

Color sensor

S11059-01WT

I²C interface-compatible color sensor

The S11059-01WT is a color sensor that supports the I²C (inter-integrated circuit) interface. It is sensitive to red ($\lambda=615$ nm), green ($\lambda=530$ nm), blue ($\lambda=460$ nm), and infrared ($\lambda=855$ nm) light, and outputs detected results as 16-bit digital data for each color. The photodiode for each color is automatically switched sequentially to perform measurements. The sensitivity and integration time can be adjusted so that light measurements can be performed over a wide range.

Features

- I²C interface compatible
- Sequential measurements of red, green, blue, and infrared light
- 2-step sensitivity switching (sensitivity ratio 1 : 10)
- Sensitivity adjustment by setting the integration time
- Low voltage (2.5 V or 3.3 V) operation
- Low current consumption: 75 μ A typ.
- Small package (WL-CSP: wafer level-chip size package)
- Internal infrared-cut filter
- Wide dynamic range (Low gain: 1 to 10 k \times)

Applications

- LCD backlight adjustment for cell phones, notebook PC, etc.
- Energy-saving sensor for large-size TV, etc.
- Various types of light detection or color adjustment

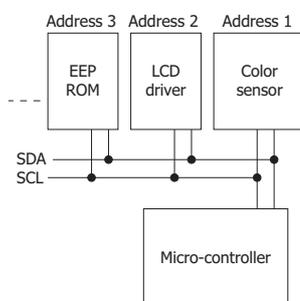
Feature 01 I²C interface-compatible to allow direct connection to micro-controller

The sensor supports the I²C interface and so can exchange data with the micro-controller using two signal lines jointly usable with other devices. The digital output makes it easy to install into electronic devices such as cell phones and flat-panel TVs whose micro-controller is compatible with the I²C interface. The sensor supports I²C Fast mode (400 kHz) and operates on 2.25 to 3.63 V.

Feature 02 WL-CSP makes the device even smaller and highly reliable

The WL-CSP measures only 1.18 × 1.68 × 0.58 mm and lead-free reflow solder (260 °C) can be used.

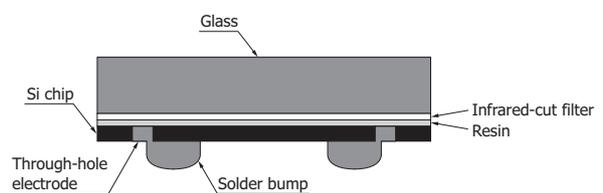
Connection example of I²C interface



SDA: serial data
SCL: serial clock

KPIC00164EA

Cross section of WL-CSP



KPIC00171EA

▣ Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vdd		-0.3 to +6	V
Load current	Io		±10	mA
Power dissipation	P		100	mW
Operating temperature	Topr	No dew condensation*1	-40 to +85	°C
Storage temperature	Tstg	No dew condensation*1	-40 to +100	°C
Reflow soldering conditions*2	Tsol		Peak temperature 260 °C max., 3 times	-

*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: Moisture absorption and reflow conditions: JEDEC J-STD-020D LEVEL2a

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	Condition	Min.	Typ.	Max.	Unit
Supply voltage	Vdd		2.25	-	3.63	V
High level input voltage (SDA, SCL)*3	Vih		0.7Vdd	-	Vdd + 0.5	V
Low level input voltage (SDA, SCL)*3	Vil		-0.5	-	0.2Vdd	V
Bus capacitance (SDA, SCL)	Cbus		-	-	400	pF

*3: Set so that Vdd=Vbus. Normal operation cannot be guaranteed unless used with this condition.

▣ Electrical and optical characteristics

■ Sensor section [Ta=25 °C, Vdd=3.3 V, A light source, unless otherwise noted (initial setting: low gain, integration time: 546 ms/ch)]

