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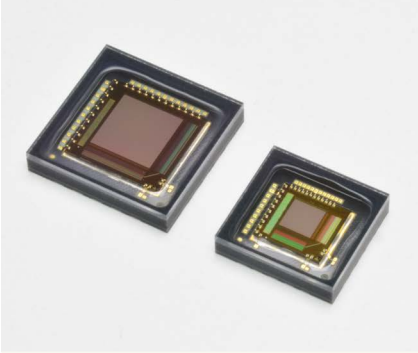
Profile sensors



S15366 series

Outputs the incident position coordinate data of light spot, built-in center-of-gravity calculation circuit

The S15366 series is a profile sensor with a center-of-gravity calculation circuit for detecting the incident position of the light spot. In the photosensitive area arranged two-dimensionally, the photosensitive area for the X-direction projection data is connected in one vertical column, and the photosensitive area for the Y-direction projection data is connected in one horizontal row using metal wiring. The sum of outputs of the photosensitive area is obtained for each line in the X and Y directions. Projection data can be obtained by obtaining the data of all lines in order. Since the data size of the projection data is small, position detection and moving object detection can be performed faster than normal area image sensors. The center-of-gravity calculation circuit is built-in, so the center-of-gravity calculation result of light spot is output. It also has a built-in light spot automatic tracking mode.

Features

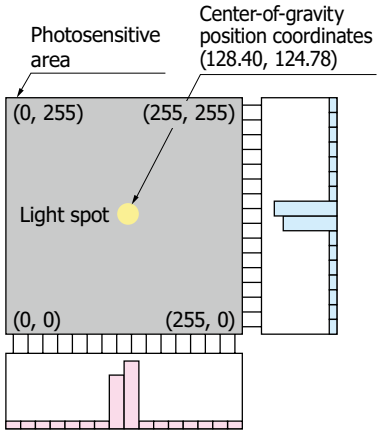
- **Sensor for acquiring 2D light spot position coordinates**
- **Built-in center-of-gravity calculation circuit**
  Directly outputs the center-of-gravity position coordinates
- **Effective photosensitive area, number of pixels:**
  2 × 2 mm, 256 + 256 pixels (S15366-256)
  4 × 4 mm, 512 + 512 pixels (S15366-512)
- **High-speed frame rate:**
  1602 frames/s max. (512 + 512 pixels)
  3156 frames/s max. (256 + 256 pixels)
  83333 frames/s max. (2 + 2 pixels)
- **Single 3.3 V power supply operation**
- **Global shutter readout**
- **Enables partial readout and binning readout**
- **Equipped with an automatic tracking mode**

Applications

- **Light spot position detection (printers, FA inspection equipment, amusement machines)**
- **Moving object detection (FA inspection equipment, amusement machines)**
- **3D measurement (FA inspection equipment, medical measurement)**

Operation schematic

The light spot center-of-gravity position coordinates are calculated by the center-of-gravity calculation circuit, then output as pixel no. + fixed point information. This product realizes position accuracy finer than pixel pitch by doing center-of-gravity calculation of the output from multiple pixels, including the maximum output pixel.



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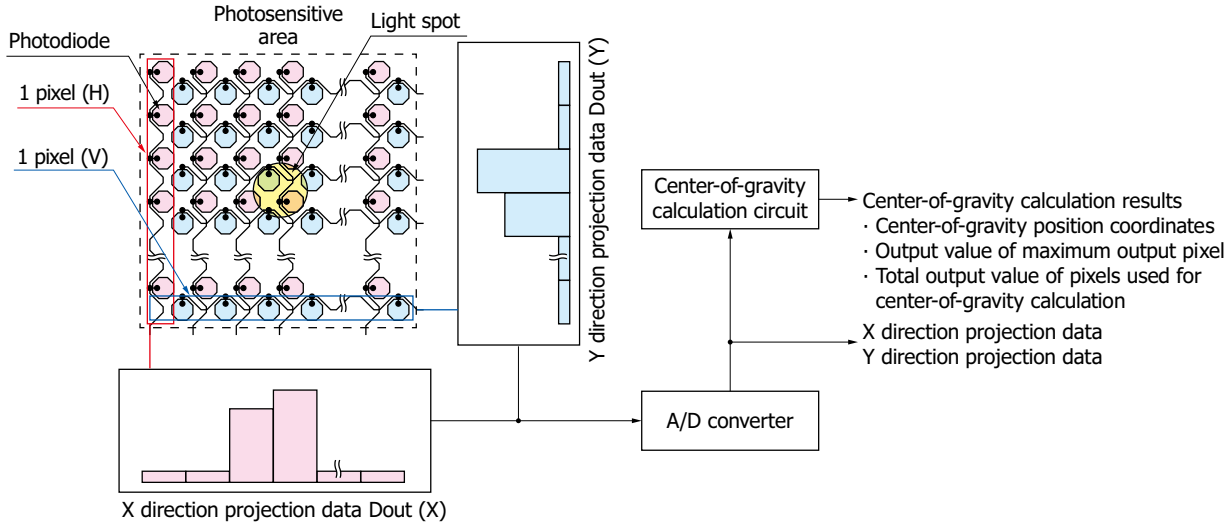
Photodetector layout and output data



Comparison of profile sensor (S15366 series) and CMOS area image sensor

The profile sensor integrates photodiodes and a readout circuit on a Si substrate, similar to a typical CMOS area image sensor, but its readout method is vastly different. The profile sensors S15366 series can directly output the center-of-gravity coordinates.

