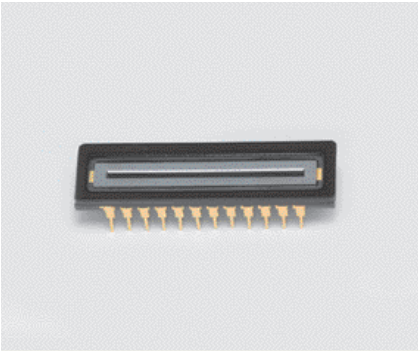
HAMAMATSU

NEW

CCD linear image sensors



S11155-2048 S11156-2048

Back-thinned CCD image sensors with electronic shutter function

The S11155-2048 and S11156-2048 are back-thinned CCD linear image sensors with an internal electronic shutter for spectrometers. These image sensors use a resistive gate structure that allows high-speed transfer. Each pixel has a lengthwise size needed by spectrometers but ensures readout with low image lag.

Features

- **Built-in electronic shutter**
- **Minimum integration time: 30 µs**
- **High sensitivity from the ultraviolet region (spectral response range: 200 to 1100 nm)**
- **Readout speed: 10 MHz max.**
- **Image lag: 0.1% typ.**

Applications

- **Spectrometers**
- **Image readout**

General ratings

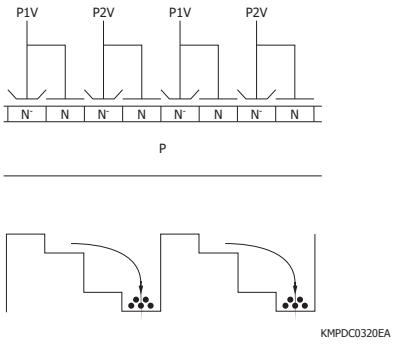
Parameter	S11155-2048	S11156-2048
Pixel size	14 (H) × 500 (V) µm	14 (H) × 1000 (V) µm
Number of total pixels	2068 (H) × 1 (V)	
Number of active pixels	2048 (H) × 1 (V)	
Active area	28.672 (H) × 0.500 (V) mm	28.672 (H) × 1.000 (V) mm
Horizontal clock phase	2-phase	
Output circuit	Two-stage MOSFET source follower	
Package	24-pin ceramic DIP (refer to dimensional outline)	
Window*1	Quartz glass	

*1: Temporary window type (ex. S11155-2048N) is available upon request.

Resistive gate structure

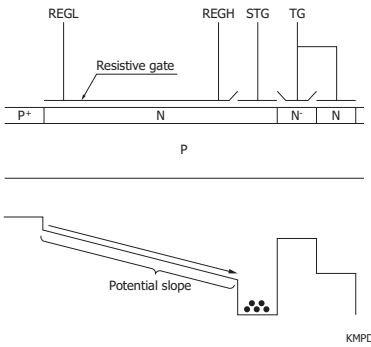
In ordinary CCDs, one pixel contains multiple electrodes and a signal charge is transferred by applying different clock pulses to those electrodes [Figure 1]. In resistive gate structures, a single high-resistance electrode is formed in the active area, and a signal charge is transferred by means of 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*2 *3		Topr	-50	-	+50	°C
Storage temperature		Tstg	-50	-	+70	°C
OD voltage		VOD	-0.5	-	+25	V
RD voltage		VRD	-0.5	-	+18	V
Vret voltage		Vret	-0.5	-	+18	V
ARD voltage		VARD	-0.5	-	+18	V
ISH voltage		VISH	-0.5	-	+18	V
ARG voltage		VARG	-10	-	+15	V
STG voltage		VSTG	-10	-	+15	V
IGH voltage		VIG1H, VIG2H	-10	-	+15	V
SG voltage		VSG	-10	-	+15	V
OG voltage		VOG	-10	-	+15	V
RG voltage		VRG	-10	-	+15	V
TG voltage		VTG	-10	-	+15	V
Resistive gate voltage	High	VREGH	-10	-	+15	V
	Low	VREGL				
Horizontal clock voltage		VP1H, VP2H	-10	-	+15	V

*2: Chip temperature
*3: The chip 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.

