HAMAMATSU
PHOTON IS OUR BUSINESS

CCD linear image sensors

S15254-2048   S15257-2048

Back-thinned CCD image sensors with electronic shutter function

The S15254-2048 and S15257-2048 are back-thinned CCD linear image sensors with an internal electronic shutter for spectrometers. These image sensors use a resistive gate structure that allows a high-speed transfer. Each pixel has a lengthwise size needed by spectrometers but ensures readout with low image lag. The S15254-2048 is suitable for short time period trigger control. The S15257-2048 features pixels that are long vertically, and have a high aspect ratio of 14 μm × 2500 μm.

Features

- **Built-in electronic shutter**
- **High sensitivity from the ultraviolet region (spectral response range: 200 to 1100 nm)**
- **Readout speed: 10 MHz max.**
- **Image lag: 0.1% typ.**
- **Charge reset time in pixels: 1 μs min. (S15254-2048)**
- **Light-shielded CCD horizontal shift registers**

Applications

- **Spectrometers**
- **Image readout**
- **Optical emission spectrophotometry**

Structure

| Parameter	S15254-2048	S15257-2048	Unit
Pixel size (H × V)	14 × 200	14 × 2500	μm
Number of total pixels (H × V)	2102 × 1	2160 × 1	-
Number of effective pixels (H × V)	2048 × 1		-
Image size (H × V)	28.672 × 0.200	28.672 × 2.500	mm
Horizontal clock phase	2-phase		-
Output circuit	Two-stage MOSFET source follower		-
Package	24-pin ceramic DIP (refer to dimensional outline)		-
Window[1]	Quartz glass (without AR coating)[2]		-
Cooling	Non-cooled		-

*1: Temporary window type (ex. S15254-2048N, S15257-2048N) is available upon request.
*2: Resin sealing

Resistive gate structure

In ordinary CCDs, one pixel contains multiple electrodes and a signal charge is transferred by applying different clock pulses to those electrodes [Figure 1]. In resistive gate structures, a single high-resistance electrode is formed in the active area, and a signal charge is transferred by means of a potential slope that is created by applying different voltages across the electrode [Figure 2]. Compared to a CCD area image sensor which is used as a linear sensor by line binning, a one-dimensional CCD having a resistive gate structure in the active area offers higher speed transfer, allowing readout with low image lag even if the pixel height is large.

**[Figure 1]
Schematic diagram and potential of ordinary 2-phase CCD**

KMPDC0320EA
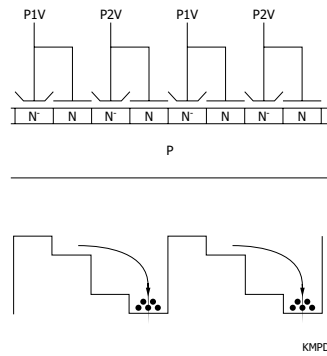
**[Figure 2]
Schematic diagram and potential of resistive gate structure**

KMPDC0321EB
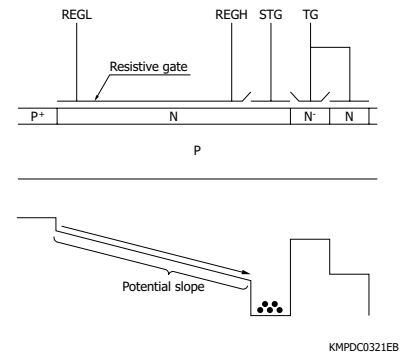
Absolute maximum ratings (Ta=25 °C)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Operating temperature[3][4][5]		Topr	-50	-	+60	°C
Storage temperature[3]		Tstg	-50	-	+70	°C
Output transistor drain voltage		V_{OD}	-0.5	-	+25	V
Reset drain voltage		V_{RD}	-0.5	-	+18	V
Output amplifier return voltage		Vret	-0.5	-	+18	V
All reset drain voltage		V_{ARD}	-0.5	-	+18	V
Horizontal input source voltage		V_{ISH}	-0.5	-	+18	V
All reset gate voltage		V_{ARG}	-12	-	+15	V
Storage gate voltage		V_{STG}	-12	-	+15	V
Horizontal input gate voltage		V_{IG1H}, V_{IG2H}	-12	-	+15	V
Summing gate voltage		V_{SG}	-12	-	+15	V
Output gate voltage		V_{OG}	-12	-	+15	V
Reset gate voltage		V_{RG}	-12	-	+15	V
Transfer gate voltage		V_{TG}	-12	-	+15	V
Resistive gate voltage	High	V_{REGH}	-12	-	+15	V
	Low	V_{REGL}				
Horizontal shift register clock voltage		V_{P1H}, V_{P2H}	-12	-	+15	V