Parameter	Profile sensor S15366 series	CMOS area image sensor
Image subject	Limited to bright spot (light spot, pattern, etc.)	General purpose (shape, color, pattern, etc.)
Photodiode	X/Y-directions honeycomb array	Horizontal/vertical directions 2D array
Pixel	Pixels connected with the respective photodiodes in the X/Y directions	Each pixel provided with a photodiode
Scanning method	Two lines readout by X/Y directions scanning circuits	Area readout with vertical/horizontal scanning circuits
Center-of-gravity calculation circuit	Built-in	None
Output data	Center-of-gravity calculation results X/Y-direction projection data	Two-dimensional image

Structure

Parameter	S15366-256	S15366-512	Unit
Number of pixels	256 (H) + 256 (V)	512 (H) + 512 (V)	-
Pixel pitch	7.8		μm
Pixel size	7.8 × 1996.8	7.8 × 3993.6	μm
Photosensitive area (H × V)	1.9968 × 1.9968	3.9936 × 3.9936	mm
Package	Glass epoxy		-
Window material	Borosilicate glass		-

Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Condition	Value	Unit
Analog supply voltage	Vdd(A)		-0.3 to +3.9	V
Digital supply voltage	Vdd(D)		-0.3 to +3.9	V
Digital input signal terminal voltage*1	Vi		-0.3 to +3.9	V
Operating temperature	Topr	No dew condensation*2	-40 to +85	°C
Storage temperature	Tstg	No dew condensation*2	-40 to +85	°C
Soldering temperature*3	Tsol		260 (three times)	°C

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.
*1: SPI_CS, SPI_SCLK, SPI_MOSI, SPI_RSTB, MCLK, TG_reset, MST
*2: 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.
*3: Reflow soldering, IPC/JEDEC J-STD-020 MSL 2a, see P.12

Recommended terminal voltage (Ta=25 °C)

Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage	Analog terminal	Vdd(A)	3.0	3.3	3.6	V
	Digital terminal	Vdd(D)	3.0	Vdd(A)	3.6	
Digital input signal terminal voltage*4	High level	Vi(H)	Vdd(D) - 0.25	Vdd(D)	Vdd(D) + 0.25	V
	Low level	Vi(L)	0	-	0.25	

*4: SPI_CS, SPI_SCLK, SPI_MOSI, SPI_RSTB, MCLK, TG_reset, MST

Electrical characteristics (Ta=25 °C)

Digital input signal

[Recommended terminal voltage Typ. value (P.3)]

Parameter	Symbol	Min.	Typ.	Max.	Unit
Master clock pulse frequency	f(MCLK)	1	-	20	MHz
Master clock pulse duty cycle	D(MCLK)	45	50	55	%
Rise time*5 *6	tr(sigi)	-	5	7	ns
Fall time*5 *6	tf(sigi)	-	5	7	ns

*5: SPI_CS, SPI_SCLK, SPI_MOSI, SPI_RSTB, MCLK, TG_reset, MST
*6: Time for the input voltage to rise or fall between 10% and 90%

Digital output signal

[Recommended terminal voltage Typ. value (P.3)]

Parameter		Symbol	Min.	Typ.	Max.	Unit
Data rate		DR		1/12 × f(MCLK)		Hz
Digital output voltage*7	High level	Vsigo(H)	Vdd(D) - 0.25	Vdd(D)	-	V
	Low level	Vsigo(L)	-	0	0.25	
Rise time*7 *8		tr(sigo)	-	10	12	ns
Fall time*7 *8		tf(sigo)	-	10	12	ns

*7: Pclk, Vsync, Hsync, Dout, SPI_MISO
*8: Time for the output voltage to rise or fall between 10% and 90% when there is a 10 pF load capacitor attached to the output terminal

Current consumption

[Recommended terminal voltage Typ. value (P.3), digital input signal Typ. value (P.3)]

Parameter		Symbol	S15366-256			S15366-512			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Analog terminal	*9	I1	-	24	35	-	40	60	mA
	Standby mode*10	I1 (PS)	-	1	2	-	1	2	µA
Digital terminal	*9	I2	-	4	6	-	5	8	mA
	Standby mode*10	I2 (PS)	-	1	2	-	1	2	µA

*9: Dark state, master clock pulse frequency=20 MHz, load capacitance of each output terminal= 5 pF
*10: Dark state, master clock pulse: low fixed