Operating conditions (Ta=25 °C)

Parameter			Symbol	Min.	Typ.	Max.	Unit
Output transistor drain voltage			VOD	12	15	18	V
Reset drain voltage			VRD	14	15	16	V
All reset drain voltage			VARD	11	12	13	V
All reset gate voltage		High*4	VARGH	7	8	9	V
		Low*5	VARGL	-2	-1.5	-1	
Output gate voltage			VOG	4.5	5	5.5	V
Storage gate voltage			VSTG	-	0	-	V
Substrate voltage			VSS	-	0	-	V
Resistive gate high voltage		High	VREGHH	-3.5	-3	-2.5	V
		Low	VREGHL	-9	-8	-7	
Resistive gate low voltage		High	VREGLH	-	VREGHH - 2.5	-	V
		Low	VREGLL	-9	-8	-7	
Output amplifier return voltage			Vret	-	1	2	V
Test point	Horizontal input source		VISH	-	VRD	-	V
	Horizontal input gate		VIG1H, VIG2H	-9	-8	-	V
Horizontal shift register clock voltage		High	VP1HH, VP2HH	5	6	7	V
		Low	VP1HL, VP2HL	-6	-5	-4	
Summing gate voltage		High	VSGH	5	6	7	V
		Low	VSGL	-6	-5	-4	
Reset gate voltage		High	VRGH	7	8	9	V
		Low	VRGL	-6	-5	-4	
Transfer gate voltage		High	VTGH	8.5	9	9.5	V
		Low	VTGL	-7.5	-7	-6.5	
External load resistance			RL	2.0	2.2	2.4	kΩ

*4: All reset on
*5: All reset off

Electrical characteristics (Ta=25 °C)

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	S11155-2048	C_{REG}	-	1000	-	pF
	S11156-2048		-	2000	-	
Summing gate capacitance		C_{SG}	-	10	-	pF
Reset gate capacitance		C_{RG}	-	10	-	pF
Transfer gate capacitance		C_{TG}	-	100	-	pF
Charge transfer efficiency*6		CTE	0.99995	0.99999	-	-
DC output level		Vout	7	8	9	V
Output impedance		Zo	-	300	-	Ω
Output amplifier return current		Iret	-	0.4	-	mA
Power consumption	S11155-2048	P_{AMP}*7	-	75	-	mW
		P_{REG}*8	1.4	2.5	12.5	
	S11156-2048	P_{AMP}*7	-	75	-	
		P_{REG}*8	0.7	1.3	6.3	
Resistive gate resistance*9	S11155-2048	R_{REG}	0.5	2.5	4.5	kΩ
	S11156-2048		1	5	9	

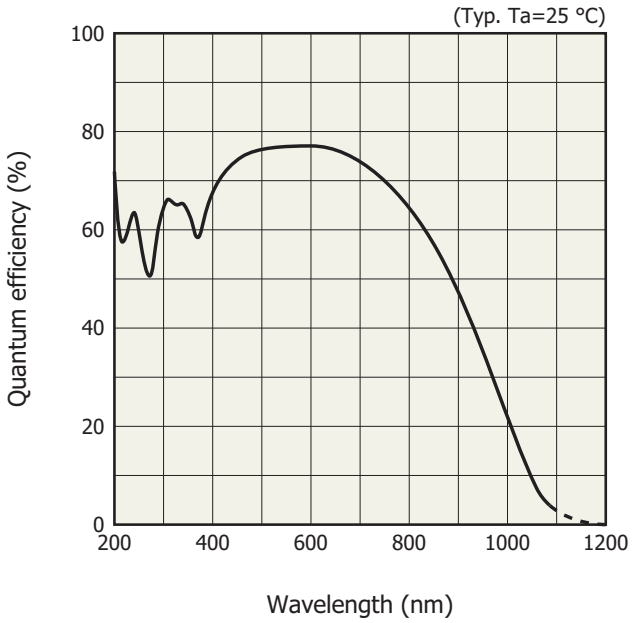
*6: Charge transfer efficiency per pixel of CCD shift register, measured at half of the full well capacity
*7: Power consumption of the on-chip amplifier plus load resistance
*8: Power consumption at REG
*9: Resistance value between REGH and REGL

Electrical and optical characteristics (Ta=25 °C, unless otherwise noted)

