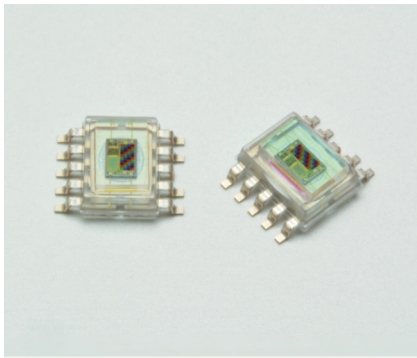


Color sensors



S13683-03DT/-04DS

I²C interface-compatible color sensor

The S13683-03DT/-04DS is a digital 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.
- With internal infrared-cut filter
- Wide dynamic range (Low gain: 1 to 10 k/x)
- Standard packing state
S13683-03DT: reel
S13683-04DS: stick

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

Absolute maximum ratings

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vdd	Ta=25 °C	-0.3 to +4.5	V
Output current	Io	Ta=25 °C	\pm 10	mA
Power dissipation	P	Ta=25 °C	300	mW
Operating temperature	Topt	No dew condensation*1	-40 to +85	°C
Storage temperature	Tstg	No dew condensation*1	-40 to +105	°C
Reflow soldering conditions*2	Tsol		Peak temperature 240 °C max., 1 time (see page 10)	-

*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 LEVEL5a

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 (Ta=25 °C unless otherwise noted)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	Vdd		2.25	-	3.63	V
I ² C bus pull-up voltage ^{*3}	Vbus	Rp=2.2 kΩ	1.65	-	Vdd + 0.5	V
High level input voltage (SDA, SCL) ^{*4}	Vih	Vbus≥2.25 V Vdd>2.75 V	0.7Vbus	-	Vdd + 0.5	V
		Vbus<2.25 V Vdd≤2.75 V	0.8Vbus	-	Vdd + 0.5	V
Low level input voltage (SDA, SCL) ^{*4}	Vil	Vbus≥2.25 V Vdd>2.75 V	-0.5	-	0.2Vbus	V
		Vbus<2.25 V Vdd≤2.75 V	-0.5	-	0.3Vbus	V
Bus capacitance (SDA, SCL)	Cbus		-	-	400	pF

*3: For details, see the I²C specifications, "The I²C-BUS SPECIFICATION VERSION 2.1".

*4: Vdd - Vbus<1.2 V

Operation is not guaranteed if this condition is not met.

Electrical and optical characteristics

■ Sensor section [Ta=25 °C, Vdd=Vbus=3.3 V, A light source, unless otherwise noted (initial setting: low gain, integration time: 546 ms/ch)]^{*5}

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit		
Spectral response range ^{*6}	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	λp	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	μA	
	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	-	-	
Photosensitivity	Low gain	Sbl	Blue	Initial setting	2.0	3.8	5.6	counts/lx
			Green		4.7	8.7	12.7	
			Red		6.8	12.4	18.0	
			Infrared		-	3.0	-	
		Sgl	Initial setting ^{*6}	Blue	2.8	3.8	4.8	
				Green	6.5	8.7	11.0	
				Red	8.6	12.4	16.2	
				Infrared	-	3.0	-	
Red/Blue sensi. ratio	Low gain	Srl/Sbl	Initial setting Same chip	2.4	3.2	4.0	-	
		Srl/Sgl		1.05	1.4	1.75		
		Sbl/Sgl		0.33	0.44	0.55		
Photosensitivity	High gain	Sbh	Integration time 546 ms/ch	Blue	22.0	40.0	58.0	counts/lx
				Green	47.0	86.0	125.0	
				Red	67.0	122.0	177.0	
				Infrared	-	30.0	-	
		Sgh	Integration time 546 ms/ch ^{*7}	Blue	30.0	40.0	50.0	
				Green	64.5	86.0	107.5	
				Red	85.0	122.0	159.0	
				Infrared	-	30.0	-	
Red/Blue sensi. ratio	High gain	Srh/Sbh	Integration time 546 ms/ch Same chip	2.25	3.0	3.75	-	
Srh/Sgh		1.05		1.40	1.75			
Sbh/Sgh		0.35		0.47	0.59			

*5: Provide light shielding so that no light enters from anywhere other than the top surface of the filter.

