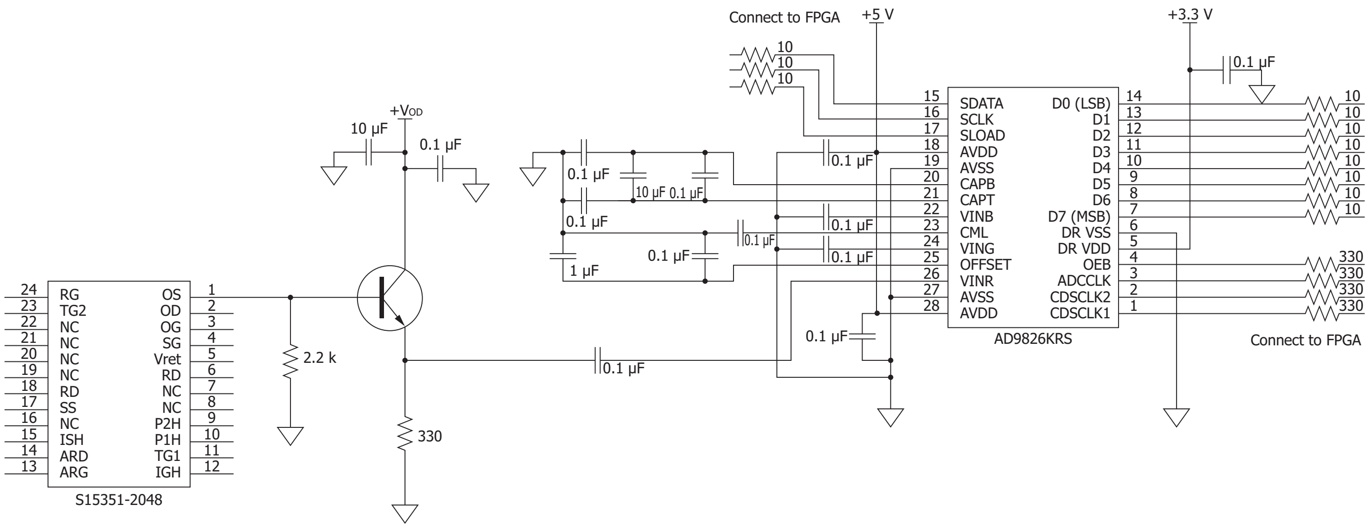
Pin connections

Pin no.	Symbol	Function	Remark (standard operation)
1	OS	Output transistor source	RL=2.2 kΩ
2	OD	Output transistor drain	+14 V
3	OG	Output gate	+3 V
4	SG	Summing gate	Same timing as P2H
5	Vret	Amplifier output return	+5 V
6	RD	Reset drain	+13 V
7	-		
8	-		
9	P2H	CCD horizontal register clock 2	+3 V/-4 V
10	P1H	CCD horizontal register clock 1	+3 V/-4 V
11	TG1	Transfer gate 1	+7 V/-4 V
12	IGH	Test point (horizontal input gate)	-4 V
13	ARG	All reset gate	+7.5 V/-4 V
14	ARD	All reset drain	+14 V
15	ISH	Test point (horizontal input source)	Connect to RD
16	-		
17	SS	Substrate	GND
18	RD	Reset drain	+13 V
19	-		
20	-		
21	-		
22	-		
23	TG2	Transfer gate 2	+7/-4 V
24	RG	Reset gate	+7/-4 V

OS output waveform example (fc=2.5 MHz, VOD=+14 V, RL=2.2 kΩ)



High-speed signal processing circuit example (using analog front-end IC)



KMPDC0831EA

Precautions

■ Electrostatic measure

· Handle these sensors with bare hands or wearing cotton gloves. In addition, wear anti-static clothing or use a wrist band with an earth ring, in order to prevent electrostatic damage due to electrical charges from friction.
· Do not place the sensor directly on workbenches or floors that may become charged with static electricity.
· Connect a ground wire to workbenches or floors in order to discharge static electricity.
· Connect a ground wire also to the tools such as tweezers and soldering irons to be used for handling the sensor.

It is not always necessary to provide all the electrostatic countermeasures stated above. Implement these countermeasures according to the extent of deterioration or damage that may occur.

■ When UV light irradiation is applied

When UV light irradiation is applied, the product characteristics may degrade. Such examples include degradation of the product's UV sensitivity and increase in dark current. This phenomenon varies depending on the irradiation level, irradiation intensity, operating time, and operating environment and also varies depending on the product model. Before employing the product, we recommend that you check the tolerance under the ultraviolet light environment that the product will be used in.

Related information

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

■ Precautions
· Disclaimer
· Image sensors

Driver circuit for CCD linear image sensor C15361 (Sold separately)

The C15361 series is a driver circuit for the S15351-2048. It can be used for spectrometers, etc. combining with a CCD linear image sensor.

Features

- **Built-in 16-bit A/D converter**
- **PC interface: USB 3.0**
- **Power supply: Operates with USB bus power + external power supply (+5 V)**

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, UK, 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.: 1201 Tower B, Jiaming Center, 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