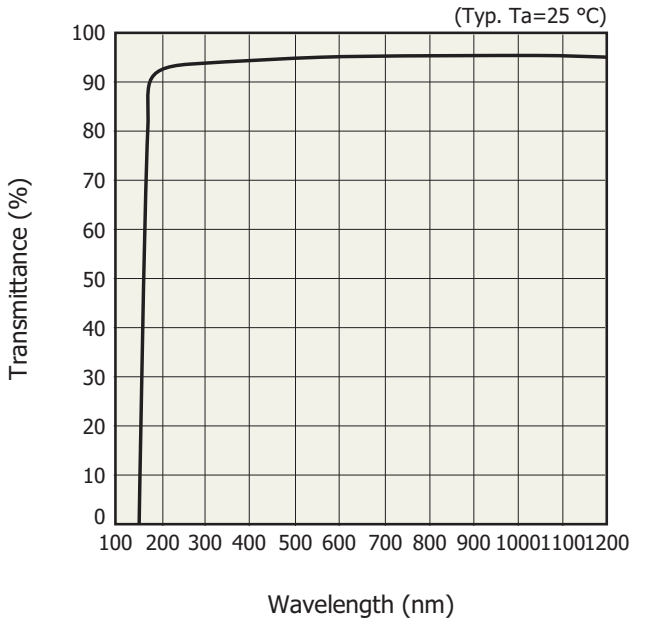
Parameter		Symbol	S11155-2048			S11156-2048			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Saturation output voltage		Vsat	-	Fw × Sv	-	-	Fw × Sv	-	V
Full well capacity		Fw	-	200	-	-	200	-	ke^-
CCD node sensitivity		Sv	7	8	9	7	8	9	$\mu V/e^-$
Dark current*10	Non-MPP operation	DS	-	50	300	-	100	600	ke^-/pixel/s
	MPP operation		-	4	16	-	8	32	
Readout noise*11		Nr	-	30	45	-	30	45	e^- rms
Dynamic range*12		DR	-	6670	-	-	6670	-	-
Spectral response range		λ	-	200 to 1100	-	-	200 to 1100	-	nm
Photo response non-uniformity*13, *14		PRNU	-	±3	±10	-	±3	±10	%
Image lag*13		L	-	0.1	1	-	0.1	1	%

*10: Dark current is reduced to half for every 5 to 7 °C decrease in temperature.
*11: Readout frequency is 2 MHz
*12: Dynamic range (DR) = Full well capacity / Readout noise
*13: Measured at one-half of the saturation output (full well capacity) using LED light (peak emission wavelength: 660 nm)
*14: Photo response non-uniformity = $\frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100$ [%]

Spectral response (without window)*15



Spectral transmittance characteristic of window material



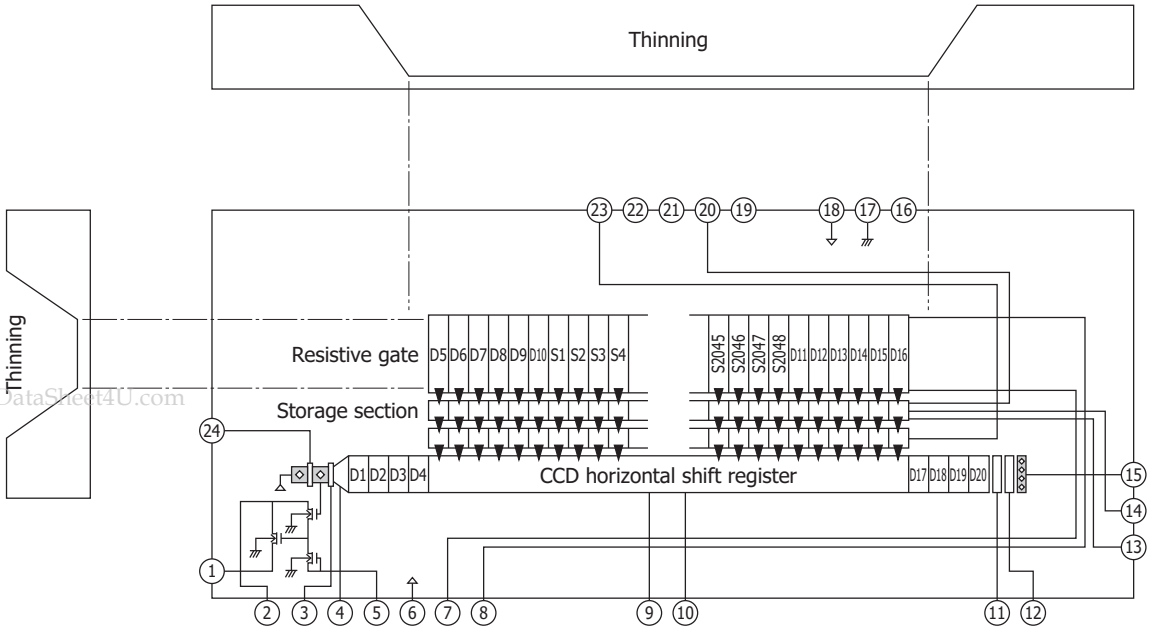
*15: Spectral response with quartz glass is decreased according to the spectral transmittance characteristic of window material.

