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CMOS area image sensors

S10831 S10835-12

CMOS area image sensors for X-ray imaging

The S10831 is CMOS area image sensor suitable for intra-oral X-ray imaging in dental diagnosis. The S10831 has 2.21 megapixels (1300 × 1700) with a pixel size of 20 × 20 µm. An FOP (fiber optic plate) is used as an input window, making S10831 high image-quality and long-term X-ray life. The S10835-12 is an easy-to-use X-ray imaging module using the S10831 with a cable. The S10831 has 14-bit A/D converter on chip and LVDS digital output signal. These features are to contribute cost reduction in a user's system. The S10830-12 and S10834-12 (1000 × 1500 pixels) are also available.

Features

- **Pixel size: 20 × 20 µm**
- **1300 (H) × 1700 (V) pixel format**
- **High resolution: 20 Lp/mm typ.**
- **14-bit A/D converter (virtual dynamic range: 58 dB)**
- **Global shutter operation**
- **Photodiode placed outside the active area to monitor x-ray irradiation**

Applications

- **Intra-oral X-ray imaging dental diagnosis**
- **General X-ray imaging**
- **Non-destructive inspection**

These products are components for incorporation into medical and industrial devices.

Structure

Parameter	S10831	S10835-12	Unit
Product type	Without cable	With cable	-
Image size (H × V)	26 × 34		mm
Pixel size (H × V)	20 × 20		µm
Pixel pitch	20		µm
Number of total pixels (H × V)	1300 × 1706		pixels
Number of effective pixels (H × V)	1300 × 1700		pixels
Number of light-shielded pixels	Uper part: 756, 758, 760 Lower part: 1300 × 3		pixels
Window material	FOS		-
Scintillator type	CsI		-
Interface	LVDS		-

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	Vdd		-0.5	5	6	V
Operating temperature	Topr	No dew condensation*1	0	-	35	°C
Operating humidity	Hopr	No dew condensation*1	-	-	70	%
Operating pressure	Popr		700	-	1060	hPa
Storage temperature	Tstg	No dew condensation*1	-20	-	70	°C
Storage humidity	Hstg	No dew condensation*1	-	-	70	%
Storage pressure	Pstg		700	-	1060	hPa
Tensile strength	TS	*2	-	-	100	N
X-ray tube voltage	Ex-ray		20	70	90	kV
Total dose irradiation	D	*3	-	-	57.6	Gy

*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.
*2: Connection between the CMOS sensor and the cable
*3: Tube voltage=60 kV, no Al added filter
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 operating conditions

Parameter		Symbol	Min.	Typ.	Max.	Unit
Power supply		Vdd	4.75	5.0	5.5	V
Digital input voltage*4	High	Vsigi(H)	2.4	3.3	Vdd + 0.25	V
	Low	Vsigi(L)	0	-	0.4	

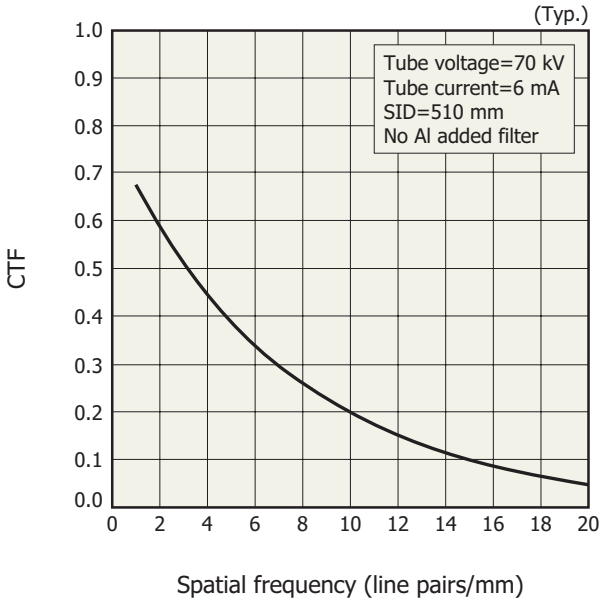
*4: Vsigi(H) is a "High" period voltage of MST and MCLK, Vsigi(L) is a "Low" period voltage of MST and MCLK.

