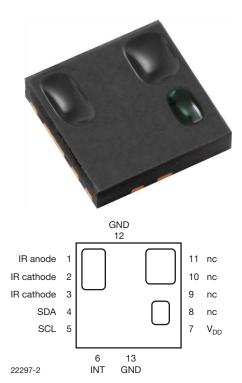
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Vishay Semiconductors

Fully Integrated Proximity and Ambient Light Sensor with Infrared Emitter, I²C Interface, and Interrupt Function



DESCRIPTION

The VCNL4010 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 I²C communication interface. It features an interrupt function.

APPLICATIONS

- Proximity sensor for mobile devices (e.g. smart phones, touch phones, PDA, GPS) for touch screen locking, power saving, etc.
- Integrated ambient light function for display/keypad contrast control and dimming of mobile devices
- Proximity/optical switch for consumer, computing and industrial devices and displays
- Dimming control for consumer, computing and industrial displays

FEATURES

- Package type: surface mount
- Dimensions (L x W x H in mm): 3.95 x 3.95 x 0.75
- Integrated infrared emitter, ambient light sensor, proximity sensor, and signal conditioning IC
- Interrupt function
- Supply voltage range V_{DD}: 2.5 V to 3.6 V
- Supply voltage range IR anode: 2.5 V to 5 V
- Communication via I2C interface
- I²C Bus H-level range: 1.7 V to 5 V
- Floor life: 168 h, MSL 3, acc. J-STD-020
- Low stand by current consumption: 1.5 μA
- Compliant to RoHS Directive 2011/65/EU and in accordance to WEEE 2002/96/EC

Note

** Please see document "Vishay Material Category Policy": www.vishay.com/doc?99902

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 modulating the infrared signal
- Proximity distance up to 200 mm

AMBIENT LIGHT FUNCTION

- Built-in ambient light photo-pin-diode with close-tohuman-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 ² C BUS VOLTAGE RANGE (V)	LED PULSE CURRENT (1) (mA)	AMBIENT LIGHT RANGE (lx)	AMBIENT LIGHT RESOLUTION (lx)	OUTPUT CODE			
VCNL4010	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 ² C			

Note

(1) Adjustable through I²C interface



ORDERING INFORMATION			
ORDERING CODE	PACKAGING	VOLUME (1)	REMARKS
VCNL4010-GS08	Tape and reel	MOQ: 1800 pcs	3.95 mm x 3.95 mm x 0.75 mm
VCNL4010-GS18	rape and reei	MOQ: 7000 pcs	3.93 11111 x 3.93 11111 x 0.73 11111
VCNL4000Demokit (2)	-	MOQ: 1 pc	-

Notes

⁽²⁾ VCNL4000 Demokit provides USB dongle, basic software including Vishay licence. The VCNL4010 sensor board could be ordered free of charge by contacting sensorstechsupport@vishay.com. Software updates for VCNL4010 can be downloaded from our web site: www.vishay.com/???/

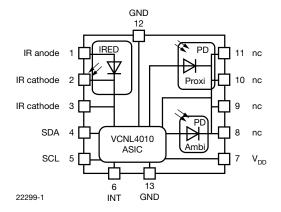
ABSOLUTE MAXIMUM RATINGS (T _{amb} = 25 °C, unless otherwise specified)									
PARAMETER	TEST CONDITION	SYMBOL	MIN.	MAX.	UNIT				
Supply voltage		V _{DD}	- 0.3	5.5	V				
Operation temperature range		T _{amb}	- 25	+ 85	°C				
Storage temperature range		T _{stg}	- 40	+ 85	°C				
Total power dissipation	T _{amb} ≤ 25 °C	P _{tot}		50	mW				
Junction temperature		Tj		100	°C				

BASIC CHARACTERIST	FICS (T _{amb} = 25 °C, unless o	therwise spe	ecified)			
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 ² 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	μΑ
Current consumption	2 measurements per second, IRED current 20 mA			5		μΑ
	250 measurements per second, IRED current 20 mA			520		μΑ
proximity mode incl. IRED (averaged)	2 measurements per second, IRED current 200 mA			35		μΑ
	250 measurements per second, IRED current 200 mA			4.0		mA
	2 measurements per second averaging = 1			2.5		μΑ
Current consumption ambient	8 measurements per second averaging = 1			10		μΑ
light mode	2 measurements per second averaging = 64			160		μΑ
	8 measurements per second averaging = 64			640		μΑ
Ambient light resolution	Digital resolution (LSB count)			0.25		lx
Ambient light output	E _V = 100 lx averaging = 64			400		counts
I ² C clock rate range		f _{SCL}			3400	kHz