Window material

Type No.	Window material
S11155-2048 S11156-2048	Quartz glass*16 (option: window-less)

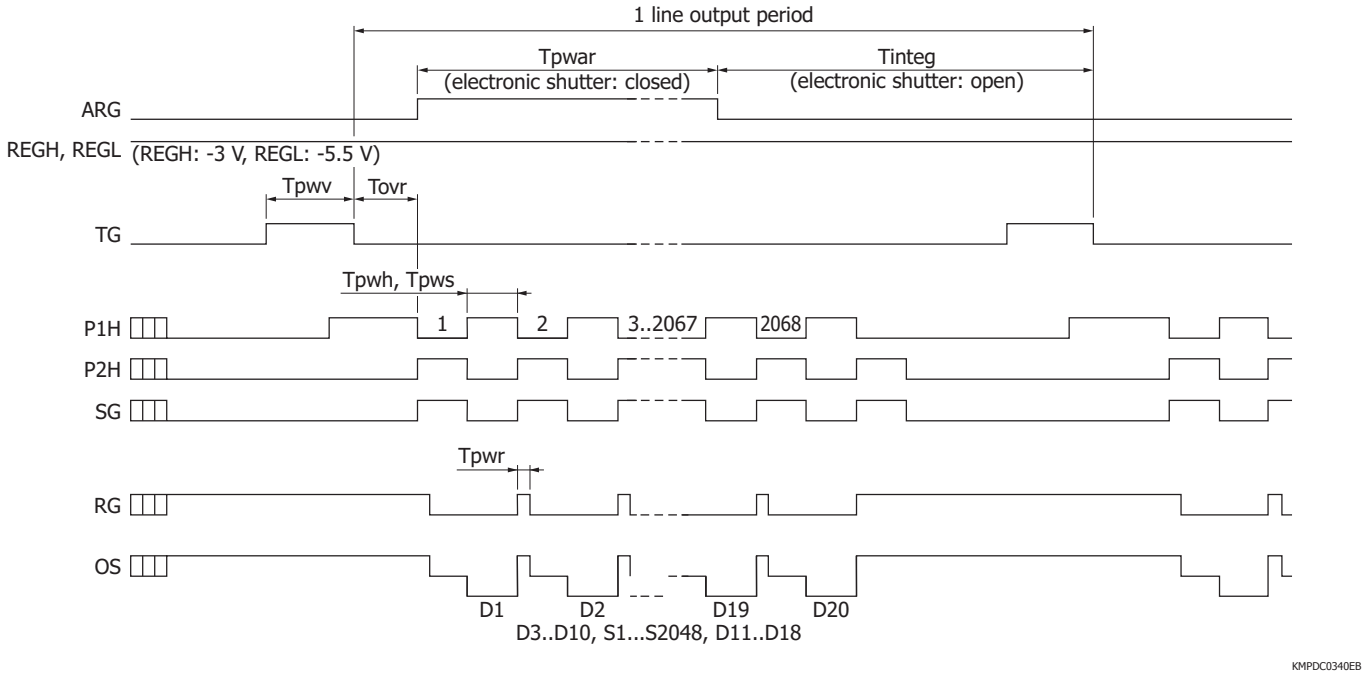
*16: Resin sealing

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



Timing chart

Non-MPP operation

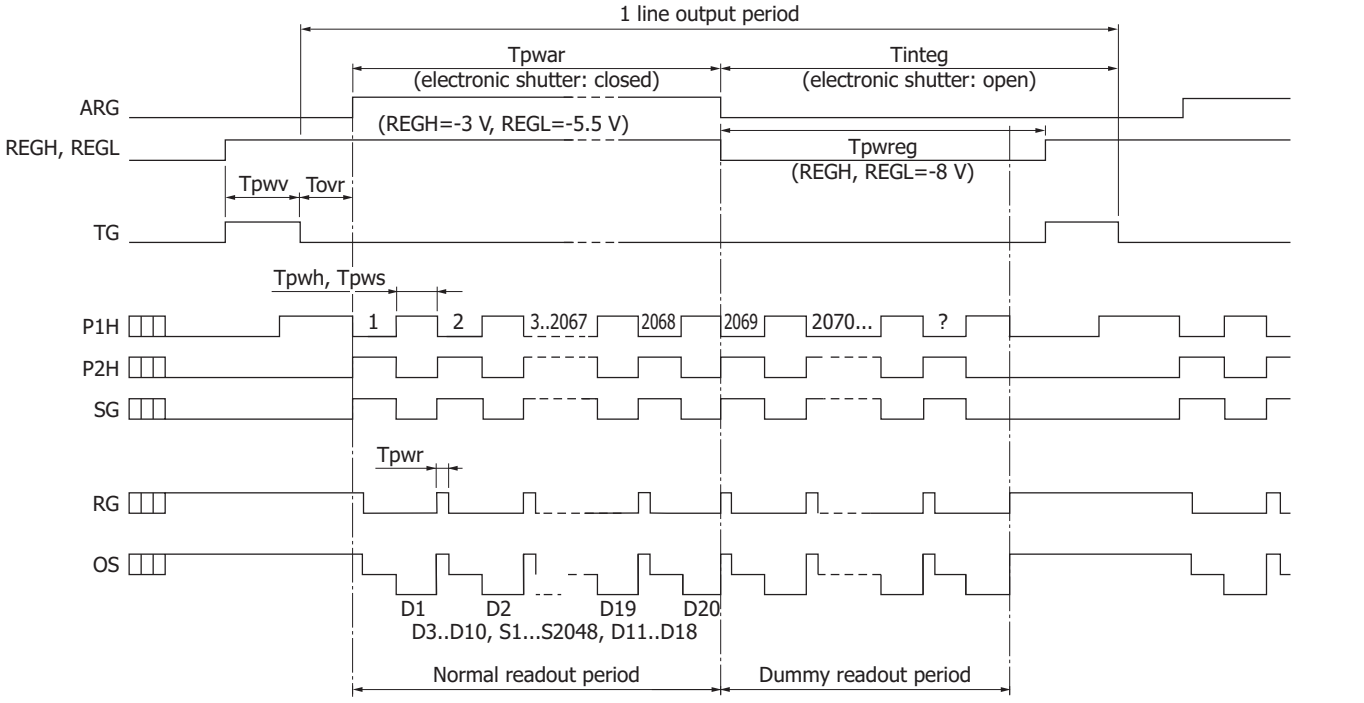


Parameter		Symbol	Min.	Typ.	Max.	Unit
ARG	Pulse width	Tpwar	1	-	-	µs
	Rise and fall times	Tprar, Tpfar	200	-	-	ns
TG	Pulse width	Tpwv	30	-	-	µs
	Rise and fall time	Tprv, Tpfv	20	-	-	ns
P1H, P2H*17	Pulse width	Tpwh	50	100	-	ns
	Rise and fall time	Tprh, Tpfh	10	-	-	ns
	Duty ratio	-	40	50	60	%
SG	Pulse width	Tpws	50	100	-	ns
	Rise and fall time	Tprs, Tpfs	10	-	-	ns
	Duty ratio	-	40	50	60	%
RG	Pulse width	Tpwr	5	15	-	ns
	Rise and fall time	Tprr, Tpfr	5	-	-	ns
TG - P1H	Overlap time	Tovr	1	2	-	µs
Integration time		Tinteg	30	-	-	µs

*17: Symmetrical clock pulses should be overlapped at 50% of maximum amplitude.