*3: No dew condensation
When there is a temperature difference between a product and the surrounding area in high humidity environments, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.
*4: Package temperature
*5: The sensor temperature may increase due to heating in high-speed operation. We recommend taking measures to dissipate heat as needed. For more details, refer to the technical information "Resistive gate type CCD linear image sensors with electronic shutter".
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		V_{OD}	12	15	18	V
Reset drain voltage		V_{RD}	13	14	15	V
All reset drain voltage		V_{ARD}	13	14	15	V
All reset gate voltage	High[6]	V_{ARGH}	7	8	9	V
	Low[7]	V_{ARGL}	0.5	1	2	
Output gate voltage		V_{OG}	2.5	3.5	4.5	V
Storage gate voltage		V_{STG}	2.5	3.5	4.5	V
Substrate voltage		V_{SS}	-	0	-	V
Resistive gate high voltage	High	V_{REGHH}	0.5	1	1.5	V
	Low	V_{REGHL}	-10.5	-9.5	-8.5	
Resistive gate low voltage	High	V_{REGLH}	-	V_{REGHH} - 8.0	-	V
	Low	V_{REGLL}	-10.5	-9.5	-	
Output amplifier return voltage[8]		Vret	-	1	2	V
Test point	Horizontal input source	V_{ISH}	-	V_{RD}	-	V
	Horizontal input gate	V_{IG1H}, V_{IG2H}	-10.5	-9.5	-	V
Horizontal shift register clock voltage	High	V_{P1HH}, V_{P2HH}	5	6	8	V
	Low	V_{P1HL}, V_{P2HL}	-6	-5	-4	
Summing gate voltage	High	V_{SGH}	5	6	8	V
	Low	V_{SGL}	-6	-5	-4	
Reset gate voltage	High	V_{RGH}	7	8	9	V
	Low	V_{RGL}	-6	-5	-4	
Transfer gate voltage	High	V_{TGH}	9.5	10.5	11.5	V
	Low	V_{TGL}	-6	-5	-4	
External load resistance		R_L	2.0	2.2	2.4	kΩ

[6]: All reset on
[7]: All reset off
[8]: Output amplifier return voltage is a positive voltage with respect to Substrate voltage, but the current flows in the direction of flow out of the sensor.

Electrical characteristics [Ta=25 °C, fc=5 MHz, operating conditions: Typ. (P.3)]

Parameter		Symbol	Min.	Typ.	Max.	Unit
Signal output frequency		fc	-	5	10	MHz
Line rate		LR	-	2	4	kHz
Horizontal shift register capacitance		C_{P1H}, C_{P2H}	-	200	-	pF
All reset gate capacitance		C_{ARG}	-	100	-	pF
Resistive gate capacitance	S15254-2048	C_{REG}	-	500	-	pF
	S15257-2048		-	3000	-	
Summing gate capacitance		C_{SG}	-	10	-	pF
Reset gate capacitance		C_{RG}	-	10	-	pF
Transfer gate capacitance		C_{TG}	-	100	-	pF
Charge transfer efficiency[9]		CTE	0.99995	0.99999	-	-
DC output level		Vout	9	10	11	V
Output impedance		Zo	-	300	-	Ω
Output amplifier return current[10]		Iret	-	0.4	-	mA
Power consumption	S15254-2048	P_{AMP}[11]	-	75	-	mW
		P_{REG}[12]	3.2	12.8	128	
	S15257-2048	P_{AMP}[11]	-	75	-	
		P_{REG}[12]	0.64	2.56	25.6	
Resistive gate resistance[13]	S15254-2048	R_{REG}	0.5	5	20	kΩ
	S15257-2048		2.5	25	100	

[9]: Charge transfer efficiency per pixel of CCD shift register, measured at half of the full well capacity
[10]: Absolute value
   The current flows in the direction of flow out of the sensor.
[11]: Power consumption of the on-chip amplifier plus load resistance
[12]: Power consumption at REG
[13]: Resistance value between REGH and REGL

Electrical and optical characteristics [Ta=25 °C, fc=5 MHz, operating conditions: Typ. (P.3)]

Parameter		Symbol	S15254-2048			S15257-2048			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Saturation output voltage		Vsat	-	Fw × CE	-	-	Fw × CE	-	V
Full well capacity[14]		Fw	150	200	-	150	200	-	ke$^-$
Linearity error[15]		LR	-	±3	±10	-	±3	±10	%
Conversion efficiency		CE	9	10	11	9	10	11	µV/e$^-$
Dark current[16]	Non-MPP operation	DS	-	40	120	-	500	1500	ke$^-$/pixel/s
	MPP operation		-	8	32	-	20	80	
Dark output nonuniformity	Non-MPP operation	DSNU	-	-	300	-	-	300	%
	MPP operation		-	-	-	-	-	-	
Readout noise		Nread	-	30	45	-	30	45	e$^-$ rms
Dynamic range[17]		Drange	-	6670	-	-	6670	-	-
Defective pixels[18]		-	-	-	0	-	-	0	-
Spectral response range		λ	200 to 1100			200 to 1100			nm
Peak sensitivity wavelength		λp	-	600	-	-	600	-	nm
Photoresponse nonuniformity[19] [20]		PRNU	-	±3	±10	-	±3	±10	%
Image lag[19] [21]	Average image lag of all pixels	L	-	0.1	1	-	0.1	1	%
	Maximum image lag of all pixels		-	1	3	-	1	3	
Charge reset time using ARG[22]		Tar	1	-	-	100	-	-	µs

[14]: Operating voltages typ.

[15]: Signal level=1 ke$^-$ to 150 ke$^-$. Defined so that the linearity error is zero when the signal level is at one-half the full well capacity.

[16]: Dark current is reduced to half for every 5 to 7 °C decrease in temperature.

