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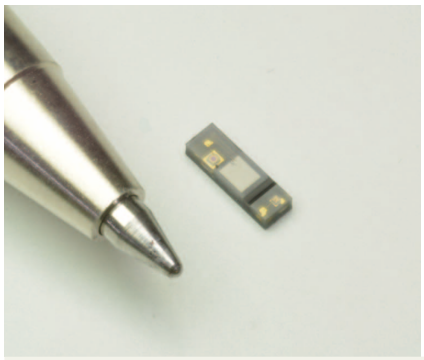
NEW

Near infrared/proximity type sensor



P13567-01CT

Reflective sensor with InGaAs photodiode and infrared LED housed in a compact package

This reflective sensor houses an InGaAs PIN photodiode and 1.45 µm band LED in a compact package. The LED irradiates infrared light on the target object, and the photodiode signal generated from the reflected light is output digitally through an I^2C interface.

Features

- **I^2C interface**
- **Low supply voltage: Vdd=2.25 V to 3.63 V**
- **I^2C bus voltage: 1.65 V**
- **Low current consumption**
- **Small package (5.5 × 1.7 × 1.0 mm)**
- **Supports lead-free reflow soldering**
- **Built-in 16-bit A/D converter**
- **Built-in LED driver**

Applications

- **Moisture level detection**
- **NIR (near infrared) photometry**

Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vdd		-0.3 to +4	V
Load current	Io		±10	mA
Power dissipation	P		100	mW
Operating temperature	Topr	No dew condensation*	-30 to +80	°C
Storage temperature	Tstg	No dew condensation*	-40 to +85	°C
Forward current	I_F		80	mA
Pulse forward current	I_{FP}	Duty ratio=1%, pulse width=10 µs	1	A
Reverse voltage	V_R		1	V
Reflow soldering conditions	Tsol	Moisture absorption and reflow conditions: JEDEC J-STD-020D LEVEL5a	Peak temperature: 260 °C max., 3 times	-

* 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.

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
I^2C bus pull-up voltage*1	Vbus	Rp=2.2 kΩ	1.65	-	Vdd + 0.5	V
High level input voltage	Vih	SDA, SCL	1.55	-	Vdd + 0.5	V
Low level input voltage	Vil	SDA, SCL	-0.5	-	0.3Vdd	V
Bus capacitance	Cbus	SDA, SCL	-	-	400	pF
Maximum incident light level	-	Light source A	-	-	100	*lx*

*1: The pull-up resistance is determined by the Cbus capacitance and Vbus voltage. Satisfy the following condition: Vdd - Vbus < 1.2 V.

Electrical and optical characteristics

■ Sensor section (Ta=25 °C, Vdd=Vbus=Vanode=3.3 V, LED: λp=1.45 μm, initial setting: high gain, integration time: 100 ms, unless otherwise noted)

Parameter		Symbol	Condition	Min.	Typ.	Max.	Unit
Spectral response range		λ		-	0.9 to 1.7	-	μm
Peak sensitivity wavelength		λp		-	1.55	-	μm
Current consumption	Operation mode	Iddc	E=0 *lx* (dark state), excluding output current	30	75	150	μA
	Standby mode	Idds		0.1	1.0	3.0	
Dark count (when LED is in standby)		Sd	Dark state, initial setting	-	-	10	counts
Dark count (when LED is being driven)		Sdl	Dark state LED driver: DC mode, 8 mA	0	3000	7500	counts
Sensitivity	High gain	Sh		22500	50000	80000	counts/mW
Sensitivity gain ratio	High/Low	-		4.8	-	7.9	times

■ I^2C section (Ta=25 °C, Vdd=Vbus=3.3 V, unless otherwise noted)

Parameter		Symbol	Condition	Min.	Typ.	Max.	Unit
I^2C address		ADDR	7-bit		0 × 2A		
I^2C clock frequency		fclk		1	-	400	kHz
SDA output voltage	High level	Voh	Rp=2.2 kΩ	0.8Vbus	-	-	V
	Low level	Vol	Rp=2.2 kΩ	0	-	0.4	V
I/O terminal capacitance		Ci		-	-	20	pF
SDA output fall time*2		tf	Rp=2.2 kΩ, Cp=400 pF	-	-	250	ns

*2: The SCL/SDA output rise time is determined by the time constant defined by Cbus × Rp.
Note: I^2C interface (SDA, SCL) timing complies with "The I^2C-bus specification version 2.1".

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Peak emission wavelength	λp	I_F=50 mA	1.4	1.45	1.5	μm
Spectral half width	Δλ	I_F=50 mA	-	120	170	nm
Radiant flux	ϕe	I_F=50 mA	1.8	2.4	-	mW
Forward voltage	V_F	I_F=50 mA	-	1.0	1.5	V
Reverse voltage	I_R	V_R=1 V	-	-	10	μA
Cutoff frequency*3	fc	I_F=50 mA ± 10 mAp-p	-	15	-	MHz
Rise time	tr	20% to 80%*4	-	22	-	μs
Fall time	tf	80% to 20%*4	-	27	-	μs

*3: Frequency at which the light output drops by 3 dB relative to the output at 100 kHz
*4: When I_F=8 mA in LED pulse mode

Register map

Adrs	Function	bit							
		7	6	5	4	3	2	1	0
00	RGB sensor control	Reset	Standby function	Standby function monitor	Register reset	Gain selection	Integration mode	Integration time setting	
01	Manual timing (high byte)	Manual timing (low byte)							
02	Manual timing (low byte)								
03	Output data (high byte)	Anode channel data (16 bits)							
04	Output data (low byte)								
05	-	Not used							
06	-								
07	-								
08	-								
09	-								
0A	-								
0B	-								
0C	-								
0D	-								
0E	LED drive control 1	LED reset	LED standby function	DC mode	1/10 mode				
0F	LED drive control 2	LED1 drive current selection							
10	Monitor		Standby function monitor						

Note: We recommend that the LEDs be used in DC mode.