Electrical characteristics (Ta=25 °C, Vdd=5 V)

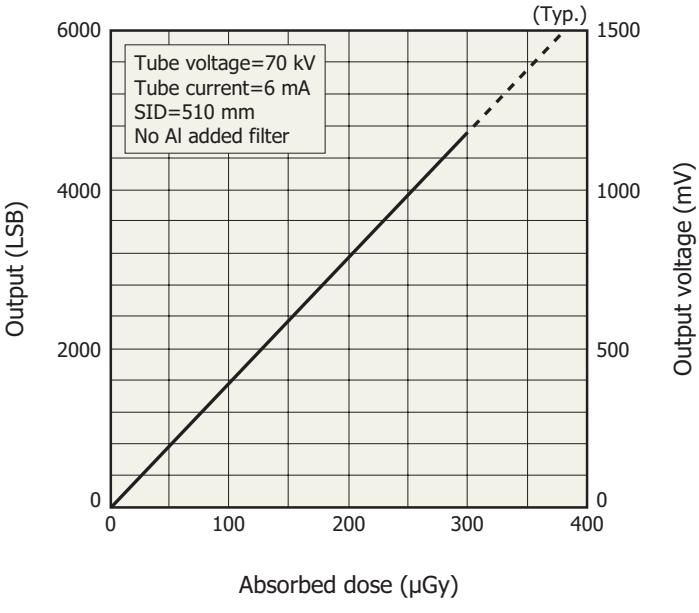
Parameter		Symbol	Min.	Typ.	Max.	Unit
Master clock pulse frequency		f(MCLK)	1	20	40	MHz
Digital output format		-		LVDS differential output		-
Digital output frequency	Image sensor*5	f1(DO)	-	f(MCLK)	-	MHz
	Monitoring photodiode*6	f2(DO)	-	f(MCLK)/56	-	
Digital output voltage*7		V(Domag)	-	350	-	mV
Digital output rise time*7 *8		tr(DO)	-	2	5	ns
Digital output fall time*7 *8		tf(DO)	-	2	5	
Video data rate	Image sensor*9	VR1	-	f(MCLK)/14	-	MHz
	Monitoring photodiode	VR2	-	f(MCLK)/7168	-	
Start pulse interval*10		T(ST-I)	3.28×10^7	-	-	MCLK
Integration time	Image sensor*11	Tint1	-	PW(MST) + 394/f(MCLK)	-	µs
	Monitoring photodiode*12	Tint2	-	6608/f(MCLK)	-	
Consumption current	Image sensor*13	P1	-	55	110	mA
	Monitoring photodiode*14	P2	-	25	50	

*5: Refer to "Timing chart (D)."
*6: Refer to "Timing chart (A)."
*7: The output voltage difference between LVDS differential terminals with 100 Ω termination
*8: The time in output from 10% to 90% or from 90% to 10%
*9: It takes 14 master clock pulse cycles to read out 1 pixel.
*10: It takes 3.28×10^7 master clock pulse cycles to read out an image. The readout of the next frame must be started after finishing the readout of previous frame.
*11: Refer to "Timing chart". PW(MST) is "Low" period of MST (master start pulse).
e.g.: When the PW(MST) is 10 ms and f(MCLK) is 20 MHz: Integration time=10 ms + 394/20 MHz=10.0197 ms
*12: Refer to "Timing chart". The monitoring photodiode outputs every 7168 cycles of MCLK. The integration time is 6608 cycles of MCLK, and resetting the monitoring photodiode takes 506 cycles of MCLK.
e.g.: Integration time=6608/20 MHz=330.4 µs when f(MCLK) is 20 MHz
*13: The consumption current of image sensor chip only. f(MCLK)=20 MHz
*14: The consumption current of image sensor chip only. Without 100 Ω termination (see "Output format" in P.7). f(MCLK)=20 MHz

Resolution (S10835-12)



Response (S10835-12)



Electrical and optical characteristics (image sensor, Ta=25 °C, Vdd=5 V)

Parameter			Symbol	Min.	Typ.	Max.	Unit
X-ray sensitivity*15			DRES	13	19	25	LSB/µGy
Saturation output			Dsat	3280	4900	-	LSB
Saturation dose*15			Lsat	130	260	380	µGy
X-ray response nonuniformity*15 *16 *17			XRNU	-	-	±30	%
Dark output effective pixels*16			Ddark	-	200	490	LSB/s
Readout noise			DNread	-	6.2	18	LSB rms
Dynamic range*18			DR	45	58	-	dB
X-ray resolution*15			Resox-ray	15	20	-	Lp/mm
Contrast transfer function*19			CTF	0.15	0.23	-	-
Blemish*15	Point defect*20	White spot	-	-	-	20	-
		Black spot		-	-	20	
	Cluster defect*21			-	-	3	
	Column defect*22			-	-	0	
Defect line*15 *23			DL	-	-	15	lines
X-ray life*24			-	-	144000	-	shots

*15: Tube voltage=70 kV, tube current=6 mA, SID=510 mm, no Al added filter
*16: Average value, excluding defect pixels
*17: XRNU (%) = (ΔS/S) × 100
S is the average value of an X-ray output signal.
ΔS is the difference between S and the maximum or the minimum value of X-ray output signals.
ΔS is calculated from an X-ray image corrected by dark subtraction excluding any defect.
XRNU specification is not applied to 5 pixels from the edge of effective pixels.
*18: DR=20 × log (Dsat/DNread)
*19: 10 line pairs/mm
*20: White spot > 4900 LSB/s at effective pixels: 10 times of the maximum of dark output
Black spot > 50% reduction in response relative to adjacent pixels, measured at half of the saturation output
*21: Continuous 2 to 9 point defects
*22: Continuos 10 or more point defects (except a defect line)
*23: A defect line consists of 10 or more point defects in 1 pixel width.
*24: 400 µGy/shot, 60 kVp, no Al added filter