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit		
Spectral response range*4	λ	Blue		400 to 540		nm		
		Green		455 to 630				
		Red		575 to 660				
		Infrared, more than 700 nm		785 to 885				
Peak sensitivity wavelength	λ_p	Blue	-	460	-	nm		
		Green	-	530	-			
		Red	-	615	-			
		Infrared, more than 700 nm	-	855	-			
Current consumption	Operating mode	Idd	E=0 lx (dark state), excluding output current	30	75	150	μ A	
	Standby mode	Idds		0.1	1.0	3.0		
Dark count	Sd	E=0 lx (dark state)	-	-	5	counts		
Gain ratio	rg	High gain/Low gain	-	10	-	-		
Photo sensitivity	Low gain	Sbl	Blue	Initial setting	2.01	3.35	4.69	counts/lx
		Sgl	Green		4.57	7.61	10.66	
		Srl	Red		5.69	9.48	13.28	
		Sirl	Infrared		-	1.66	-	
		Sbl	Blue	Initial setting*5	2.51	3.35	4.19	
		Sgl	Green		5.71	7.61	9.52	
		Srl	Red		7.11	9.48	11.85	
		Sirl	Infrared		-	1.66	-	
Red/Blue sensi. ratio	Low gain	Srl/Sbl	Initial setting	2.12	2.83	3.54	-	
Red/Green sensi. ratio		Srl/Sgl	Same chip	0.93	1.25	1.56		
Blue/Green sensi. ratio		Sbl/Sgl		0.33	0.44	0.55		
Photo sensitivity	High gain	Sbh	Blue	Integration time 546 ms/ch	19.0	31.7	44.4	counts/lx
		Sgh	Green		45.7	76.2	106.7	
		Srh	Red		56.7	94.5	132.4	
		Sirh	Infrared		-	15.3	-	
		Sbh	Blue	Integration time 546 ms/ch*5	23.8	31.7	39.7	
		Sgh	Green		57.2	76.2	95.3	
		Srh	Red		70.9	94.5	118.2	
		Sirh	Infrared		-	15.3	-	
Red/Blue sensi. ratio	High gain	Srh/Sbh	Integration time 546 ms/ch	2.24	2.98	3.73	-	
Red/Green sensi. ratio		Srh/Sgh	Same chip	0.93	1.24	1.55		
Blue/Green sensi. ratio		Sbh/Sgh		0.31	0.42	0.52		
Integration time	-	-	Integration time setting (Tint) "00"	105	175	245	μ s	

*4: Relative sensitivity=more than 10%

*5: Integration time is measured and corrected. See "Compensation method for sensitivity variation". Integration time measurement accuracy is 0.36%.

■ I²C section (Ta=25 °C, Vdd=3.3 V, unless otherwise noted)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
I ² C address	ADDR	7 bits	0x2A (0101010)			
I ² C clock frequency	fclk		1	-	400	kHz
SDA, SCL output voltage	High level	Voh	Rp=2.2 kΩ	0.7Vbus	-	V
	Low level	Vol	Rp=2.2 kΩ	0	0.4	V
Input/output terminal capacitance	Ci		-	-	20	pF
SDA/SCL output fall time*6	tf	Rp=2.2 kΩ, Cp=400 pF	-	-	250	ns

*6: SCL/SDA output rise time is determined by a time constant of Cbus × Rp.

Note: The I²C interface (SDA, SCL) timings conform to the "I²C bus specification version 2.1".

Register map

Adrs	Function	bit								
		7	6	5	4	3	2	1	0	
00	Control	ADC reset 1: Reset 0: Operation	Standby function 1: Standby mode 0: Operating mode	Standby function monitor	-	Gain selection 1: High gain 0: Low gain	Integration mode 1: Manual setting mode 0: Fixed period mode	Integration time setting (00) 87.5 μs, (01) 1.4 ms (10) 22.4 ms, (11) 179.2 ms		
01	Manual timing register	Integration time manual setting register (MSB)								
02		Integration time manual setting register (LSB)								
03	Sensor data register	Output data (red, MSB)								
04	(red)	Output data (red, LSB)								
05	Sensor data register	Output data (green, MSB)								
06	(green)	Output data (green, LSB)								
07	Sensor data register	Output data (blue, MSB)								
08	(blue)	Output data (blue, LSB)								
09	Sensor data register	Output data (infrared, MSB)								
0A	(infrared)	Output data (infrared, LSB)								

Adrs 00 bit 7: Asserting this bit to "1", the ADC block is reset. The register data is not reset. To start the operation, set this bit to "0".

Adrs 00 bit 6: Asserting this bit to "1" the device goes into standby mode. The ADC block stops its operation. The register data is not reset. To start the operation, set this bit to "0".

Adrs 00 bit 5: This monitors auto standby function. "1" means standby mode. This is read only.

Adrs 00 bit 3: Gain selection bit. "1" is high gain mode and "0" is low gain mode. This bit is selecting the photodiode area. The size ratio of high gain photodiode area and low gain photodiode area is 10 : 1. Therefore the gain ratio is 10 times from low to high.