■ Details of 00, 0E, 0F

Adrs		bit							
		7	6	5	4	3	2	1	0
00	Initial setting	Reset	Standby	Standby function monitor	Register reset	Gain	Integration mode	Integration time	
		1	1	-	1	0	1	0	0
	Function	0: Operation 1: reset	0: Operation 1: Standby	Readout only	0: Reset release 1: Address 03-0A Data reset	0: High gain 1: Low gain	0: Fixed time mode 1: manual setting mode	(00) 32 µs (01) 1 ms (10) 16.4 ms (11) 131 ms	
0E	Initial setting	LED reset	LED standby	DC mode	1/10 mode				
		1	1	0	0				
	Function	0: Operation 1: reset	0: Operation 1: Standby	0: Pulse mode 1: DC mode	0: Normal mode 1: 1/10 mode				
0F	Initial setting	LED drive current							
		0	0	0	0				
	Function	0: 0 mA 1: 64 mA	0: 0 mA 1: 32 mA	0: 0 mA 1: 16 mA	0: 0 mA 1: 8 mA				

Program example

Condition 1: Initial settings [manual setting mode, Tint=00 (32 µs), integration time=100 ms/ch (manual timing register set to 0x0C30)]

■ 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	Specifies the control byte
Register write (0x84)		1	0	0	0	0	1	0	0	A	ADC reset, standby release
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	Specifies the control byte
Register write (0x04)		0	0	0	0	0	1	0	0	A	P ADC reset release, bus release
Stands by for longer than the integration time (standby time > 400 ms)											
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x05)		0	0	0	0	0	1	0	1	A	Specifies the sensor data byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	R	A	Changes to read mode
Data read out (MSB)		X	X	X	X	X	X	X	X	*A*	Data output
Data read out (LSB)		X	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

The rest is the same as the above command list.

S	0x2A (7 bits)	W	A	0x00	A	0x84	A

Sr	0x2A (7 bits)	W	A	0x00	A	0x04	A	P

When the SCL clock is 400 kHz, the write time is 135 µs.

Standby

S	0x2A (7 bits)	W	A	0x05	A	Sr	0x2A (7 bits)	R	A

Sensor data	A	Sensor data	$\bar{A}$	P

The readout time is 112.5 µs.

from master to slave from slave to master

Condition 2: [Fixed time mode, Tint=01 (0.5 ms), integration time=1.0 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	Specifies the control byte
Register write (0x81)		1	0	0	0	0	0	0	1	A	ADC reset, standby release
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	Restart, bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Specifies the control byte
Register write (0x01)		0	0	0	0	0	0	0	1	A	P ADC reset release, bus release
Stands by for longer than the integration time. Measurement takes place during standby (standby time > 4 ms). Measurements are repeated continuously.											
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x05)		0	0	0	0	0	1	0	1	A	Specifies the sensor data byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	R	A	Changes to read mode
Data read out (infrared: MSB)		X	X	X	X	X	X	X	X	*A*	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, *A*=Acknowledge by host, P=Stop condition, R=Read mode (1), W=Write mode (0), $\bar{A}$=not acknowledge

■ Format

The rest is the same as the above command list.

S	0x2A (7 bits)	W	A	0x00	A	0x81	A

Sr	0x2A (7 bits)	W	A	0x00	A	0x01	A	P

When the SCL clock is 400 kHz, the write time is 135 µs.

Standby

S	0x2A (7 bits)	W	A	0x05	A	Sr	0x2A (7 bits)	R	A

Sensor data	A	Sensor data	$\bar{A}$	P

The readout time is 112.5 µs.

from master to slave from slave to master

Condition 3: [Manual setting mode, Tint=01 (0.5 ms), manual timing=357 (0x165), integration time=357 ms/ch, low gain]

■ 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	Specifies the control byte
Register write (0x8D)		1	0	0	0	1	1	0	1	A	ADC reset, standby release
Register write (0x01)		0	0	0	0	0	0	0	1	A	Manual timing high byte
Register write (0x65)		0	1	1	0	0	1	0	1	A	Manual timing low byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	Restart, 7-bit address
Register call (0x00)		0	0	0	0	0	0	0	0	A	Specifies the control byte
Register write (0x0D)		0	0	0	0	1	1	0	1	A	P ADC reset release, bus release
Stands by for longer than the integration time. Measurement takes place during standby (standby time > 1428 ms). Measurements are repeated continuously.											
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x05)		0	0	0	0	0	1	0	1	A	Specifies the sensor data byte
Address call (0x2A)	Sr	0	1	0	1	0	1	0	R	A	Changes to read mode
Data read out (MSB)		X	X	X	X	X	X	X	X	*A*	Data output
Data read out (LSB)		X	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

The rest is the same as the above command list.

S	0x2A (7 bits)	W	A	0x00	A	0x85	A

0x01	A	0x65	A

Sr	0x2A (7 bits)	W	A	0x00	A	0x0D	A	P

When the SCL clock is 400 kHz, the write time is 180 µs.