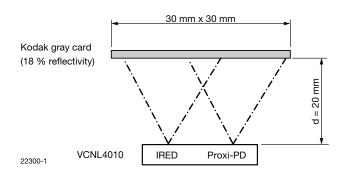
⁽¹⁾ MOQ: minimum order quantity



CIRCUIT BLOCK DIAGRAM



TEST CIRCUIT



Note

nc must not be electrically connected
 Pads 8 to 11 are only considered as solder pads

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

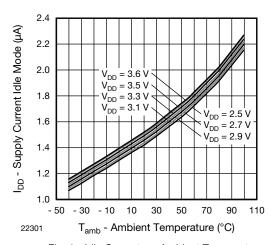


Fig. 1 - Idle Current vs. Ambient Temperature

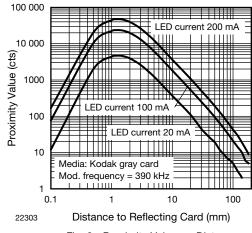
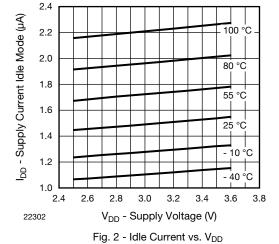


Fig. 3 - Proximity Value vs. Distance



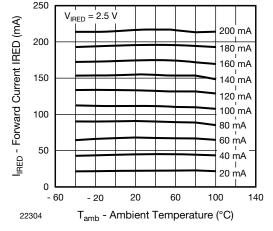


Fig. 4 - Forward Current vs. Temperature

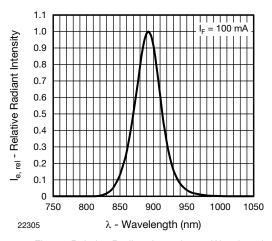


Fig. 5 - Relative Radiant Intensity vs. Wavelength

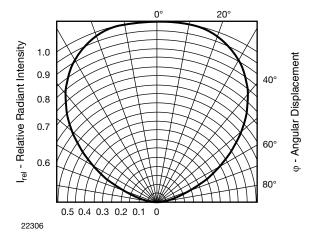


Fig. 6 - Relative Radiant Intensity vs. Angular Displacement

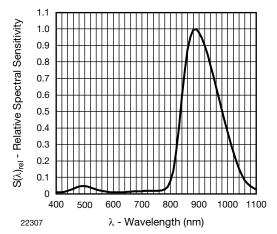


Fig. 7 - Relative Spectral Sensitivity vs. Wavelength (Proximity Sensor)

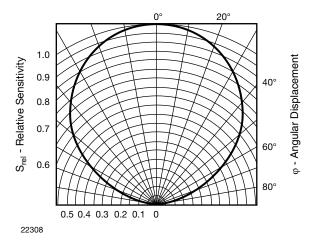


Fig. 8 - Relative Radiant Sensitivity vs. Angular Displacement (Proximity Sensor)

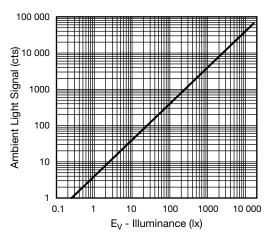


Fig. 9 - Ambient Light Value vs. Illuminance

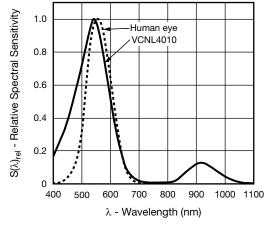


Fig. 10 - Relative Spectral Sensitivity vs. Wavelength (Ambient Light Sensor)



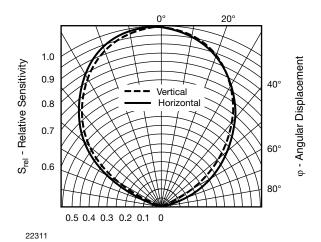


Fig. 11 - Relative Radiant Sensitivity vs. Angular Displacement (Ambient Light Sensor)

APPLICATION INFORMATION

VCNL4010 is a cost effective solution of proximity and ambient light sensor with I²C 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

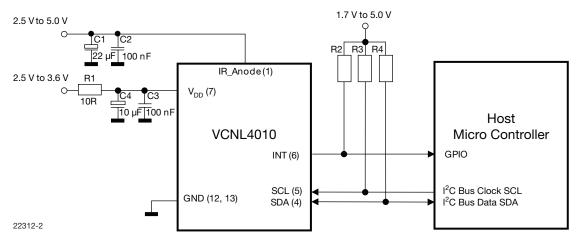


Fig. 12 - Application Circuit (x) = Pin Number

Note

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 I²C bus speed.
 For detailed description about set-up and use of the interrupt as well as more application related information see AN: "Designing VCNL4010 into an Application".