Electrical and optical characteristics (monitoring photodiode, Ta=25 °C, Vdd=5 V)

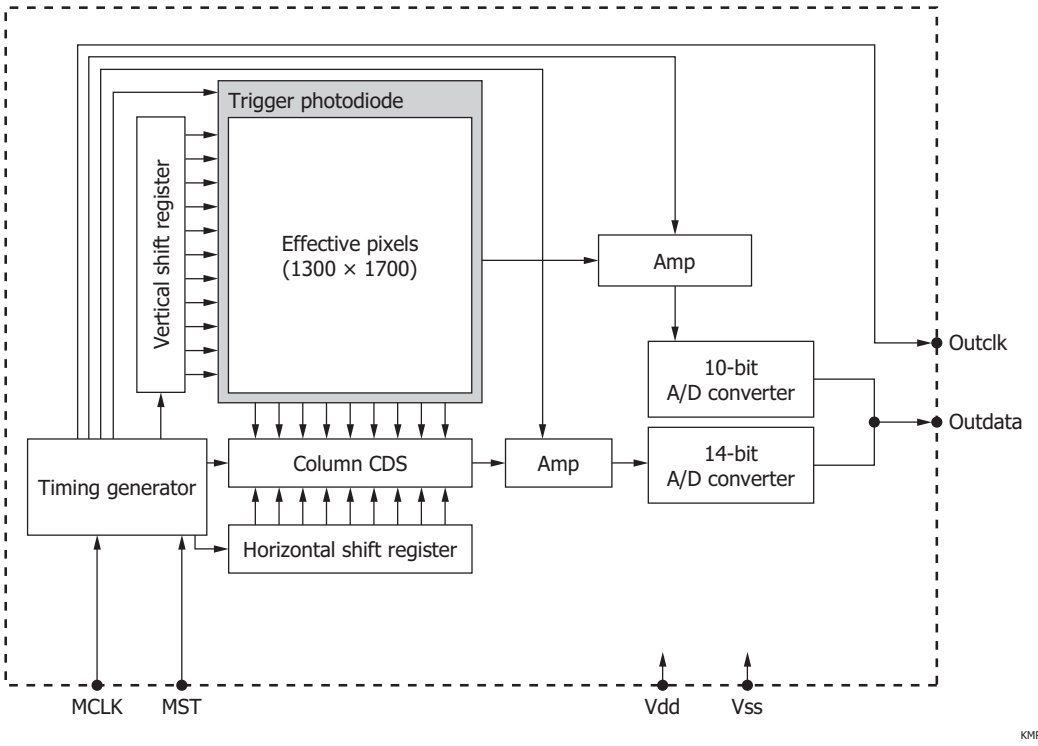
Parameter	Symbol	Min.	Typ.	Max.	Unit
X-ray sensitivity*25	S_MPD	-	63	-	LSB*26
Saturation output*25	Dsat_MPD	-	-	1023	LSB
A/D converter offset*27	Offset_MPD	426	432	438	LSB
Random noise*28	Nmd_MPD	0.1	0.4	1.0	LSB rms

*25: Tube voltage=70 kV, tube current=6 mA, SID=510 mm and no Al added filter
*26: The unit means the output of the monitoring photodiode when the dose rate is 1 µGy/ms.
*27: An A/D converter offset is a mode value of monitoring photodiode data without X-ray irradiation. "Mode" is a statistic term and the number that appears the most often in a set of numbers. This value is dependent on the PC and environment, and varies per sensor.
*28: Random noise is a standard deviation of a series of monitoring photodiode data without X-ray irradiation.

Electrical and optical characteristics (A/D converter, Ta=25 °C, Vdd=5 V)