Standby

S	0x2A (7 bits)	W	A	0x05	A	Sr	0x2A (7 bits)	R	A

Sensor data	A	Sensor data	$\bar{A}$	P

The readout time is 112.5 µs.

from master to slave from slave to master

Condition 4: (LED drive DC mode, LED drive current=48 mA)

■ Command

· When starting operation

Action		Data body								Ack	Remark
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x0E)		0	0	0	0	1	1	1	0	A	Specifies the control byte
Register write (0xA0)		1	0	1	0	0	0	0	0	A	Standby release, DC mode
Register write (0x60)		0	1	1	0	0	0	0	0	A	Drive current
Address call (0x2A)	Sr	0	1	0	1	0	1	0	W	A	Restart, 7-bit address
Register call (0x0E)		0	0	0	0	1	1	1	0	A	Specifies the control byte
Register write (0x20)		0	0	1	0	0	0	0	0	A	P LED driver reset release, bus release

· When ending operation

Action		Data body								Ack	Remark
Address call (0x2A)	S	0	1	0	1	0	1	0	W	A	7-bit address
Register call (0x0E)		0	0	0	0	1	1	1	0	A	Specifies the control byte
Register write (0xC0)		1	1	0	0	0	0	0	0	A	P Standby

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

The rest is the same as the above command list.

· When starting operation

S	0x2A (7 bits)	W	A	0x0E	A	0xA1	A

0x60	A

Sr	0x2A (7 bits)	W	A	0x0E	A	0x20	A	P

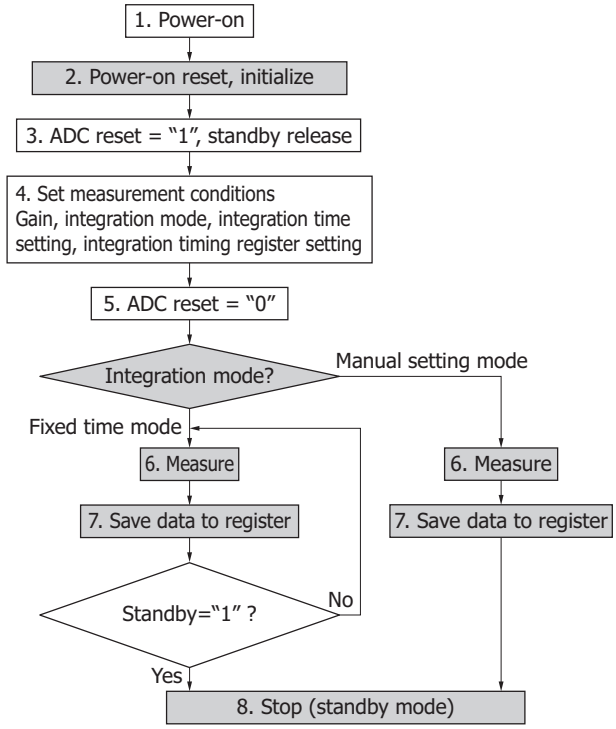
· When ending operation

S	0x2A (7 bits)	W	A	0x0E	A	0xC0	A	P

from master to slave from slave to master

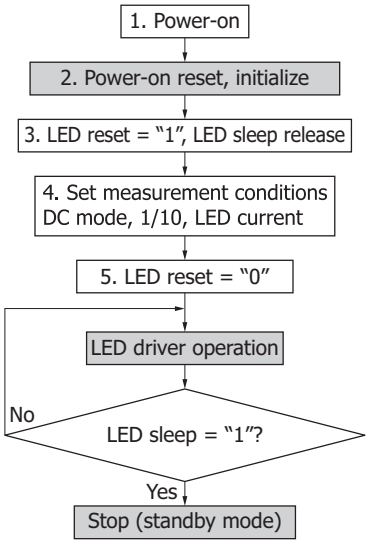
Flowcharts

Sensor section



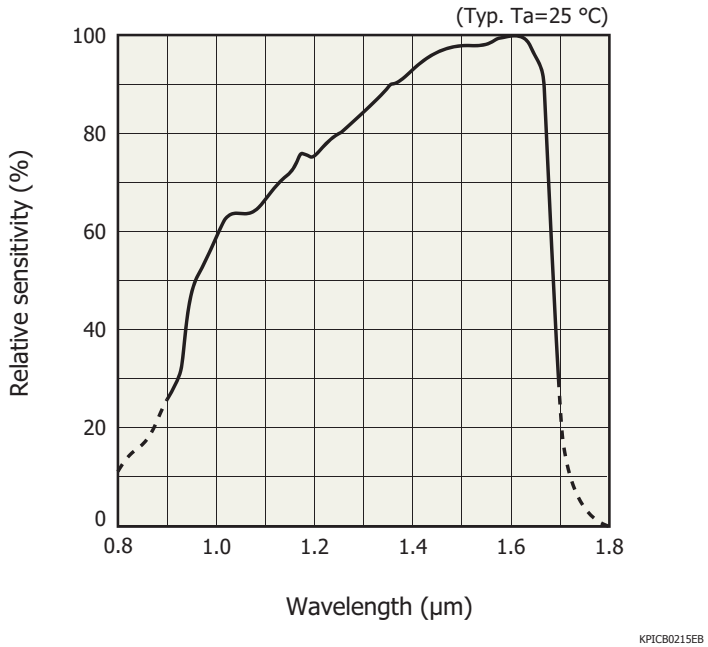
After power-on, the built-in power-on reset circuit operates to set all registers to their initial conditions (2.).
With the initial settings, the product is in standby mode, waiting for commands.
To set measurement conditions, enter commands via the I^2C bus. This product starts measuring when ADC reset changes from 1 to 0. Therefore, to write to registers, ADC reset must be set to 1 (3.).
After setting measurement conditions (4.), release ADC reset to start measuring (5.). There are two operation modes: fixed time mode and manual setting mode. In manual setting mode, the product automatically enters standby mode after completing a single measurement. In fixed time mode, the product repeats measurement and data storage. During this repetition, if ADC reset or standby is set to 1 with an I^2C command, the product stops its operation.