Adrs 00 bit 2: Asserting this bit to "1", the device goes into manual setting mode. Deasserting this bit to 0, goes into fixed period mode. In manual setting mode, the S11059-01WT automatically goes to standby mode after a measurement is made. In fixed period mode, measurements are continuously repeated.

Adrs 00 bit 1,0: These bits select the period of internal basis clock. The period is equal to integration time per color in fixed period mode. "00" is 87.5 μs, "01" is 1.4 ms, "10" is 22.4 ms, "11" is 179.2 ms. In manual setting mode, "00" is 175 μs, "01" is 2.8 ms, "10" is 44.8 ms, "11" is 368 ms. The integration time per color is set to multiple value (Adrs 01 & 02) with the period.

Adrs 01 & 02: This is a multiple value setting in manual setting mode, and can be set to a minimum of 0x0000 and a maximum of 0xFFFF (65535). This is used to set how far to expand the integration time per color which specified by "Integration time setting" (Tint). For example, if you want to set the integration time per color to 546 ms, set 175 μs by Tint="00" and then set this register to N=3120 (0xC30).

Mode	Manual timing register (Adrs 01 & 02)	Integration time setting (Tint)			
		00	01	10	11
Fixed period mode	Disabled	87.5 μs	1.4 ms	22.4 ms	179.2 ms
Manual setting mode	N	175 × N μs	2.8 × N ms	44.8 × N ms	358.4 × N ms

Adrs 03 to 0A: These bytes are register for sensor data. S11059-01WT measurement result is stored in these registers when the I²C command is changed to read mode. The values are kept until next read cycle.

Initial setting [Low gain, manual setting mode, Tint=00 (175 μs), integration time 546 ms/ch]

Adrs	Function	bit								Hex
		7	6	5	4	3	2	1	0	
00	Control	1	1	1	-	0	1	0	0	0xE4
01	Manual timing register	0	0	0	0	1	1	0	0	0x0C
02		0	0	1	1	0	0	0	0	0x30

Program example

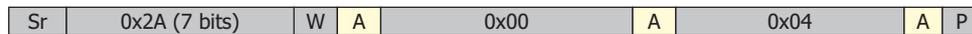
Condition 1: Initial setting [manual setting mode, low gain, Tint=00 (175 μ s), integration time 546 ms/ch (0x0C30 is set in manual timing register)]

Command

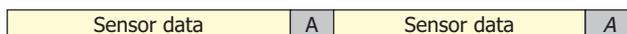
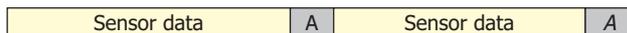
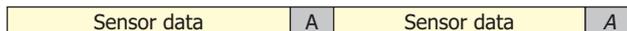
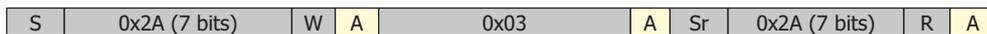
Action		Data body								Ack	Remark
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Register write (0x84)		1	0	0	0	0	1	0	0	A	ADC reset, standby disabled
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	Restart, address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Register write (0x04)		0	0	0	0	0	1	0	0	A	P ADC reset disabled, bus release
Wait longer than integration time (>2184 ms)											
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x03)		0	0	0	0	0	0	1	1	A	Calls output data byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	R	A	Changes to read mode
Data read out (R: MSB)		X	X	X	X	X	X	X	X	A	Red data output
Data read out (R: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (G: MSB)		X	X	X	X	X	X	X	X	A	Green data output
Data read out (G: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (B: MSB)		X	X	X	X	X	X	X	X	A	Blue data output
Data read out (B: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (Infrared: MSB)		X	X	X	X	X	X	X	X	A	Infrared data output
Data read out (Infrared: LSB)		X	X	X	X	X	X	X	X	\bar{A} P	

S=Start condition, Sr=Restart condition, A=Acknowledge, \bar{A} =Acknowledge by host, P=Stop condition, R=Read mode (1), W=Write mode (0), \bar{A} =not acknowledge

Format



Wait



from master to slave from slave to master

Condition 2 [fixed period mode, high gain, Tint=01 (1.4 ms), integration time 1.4 ms/ch]

