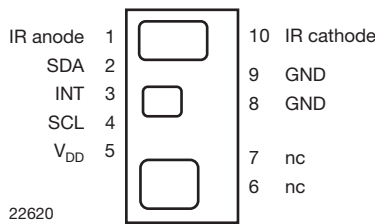
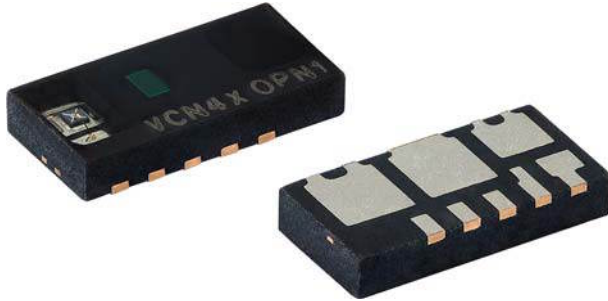


# Fully Integrated Proximity and Ambient Light Sensor With Infrared Emitter, I<sup>2</sup>C Interface, and Interrupt Function



## DESCRIPTION

The VCNL4020X01 is a fully integrated proximity and ambient light sensor. Fully integrated means that the infrared emitter is included in the package. It has 16 bit resolution. It includes a signal processing IC and features standard I<sup>2</sup>C communication interface. It features an interrupt function.

## APPLICATIONS

- Proximity sensor for:
  - **Mobile devices** (e.g. smart phones, touch phones, PDAs, GPS) for touch screen locking, power saving etc.
  - **Automotive** for presence detection
- Integrated ambient light function for display / keypad contrast control and dimming of mobile devices
- Rear view mirror dimming in automotive
- Proximity / optical switch for consumer, computing, automotive and industrial devices, and displays (like notebooks, tablet PCs, and automotive touch panels)
- Dimming control for consumer, computing, industrial, and automotive displays

## FEATURES

- Package type: surface-mount
- Dimensions (L x W x H in mm): 4.90 x 2.40 x 0.83
- AEC-Q101 qualified
- Integrated modules: infrared emitter (IRED), ambient light sensor (ALS-PD), proximity sensor (PD), and signal conditioning IC
- Interrupt function
- Supply voltage range V<sub>DD</sub>: 2.5 V to 3.6 V
- Supply voltage range IR anode: 2.5 V to 5 V
- Communication via I<sup>2</sup>C interface
- I<sup>2</sup>C bus H-level range: 1.7 V to 5 V
- Floor life: 168 h, MSL 3, according to J-STD-020
- Low stand by current consumption: 1.5  $\mu$ A
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

AUTOMOTIVE GRADE


**RoHS**  
 COMPLIANT  
 HALOGEN  
**FREE**  
**GREEN**  
 (5-2008)

## PROXIMITY FUNCTION

- Built-in infrared emitter and photo-pin-diode for proximity function
- 16 bit effective resolution for proximity detection range ensures excellent cross talk immunity
- Programmable LED drive current from 10 mA to 200 mA in 10 mA steps
- Excellent ambient light suppression by signal modulation
- Proximity distance up to 200 mm

## AMBIENT LIGHT FUNCTION

- Built-in ambient light photo-pin-diode with close-to-human-eye sensitivity
- 16 bit dynamic range from 0.25 lx to 16 klx
- 100 Hz and 120 Hz flicker noise rejection

PRODUCT SUMMARY								
PART NUMBER	OPERATING RANGE (mm)	OPERATING VOLTAGE RANGE (V)	I <sup>2</sup> C BUS VOLTAGE RANGE (V)	LED PULSE CURRENT <sup>(1)</sup> (mA)	AMBIENT LIGHT RANGE (lx)	AMBIENT LIGHT RESOLUTION (lx)	OUTPUT CODE	ADC RESOLUTION PROXIMITY / AMBIENT LIGHT
VCNL4020X01	1 to 200	2.5 to 3.6	1.7 to 5	10 to 200	0.25 to 16 383	0.25	16 bit, I <sup>2</sup> C	16 bit / 16 bit

### Note

<sup>(1)</sup> Adjustable through I<sup>2</sup>C interface



ORDERING INFORMATION			
ORDERING CODE	PACKAGING	VOLUME <sup>(1)</sup>	REMARKS
VCNL4020X01-GS08	Tape and reel	MOQ: 3300 pcs	4.90 mm x 2.40 mm x 0.83 mm
VCNL4020X01-GS18		MOQ: 13 000 pcs	