A/D converter

[Recommended terminal voltage Typ. value (P.3), digital input signal Typ. value (P.3)]

Parameter	Symbol	Specification	Unit
Digital output format	-	Serial output	-
Resolution	Reso	8	bit
Conversion time	tcon	12/f(MCLK)	s
Conversion voltage range*11	-	1 to 2.25	V

*11: Can be changed by SPI

Electrical and optical characteristics

[Ta=25 °C, recommended operating conditions Typ. value (P.3), digital input signal Typ. value (P.3), MCLK=20 MHz]

Specifications based on gain 1 settings

(Conversion voltage range of A/D converter: upper voltage limit: 2.25 V, lower voltage limit=1.0 V, gain2=1x, number of binning pixels=1)

Parameter	Symbol	Gain 1	S15366-256			S15366-512			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range	λ	-	400 to 1000			400 to 1000			nm
Peak sensitivity wavelength	λp	-	-	650	-	-	650	-	nm
Photosensitivity*12 *13	Sw	1	18	25	-	18	25	-	DN/pJ
		1.33	23	33	-	23	33	-	
		2	35	50	-	35	50	-	
		4	70	100	-	70	100	-	
Photoresponse nonuniformity*14	PRNU	1	-	-	±10	-	-	±10	%
		1.33							
		2							
		4							
Offset output*13 *15	Voffset	1	5	30	55	5	30	55	DN
		1.33							
		2							
		4							
Offset output variation*13 *16	DSNU	1	-	1.5	4.0	-	1.5	4.0	DN rms
		1.33							
		2							
		4							
Dark output*13 *15 *17	DS	1	-	5	15	-	10	30	DN
		1.33	-	7	21	-	14	42	
		2	-	10	30	-	20	60	
		4	-	20	60	-	40	120	
Random noise*13 *18	RN	1	-	0.3	1.0	-	0.3	1.0	DN rms
		1.33	-			-			
		2	-			-			
		4	-	0.5	1.5	-	0.5	1.5	
Saturation output*13 *19	Vsat	1	200	225	-	200	225	-	DN
		1.33							
		2							
		4							
Saturation exposure*12	Lsat	1	-	9	-	-	9	-	pJ
		1.33	-	6.8	-	-	6.8	-	
		2	-	4.5	-	-	4.5	-	
		4	-	2.3	-	-	2.3	-	

*12: λ=635 nm
*13: 1 DN (digital number)≈4.88 mV (1.25 V range divided into 256 steps)
*14: The output nonuniformity when illuminated with uniform light about 50% of saturation. It is defined as follows for the 254 pixels (S15366-256) or 510 pixels (S15366-512) excluding the pixels at each end of the sensor.
PRNU = (ΔX/X) × 100 [%]
X: average of the output of all pixels excluding the pixels at each end of the sensor, ΔX: difference between the maximum or minimum output and X
*15: Average output of all pixels under light-shielded condition
*16: Standard deviation of output of all pixels under light-shielded condition
*17: Integration time=100 ms
*18: Average value of all pixels for standard deviation of variation in output time of each pixel in the light-shielded condition
*19: Average output of all pixels when saturated. Offset output subtracted value.

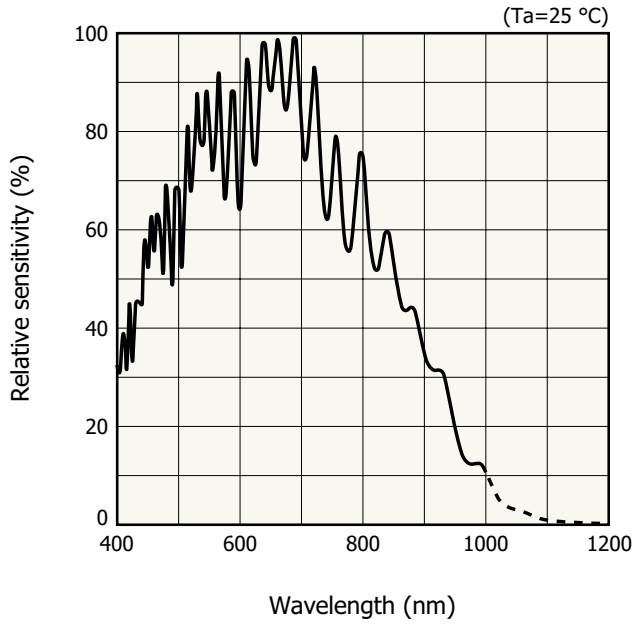
Specifications based on binning pixel number settings

(Conversion voltage range of A/D converter*20, gain1=4x, gain2=1x)