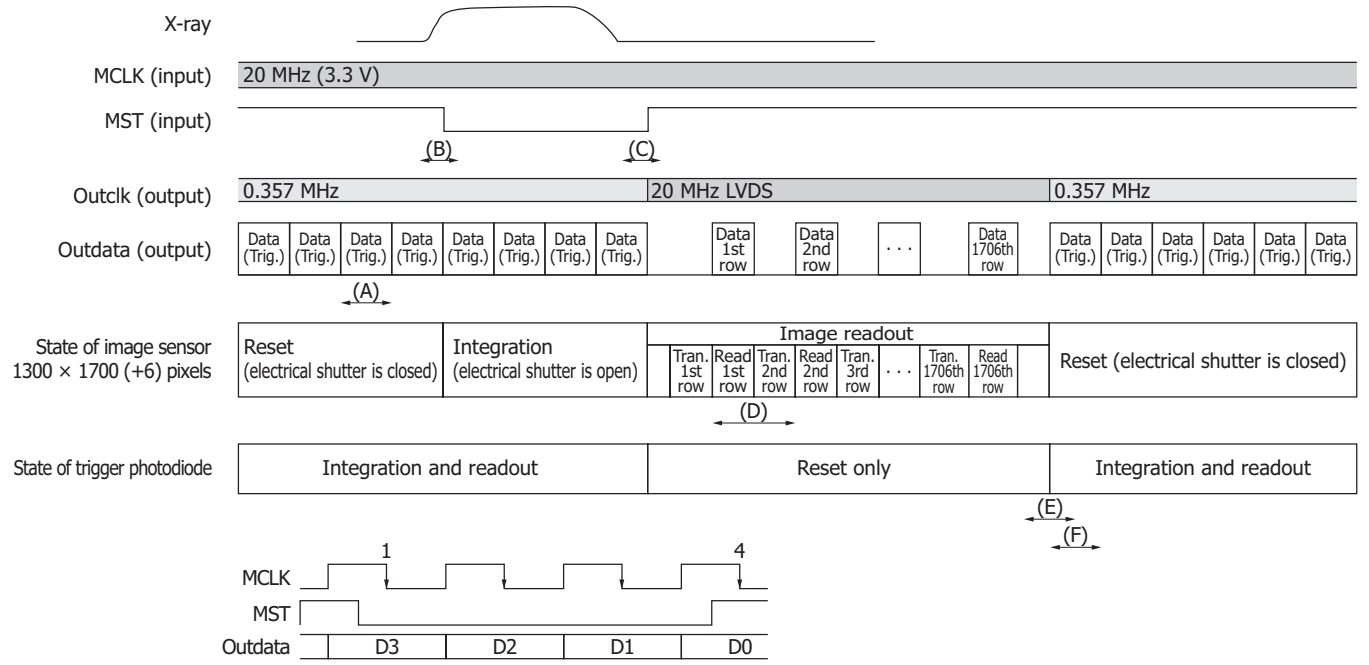
Parameter	Symbol	Image sensor	Trigger photodiode	Unit
Resolution	RESO	14	10	bit
Connection time	tCON	14/f(MCLK)	7168/f(MCLK)	s
Conversion voltage range	-	0 to 4	0 to Vdd	V

Block diagram



Timing chart

Total timing chart



(A) Continuously checking some X-ray radiation with monitoring the data of trigger photodiode by an external circuit
(B) The MST should be set at low and integration of each pixel is to start when X-ray input is detected.
The Integration time is almost same as the low width of the MST. It can be controlled by an external circuit (software, firmware, etc.).
(C) Just after the MST is set at high, the integration is to finish and readout starts.
(D) Each readout row has a header part, which consists of 28 high levels of the Outdata.
(E) (F) After completion readout, the Outclk and the Outdata automatically move to state of trigger photodiode
Note: For details of timing charts (A) to (F), see P.6 to 7.

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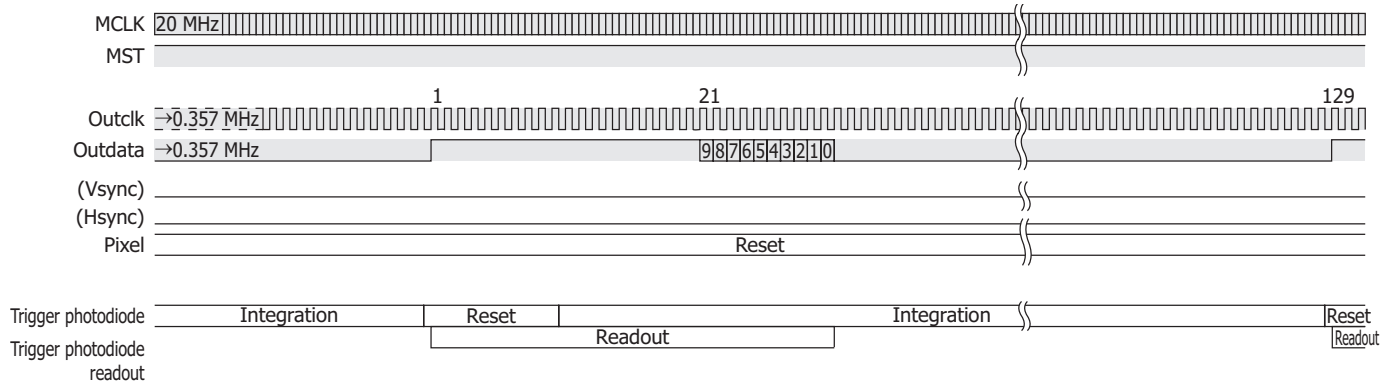
(A) Trigger photodiode data readout