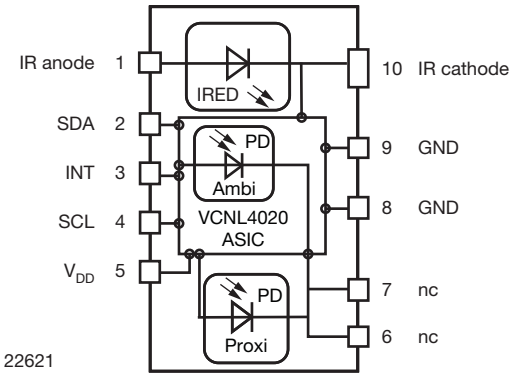
**Note**

(1) MOQ: minimum order quantity

ABSOLUTE MAXIMUM RATINGS ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified)					
PARAMETER	TEST CONDITION	SYMBOL	MIN.	MAX.	UNIT
Supply voltage		$V_{DD}$	-0.3	5.5	V
Operation temperature range		$T_{amb}$	-40	+105	$^{\circ}\text{C}$
Storage temperature range		$T_{stg}$	-40	+105	$^{\circ}\text{C}$
Total power dissipation	$T_{amb} \leq 25\text{ }^{\circ}\text{C}$	$P_{tot}$		50	mW
Junction temperature		$T_j$		105	$^{\circ}\text{C}$

BASIC CHARACTERISTICS ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified)						
PARAMETER	TEST CONDITION	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply voltage $V_{DD}$			2.5		3.6	V
Supply voltage IR anode			2.5		5	V
I <sup>2</sup> C Bus H-level range			1.7		5	V
INT H-level range			1.7		5	V
INT low voltage	3 mA sink current				0.4	V
Current consumption	Standby current, no IRED-operation			1.5	2	$\mu\text{A}$
Current consumption proximity mode incl. IRED (averaged)	2 measurements per second, IRED current 20 mA			5		$\mu\text{A}$
	250 measurements per second, IRED current 20 mA			520		$\mu\text{A}$
	2 measurements per second, IRED current 200 mA			35		$\mu\text{A}$
	250 measurements per second, IRED current 200 mA			4		mA
Current consumption ambient light mode	2 measurements per second averaging = 1			2.5		$\mu\text{A}$
	8 measurements per second averaging = 1			10		$\mu\text{A}$
	2 measurements per second averaging = 64			160		$\mu\text{A}$
	8 measurements per second averaging = 64			640		$\mu\text{A}$
Ambient light resolution	Digital resolution (LSB count)			0.25		lx
Ambient light output	$E_v = 100\text{ lx}$ averaging = 64			400		counts
I <sup>2</sup> C clock rate range		$f_{SCL}$			3400	kHz

## CIRCUIT BLOCK DIAGRAM

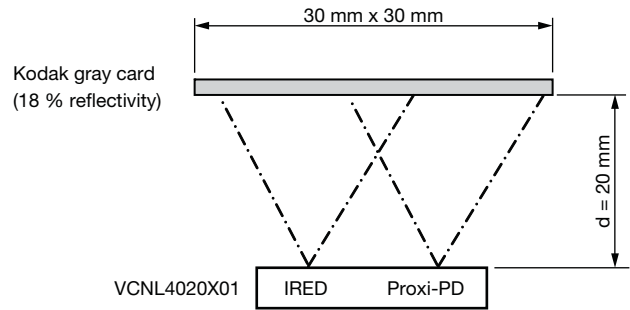


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### Note

- nc must not be electrically connected
- Pads 6 and 7 are only considered as solder pads