■ Command

Action		Data body							Ack	Remark	
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Register write (0x89)		1	0	0	0	1	0	0	1	A	ADC reset, standby disabled
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Resistor write (0x09)		0	0	0	0	1	0	0	1	A	P ADC reset disabled, bus release
Wait longer than integration time (> 5.6 ms). Within this period, repeat measurement is continued.											
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x03)		0	0	0	0	0	0	1	1	A	Calls output data byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	R	A	Changes to read mode
Data read out (R: MSB)		X	X	X	X	X	X	X	X	A	Red data output
Data read out (R: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (G: MSB)		X	X	X	X	X	X	X	X	A	Green data output
Data read out (G: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (B: MSB)		X	X	X	X	X	X	X	X	A	Blue data output
Data read out (B: LSB)		X	X	X	X	X	X	X	X	A	
Data read out (Infrared: MSB)		X	X	X	X	X	X	X	X	A	Infrared data output
Data read out (Infrared: LSB)		X	X	X	X	X	X	X	\bar{A}	P	

S=Start condition, Sr=Restart condition, A=Acknowledge, A=Acknowledge by host, P=Stop condition, R=Read mode(1), W=Write mode(0), \bar{A} =not acknowledge

■ Format

S	0x2A (7 bits)	W	A	0x00	A	0x89	A
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Sr	0x2A (7 bits)	W	A	0x00	A	0x09	A	P
----	---------------	---	---	------	---	------	---	---

Wait

S	0x2A (7 bits)	W	A	0x03	A	Sr	0x2A (7 bits)	R	A
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Sensor data	A	Sensor data	A
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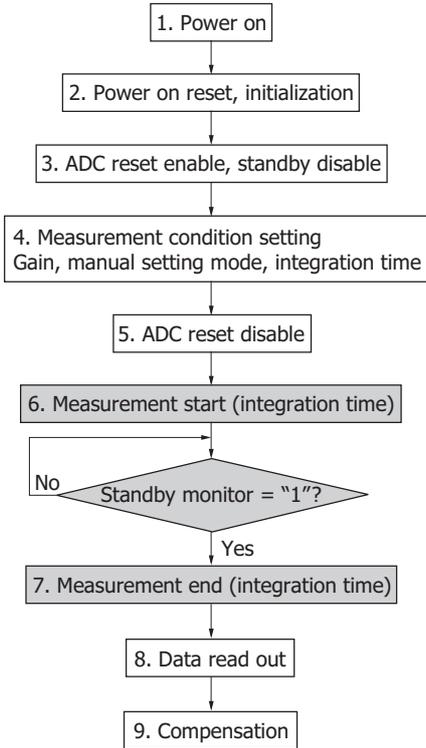
Sensor data	A	Sensor data	A
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Sensor data	A	Sensor data	A
-------------	---	-------------	---

Sensor data	A	Sensor data	\bar{A}	P
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from master to slave from slave to master

Compensation method for sensitivity variation



Sensitivity variation can be decreased using the compensation coefficient which is calculated from the integration time measurement result. Explanation of compensation method is shown as follows.

■ Integration time measurement method

In case of integration time measurement, it is necessary to set manual setting mode. The integration time measurement starts after "ADC reset" disabled. To measure the finishing integration time (measurement) T_{meas}, check "Standby monitor" bit until it becomes to "1".

■ Compensation method

The sensitivity compensation that used integration time is as follows:

$$K = \frac{T_{set}}{T_{meas}}$$

$$S' = S \cdot K$$

- K : compensation coefficient
- T_{set} : integration time (setting)
- T_{meas}: integration time (measurement)
- S : photo sensitivity (measurement)
- S' : photo sensitivity (compensation)

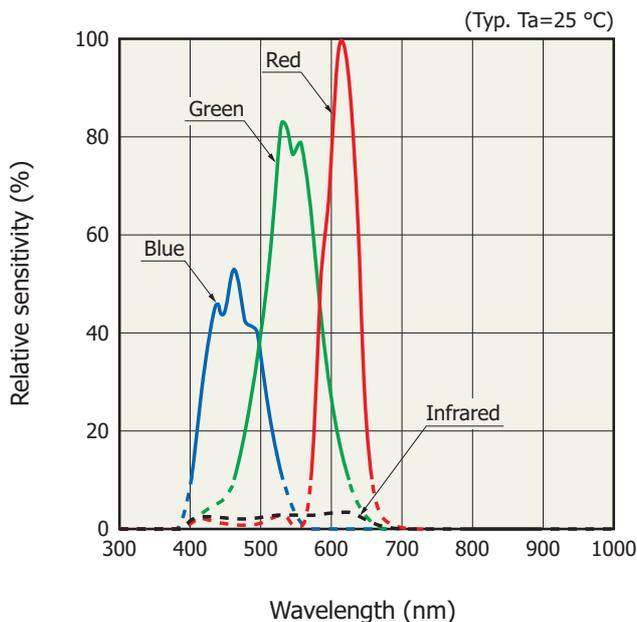
■ Measurement accuracy of integration time