Parameter	Symbol	Number of binning pixels	S15366-256			S15366-512			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Offset output variation*21 *22	DSNU	1	-	1.5	4	-	1.5	4	DN rms
		2	-	2.1	8	-	2.1	8	
		4	-	3	16	-	3	16	
		8	-	4.2	32	-	4.2	32	
Dark output*21 *22 *23	DS	1	-	20	60	-	40	120	DN
		2	-	40	120	-	80	240	
		4	-	80	240	-	160	480	
		8	-	160	480	-	320	960	
Random noise*21 *24	RN	1	-	0.5	1.5	-	0.5	1.5	DN rms
		2	-	0.7	2.1	-	0.7	2.1	
		4	-	1	3	-	1	3	
		8	-	1.4	4.2	-	1.4	4.2	
Saturation output*21 *25	Vsat	1	200	225	-	200	225	-	DN
		2							
		4							
		8							
Saturation exposure*26	Lsat	1	-	2.3	-	-	2.3	-	pJ
		2	-	1.1	-	-	1.1	-	
		4	-	0.6	-	-	0.6	-	
		8	-	0.3	-	-	0.3	-	

*20: Set such that "upper voltage limit – lower voltage limit = 1.25 V". Offset values vary due to the number of binning pixels, therefore set the A/D conversion voltage range such that the offset average values are nearest as possible to 30 DN.
*21: 1 DN (digital number)≈4.88 mV (1.25 V range divided into 256 steps)
*22: Average output of all pixels under light-shielded condition
*23: Integration time=100 ms
*24: Average value of all pixels for standard deviation of variation in output time of each pixel in the light-shielded condition
*25: Average output of all pixels when saturated. Offset output subtracted value.
*26: λ=635 nm

Spectral response (typical example)



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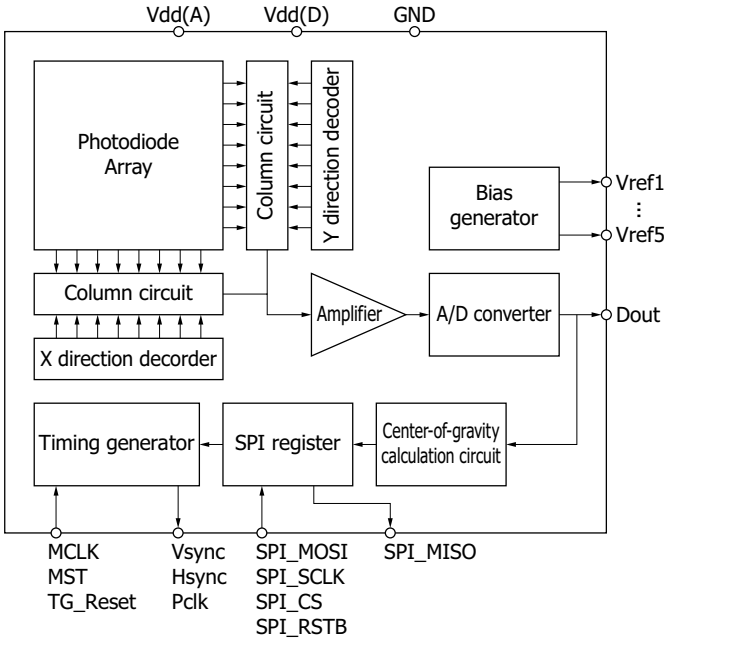
Block diagram



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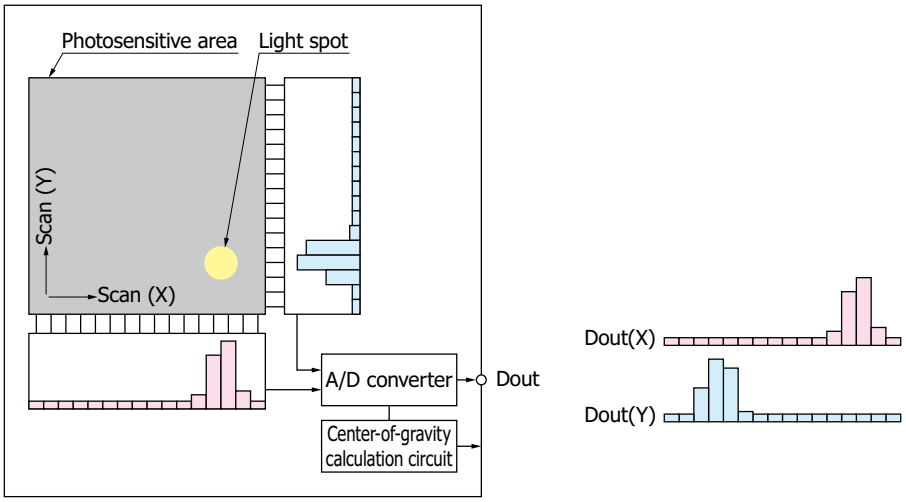
Setting using the SPI and the like

The following parameters can be set using the serial peripheral interface (SPI). However, use MST (external input signal) to set the integration time and blanking period in external start pulse mode.