## TEST CIRCUIT



## BASIC CHARACTERISTICS (T<sub>amb</sub> = 25 °C, unless otherwise specified)

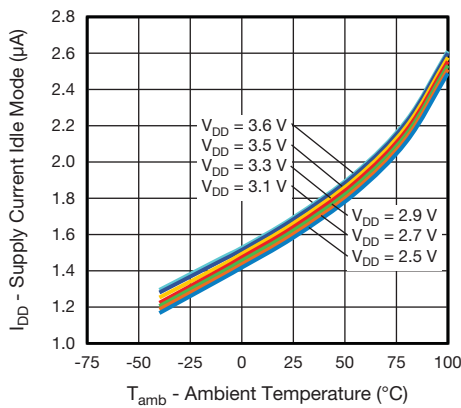


Fig. 1 - Idle Current vs. Ambient Temperature

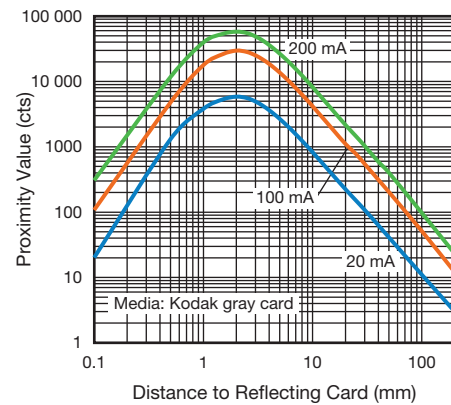


Fig. 3 - Proximity Value vs. Distance

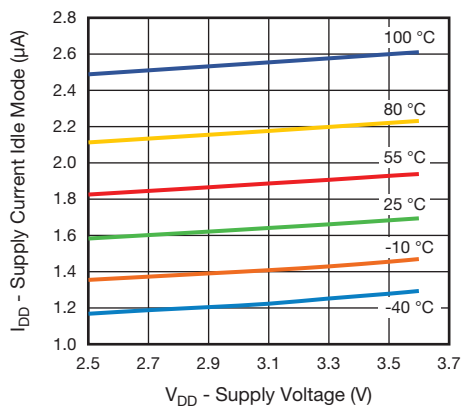


Fig. 2 - Idle Current vs. V<sub>DD</sub>

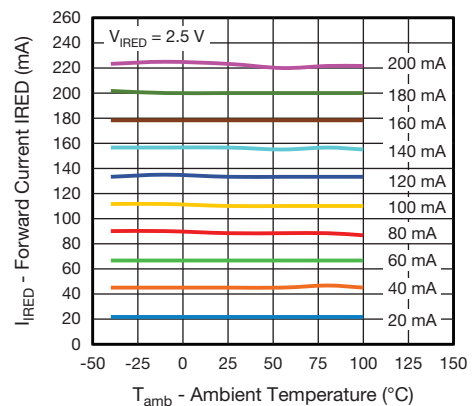


Fig. 4 - Forward Current vs. Temperature

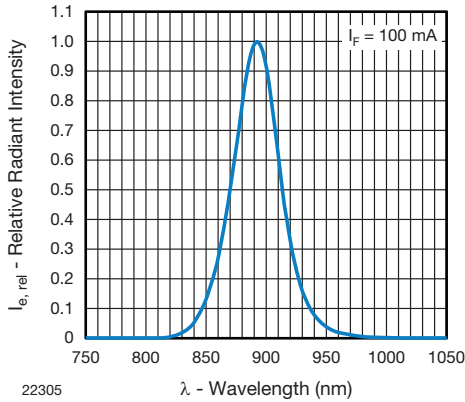


Fig. 5 - Relative Radiant Intensity vs. Wavelength

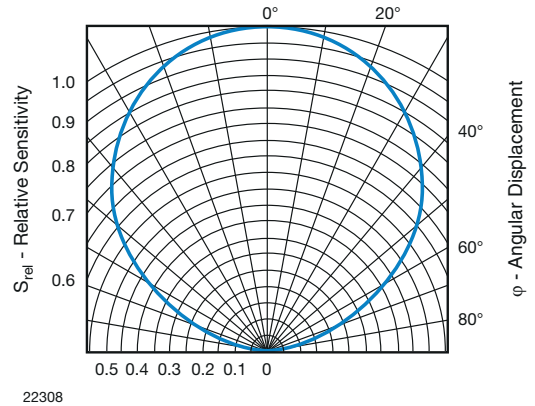


Fig. 8 - Relative Radiant Sensitivity vs. Angular Displacement (Proximity Sensor)

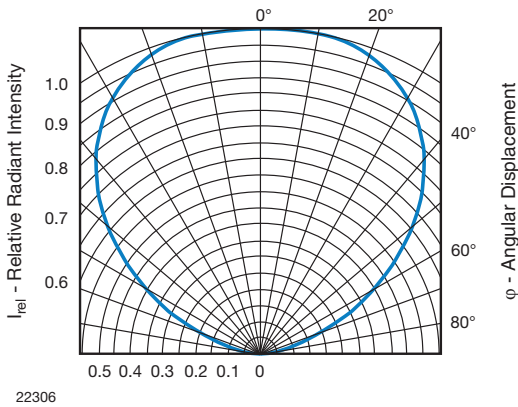


Fig. 6 - Relative Radiant Intensity vs. Angular Displacement

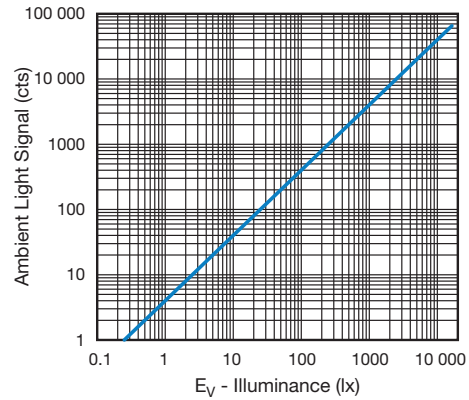


Fig. 9 - Ambient Light Value vs. Illuminance

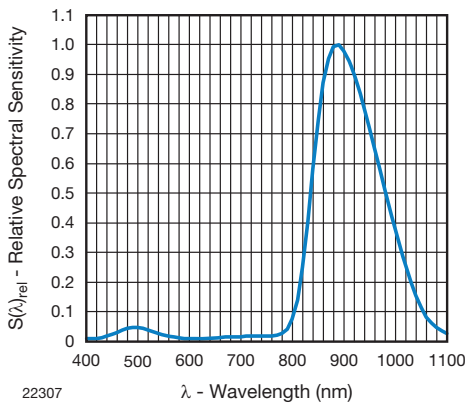


Fig. 7 - Relative Spectral Sensitivity vs. Wavelength (Proximity Sensor)