[17]: Dynamic range (Drange) = Full well capacity / Readout noise

[18]: Pixels that exceed the DSNU or PRNU maximum

[19]: Measured at one-half of the saturation output (full well capacity) using LED light (peak emission wavelength: 660 nm)

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

[21]: Percentage of unread signal level when a one-shot light pulse is irradiated so that the output is half the saturation output. The integration time during measurement is 5 µs for the S15254-2048 and 100 µs for the S15257-2048. For details, see the technical information (resistive gate type CCD linear image sensor with electronic shutter).

[22]: 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)[23]
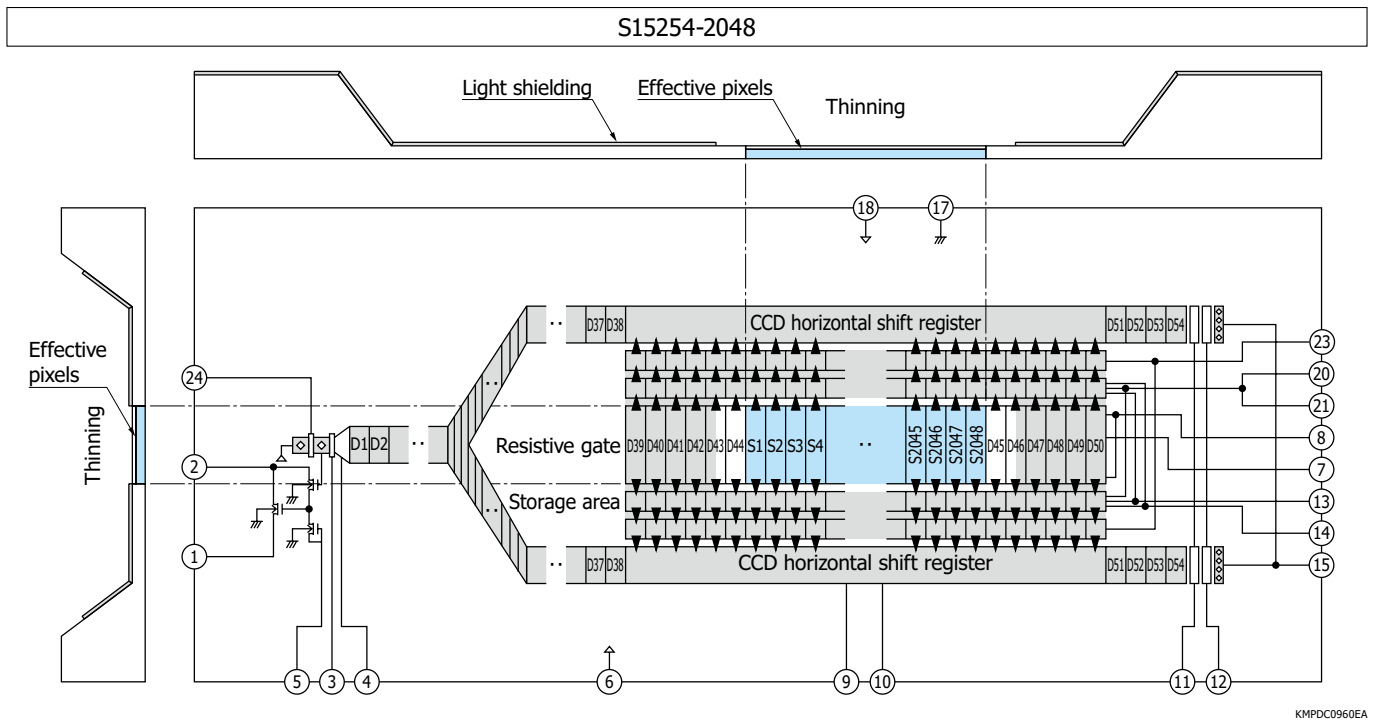