Timing chart

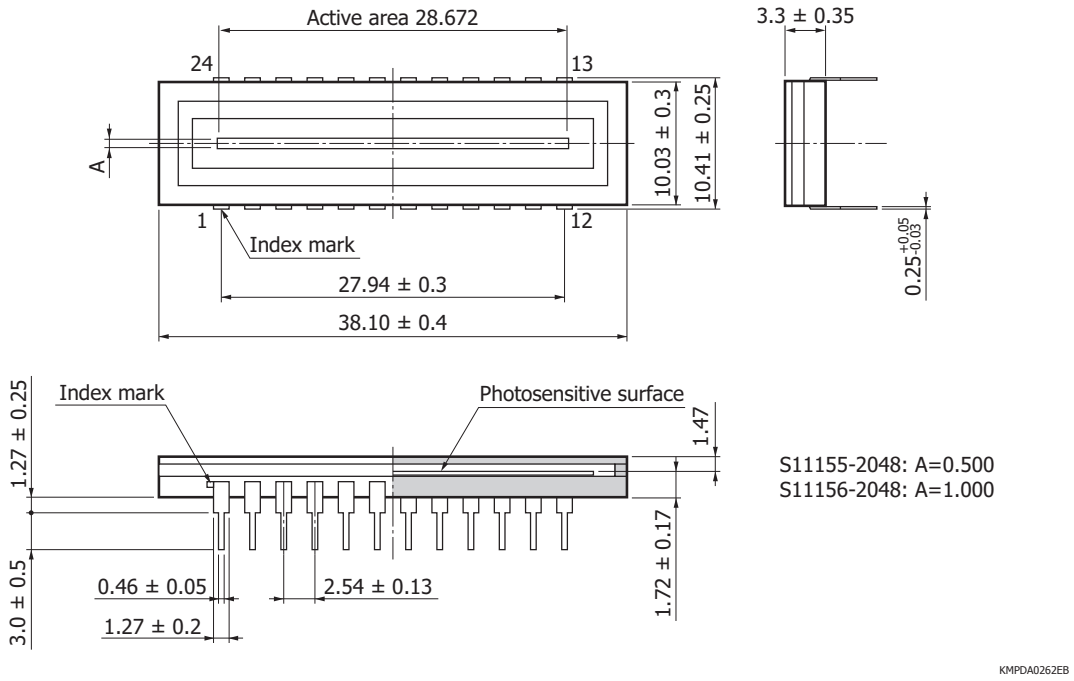
MPP operation



Parameter		Symbol	Min.	Typ.	Max.	Unit
ARG	Pulse width	Tpwar	*18	-	-	µs
	Rise and fall times	Tprar, Tpfar	200	-	-	ns
REGH, REGL	Pulse width	Tpwreg	-	Tinteg - Tpwv	-	µs
	Rise and fall times	Tprreg, Tpfreg	100	-	-	ns
TG	Pulse width	Tpwv	30	-	-	µs
	Rise and fall times	Tprv, Tpfv	20	-	-	ns
P1H, P2H*19	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		Tinteg	30	-	-	µs

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

Dimensional outline (unit: mm)



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	+5 V
4	SG	Summing gate	Same pulse as P2H
5	Vret	Output amplifier return	+1 V
6	RD	Reset drain	+15 V
7	REGL	Resistive gate (low)	-5.5 V (Non-MPP operation)
8	REGH	Resistive gate (high)	-3 V (Non-MPP operation)
9	P2H	CCD horizontal register clock-2	
10	P1H	CCD horizontal register clock-1	
11	IG2H	Test point (horizontal input gate-2)	-8 V
12	IG1H	Test point (horizontal input gate-1)	-8 V
13	ARG	All reset gate	
14	ARD	All reset drain	+12 V
15	ISH	Test point (horizontal input source)	Connect to RD
16	-		
17	SS	Substrate	GND
18	RD	Reset drain	+15 V
19	-		
20	STG	Storage gate	0 V
21	-		
22	-		
23	TG	Transfer gate	
24	RG	Reset gate	

Related information
http://jp.hamamatsu.com/sp/ssd/CCD_e.html

- Characteristics and use of resistive gate type CCD linear image sensors with electronic shutter

Driver circuits for CCD linear image sensor (S11155-2048, S11156-2048) C11165 [sold separately]

The C11165 is a driver circuit designed for HAMAMATSU CCD linear image sensors S11155-2048, S11156-2048. The C11165 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 2.0**
- **Operates by DC+5 V**

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