The measurement minimum resolution of T_{meas} is defined by the looping duration (T_{unit}). In case of default setting, the T_{set} is 2184 ms and assuming the T_{unit} to 7.8 ms, the accuracy of integration time is calculated by following formula.

$$\frac{T_{unit}}{T_{set}} \times 100 = \frac{7.8}{2184} \times 100 = 0.36\%$$

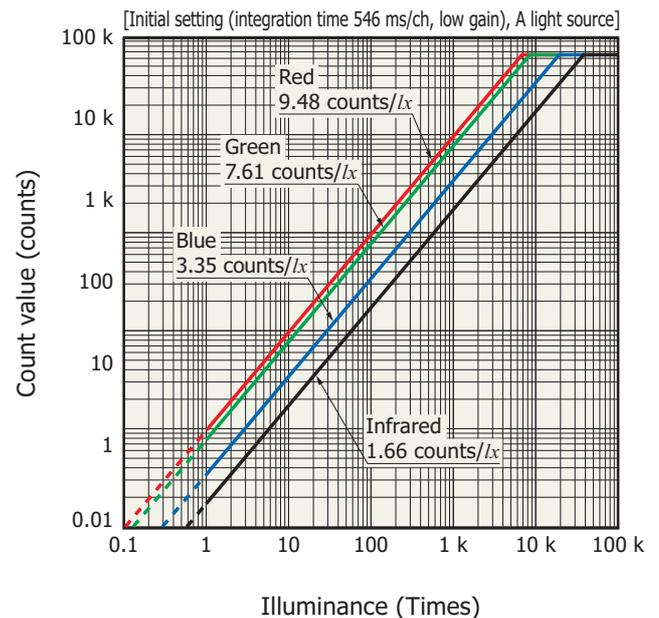
The specification of compensated sensitivity is defined as 0.36% accuracy.

Spectral response



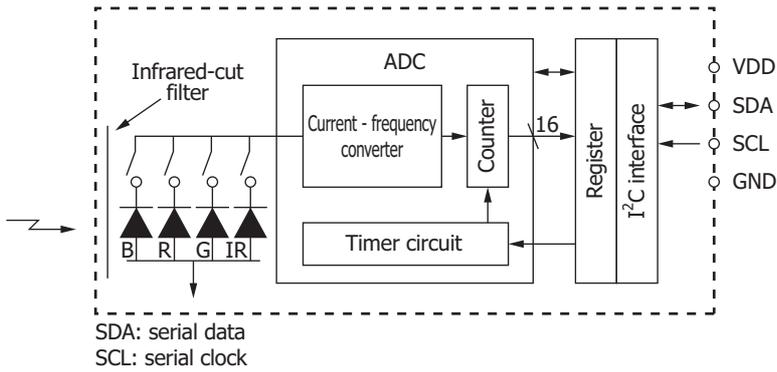
KPICB0132EA

Count value vs. illuminance (typical example)