KMPDB0316EA

KMPDB0440EA
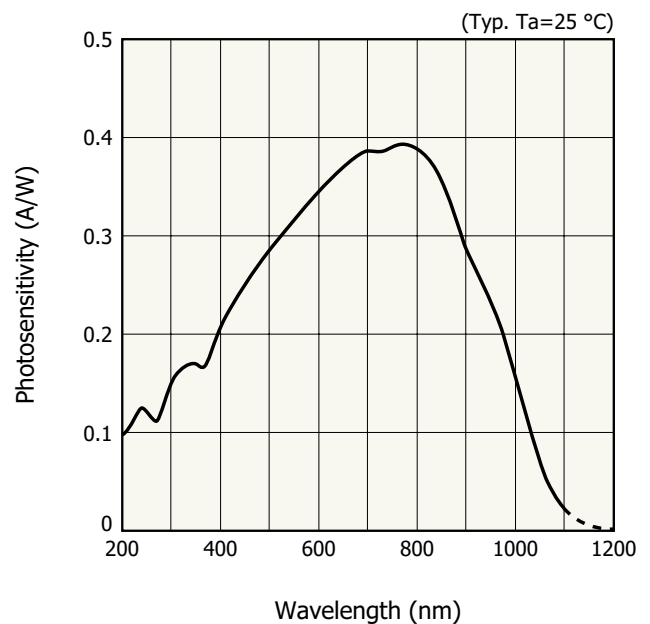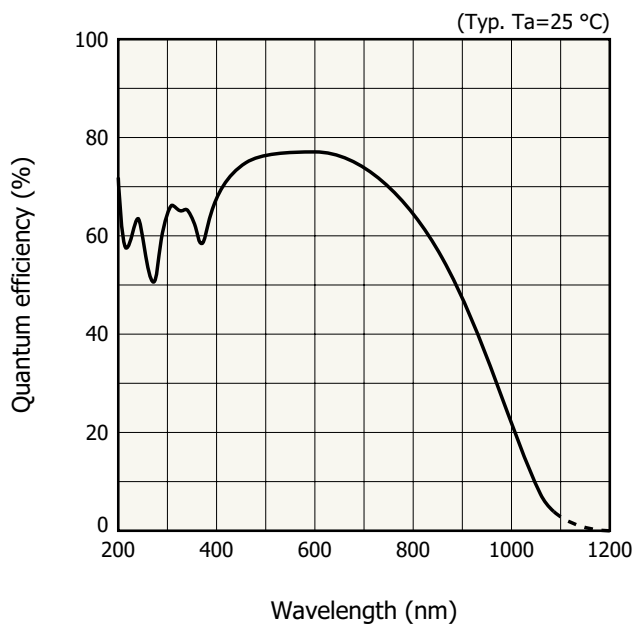
[23]: Spectral response with quartz glass is decreased according to the spectral transmittance characteristic of window material.
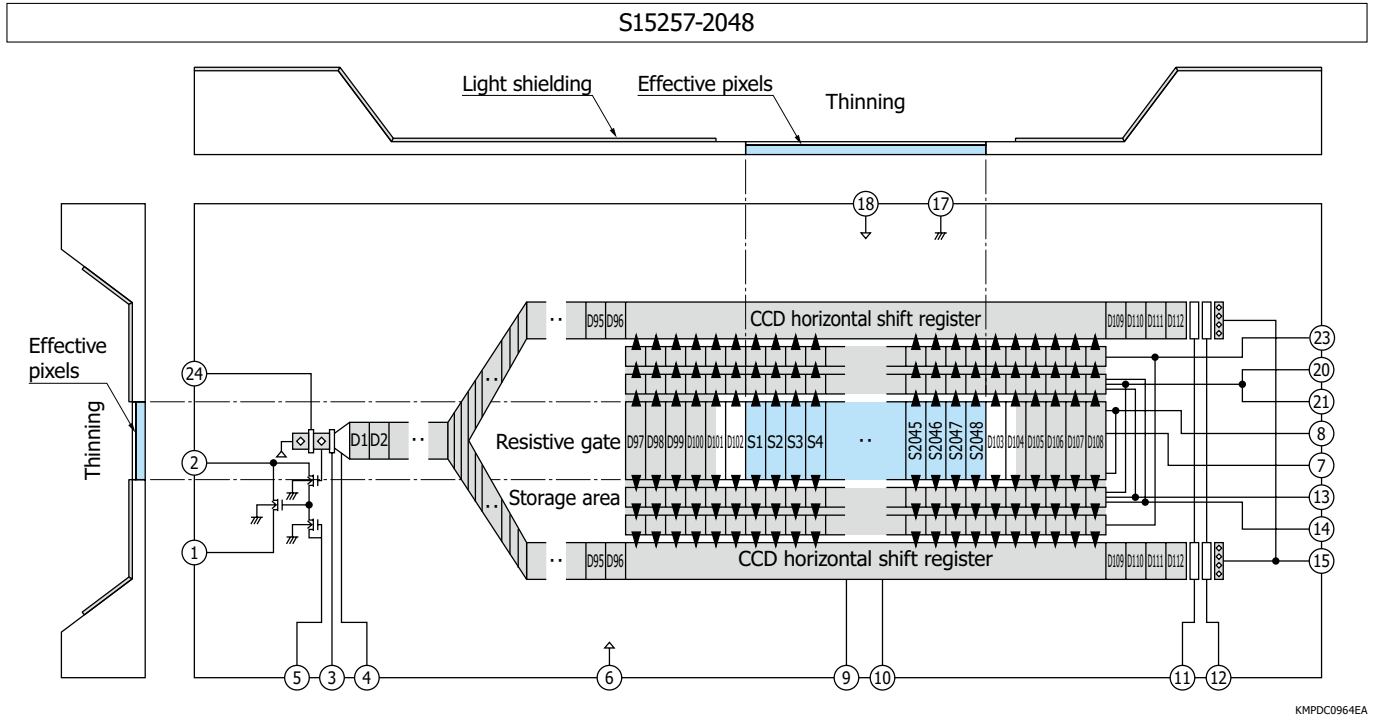
Spectral transmittance characteristic of window material

(Typ. Ta=25 °C)

Transmittance (%) vs Wavelength (nm)
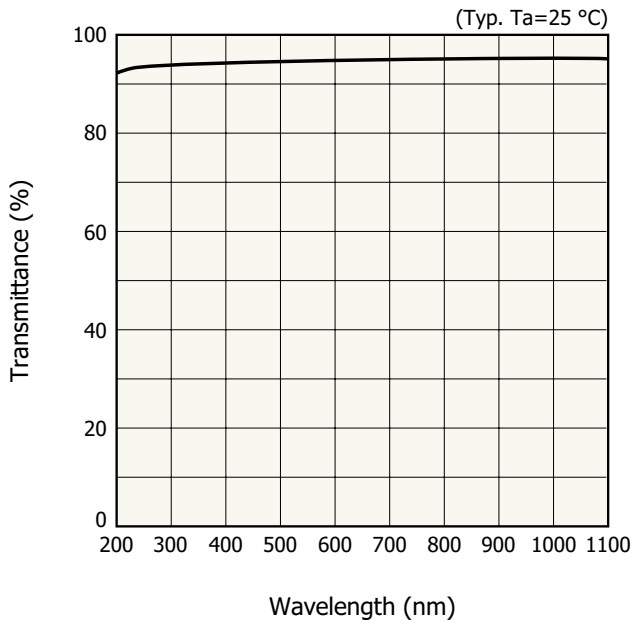
KMPDB0303EB