LED driver

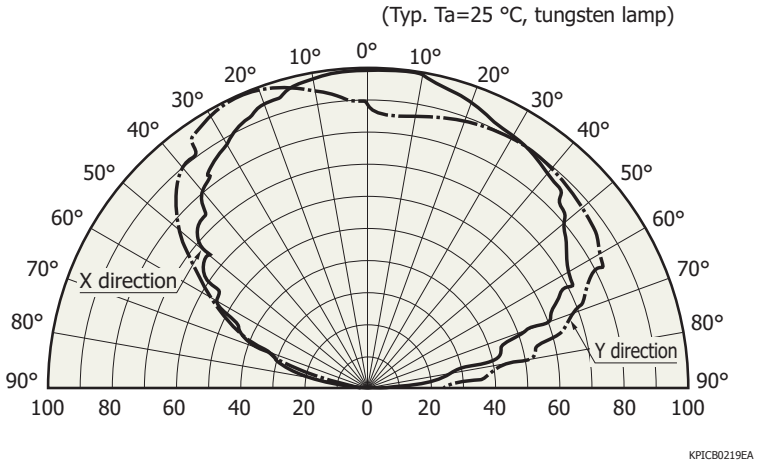


With the initial settings, the LED drivers are also in standby mode. Therefore, first disable the standby mode (3.). Next, set the LED current, 1/10 mode, DC mode, and the like. Then, release the reset to start operating (4. 5.). LED drivers continue to operate until they are set to standby mode. To end operation, enable standby mode.