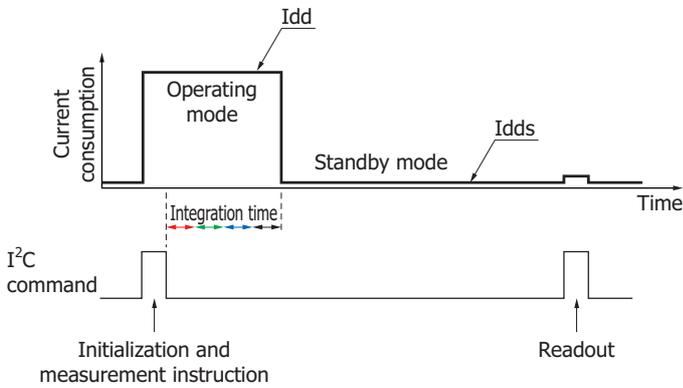
KPICB0130EC

Block diagram



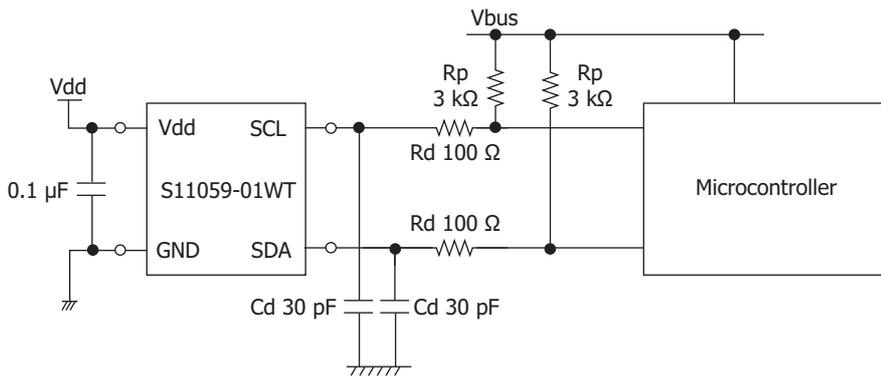
KPIC00152EA

Timing chart of standby function



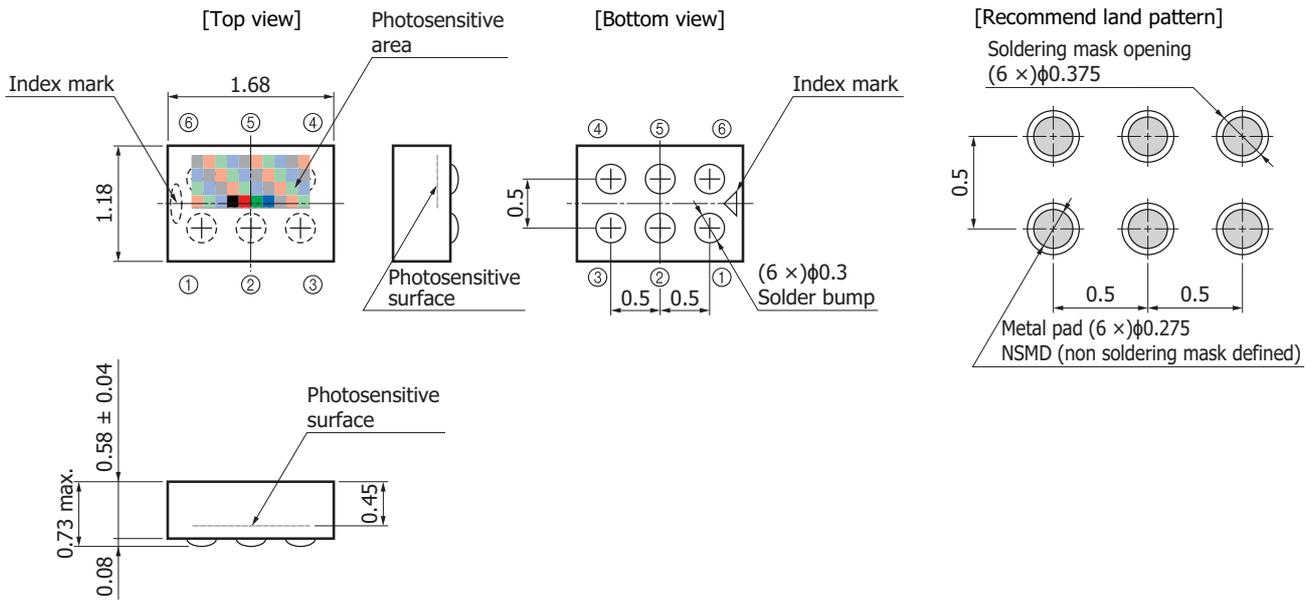
KPIC00158EA

Connection example



KPIC00174ED

Dimensional outline (unit: mm)

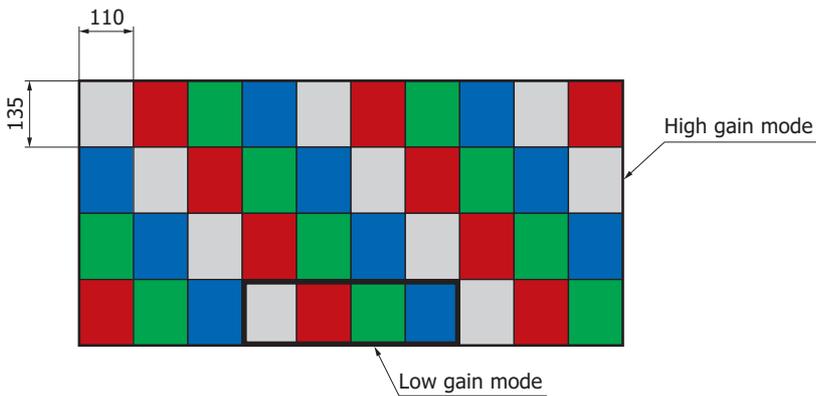


- ① Vdd
- ② NC
- ③ GND
- ④ SCL
- ⑤ NC
- ⑥ SDA

Tolerance unless otherwise noted: ±0.05

KPICA0081EC

Details of photosensitive area (unit: μm)