*6: Relative sensitivity=more than 10%

*7: 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	0.7 Vbus	-	V
	Low level	Vol	Rp=2.2 kΩ	0	0.4	V
Input/output terminal capacitance	Ci		-	-	20	pF
SDA/SCL output fall time*8	tf	Rp=2.2 kΩ, Cp=400 pF	-	-	250	ns

*8: 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 (red)	Output data (red, MSB)								
04		Output data (red, LSB)								
05	Sensor data register (green)	Output data (green, MSB)								
06		Output data (green, LSB)								
07	Sensor data register (blue)	Output data (blue, MSB)								
08		Output data (blue, LSB)								
09	Sensor data register (infrared)	Output data (infrared, MSB)								
0A		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 S11059-02DT 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. S11059-02DT measurement result is stored in these registers when the I²C command is changed to read mode. The values are kept until the next measurement 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

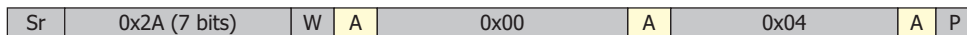
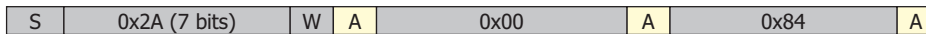
Condition 1: Initial setting [manual setting mode, low gain, Tint=00 (175 μs), integration time 546 ms/ch (0x0C30 is set in manual timing register)]

Command

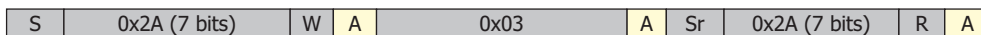
Action		Data body								Ack	Remark
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Register write (0x84)		1	0	0	0	0	1	0	0	A	ADC reset, standby disabled
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	Restart, address
Register call (0x00)		0	0	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}	

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

KPIC00334EA

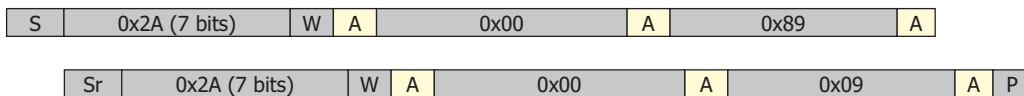
Condition 2 [fixed period mode, high gain, Tint=01 (1.4 ms), integration time 1.4 ms/ch]

■ Command

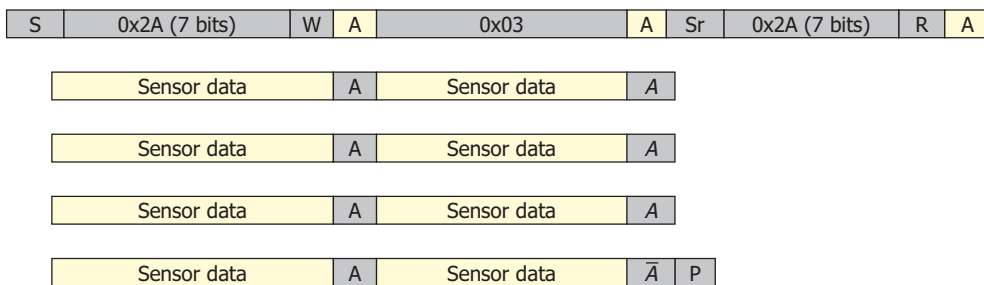
Action		Data body								Ack	Remark
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Calls control byte
Register write (0x89)		1	0	0	0	1	0	0	1	A	ADC reset, standby disabled
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x00)		0	0	0	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	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



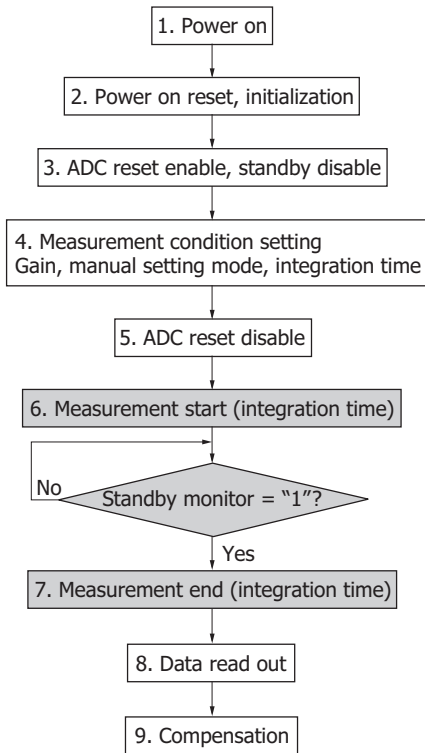
Wait



from master to slave from slave to master

KPIC0335EA

Compensation method for sensitivity variation



KPIC0336EA

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)