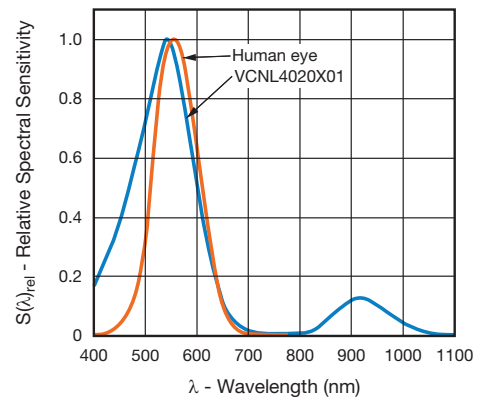
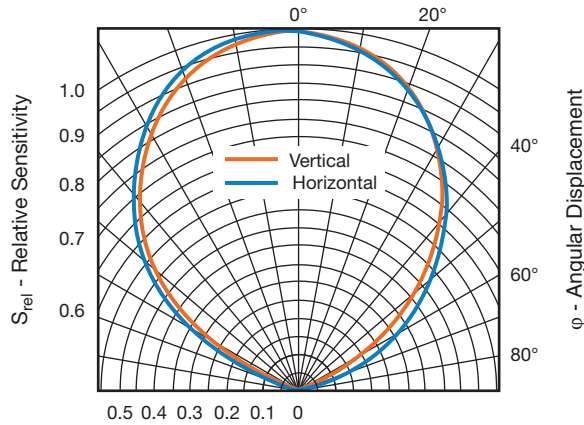


Fig. 10 - Relative Spectral Sensitivity vs. Wavelength (Ambient Light Sensor)



22311

Fig. 11 - Relative Radiant Sensitivity vs. Angular Displacement (Ambient Light Sensor)

**APPLICATION INFORMATION**

VCNL4020X01 is a cost effective solution of proximity and ambient light sensor with I<sup>2</sup>C bus interface. The standard serial digital interface is easy to access “Proximity Signal” and “Light Intensity” without complex calculation and programming by external controller. Beside the digital output also a flexible programmable interrupt pin is available.

**1. Application Circuit**

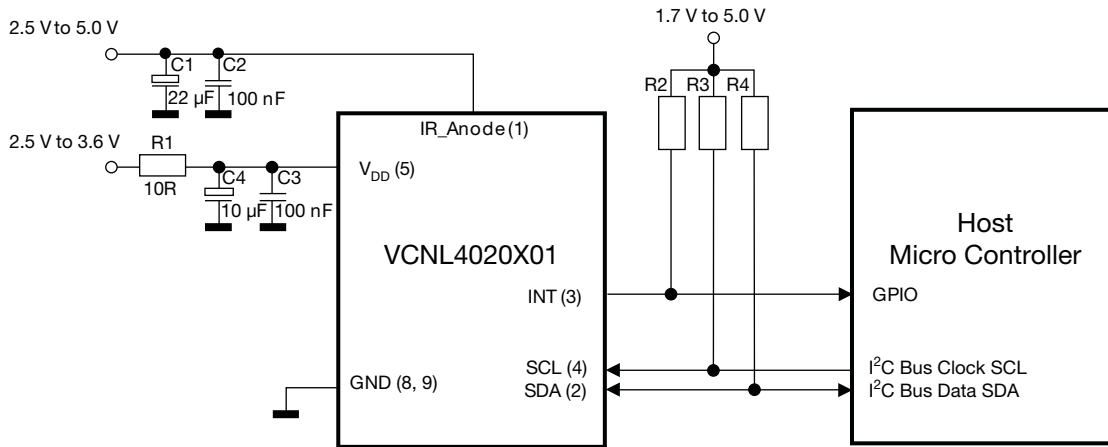


Fig. 12 - Application Circuit (x) = Pin Number

**Notes**

- The interrupt pin is an open drain output. The needed pull-up resistor may be connected to the same supply voltage as the application controller and the pull-up resistors at SDA/SCL. Proposed value R2 should be >1 kΩ , e.g. 10 kΩ to 100 kΩ. Proposed value for R3 and R4, e.g. 2.2 kΩ to 4.7 kΩ, depend also on the I<sup>2</sup>C bus speed. For detailed description about set-up and use of the interrupt as well as more application related information see AN: “Designing VCNL4020 into an Application”.
- IR\_Cathode needs no external connection. The needed connection to the driver is done internally.





Register #1 Product ID Revision Register

Register address = 81h. This register contains information about product ID and product revision.

Register data value of current revision = 21h.

TABLE 2 - PRODUCT ID REVISION REGISTER #1							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Product ID				Revision ID			
Description							
Product ID		Read only bits. Value = 2					
Revision ID		Read only bits. Value = 1					

Register #2 Rate of Proximity Measurement

Register address = 82h.