KPIC00153EA

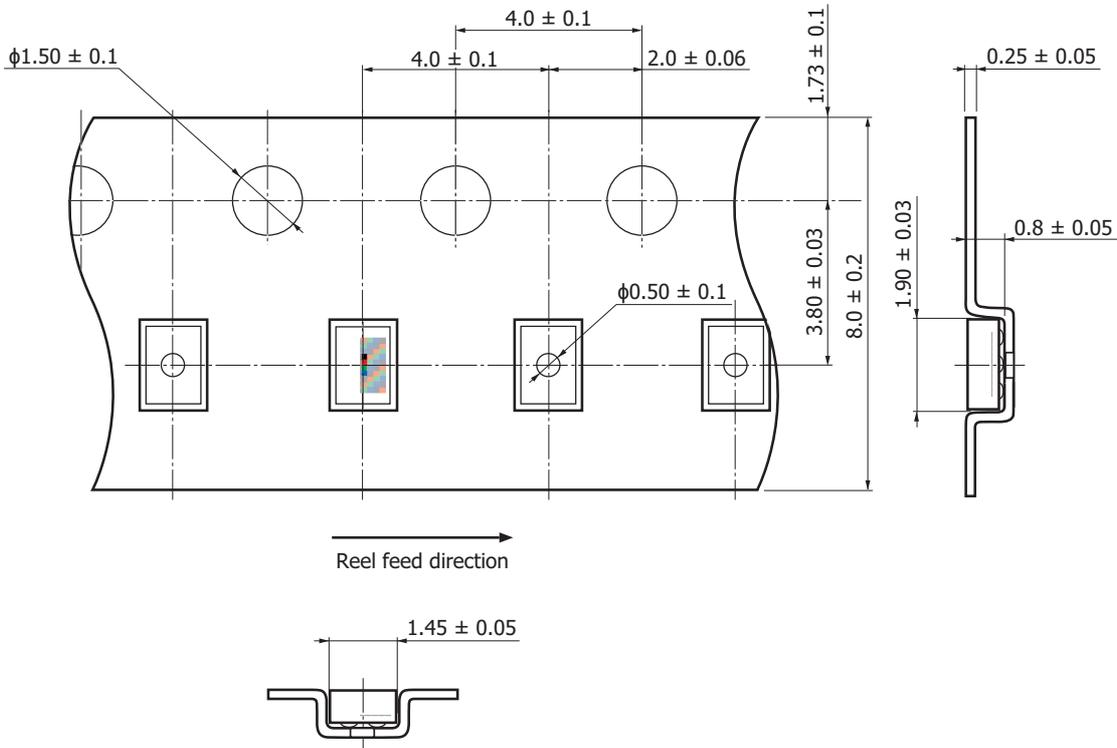
Note: When using this product, please request our technical information (S11059 series) and ensure appropriate design according to the information.

Standard packing specifications

■ Reel (conforms to JEITA ET-7200)

Dimension	Hub diameter	Tape width	Material	Electrostatic characteristics
180 mm	60 mm	8 mm	PS (polystyrene)	-

■ Embossed tape (unit: mm, material: PS, conductive)



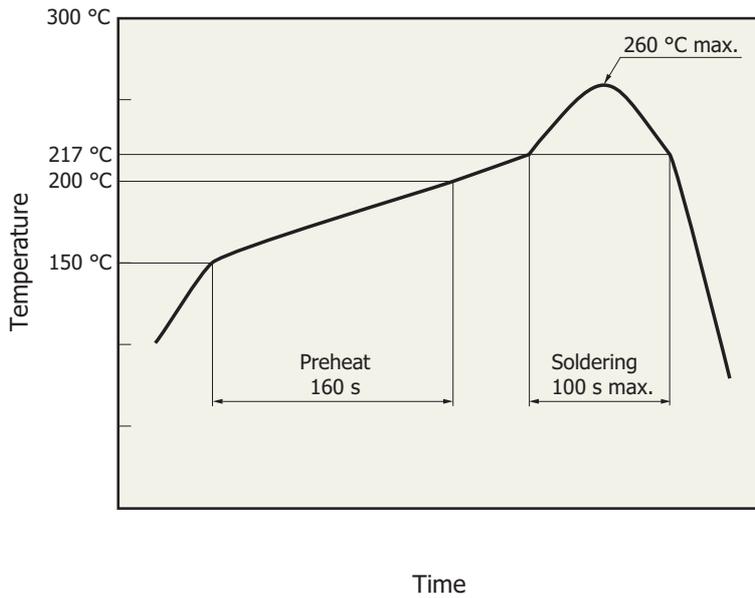
KPIC0196EA

■ Packing quantity

3000 pcs/reel

■ Packing type

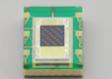
Reel and desiccant in moisture-proof packaging (vacuum-sealed)