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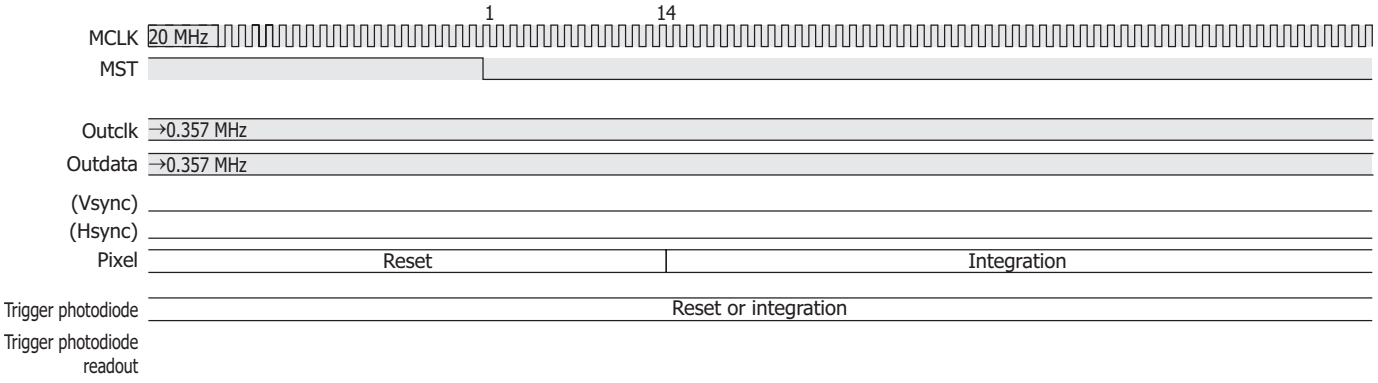
(B) Image data integration start



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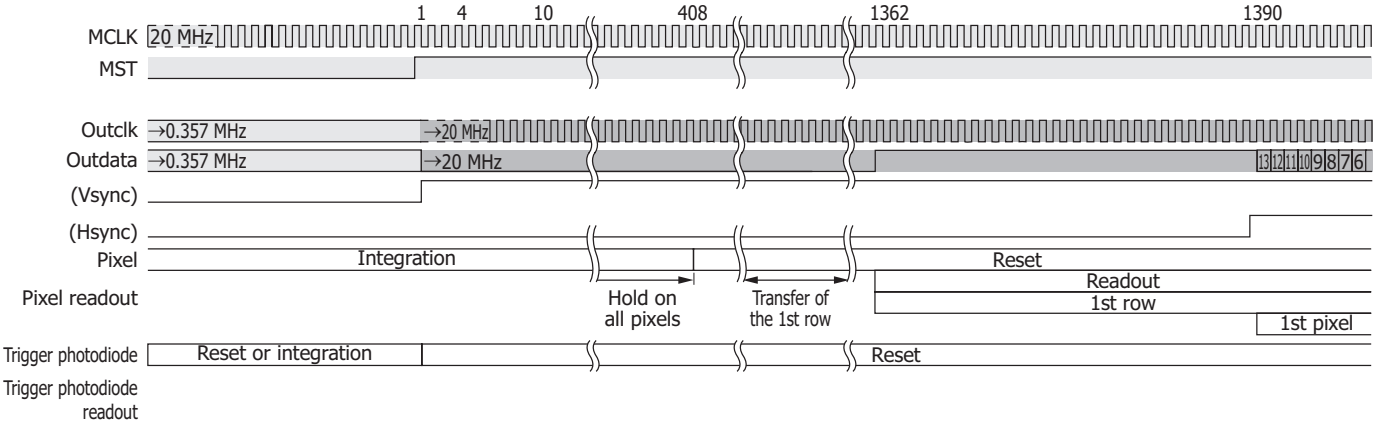
(C) Image data readout start



Note: All on-chip timing circuits are reset at rise of MST, and the operations of trigger photodiode readout are stopped at this time.