2. I²C Interface

The VCNL4010 contains seventeen 8 bit registers for operation control, parameter setup and result buffering. All registers are accessible via I²C communication. Figure 13 shows the basic I²C communication with VCNL4010.

The built in I²C interface is compatible with all I²C modes (standard, fast and high speed).

 I^2C H-level range = 1.7 V to 5 V.

Please refer to the I²C specification from NXP for details.

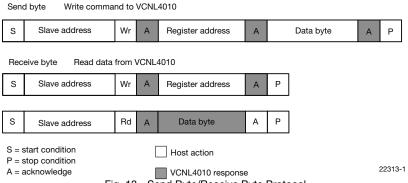


Fig. 13 - Send Byte/Receive Byte Protocol

Device Address

The VCNL4010 has a fix slave address for the host programming and accessing selection. The predefined 7 bit I^2C bus address is set to 0010 011 = 13h. The least significant bit (LSB) defines read or write mode. Accordingly the bus address is set to 0010 011x = 26h for write, 27h for read.

Register Addresses

VCNL4010 has seventeen user accessible 8 bit registers. The register addresses are 80h (register #0) to 90h (register #16).

REGISTER FUNCTIONS

Register #0 Command Register

Register address = 80h

The register #0 is for starting ambient light or proximity measurements. This register contains 2 flag bits for data ready indication.

TABLE 1 -	COMMAND	REGISTER #0						
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
config_lock	als_data_rdy	prox_data_rdy	als_od	prox_od	als_en	prox_en	selftimed_er	
			Desc	ription				
confi	g_lock	Read only bit. V	alue = 1					
als_data_rdy Read only bit. Value = 1 when ambient light measurement data is available in the result registers. This bit will be reset when one of the corresponding result registers (reg #5, reg #6) is read.								
prox_c	lata_rdy	Read only bit. Value = 1 when proximity measurement data is available in the result registers. This bit will be reset when one of the corresponding result registers (reg #7, reg #8) is read.						
als	_od	sequence of rea	a single on-dema adings and stores egisters #5(HB) ar	nd measurement for the averaged resulted and #6(LB).	or ambient light. ılt. Result is avail	If averaging is ena able at the end of	abled, starts a conversion for	
pro	x_od			nd measurement for read		rs #7(HB) and #8(LB).	
als	_en	R/W bit. Enable	s periodic als me	asurement				
pro	x_en	R/W bit. Enable	R/W bit. Enables periodic proximity measurement					
selftimed_en R/W bit. Enables state machine and LP oscillator for self timed measurements; no measurement is performed until the corresponding bit is set						asurement is		

Note

• With setting bit 3 and bit 4 at the same write command, a simultaneously measurement of ambient light and proximity is done. Beside als_en and/or prox_en first selftimed_en needs to be set. On-demand measurement modes are disabled if selftimed_en bit is set. For the selftimed_en mode changes in reading rates (reg #4 and reg #2) can be made only when b0 (selftimed_en bit) = 0. For the als_od mode changes to the reg #4 can be made only when b4 (als_od bit) = 0; this is to avoid synchronization problems and undefined states between the clock domains. In effect this means that it is only reasonable to change rates while no selftimed conversion is ongoing.



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			
	Prod	uct ID		Revision ID						
			Descr	ription						
Prod	Product ID Read only bits. Value = 2									
Revision ID Read only bits. Value = 1										

Register #2 Rate of Proximity Measurement

Register address = 82h.

ABLE 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)						
			Desc	ription							
Proxir	mity rate		easurements/s asurements/s surements/s surements/s	AULT)							

Note

• If self_timed measurement is running, any new value written in this register will not be taken over until the mode is actualy 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 -	TABLE 4 - IR LED CURRENT REGISTER #3									
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0			
Fuse p	Fuse prog ID IR LED current value									
Description										
Fuse p	Fuse prog ID Read only bits. Information about fuse program revision used for initial setup/calibration of the device.									
IR LED cu	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.

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 of measurements	
			Desc	ription			
Cont. conve	ersion mode	Enable = 1; Dis This function ca				ements. Please re	efer to the
Ambient light m	easurement rate	000 - 1 sample:	s/s = DEFAULT s/s s/s s/s s/s s/s	ment rate			
Auto offset compensation In order to compensate a technology, package or temperature related drift of the ambient there is a built in automatic offset compensation function. With active auto offset compensation the offset value is measured before each ambient in measurement and subtracted automatically from actual reading.					Ü		
Averagin	g 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 ^{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 actualy 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		
	Description								
	Read only bits. High byte (15:8) of ambient light measurement result								

TABLE 7 - AMBIENT LIGHT RESULT REGISTER #6										
Bit 7	Bit 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0									
	Description									
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		
Description									
		Read only bits	. High byte (15:8)	of proximity meas	urement result				

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

Register #9 Interrupt Control Register

Register address = 89h.