Device structure (conceptual drawing of top view in dimensional outline)

S15254-2048

Light shielding Effective pixels Thinning

Effective pixels
Thinning

CCD horizontal shift register
Resistive gate
Storage area
CCD horizontal shift register

D37 D38 ... D39 D40 D41 D42 D43 D44 S1 S2 S3 S4 ... S2045 S2046 S2047 S2048 D45 D46 D47 D48 D49 D50 D51 D52 D53 D54

D1 D2

KMPDC0960EA

S15257-2048

KMPDC0964EA

Note: When viewed from the direction of the incident light, the horizontal shift register is covered with a thick silicon layer (dead layer). However, long-wavelength light passes through the silicon dead layer and may possibly be detected by the horizontal shift register. To prevent this, provide light shield on that area as needed. Note that the transmission of long wavelengths in the dead layer covering the horizontal shift register was reduced compared to previous products.

Signal charges that undergo photoelectric conversion at each pixel of the photosensitive area are directed upward or downward based on the boundary line at the center of the photosensitive area and transferred.Then, they are combined through the horizontal registers and read out by the amplifier.

Timing chart
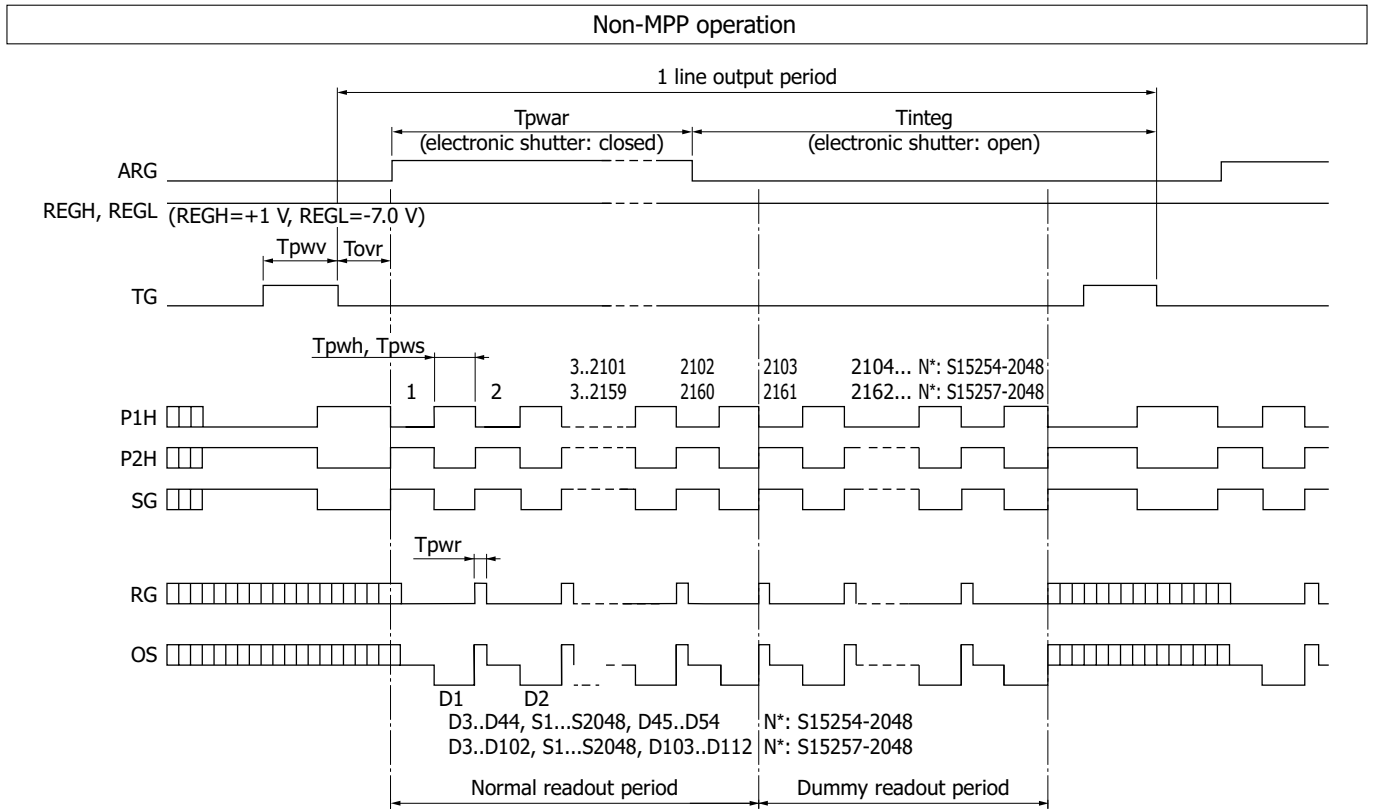
Non-MPP operation

* Apply clock pulses to the specified terminals during the period of dummy readout.
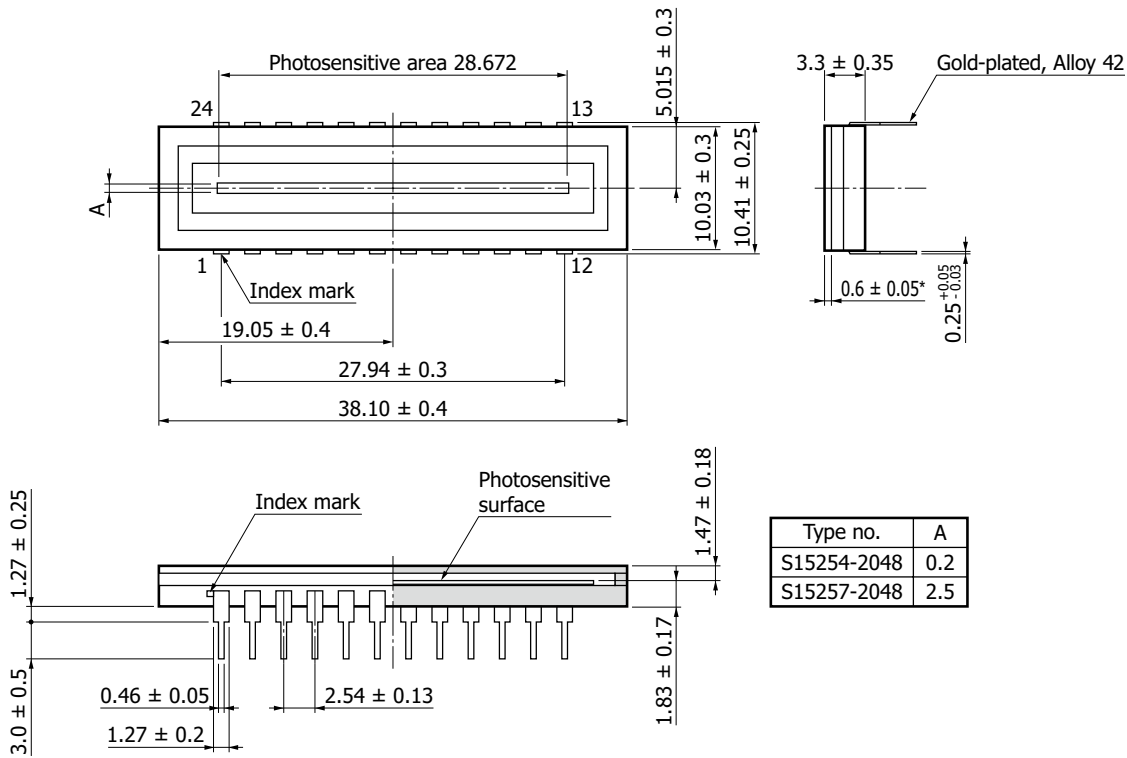 Set the total number of clock pulses N, according to the integration time.

KMPDC0961EA

Parameter		Symbol	Min.	Typ.	Max.	Unit
ARG	Pulse width	Tpwar	1	-	-	µs
	Rise and fall times	Tprar, Tpfar	200	-	-	ns
TG	Pulse width	Tpwv	2	-	-	µs
	Rise and fall times	Tprv, Tpfv	20	-	-	ns
P1H, P2H[24]	Pulse width	Tpwh	50	100	-	ns
	Rise and fall times	Tprh, Tpfh	10	-	-	ns
	Duty ratio		40	50	60	%
SG	Pulse width	Tpws	50	100	-	ns
	Rise and fall times	Tprs, Tpfs	10	-	-	ns
	Duty ratio		40	50	60	%
RG	Pulse width	Tpwr	5	15	-	ns
	Rise and fall times	Tprr, Tpfr	5	-	-	ns
TG - P1H	Overlap time	Tovr	1	2	-	µs
Integration time	S15254-2048	Tinteg	5	20	-	µs
	S15257-2048		100	150	-	