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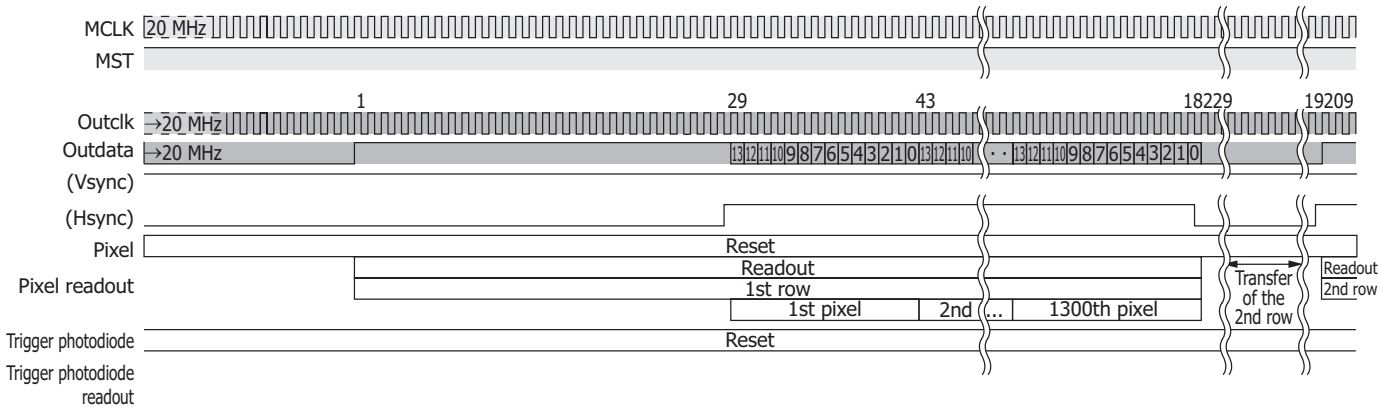
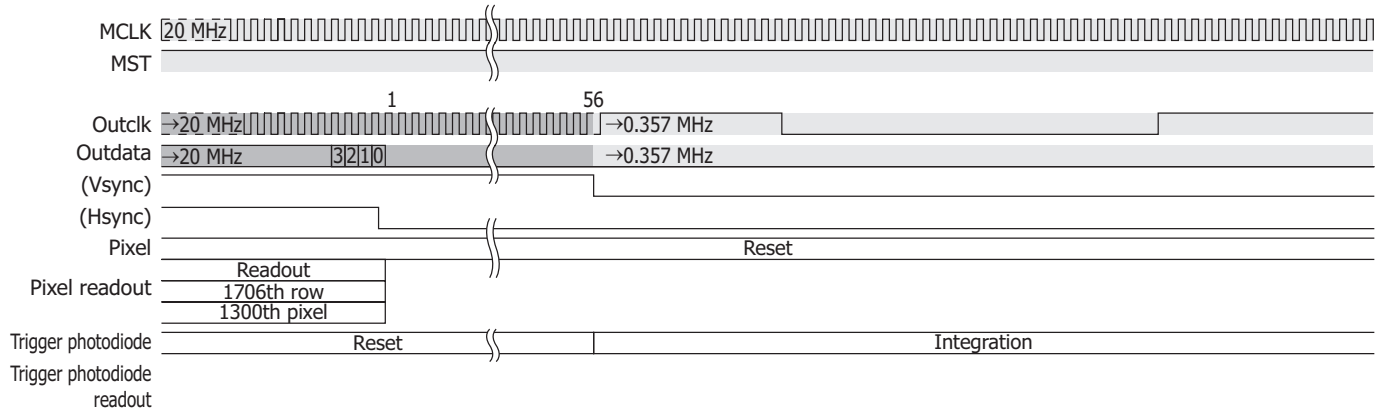
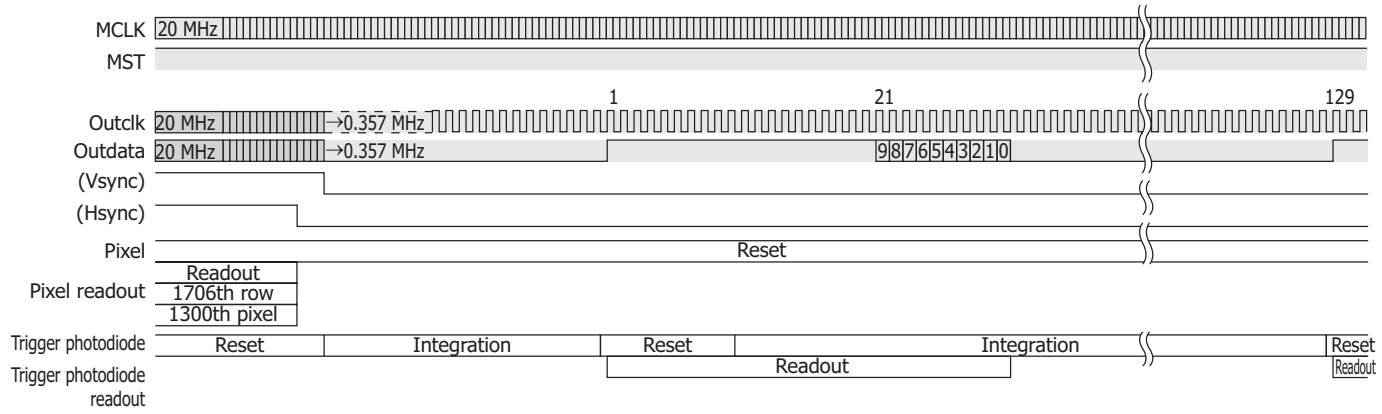
(D) Image data readout



(E) Image readout end



(F) Image readout end (trigger photodiode)



Note: Just after image data is finished, the 1st readout of trigger photodiode is not valid, because integration time is shorter than others.