ABLE 10	- INTERRUP	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		
			Desci	ription				
R/W bits. These bits threshold			DEFAULT	number of consec	utive measureme	nts needed above/	below the	
INT_PROX	C_ready_EN	R/W bit. Enable	s interrupt genera	tion at proximity o	lata ready			
INT_ALS_	ready_EN	R/W bit. Enable	R/W bit. Enables interrupt generation at ambient data ready					
INT_TH	RES_EN	R/W bit. Enables interrupt generation when high or low threshold is exceeded						
INT_THE	RES_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 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0								
Description									
R/W bits. High byte (15:8) of low threshold value									

TABLE 12 - LOW THRESHOLD REGISTER #11									
Bit 7	Bit 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0								
Description									
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 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0								
Description									
R/W bits. High byte (15:8) of high threshold value									

TABLE 14 - HIGH THRESHOLD REGISTER #13										
Bit 7	Bit 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0									
Description										
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								
	Description								
int_pro	x_ready	R/W bit. Indicat	es a generated in	nterrupt for proximity					
int_als	_ready	R/W bit. Indicat	es a generated in	terrupt for als					
int_th_low R/W bit. Indicates a low threshold exceed									
int_t	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.



Register #15 Proximity Modulator Timing Adjustment

Register address = 8Fh.

ABLE 16 - PROXIMITY MODULATOR TIMING ADJUSTMENT #15									
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0		
N	lodulation delay ti	me	Proximity	frequency	M	lodulation dead ti	me		
			Desc	ription					
Modulation delay time R/W bits. Setting a delay time between IR LED signal and IR input signal evaluation. This function is for compensation of delays from IR LED and IR photo diode. Also in respect possibility for setting different proximity signal frequency. Correct adjustment is optimizing me signal level. (DEFAULT = 0)									
R/W bits. Settin			neasurement is us Hz (DEFAULT) z Hz	R test signal freque ing a square IR sig	•	ent signal. Four di	fferent values are		
Modulatio	n dead time	This function is	for reducing of po	evaluation of IR signs sossible disturbancevel and should be	e effects.	of the IR signal. (DEFAULT = 1)		

Note

The settings for best performance will be provided by Vishay. With first samples this is evaluated to:
 Delay Time = 0; Dead Time = 1 and Prox Frequency = 0. With that register#15 should be programmed with 1 (= default value).

Register #16 Ambient IR Light Level Register

Register address = 90h.

This register is not intended to be used by customer.

3. IMPORTANT APPLICATION HINTS AND EXAMPLES

3.1 Receiver standby mode

In standby mode the receiver has the lowest current consumption of about 1.5 μ A. In this mode only the I²C interface is active. This is always valid, when there are no measurement demands for proximity and ambient light executed. Also the current sink for the IR-LED is inactive, so there is no need for changing register #3 (IR LED current).

3.2 Data Read

In order to get a certain register value, the register has to be addressed without data like shown in the following scheme. After this register addressing, the data from the addressed register is written after a subsequent read command.

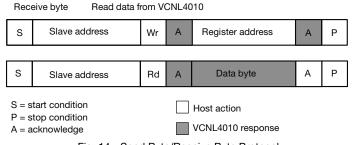


Fig. 14 - Send Byte/Receive Byte Protocol

The stop condition between these write and read sequences is not mandatory. It works also with a repeated start condition.

Note

For reading out 2 (or more) subsequent registers like the result registers, it is not necessary to address each of the registers separately. After
one read command the internal register counter is increased automatically and any subsequent read command is accessing the next
register.



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

Addressing:command: 26h, 85h (VCNL4010_l²C_Bus_Write_Adr., Ambient Light Result Register #5 [85])

Read register #5:command: 27h, data (VCNL4010_I²C_Bus_Read_Adr., {High Byte Data of Ambient Light Result register #5 [85])}

Read register #6:command: 27h, data (VCNL4010_I²C_Bus_Read_Adr., {Low Byte Data of Ambient Light Result register #6 [86])}

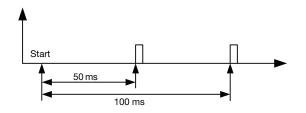
3.3 Continuous Conversion Mode in Ambient Light Measurement

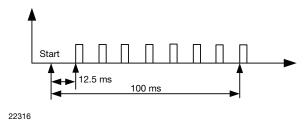
In the following is a detail description of the function "continuous conversion" (bit 7 of register #4)

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 µs.