TABLE 3 - PROXIMITY RATE REGISTER #2							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
n/a					Rate of Proximity Measurement (no. of measurements per second)		
Description							
Proximity rate		R/W bits. 000 - 1.95 measurements/s (DEFAULT) 001 - 3.90625 measurements/s 010 - 7.8125 measurements/s 011 - 16.625 measurements/s 100 - 31.25 measurements/s 101 - 62.5 measurements/s 110 - 125 measurements/s 111 - 250 measurements/s					

Note

- If self\_timed measurement is running, any new value written in this register will not be taken over until the mode is actually cycled.

Register #3 LED Current Setting for Proximity Mode

Register address = 83h. This register is to set the LED current value for proximity measurement.

The value is adjustable in steps of 10 mA from 0 mA to 200 mA.

This register also contains information about the used device fuse program ID.

TABLE 4 - IR LED CURRENT REGISTER #3							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Fuse prog ID		IR LED current value					
Description							
Fuse prog ID		Read only bits. Information about fuse program revision used for initial setup/calibration of the device.					
IR LED current value		R/W bits. IR LED current = Value (dec.) x 10 mA. Valid Range = 0 to 20d. e.g. 0 = 0 mA , 1 = 10 mA, ..., 20 = 200 mA (2 = 20 mA = DEFAULT) LED Current is limited to 200 mA for values higher as 20d.					



Register #4 Ambient Light Parameter Register

Register address = 84h.

TABLE 5 - AMBIENT LIGHT PARAMETER REGISTER #4							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Cont. conv. mode	als_rate			Auto offset compensation	Averaging function (number of measurements per run)		
<b>Description</b>							
Cont. conversion mode		R/W bit. Continuous conversion mode. Enable = 1; Disable = 0 = DEFAULT This function can be used for performing faster ambient light measurements. This mode should only be used with ambient light on-demand measurements. Do not use with self-timed mode. Please refer to the application information chapter 3.3 for details about this function.					
Ambient light measurement rate		R/W bits. Ambient light measurement rate 000 - 1 samples/s 001 - 2 samples/s = DEFAULT 010 - 3 samples/s 011 - 4 samples/s 100 - 5 samples/s 101 - 6 samples/s 110 - 8 samples/s 111 - 10 samples/s					
Auto offset compensation		R/W bit. Automatic offset compensation. Enable = 1 = DEFAULT; Disable = 0 In order to compensate a technology, package or temperature related drift of the ambient light values there is a built in automatic offset compensation function. With active auto offset compensation the offset value is measured before each ambient light measurement and subtracted automatically from actual reading.					
Averaging function		R/W bits. Averaging function. Bit values sets the number of single conversions done during one measurement cycle. Result is the average value of all conversions. Number of conversions = $2^{\text{decimal\_value}}$ e.g. 0 = 1 conv., 1 = 2 conv, 2 = 4 conv., ....7 = 128 conv. DEFAULT = 32 conv. (bit 2 to bit 0: 101)					

Note

- If self\_timed measurement is running, any new value written in this register will not be taken over until the mode is actually cycled.

Register #5 and #6 Ambient Light Result Register

Register address = 85h and 86h. These registers are the result registers for ambient light measurement readings.

The result is a 16 bit value. The high byte is stored in register #5 and the low byte in register #6.

TABLE 6 - AMBIENT LIGHT RESULT REGISTER #5							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
Read only bits. High byte (15:8) of ambient light measurement result							

TABLE 7 - AMBIENT LIGHT RESULT REGISTER #6							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
Read only bits. Low byte (7:0) of ambient light measurement result							





Register #7 and #8 Proximity Measurement Result Register

Register address = 87h and 88h. These registers are the result registers for proximity measurement readings.

The result is a 16 bit value. The high byte is stored in register #7 and the low byte in register #8.

TABLE 8 - PROXIMITY RESULT REGISTER #7							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
Read only bits. High byte (15:8) of proximity measurement result							

TABLE 9 - PROXIMITY RESULT REGISTER #8							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
Read only bits. Low byte (7:0) of proximity measurement result							

Register #9 Interrupt Control Register

Register address = 89h.

TABLE 10 - INTERRUPT CONTROL REGISTER #9							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Int count exceed			n/a	INT_PROX_ready_EN	INT_ALS_ready_EN	INT_THRES_EN	INT_THRES_SEL
<b>Description</b>							
Int count exceed	R/W bits. These bits contain the number of consecutive measurements needed above/below the threshold 000 - 1 count = DEFAULT 001 - 2 count 010 - 4 count 011 - 8 count 100 - 16 count 101 - 32 count 110 - 64 count 111 - 128 count						
INT_PROX_ready_EN	R/W bit. Enables interrupt generation at proximity data ready						
INT_ALS_ready_EN	R/W bit. Enables interrupt generation at ambient data ready						
INT_THRES_EN	R/W bit. Enables interrupt generation when high or low threshold is exceeded						
INT_THRES_SEL	R/W bit. If 0: thresholds are applied to proximity measurements If 1: thresholds are applied to als measurements						



Register #10 and #11 Low Threshold

Register address = 8Ah and 8Bh. These registers contain the low threshold value. The value is a 16 bit word. The high byte is stored in register #10 and the low byte in register #11.