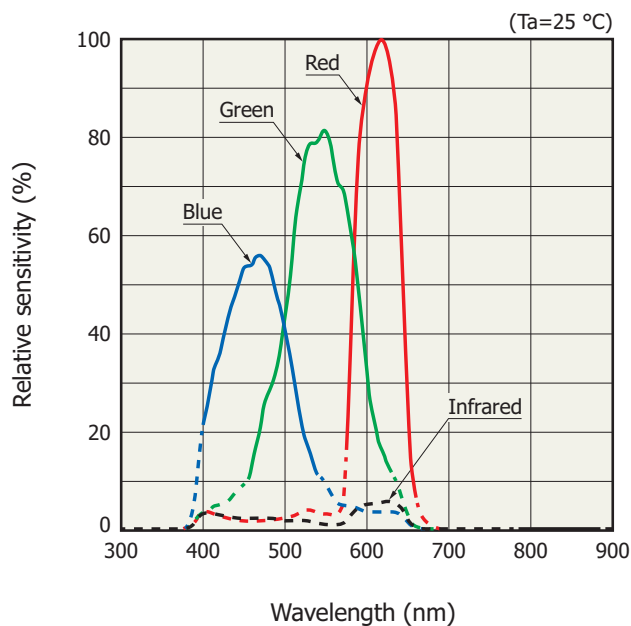
■ Measurement accuracy of integration time

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.

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

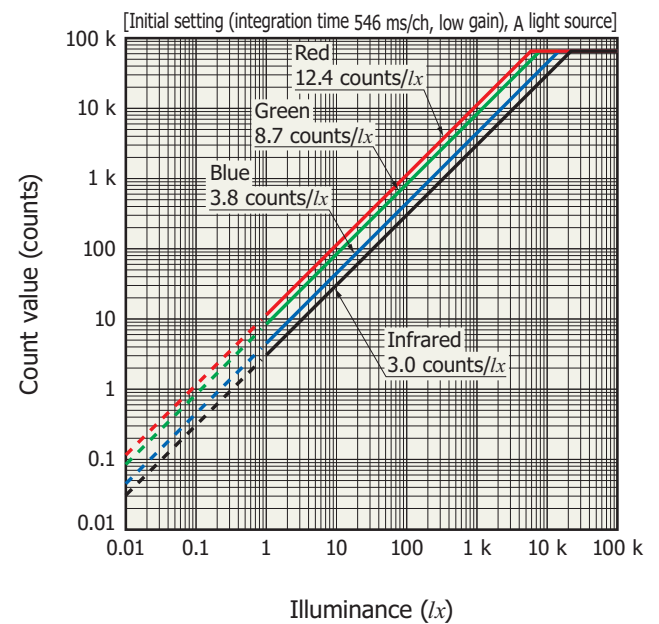
The specification of compensated sensitivity is defined as 0.36% accuracy.

Spectral response (typical example)



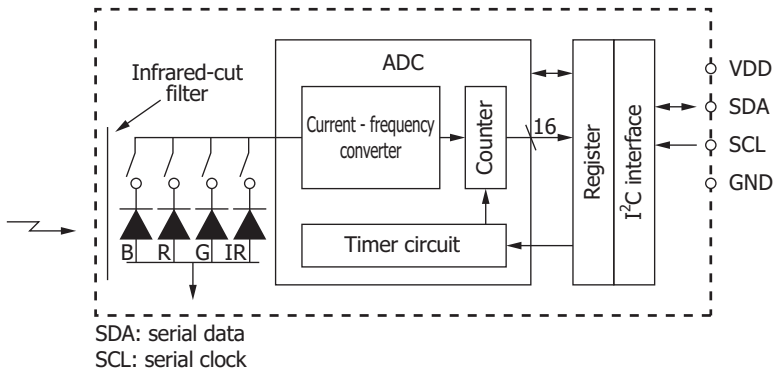
KPIC0251EA

Count value vs. illuminance (typical example)