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).





22315

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

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

Note

• ≥ 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

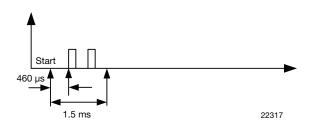


Fig. 17 - Ambient Light Measurement with Averaging = 2; using Continuous Conversion Mode

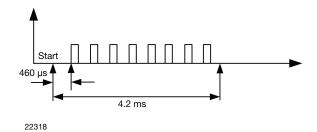
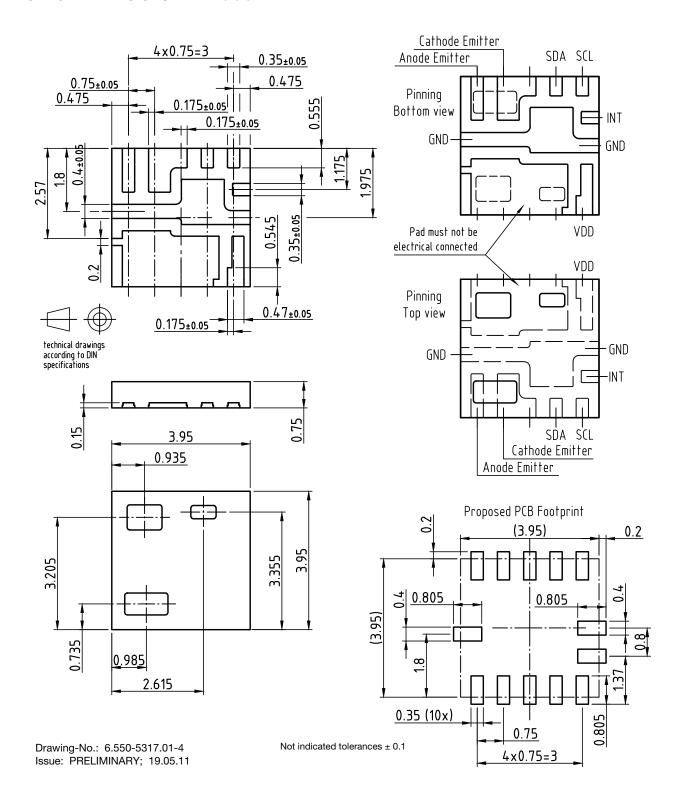


Fig. 18 - Ambient Light Measurement with Averaging = 8; using Continuous Conversion Mode



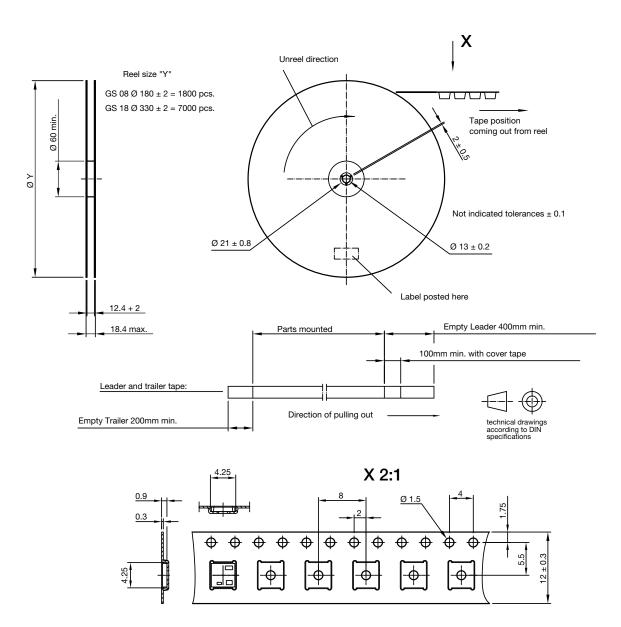


PACKAGE DIMENSIONS in millimeters





TAPE AND REEL DIMENSIONS in millimeters



Drawing-No.: 9.800-510301-4 Issue: prel; 02.12.09

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SOLDER PROFILE

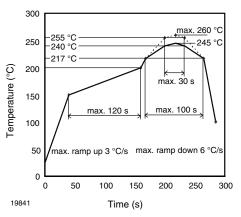


Fig. 19 - Lead (Pb)-free Reflow Solder Profile acc. J-STD-020

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 °C, 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 $^{\circ}$ C (+ 5 $^{\circ}$ C), RH < 5 $^{\circ}$ M.



Legal Disclaimer Notice

Vishay

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- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
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- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001:
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

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- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



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