TABLE 11 - LOW THRESHOLD REGISTER #10							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
R/W bits. High byte (15:8) of low threshold value							

TABLE 12 - LOW THRESHOLD REGISTER #11							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
R/W bits. Low byte (7:0) of low threshold value							

Register #12 and #13 High Threshold

Register address = 8Ch and 8Dh. These registers contain the high threshold value. The value is a 16 bit word. The high byte is stored in register #12 and the low byte in register #13.

TABLE 13 - HIGH THRESHOLD REGISTER #12							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
R/W bits. High byte (15:8) of high threshold value							

TABLE 14 - HIGH THRESHOLD REGISTER #13							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
<b>Description</b>							
R/W bits. Low byte (7:0) of high threshold value							

Register #14 Interrupt Status Register

Register address = 8Eh. This register contains information about the interrupt status for either proximity or ALS function and indicates if high or low going threshold exceeded.

TABLE 15 - INTERRUPT STATUS REGISTER #14							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
n/a				int_prox_ready	int_als_ready	int_th_low	int_th_hi
<b>Description</b>							
int_prox_ready		R/W bit. Indicates a generated interrupt for proximity					
int_als_ready		R/W bit. Indicates a generated interrupt for als					
int_th_low		R/W bit. Indicates a low threshold exceed					
int_th_hi		R/W bit. Indicates a high threshold exceed					

Note

- Once an interrupt is generated the corresponding status bit goes to 1 and stays there unless it is cleared by writing a 1 in the corresponding bit. The int pad will be pulled down while at least one of the status bit is 1.



Example: read register “Ambient Light Result Register” #5 and #6:

Addressing: command: 26h, 85h (VCNL4020X01\_I<sup>2</sup>C\_Bus\_Write\_Adr., Ambient Light Result Register #5 [85])

Read register #5: command: 27h, data (VCNL4020X01\_I<sup>2</sup>C\_Bus\_Read\_Adr., {High Byte Data of Ambient Light Result register #5 [85]})

Read register #6: command: 27h, data (VCNL4020X01\_I<sup>2</sup>C\_Bus\_Read\_Adr., {Low Byte Data of Ambient Light Result register #6 [86]})

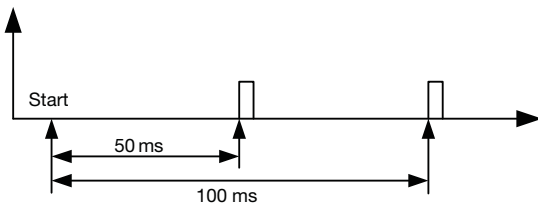
### 3.3 Continuous Conversion Mode in Ambient Light Measurement

In the following is a detail description of the function “continuous conversion” (bit 7 of register #4)

#### Standard mode (bit 7 of reg #4 = 0):

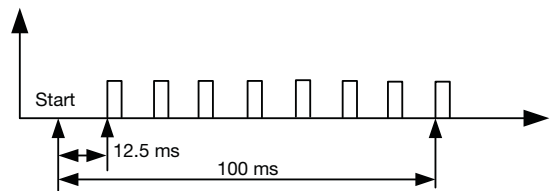
In standard mode the ambient light measurement is done during a fixed time frame of 100 ms. The single measurement itself takes actually only appr. 300  $\mu$ s.

The following figures show examples of this measurement timing in standard mode using averaging function 2 and 8 as examples for illustration (possible values up to 128).



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Fig. 15 - Ambient Light Measurement with Averaging = 2; Final Measurement Result = Average of these 2 Measurements



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Fig. 16 - Ambient Light Measurement with Averaging = 8; Final Measurement Result = Average of these 8 Measurements

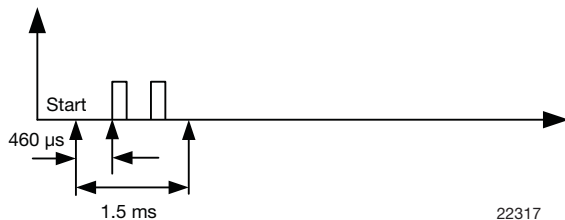
#### Note

- $\geq$  Independent of setting of averaging the result is available only after 100 ms.