Output format (Ta=25 °C, Vdd=5 V)

■ With 100 Ω termination (LVDS output mode)

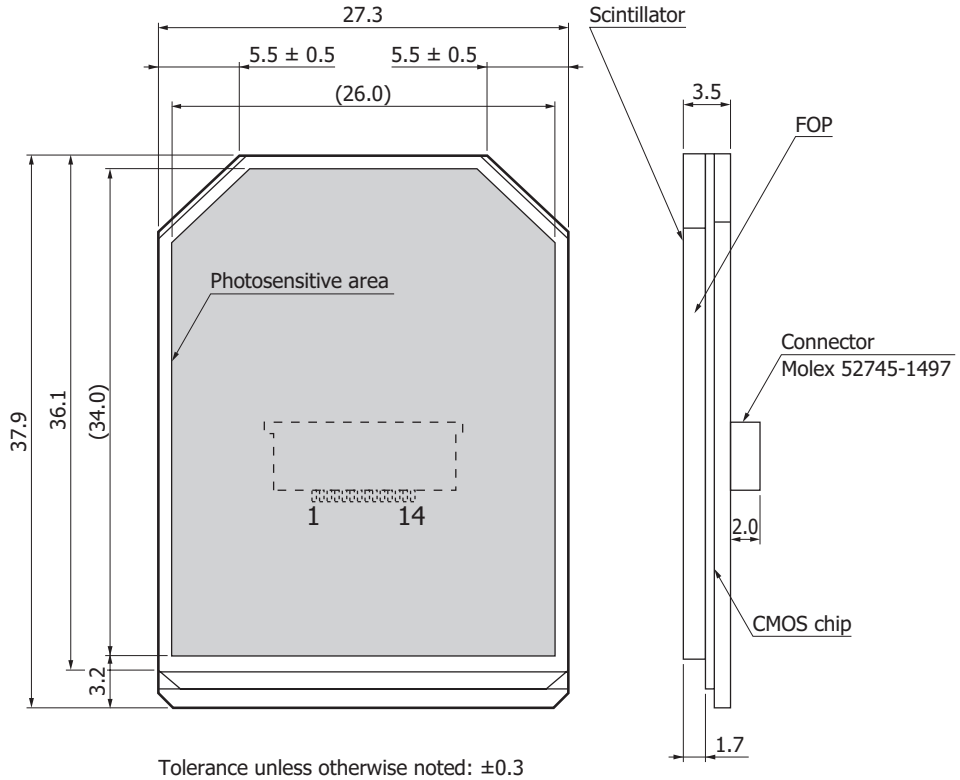
Parameter	Symbol	Min.	Typ.	Max.	Unit
Differential output swing	Vod	247	-	454	mV
Offset voltage	Vos	-	1.2	-	V
Current (100 Ω termination)	I100	-	3.5	-	mA

■ Without 100 Ω termination (CMOS output mode)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Output voltage	High level	Vod	-	2.4	-	V
	Low level	Vos	-	0	0.4	V

Dimensional outlines (unit: mm)

S10831



Tolerance unless otherwise noted: ±0.3
Values in parentheses indicate reference.
Weight: 11.3 g

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■ Pin connections

Pin no.	Description	I/O	Function
1	Vdd	I	Power supply voltage (5 V)
2	Vss	I	Ground
3	Outdata a	O	Video output signal (LVDS, positive)
4	Reserve	-	
5	Outdata b	O	Video output signal (LVDS, negative)
6	Reserve	-	
7	Outclk a	O	Trigger signal (LVDS, positive)
8	Reserve	-	
9	Outclk b	O	Trigger signal (LVDS, negative)
10	Reserve	-	
11	MST	I	Master start signal
12	Reserve	-	
13	MCLK	I	Master clock signal
14	Reserve	-	

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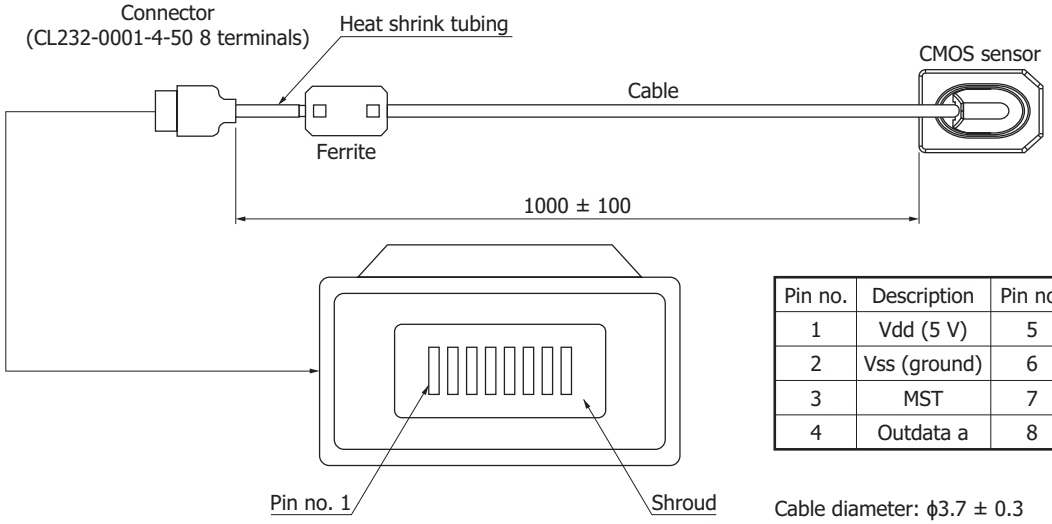
■ Entire view