Parameter	Mode and description	
Frame start mode (Initial setting: internal start pulse mode)	Internal start pulse mode	Readout starts automatically when the power is turned on. The frame cycle is determined by the number of readout pixels and the blanking period.
	External start pulse mode	Readout starts when the rising edge of MST is detected. MST is also used to control the integration time. The low period of MST is roughly the integration time.
Integration time	Internal start pulse mode	Integration time is set using SPI.
	External start pulse mode	Integration time is set using MST.
Blanking period	Internal start pulse mode	Blanking period is set for 0 to 255 rows using SPI.
	External start pulse mode	Blanking period is from the end of a readout to the falling edge of the next Vsync.
Readout region	The readout region can be set at the pixel level. A single readout region can be set in each frame.	
Gain 1	Select gain of the column circuit from 1x, 1.33x, 2x, and 4x. Initial value: 1x	
Gain 2	To avoid output saturation during binning, set gain to 1x to 0.063x, according to output. Initial value: 1x	
Number of binning pixels	Select the number of binning pixels from 1, 2, 4, or 8 pixels. Initial value: 1 pixel	
Voltage conversion range of the A/D converter	The lower voltage limit can be set between 0.8 to 1.55 V and the upper voltage limit between 1.85 to 2.6 V. Initial value: lower voltage limit=1.0 V, upper voltage limit=2.25 V	
Standby mode	The SPI sets the standby mode to reduce current consumption. In standby mode, projection data and center-of-gravity calculation results cannot be acquired.	
Center-of-gravity calculation mode	Using SPI, the center-of-gravity position coordinates are calculated from the projection data for output. The center-of-gravity calculation result is not updated (projection data is output) when center-of-gravity calculation mode is off.	
Automatic tracking mode	Readout region centered on the maximum output pixel is set automatically.	

Data acquisition function

Acquire projection data



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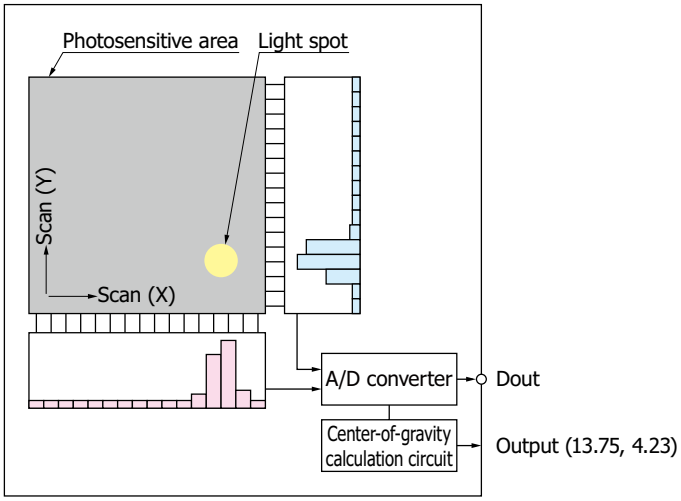
Projection data is output in serial format from the Dout terminal. By analyzing this data, it is possible to obtain information such as luminance, position, and movement.

Center-of-gravity calculation mode



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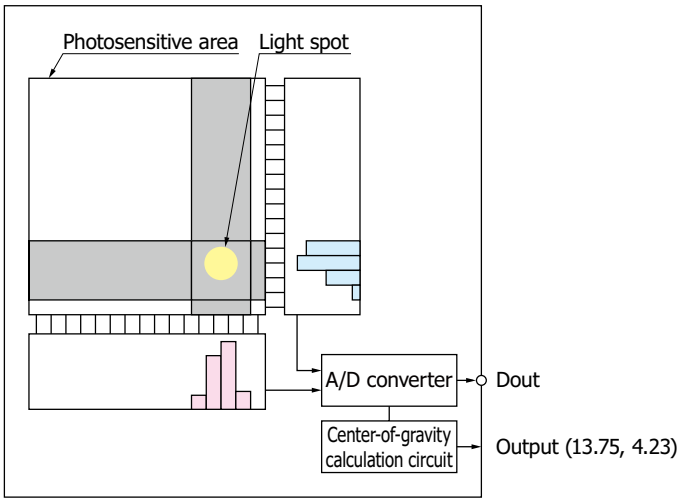
Center-of-gravity calculation results can be obtained with the use of SPI. The update cycle for projection data is determined by the Vsync pulse timing. In order to improve position accuracy, it is necessary to check projection data in the X and Y directions output from the Dout terminal first, then set the partial readout region, the number of pixels, the threshold, the integration time, and the gain for the center-of-gravity calculation, etc.