*24: Symmetrical clock pulses should be overlapped at 50% of maximum pulse amplitude.
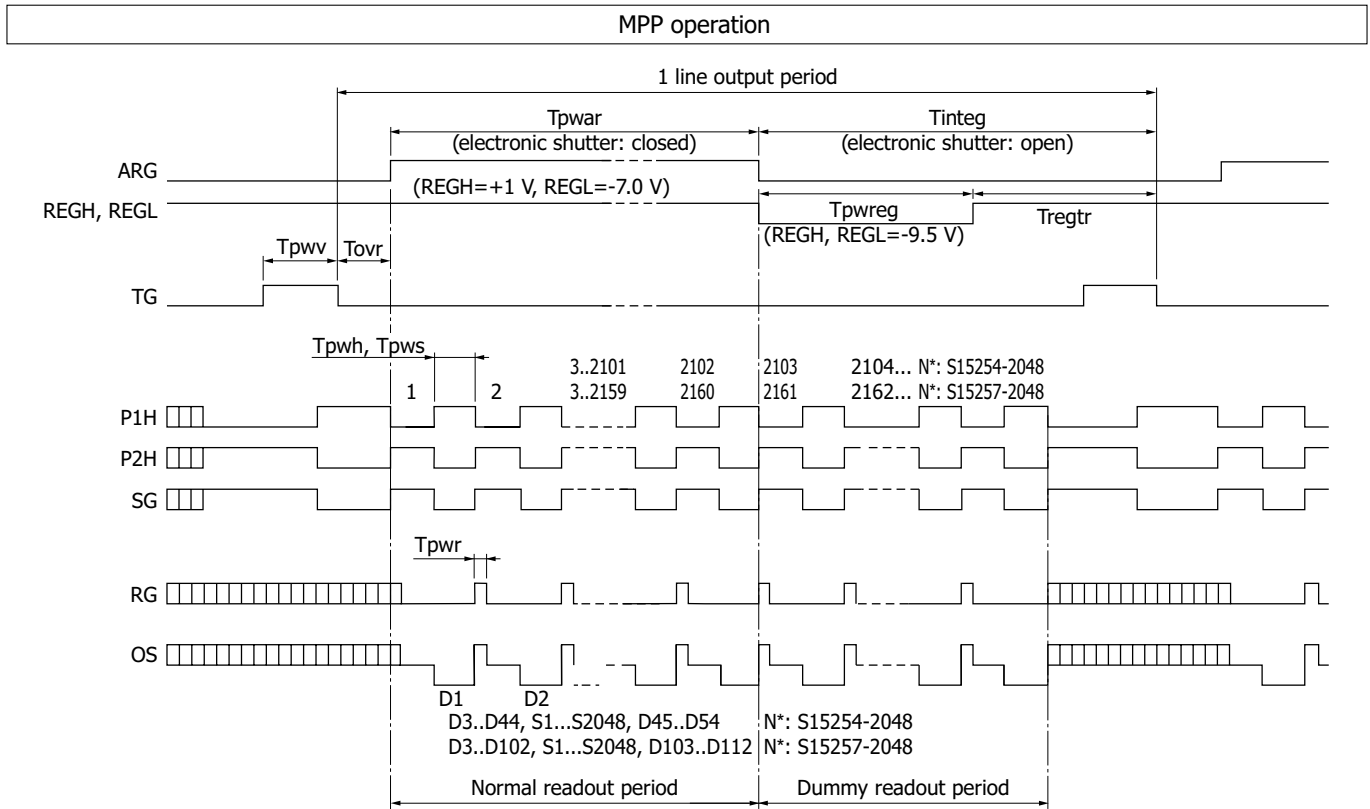
MPP operation

* Apply clock pulses to the specified terminals during the period of dummy readout.
  Set the total number of clock pulses N, according to the integration time.

KMPDC0962EA

Parameter		Symbol	Min.	Typ.	Max.	Unit
ARG	Pulse width	Tpwar	*25	-	-	µs
	Rise and fall times	Tprar, Tpfar	200	-	-	ns
REGH, REGL	Pulse width	Tpwreg	-	Tinteg - Tregtr	-	µs
	Rise and fall times	Tprreg, Tpfreg	100	-	-	ns
	Transfer time S15254-2048	Tregtr	5	20	-	µs
	Transfer time S15257-2048	Tregtr	100	150	-	µs
TG	Pulse width	Tpwv	2	-	-	µs
	Rise and fall times	Tprv, Tpfv	20	-	-	ns
P1H, P2H*26	Pulse width	Tpwh	50	100	-	ns
	Rise and fall times	Tprh, Tpfh	10	-	-	ns
	Duty ratio		-	40	50	60	%
SG	Pulse width	Tpws	50	100	-	ns
	Rise and fall times	Tprs, Tpfs	10	-	-	ns
	Duty ratio		-	40	50	60	%
RG	Pulse width	Tpwr	5	15	-	ns
	Rise and fall times	Tprr, Tpfr	5	-	-	ns
TG - P1H	Overlap time	Tovr	1	2	-	µs
Integration time S15254-2048		Tinteg	5	20	-	µs
Integration time S15257-2048		Tinteg	100	150	-	µs

*25: The Min. value of Tpwar is equal to the normal readout period.
*26: Symmetrical clock pulses should be overlapped at 50% of maximum pulse amplitude.

Dimensional outline (unit: mm)

Photosensitive area 28.672

5.015 ± 0.3
10.03 ± 0.3
10.41 ± 0.25

19.05 ± 0.4
27.94 ± 0.3
38.10 ± 0.4

Index mark

3.3 ± 0.35   Gold-plated, Alloy 42

0.6 ± 0.05*
0.25 +0.05 -0.03*

Index mark   Photosensitive surface

1.27 ± 0.25
1.47 ± 0.18
3.0 ± 0.5
0.46 ± 0.05
2.54 ± 0.13
1.27 ± 0.2
1.83 ± 0.17

Type no.	A
S15254-2048	0.2
S15257-2048	2.5

* Glass thickness (refractive index≈1.5)
Weight: 3.8 g

KMPDA0643EA

Pin connections

Pin no.	Symbol	Function	Remark (standard operation)
1	OS	Output transistor source	R_L=2.2 kΩ
2	OD	Output transistor drain	+15 V
3	OG	Output gate	+3.5 V
4	SG	Summing gate	Same pulse as P2H
5	Vret	Output amplifier return	+1 V
6	RD	Reset drain	+14 V
7	REGL	Resistive gate (low)	-7 V (Non-MPP operation)
8	REGH	Resistive gate (high)	+1 V (Non-MPP operation)
9	P2H	CCD horizontal register clock-2	+6 V/-5 V
10	P1H	CCD horizontal register clock-1	+6 V/-5 V
11	IG2H	Test point (horizontal input gate-2)	-9.5 V
12	IG1H	Test point (horizontal input gate-1)	-9.5 V
13	ARG	All reset gate	+8 V/+1 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	+14 V
19	-		
20*27	STG	Storage gate	+3.5 V
21*27	STG	Storage gate	+3.5 V
22	-		
23	TG	Transfer gate	+10.5 V/-5 V
24	RG	Reset gate	+8 V/-5 V