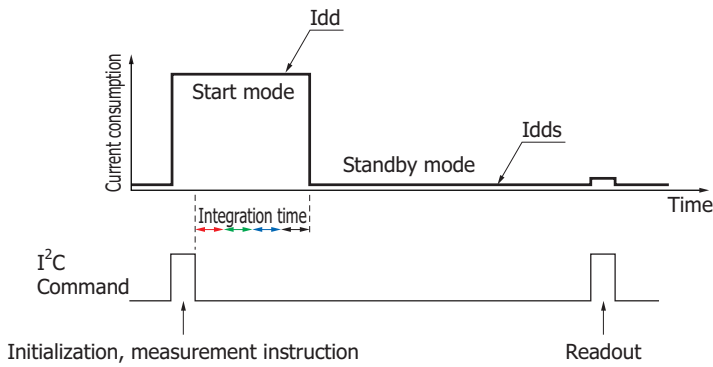
KPIC0252EA

Block diagram



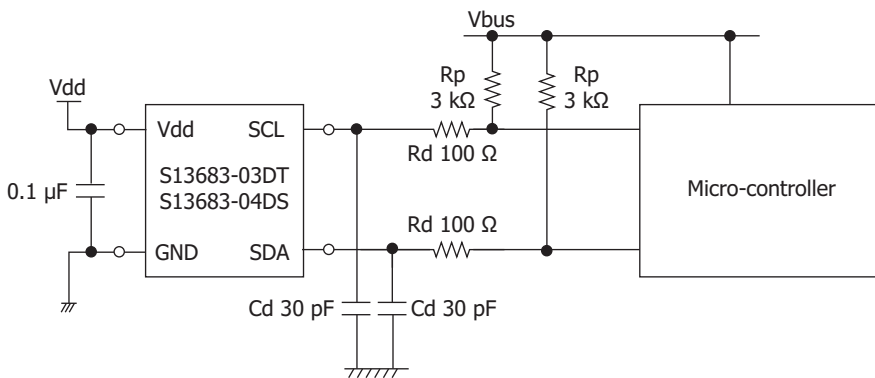
KPIC00152EA

Timing chart of standby function



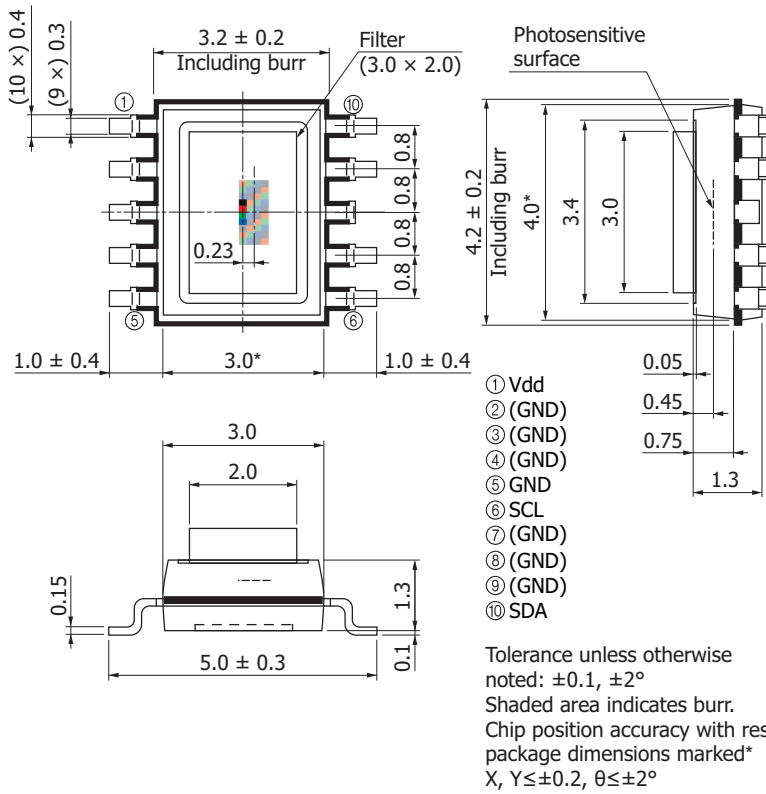
KPIC00158EA

Connection example



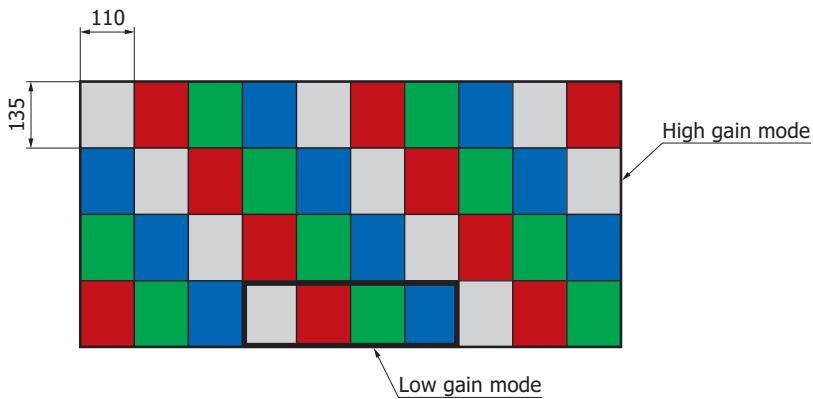
KPIC00339EA