Measured example of temperature profile with our hot-air reflow oven for product testing

KPICB0168EB

- 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 1 month.
- The effect that the product receives during reflow soldering varies depending on the circuit board and reflow oven that are used. Before actual reflow soldering, check for any problems by testing out the reflow soldering methods in advance.

Line-up of RGB color sensors

Type no.	Type	Photosensitive area (mm)	Package (mm)	Peak sensitivity wavelength (nm)		Photosensitivity				Photo		
				B	G	B	G	R	B		G	R
S9032-02	Photodiode	 $\phi 2.0$	4 × 4.8 × 1.8 ^t 6 pin (filter 0.75 ^t)	B	460	B	0.18 (A/W) [$\lambda=460$ nm]					
				G	540	G	0.23 (A/W) [$\lambda=540$ nm]					
				R	620	R	0.16 (A/W) [$\lambda=620$ nm]					
S9702	Photodiode	 1.0 × 1.0	3 × 4 × 1.3 ^t 4 pin (filter 0.75 ^t)	B	460	B	0.18 (A/W) [$\lambda=460$ nm]					
				G	540	G	0.23 (A/W) [$\lambda=540$ nm]					
				R	620	R	0.16 (A/W) [$\lambda=620$ nm]					
S10917-35GT	Photodiode	 1.0 × 1.0	3 × 1.6 × 1.0 ^t COB (on-chip filter)	B	460	B	0.2 (A/W) [$\lambda=460$ nm]					
				G	540	G	0.23 (A/W) [$\lambda=540$ nm]					
				R	620	R	0.17 (A/W) [$\lambda=620$ nm]					
S10942-01CT	Photodiode	 1.0 × 1.0	3 × 1.6 × 1.0 ^t COB (on-chip filter)	*		B	0.21 (A/W) [$\lambda=460$ nm]					
						G	0.25 (A/W) [$\lambda=540$ nm]					
						R	0.45 (A/W) [$\lambda=640$ nm]					
S9706	Digital photo IC	 1.2 × 1.2	4 × 4.8 × 1.8 ^t 6 pin (filter 0.75 ^t)	B	465	Low	B	0.21 (LSB/lx)	High	B	1.9 (LSB/lx)	
				G	540		G	0.45 (LSB/lx)		G	4.1 (LSB/lx)	
				R	615		R	0.64 (LSB/lx)		R	5.8 (LSB/lx)	
S11012-01CR	Digital photo IC	 1.2 × 1.2	3.43 × 3.8 × 1.6 ^t COB (on-chip filter)	*		Low	B	0.3 (LSB/lx)	High	B	2.6 (LSB/lx)	
							G	0.6 (LSB/lx)		G	5.3 (LSB/lx)	
							R	1.4 (LSB/lx)		R	12.9 (LSB/lx)	
S11059-02DT /-03DS	I ² C compatible color sensor	 0.56 × 1.22	3 × 4.2 × 1.3 ^t 10 pin (on-chip filter)	B	460	Low	B	4.4 (count/lx)	High	B	44.8 (count/lx)	
				G	530		G	8.3 (count/lx)		G	85.0 (count/lx)	
				R	615		R	11.2 (count/lx)		R	117.0 (count/lx)	
				IR	855		IR	3.0 (count/lx)		IR	30.0 (count/lx)	
S11059-01WT	I ² C compatible color sensor	 1.22 × 0.56	1.68 × 1.18 × 0.58 ^t WL-CSP (on-chip filter)	B	460	Low	B	3.35 (count/lx)	High	B	31.7 (count/lx)	
				G	530		G	7.61 (count/lx)		G	76.2 (count/lx)	
				R	615		R	9.48 (count/lx)		R	94.5 (count/lx)	
				IR	855		IR	1.66 (count/lx)		IR	15.3 (count/lx)	

* Refer to the spectral response of each product's datasheet.

Related information

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

Precautions

- Disclaimer
- Metal, ceramic, plastic package products
- Surface mount type products

Information described in this material is current as of August, 2015.

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.

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