Center-of-gravity calculation mode and automatic tracking mode



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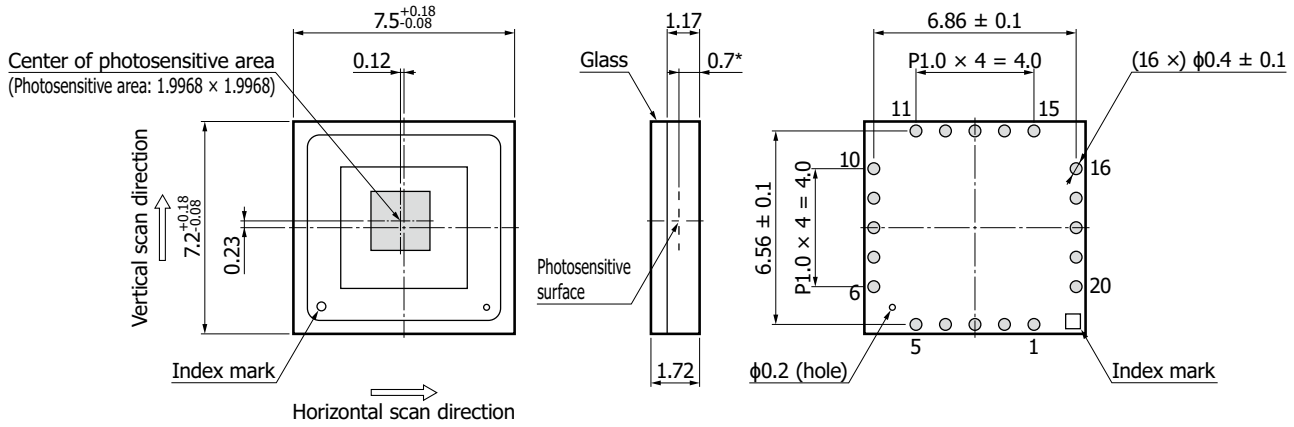
By setting the automatic tracking mode together with the center-of-gravity calculation mode, incident position coordinates of the light spot are output at high speed. Partial readout pixels (number of pixels is adjustable) around the incident position move depending on movement of the light spot. This results in higher speed response compared to all pixel readout.

Dimensional outlines (unit: mm)

S15366-256



Tolerance unless otherwise noted: ±0.2
* Distance from package bottom to photosensitive surface

Note: Do not do cleaning or vapor phase soldering, as cleaning liquid or water may get inside the package through the hole on the bottom of the package.

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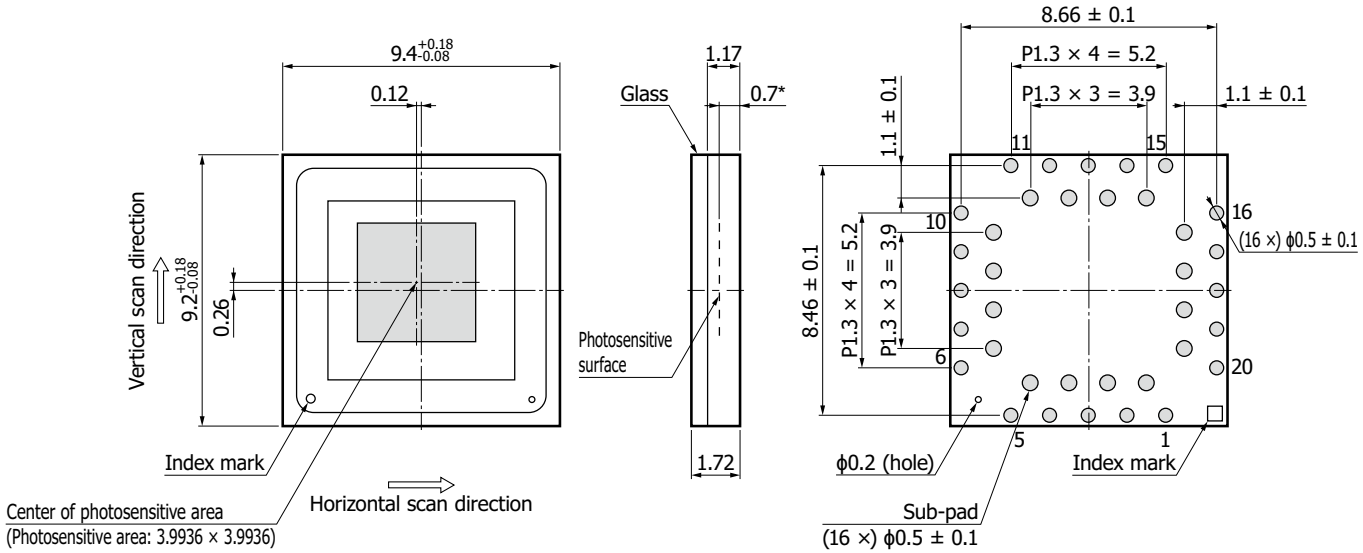
S15366-512



Tolerance unless otherwise noted: ±0.2
* Distance from package bottom to photosensitive surface

Note:
· Connect all 16 sub-pads to a ground.
· Do not do cleaning or vapor phase soldering, as cleaning liquid or water may get inside the package through the hole on the bottom of the package.