#### Continuous conversion mode (bit 7 of register #4 = 1):

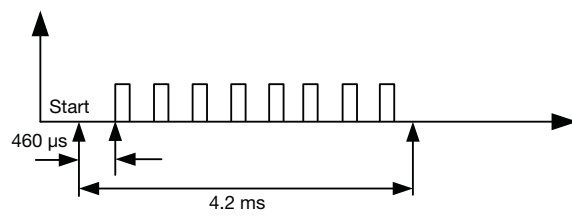
In continuous conversion mode the single measurements are done directly subsequent after each other.

See following examples in figure 17 and 18



22317

Fig. 17 - Ambient Light Measurement with Averaging = 2; using Continuous Conversion Mode

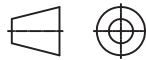
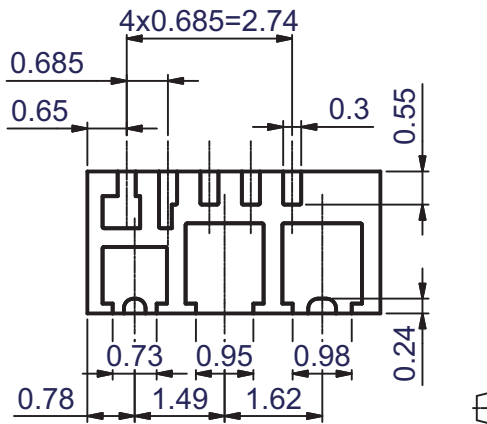


22318

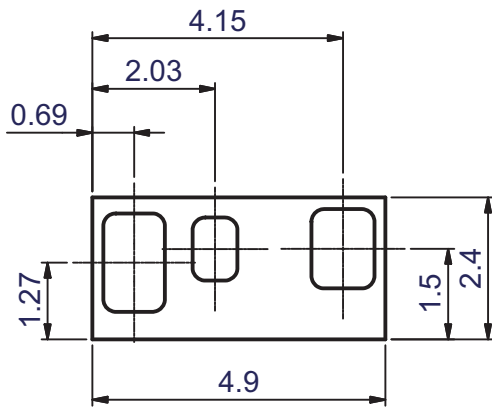
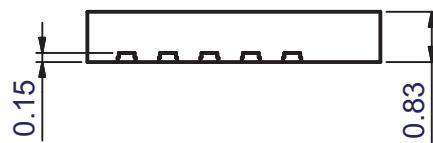
Fig. 18 - Ambient Light Measurement with Averaging = 8; using Continuous Conversion Mode



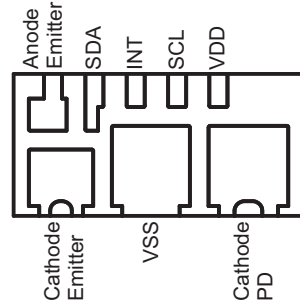
PACKAGE DIMENSIONS in millimeters



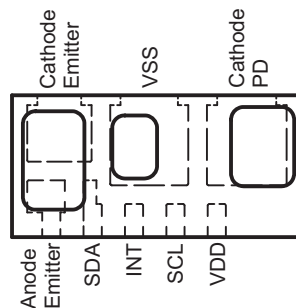
technical drawings according to DIN specifications