Pin no.	Description	Pin no.	Description
1	Vdd (5 V)	5	Outdata b
2	Vss (ground)	6	Outclk a
3	MST	7	Outclk b
4	Outdata a	8	MCLK

Cable diameter: ϕ3.7 ± 0.3
Material of CMOS sensor package: ABS
Material of cable sheath: PVC
Weight: 48 g

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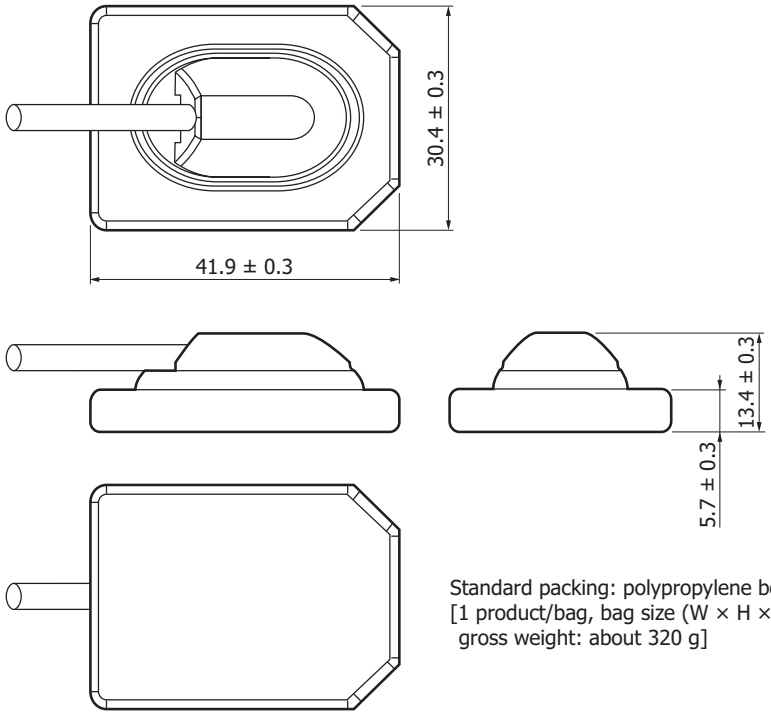
■ CMOS sensor



Standard packing: polypropylene box in moisture-proof bag
[1 product/bag, bag size (W × H × D): 200 × 50 × 150
gross weight: about 320 g]

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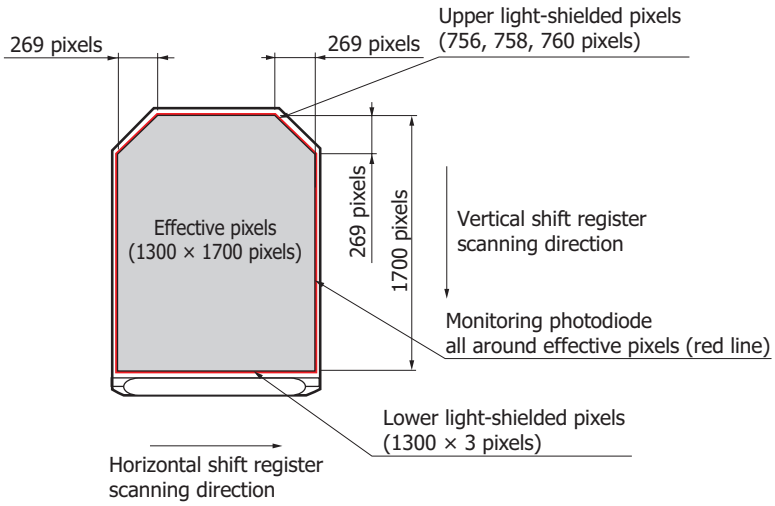
Effective photosensitive area



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Labelings

· Documents (precautions for using image sensors, final inspection sheet)

Notice

This product is warranted for a period of 12 months after the date of the shipment.
The warranty is limited to replacement or repair of any defective product due to defects in workmanship or materials used in manufacture. The warranty does not cover loss or damage caused by natural disaster, misuse (including modifications and any use not complying with the environment, application, usage and storage conditions described in this datasheet), or total radiation dose over 57.6 Gy (tube voltage=60 kV) even within the warranty period.

Estimated useful life*29

5 years
(if you keep the product safely according to this datasheet)

*29: Estimated useful life does not mean a warranty period.

Related information

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

■ Precautions
· Disclaimer

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