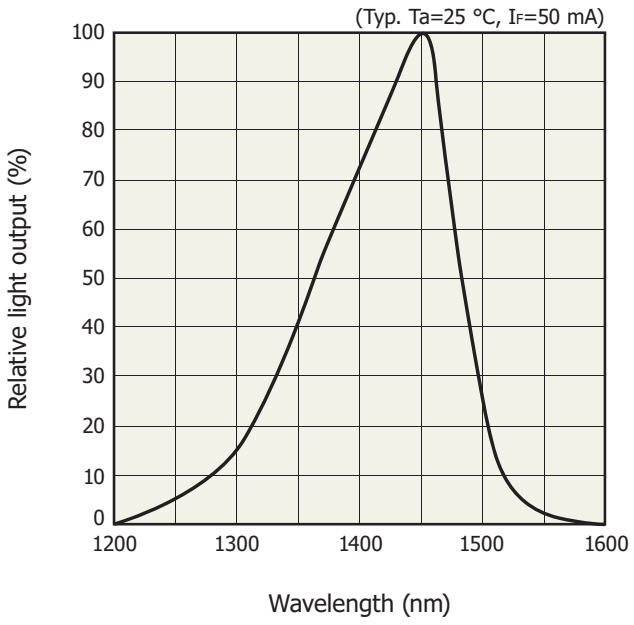
Spectral response



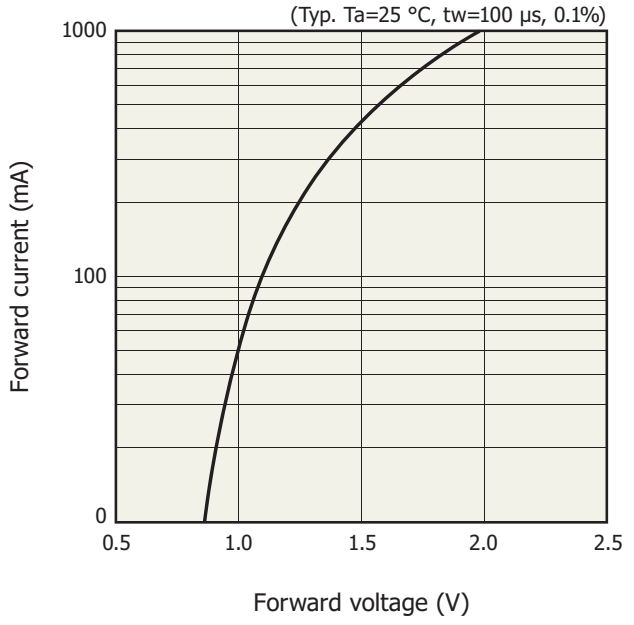
Directivity



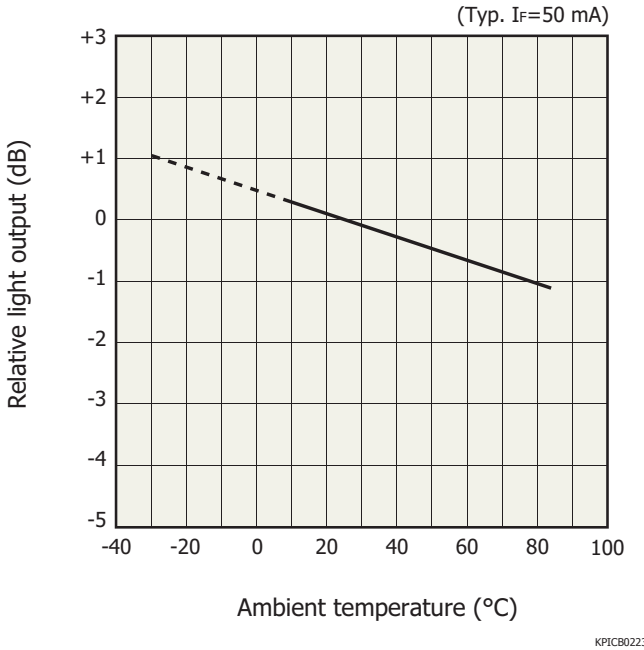
Emission spectrum



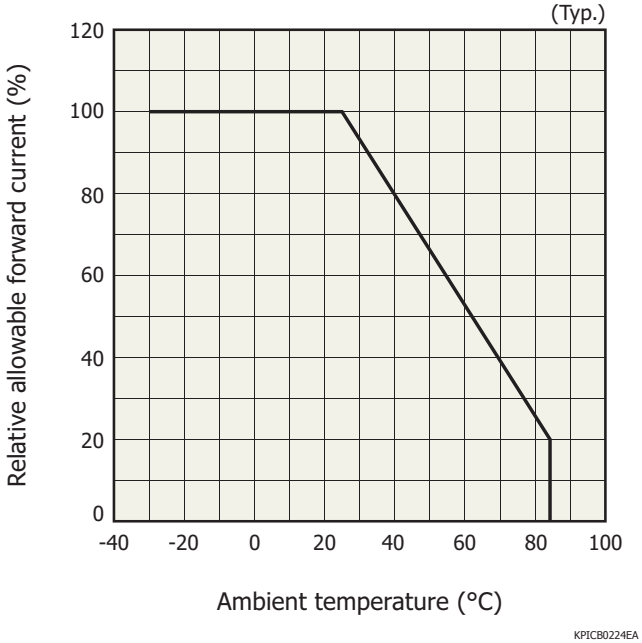
Forward current vs. forward voltage (LED)