KMPDA0637EA

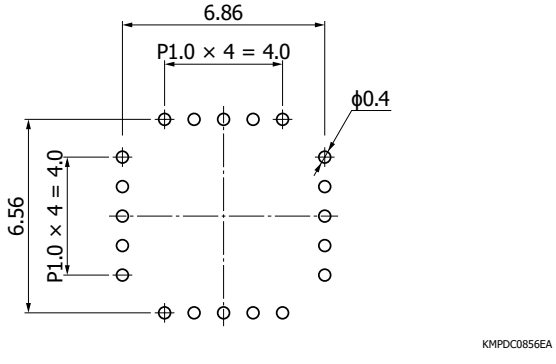
Pin connections

Pin no.	Symbol	I/O	Description
1	GND	I	Ground
2	Vdd(D)	I	Digital supply voltage*27
3	SPI_MISO	O	SPI output signal*28
4	SPI_CS	I	SPI enable signal
5	SPI_SCLK	I	SPI clock signal
6	SPI_MOSI	I	SPI input signal
7	SPI_RSTB	I	SPI reset signal
8	Vref1	O	Bias voltage*29 *30
9	Vref2	O	Bias voltage*29 *30
10	Vref3	O	Bias voltage*29 *30
11	Vref4	O	Bias voltage*29 *30
12	Vref5	O	Bias voltage*29 *30
13	Vdd(A)	I	Analog supply voltage*27
14	Dout	O	Video output signal
15	Pclk	O	Video output sync signal
16	Vsync	O	Frame sync signal
17	Hsync	O	X/Y direction sync signal
18	MCLK	I	Master clock signal
19	MST	I	External trigger signal
20	TG_reset	I	Reset signal

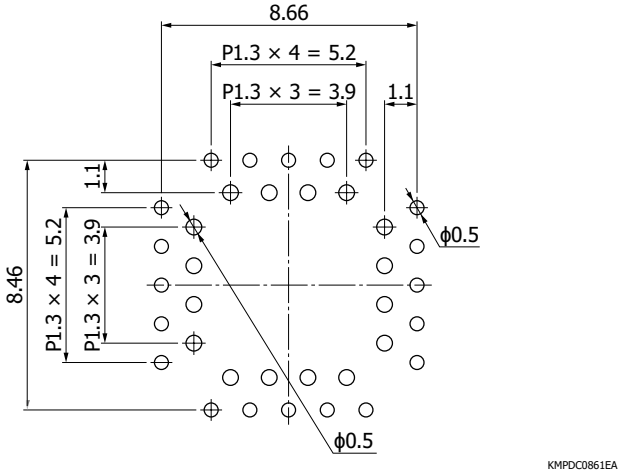
*27: Insert capacitors of about 1 µF and 10 µF.
*28: Outputs operating conditions of the sensor and the center-of-gravity calculation results. Center-of-gravity position coordinates are pixel no. + fixed point information.
*29: To reduce noise, insert a 1 µF capacitor between each terminal and GND.
*30: A terminal for monitoring the bias voltage generated inside the chip

Recommended land patterns (unit: mm)

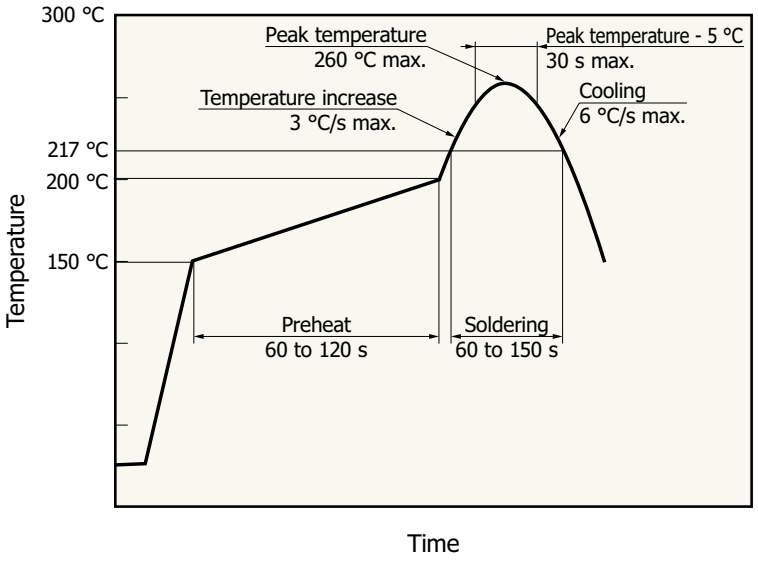
S15366-256



S15366-512



Recommended reflow soldering conditions (typical example)



· This product supports lead-free soldering. After unpacking, store it in an environment at a temperature of 30 °C or less and a humidity of 60% or less, and perform soldering within 4 weeks.
· The effect that the product receives during reflow soldering varies depending on the circuit board and reflow oven that are used (steam method is unacceptable). When you set reflow soldering conditions, check that problems do not occur in the product by testing out the conditions in advance.