*27: Pins 20 and 21 are shorted inside the package.

OS output waveform example (fc=5 MHz, R_L=2.2 kΩ, V_{OD}=+15 V)
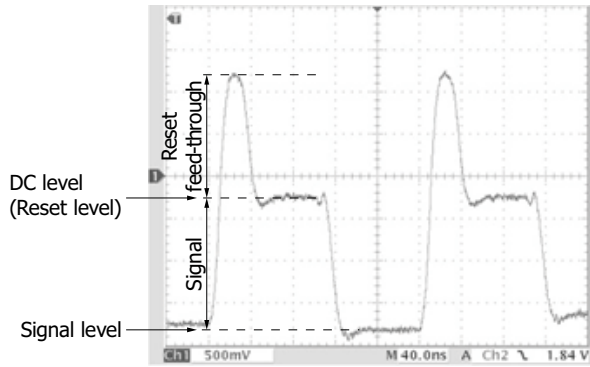
High-speed signal processing circuit example (using S15254/S15257-2048 and analog front-end IC)

KMPDC0963EA
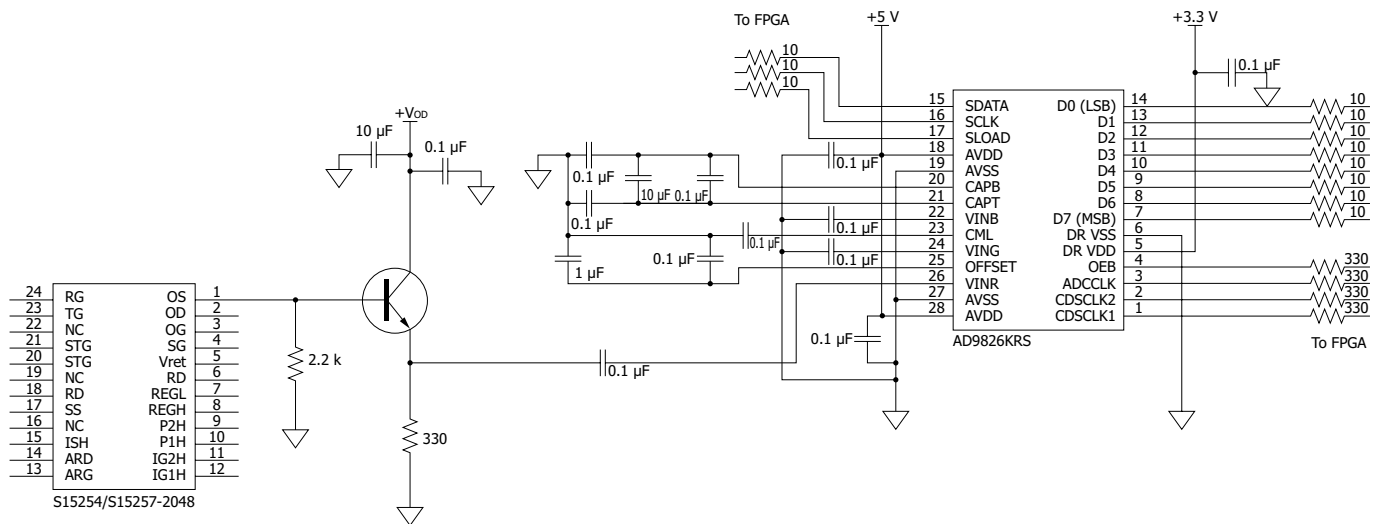
Recommended soldering conditions

Parameter	Specification	Remarks
Solder temperature	260 °C max. (5 s or less)	At least 2 mm away from lead roots

Note: When you set the soldering conditions, check that problems do not occur in the product by testing out the conditions in advance.

Precautions (electrostatic countermeasures)

· 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.
· Ground tools, such as tweezers and soldering irons, that are used to handle 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 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, usage time, and ambient 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.

HAMAMATSU

PHOTON IS OUR BUSINESS

Related information

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

■ Precautions
· Disclaimer
· Image sensors

■ Technical information
· Resistive gate type CCD linear image sensors with electronic shutter

C15361-2105 Driver circuit for CCD linear image sensor (sold separately)

The C15361-2105 is a driver circuit designed for HAMAMATSU CCD linear image sensors S15254-2048 and S15257-2048. The C15361-2105 can be used in spectrometer when combined with the CCD linear image sensor.

Features

→ **Built-in 16-bit A/D converter**
→ **Interface of computer: USB 3.1 Gen 1**
→ **Operates by DC+5 V**

Information described in this material is current as of December 2021.

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