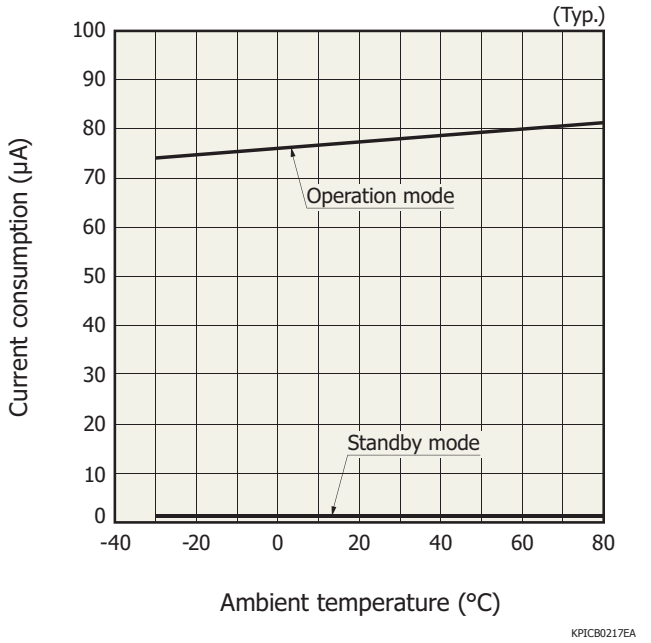
Light output vs. ambient temperature



Allowable forward current vs. ambient temperature

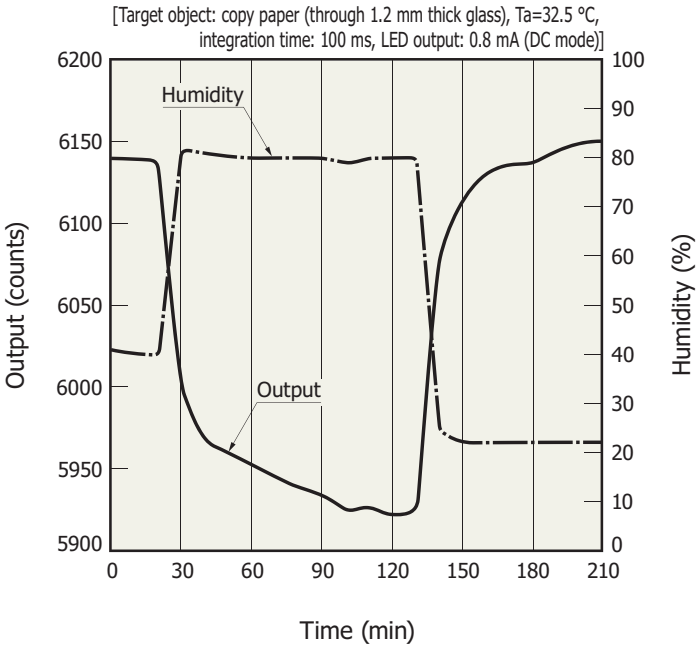


Current consumption vs. ambient temperature



KPICB0217EA

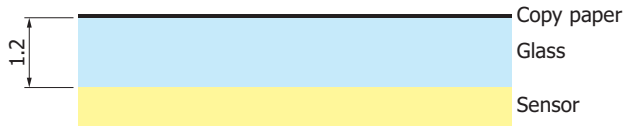
Measurement example of moisture level



KPICB0236EA

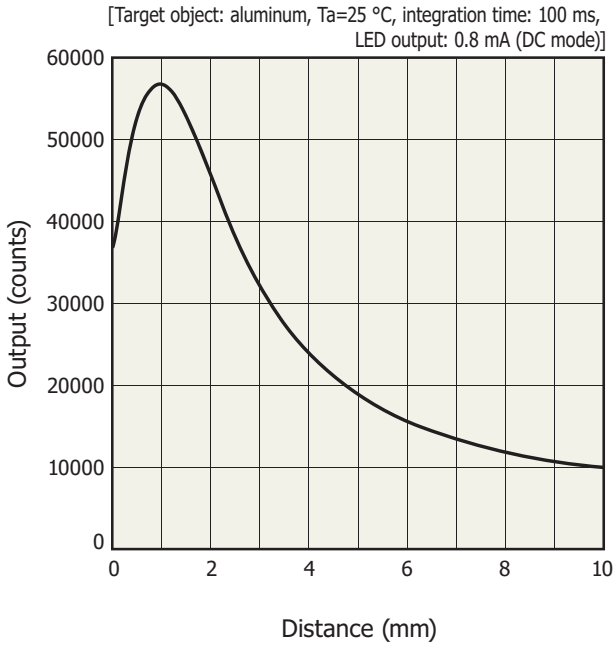
The moisture level of the copy paper is detected when the humidity is changed (40% to 80% to 20%).

■ Cross section (unit: mm)



KPICC0313EA

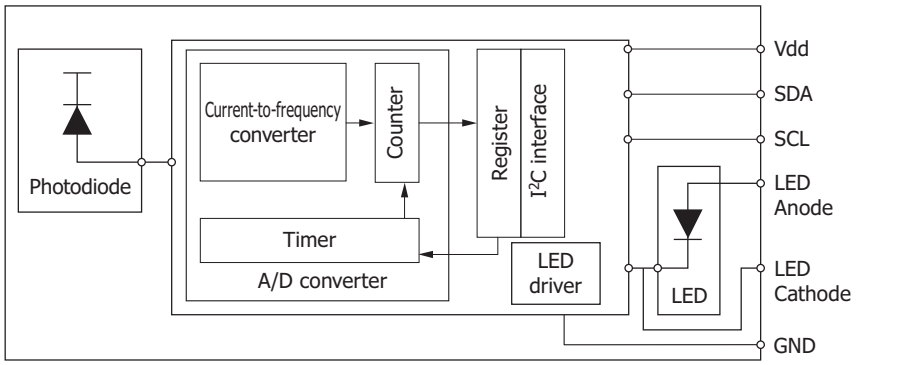
Distance between the sensor and target object



KPICB0235EA

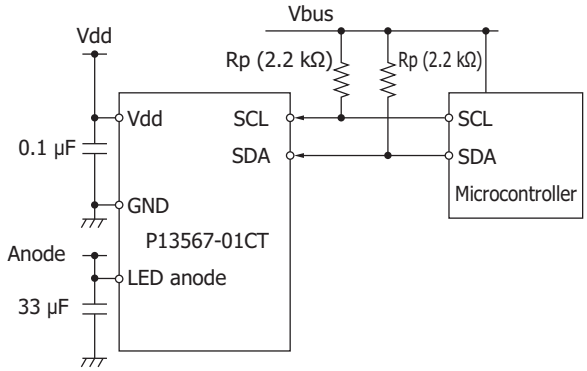
The sensor output is maximum when the distance between the sensor and target object is about 1 mm.

Block diagram



KPICC0299EA

Connection example

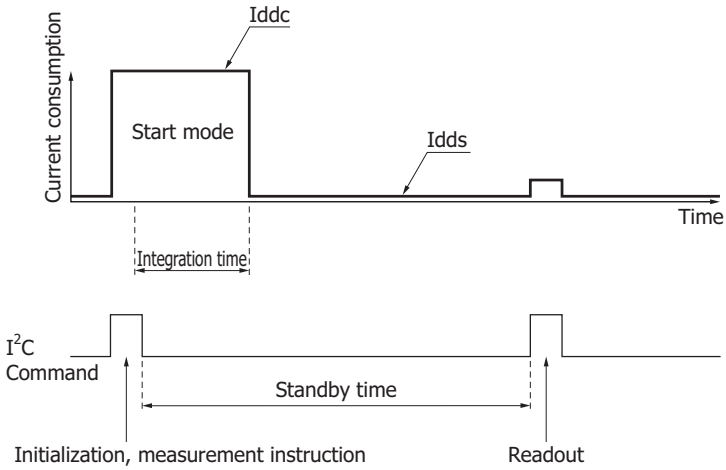


Note: When the LED is emitting light, do not externally control the LED.
If you are using Vdd and Vbus at different voltages, use them in the range that satisfies Vdd - Vbus<1.2 V.
Set the LED's anode voltage to $V_F + \alpha$ or higher of the LED in use.