Dimensional outline (unit: mm)



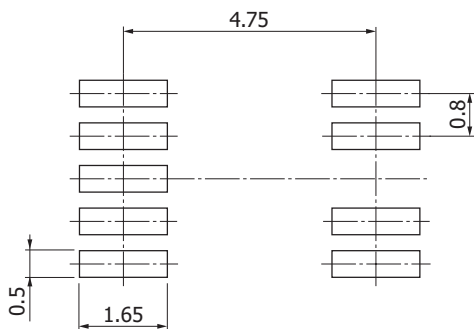
KPICA0111EB

Details of photosensitive area (unit: μm)



KPIC0153EA

Recommended land pattern (unit: mm)



KPIC0223EA

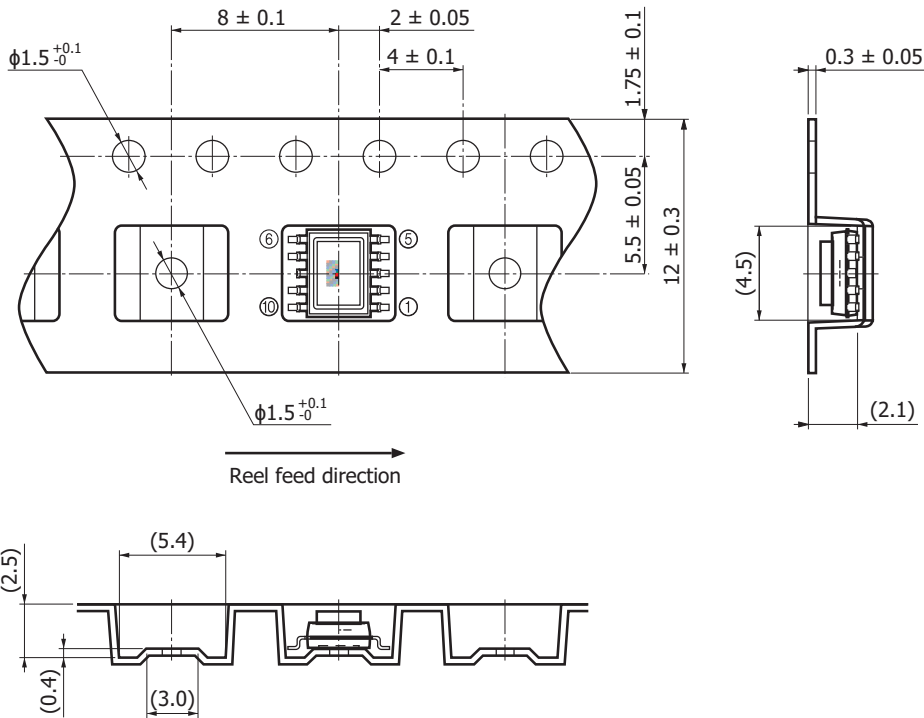
Standard packing specifications

S13683-03DT

■ Reel (conforms to JEITA ET-7200)