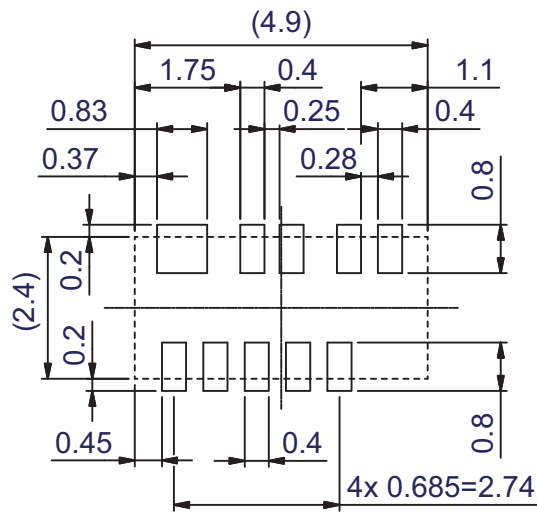
Pinning Bottom view



Pinning Top view



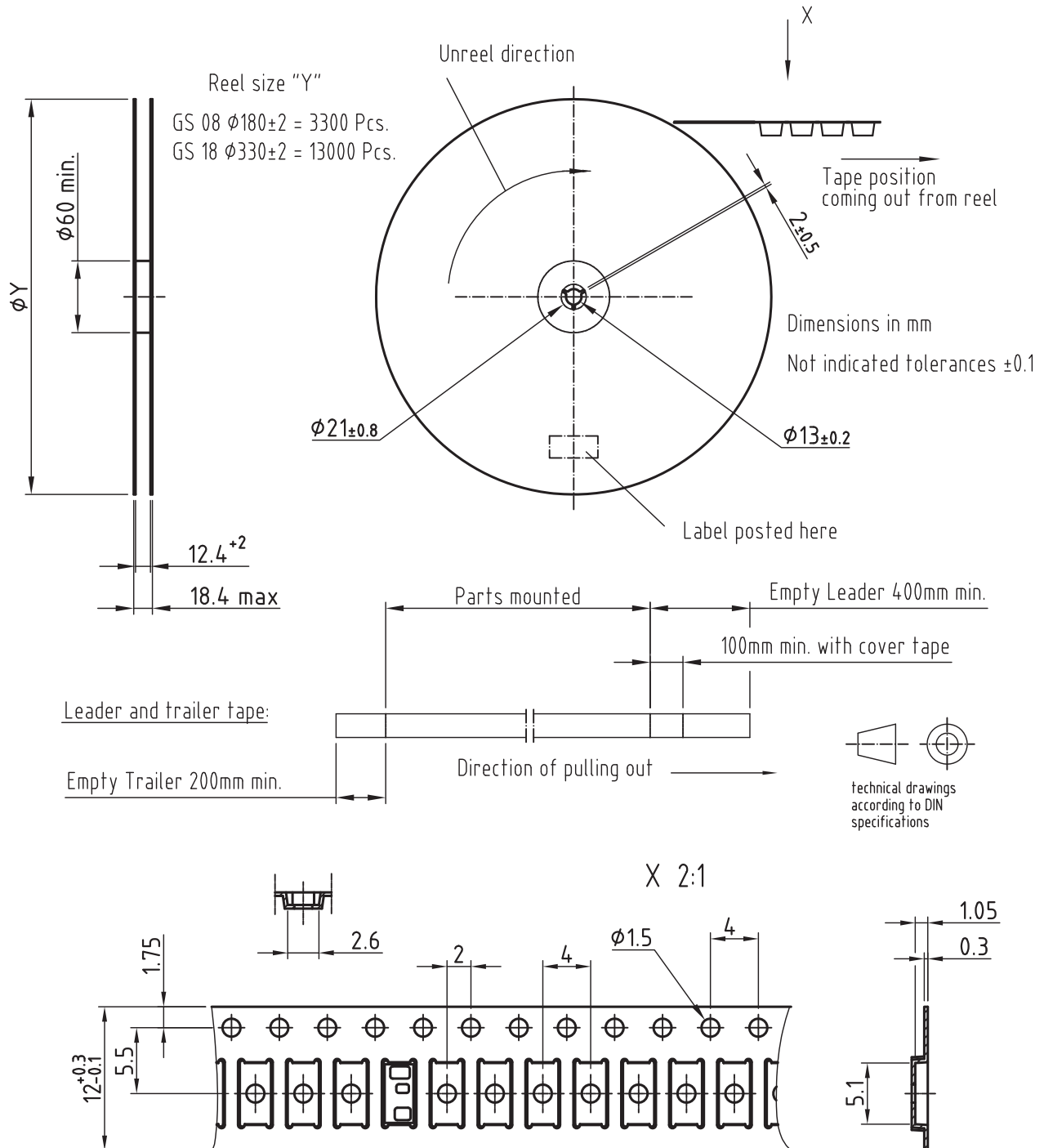
Proposed PCB Footprint



Drawing-No.: 6.550-5319

Not indicated tolerances ± 0.1

**TAPE AND REEL DIMENSIONS** in millimeters



Drawing-No.: 9.700-5387.01-4



**SOLDER PROFILE**

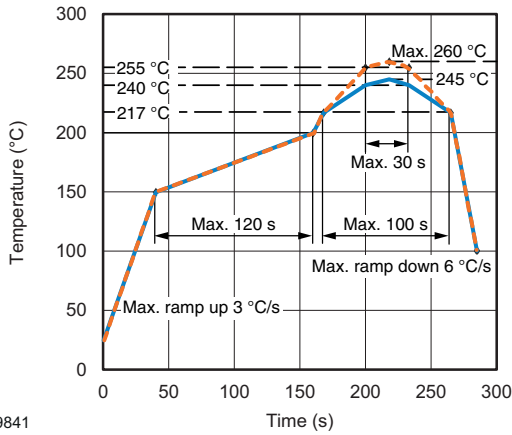


Fig. 19 - Lead (Pb)-free Reflow Solder Profile According to J-STD-020

**DRYPACK**

Devices are packed in moisture barrier bags (MBB) to prevent the products from moisture absorption during transportation and storage. Each bag contains a desiccant.

**FLOOR LIFE**

Floor life (time between soldering and removing from MBB) must not exceed the time indicated on MBB label:

Floor life: 168 h

Conditions:  $T_{amb} < 30\text{ }^{\circ}\text{C}$ ,  $\text{RH} < 60\%$

Moisture sensitivity level 3, according to J-STD-020.

**DRYING**

In case of moisture absorption devices should be baked before soldering. Conditions see J-STD-020 or label. Devices taped on reel dry using recommended conditions 192 h at 40 °C (+ 5 °C), RH < 5 %.



## **Disclaimer**

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