KPICC0301EA

Timing chart

■ Sensor section (manual mode)

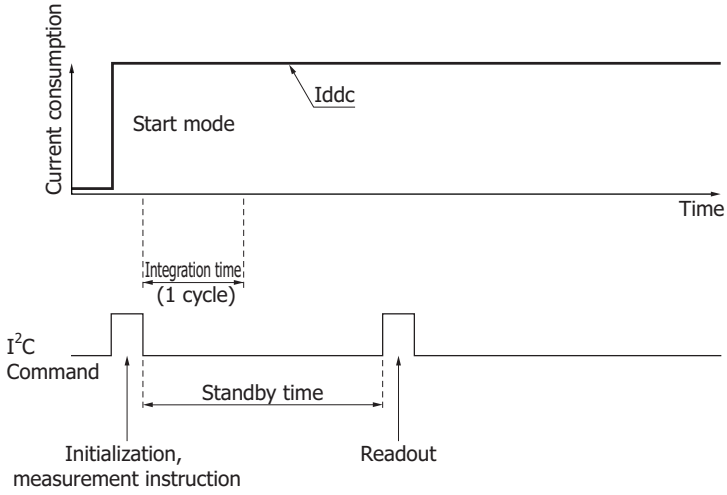


KPICC0293EA

The photodiode data is stored temporarily in a buffer register (not the I^2C register). After the completion of the measurement, the entire set of data is stored in the I^2C register. If this product is set to manual mode, after the integration time elapses, it will automatically switch to sleep mode. I^2C register values are not initialized with ADC reset or in standby mode. They are initialized only during a power-on reset when the power is turned on. The integration time per cycle is the sum of the three detection times indicated in the timing chart on the left.

· Initialization, measurement instruction
· Standby time (>integration time)
· Readout time

■ Sensor section (fixed time mode)



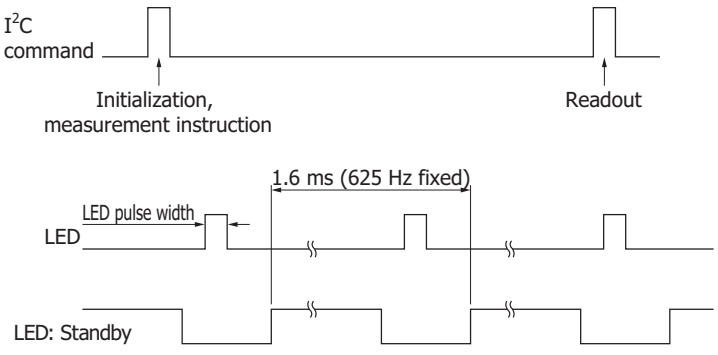
KPICC0294EA

The measurement time is the shortest under the following conditions.

<Conditions>
· Fixed time mode, Tint=00 (32 µs)
· Integration time: 32 µs/ch
· SCL frequency: 400 kHz
· Initialization, measurement instruction: 135 µs
· Standby time (>integration time): 128 µs
· Readout time: 112.5 µs

Measurement time: 375.5 µs

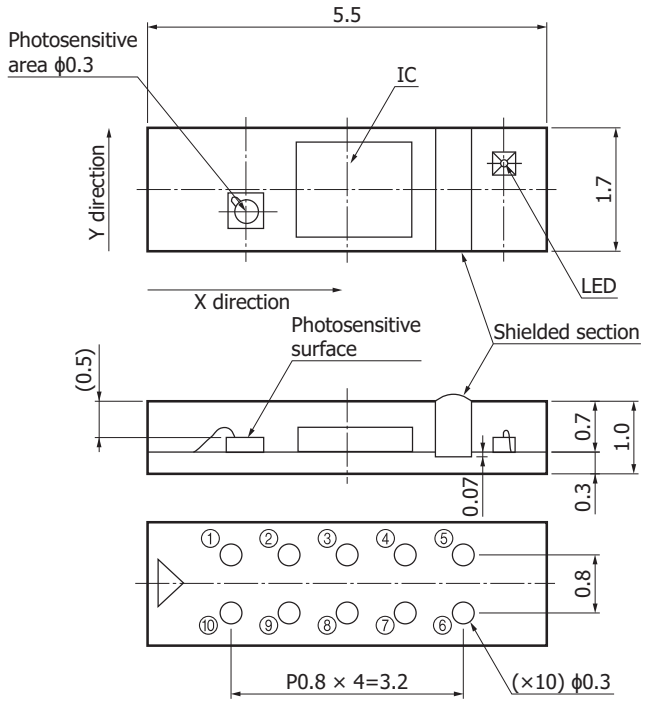
■ LED driver (pulse drive)



KPICC0300EA

The LED driver can set the light emission pulse width in the range of 0 µs to 240 µs in 16 µs steps (16 levels total). The light emission cycle is approximately 1.6 ms. The drive current is fixed at 8 mA.
When set to low current mode, the drive current is reduced to one-tenth (0.8 mA).
We recommend that you use the LED driver in DC mode.

Dimensional outline (unit: mm)



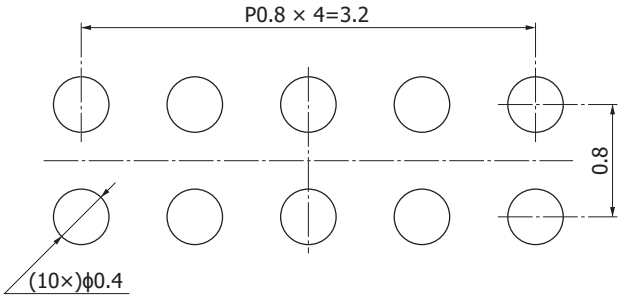
①	Vdd	⑥	LED anode
②	NC	⑦	LED cathode
③	NC	⑧	GND
④	NC	⑨	SDA
⑤	NC	⑩	SCL

Tolerance unless otherwise noted: ±0.2

KPICA0106EA

Note: When using this product, contact us for the technical note. Please check the technical note first, and then create an appropriate device design.