Precautions

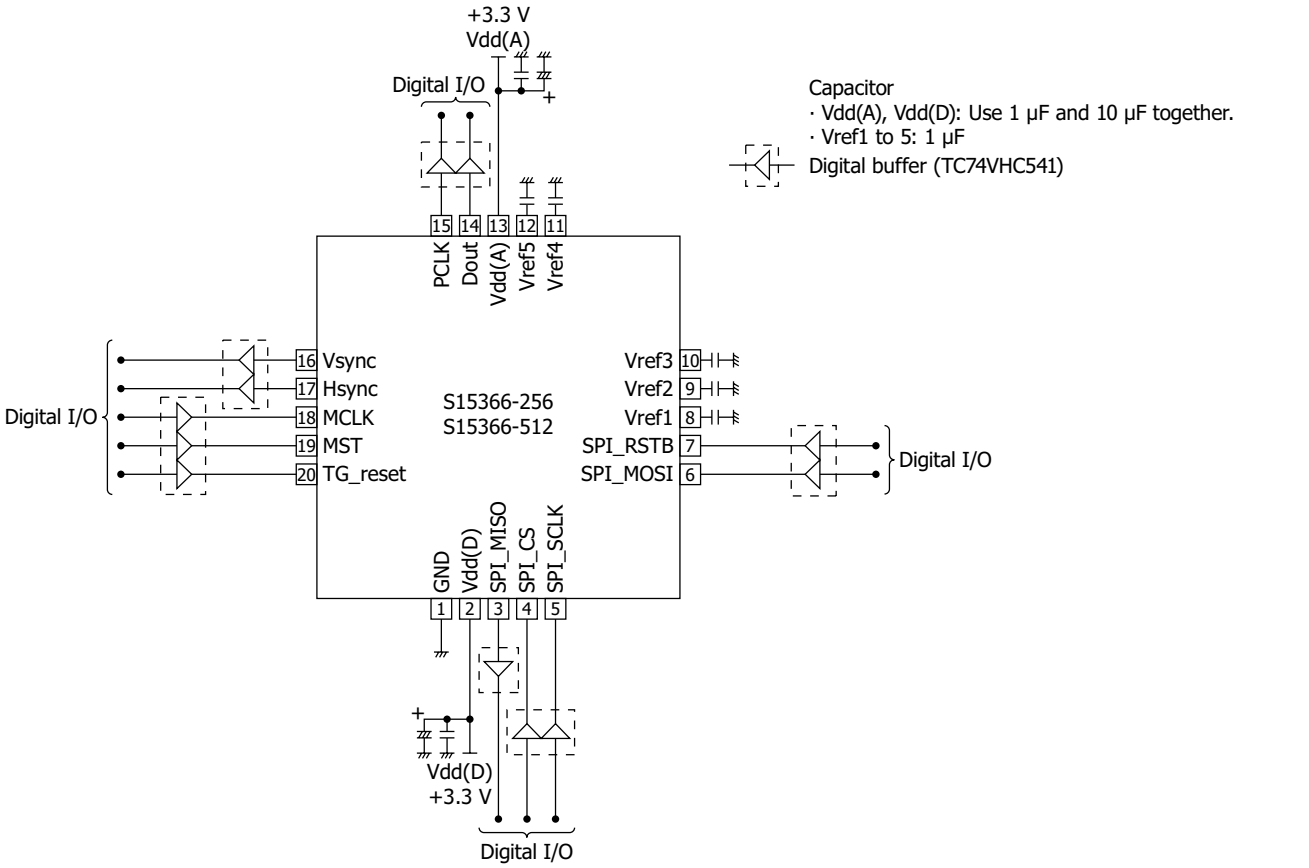
(1) Electrostatic countermeasures
This device has a built-in protection circuit against static electrical charges. However, to prevent destroying the device with electrostatic charges, take countermeasures such as grounding yourself, the workbench, and tools to prevent static discharges. Also protect this device from surge voltages which might be caused by peripheral equipment.

(2) Input window
If dust or stain adheres to the surface of the input window glass, it will appear as black spots on the image. When cleaning, avoid rubbing the window surface with dry cloth, dry cotton swab or the like, since doing so may generate static electricity. Use soft cloth, a cotton swab, or the like moistened with alcohol to wipe off dust and stain. Then blow compressed air so that no stain remains.

(3) UV light irradiation
This product is not designed to resist characteristic deterioration under UV light irradiation. Do not apply UV light to it.

(4) Cleaning, vapor phase soldering
Do not do cleaning or vapor phase soldering, as cleaning liquid or water may get inside the package through the hole on the bottom of the package.

Connection circuit example



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Related information

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

■ Precautions
· Disclaimer
· Image sensors
· Surface mount type products

■ Technical note
· Profile sensors S15366 series

The content of this document is current as of July 2024.
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.

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