Dimension	Hub diameter	Tape width	Material	Electrostatic characteristics
254 mm	80 mm	12 mm	PS (polystyrene)	Conductive

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



KPIC00197EB

■ Packing quantity

1500 pcs/reel

■ Packing type

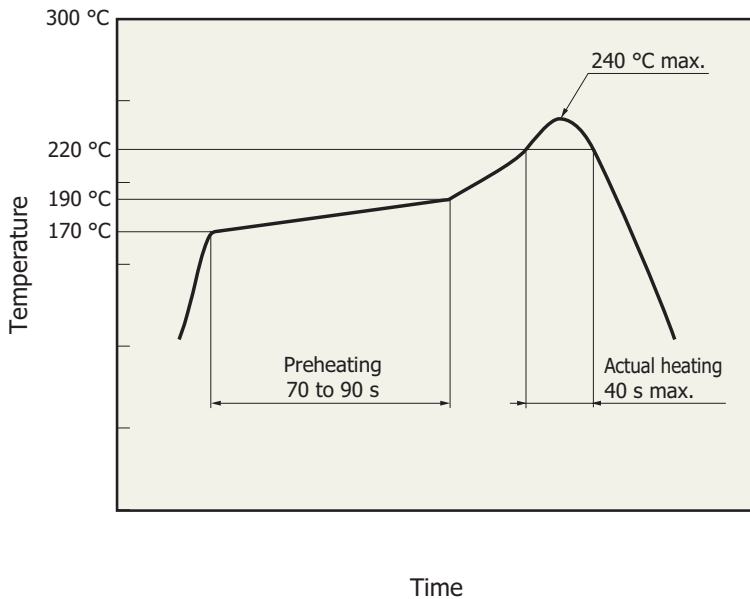
Reel and desiccant in moisture-proof packaging (vacuum-sealed)

S13683-04DS

■ Packing quantity/type

100 pcs/stick

Recommended reflow soldering condition



KPICB0164EC

- 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 24 hours.
- 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.

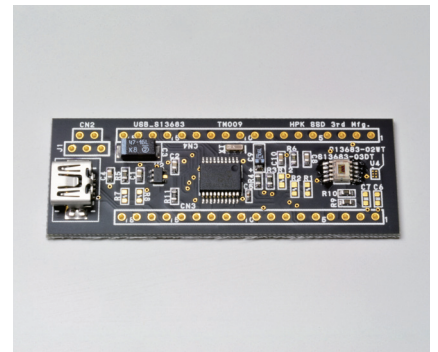
Related information

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

- Precautions
 - Disclaimer
 - Metal, ceramic, plastic packages
 - Surface mount type products

Evaluation kit for color sensors C15701-01

An evaluation kit [60 mm (H) × 21.5 mm (V)] for understanding the operating principle of Hamamatsu's S13683-03DT/-04DS color sensors is available (with S13683-03DT/-04DS). Contact us for detailed information.



Information described in this material is current as of May 2020.

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.

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HAMAMATSU

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HAMAMATSU PHOTONICS K.K., Solid State Division

1126-1 Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81)53-434-3311, Fax: (81)53-434-5184

U.S.A.: Hamamatsu Corporation: 360 Foothill Road, Bridgewater, N.J. 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218, E-mail: usa@hamamatsu.com

Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8, E-mail: info@hamamatsu.de

France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10, E-mail: infos@hamamatsu.fr

United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, United Kingdom, Telephone: (44)1707-294888, Fax: (44)1707-325777, E-mail: info@hamamatsu.co.uk

North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01, E-mail: info@hamamatsu.se

Italy: Hamamatsu Photonics Italia S.r.l.: Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41, E-mail: info@hamamatsu.it

China: Hamamatsu Photonics (China) Co., Ltd.: B1201, Jiaming Center, No.27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R.China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866, E-mail: hpc@hamamatsu.com.cn

Taiwan: Hamamatsu Photonics Taiwan Co., Ltd.: 8F-3, No. 158, Section2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081, E-mail: info@hamamatsu.com.tw