Recommended land pattern (unit: mm)



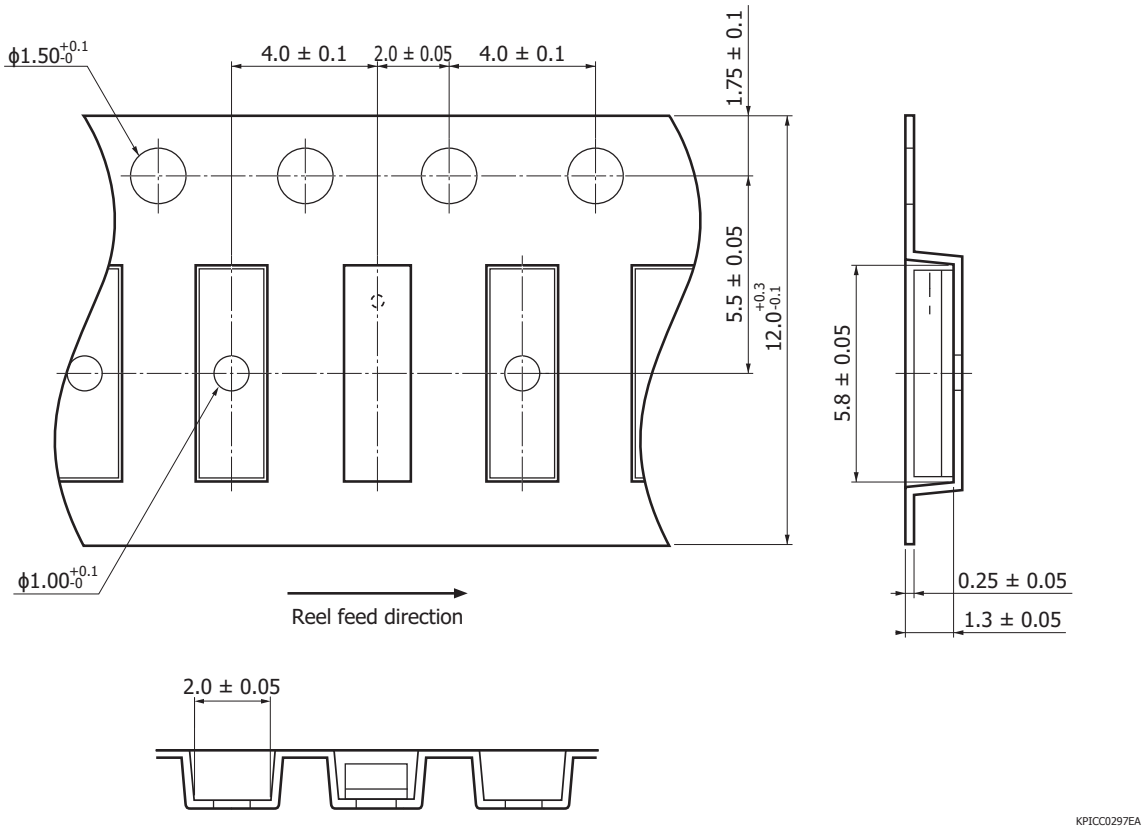
KPICC0251EA

Standard packing specifications

■ Reel

Dimensions	Hub diameter	Tape width	Material	Electrostatic characteristics
180 mm	60 mm	12 mm	PS	Conductive

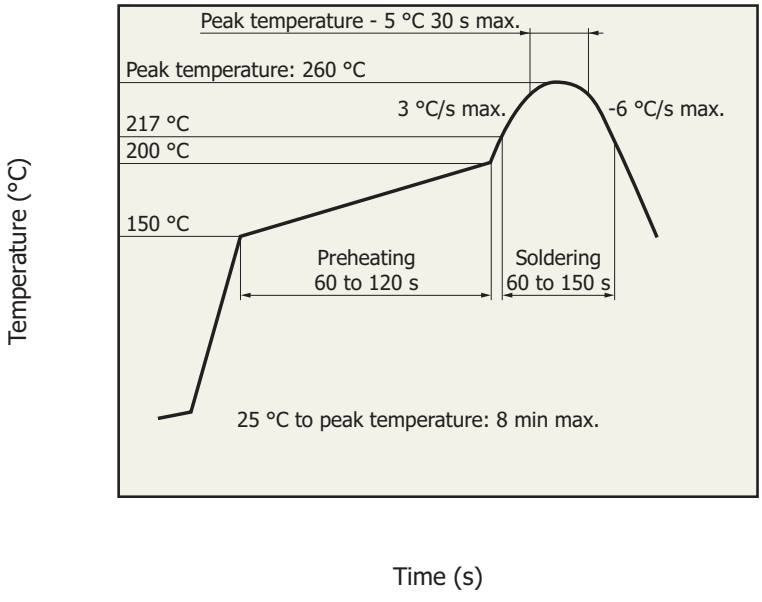
■ Embossed tape (unit: mm, material: PS, conductive)



■ Packing quantity
2000 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



- 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 168 hours.
- If it is not stored in the above environment after unpacking or more than three months has passed without unpacking, perform baking. For the baking method, see the related information "Precautions of Surface mount type products."
- The effect that the product receives during reflow soldering varies depending on the circuit board and reflow oven that are used. When you set reflow soldering conditions, check that problems do not occur in the product by testing out the conditions in advance.

Related information

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

■ Precautions
- Disclaimer
- Surface mount type products

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