Designing the VCNL4100 into an Application

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INTRODUCTION AND BASIC OPERATION

The VCNL4100 is a fully integrated proximity and ambient light sensor. It combines an infrared emitter and photodiode for proximity measurement, ambient light sensor (ALS), and signal processing IC in a single package with an 8-bit ADC. The device provides ambient light sensing to support conventional backlight and display brightness auto-adjustment, and proximity sensing to recognize objects up to a distance of 1 m (40").

This stand-alone component greatly simplifies the use and design-in of a proximity sensor (PS) in consumer and industrial applications, because the embedded IRED as well as photodiode are exactly matched to each other. The VCNL4100 features a miniature, surface-mount 8.0 mm by 3.0 mm leadless package (LLP) with a height of 1.8 mm. The device is designed specifically to meet the requirements for applications where objects need to be identified at far distances.

Through its standard I^2C bus serial digital interface, it allows easy access to a “proximity signal” and “light intensity” measurements. The programmable interrupt function offers wake-up functionality for the microcontroller when a proximity event or ambient light change occurs, which reduces processing overhead by eliminating the need for continuous polling.

Fig. 1 - VCNL4100 Top View

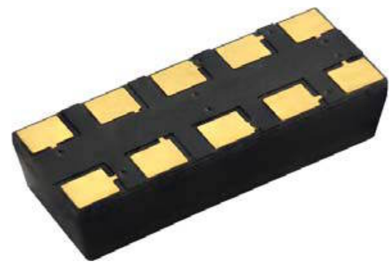

Fig. 2 - VCNL4100 Bottom View

COMPONENTS (BLOCK DIAGRAM)

The major components of the VCNL4100 are shown in the block diagram.

In addition to the ASIC with the ambient light and proximity photodiode, the infrared emitter is also implemented. Its cathode needs to be connected to the driver (pin 2) externally.

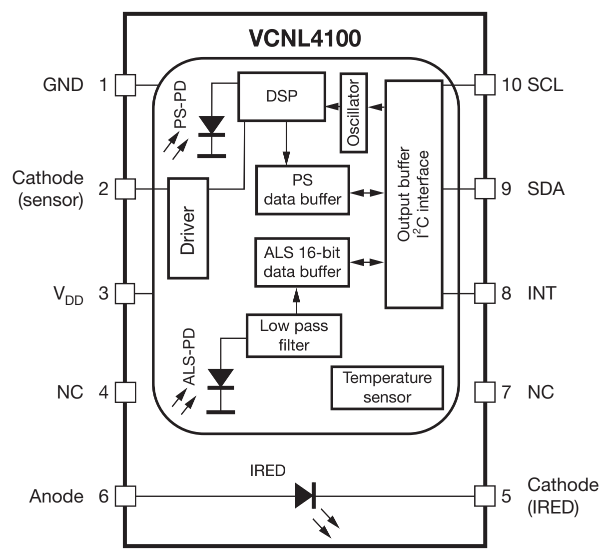

Fig. 3 - VCNL4100 Detailed Block Diagram

The integrated infrared emitter has a peak wavelength of 940 nm. It emits light that reflects off an object within 100 cm of the sensor. Two added lenses help to increase peak intensity and sensitivity by enabling a small angle of just ± 15° for the emitter and ± 30° for the detector, as shown in Fig. 4 and Fig. 5.

Designing the VCNL4100 into an Application

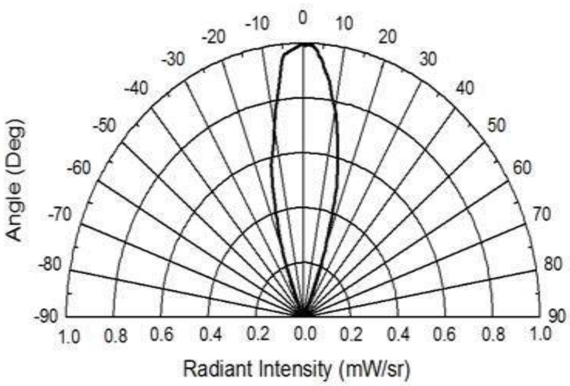

Fig. 4 - Relative Radiant Intensity vs. Angular Displacement

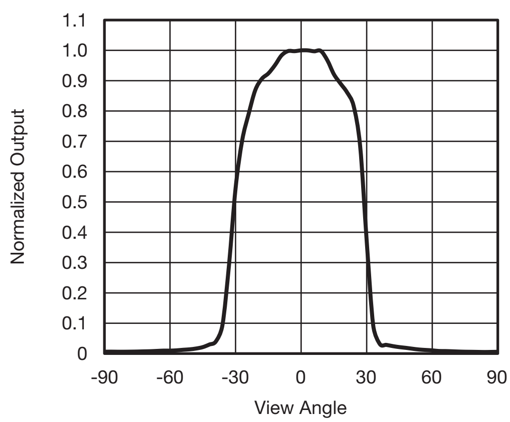

Fig. 5 - ALS Normalized Output vs. View Angle

The ASIC delivers a fixed current high enough to drive a small external FET. A series resistor added to the IRED defines the wanted pulse current, as shown in Fig. 6. The infrared light is emitted in short pulses with a programmable duty ratio from 1/20 to 1/5120. The proximity photodiode receives the light that is reflected off the object and converts it to a current. It has a peak sensitivity of 940 nm, matching the peak wavelength of the emitter. The sensitivity of the proximity stage is also programmable by choosing from four different integration times. It is insensitive to ambient light. It ignores the DC component of light and "looks for" the pulsed light at the proximity frequency used by the emitter.

The ambient light sensor receives the visible light and converts it to a current. The human eye can see light with wavelengths from 400 nm to 700 nm, with a peak of 560 nm. Vishay's ambient light sensor closely matches this range of sensitivity. It has peak sensitivity at 540 nm and a bandwidth from 430 nm to 610 nm.

The application-specific integrated circuit, or ASIC, includes an LED driver, I^2C bus interface, amplifier, integrated analog-to-digital converter, oscillator, and Vishay's "secret sauce" signal processor. For proximity, it converts the current from the photodiode to an 8-bit digital data output value. For ambient light sensing, it converts the current from the ambient light detector, amplifies it, and converts it to a 16-bit digital output stream.

PIN CONNECTIONS

Fig. 3 shows the pin assignments of the VCNL4100.

The connections include:

- Pin 1 - connect to ground
- Pin 2 - IR cathode (sensor side)
- Pin 3 - V_{DD} to the power supply
- Pin 4 - no connection
- Pin 5 - IRED cathode (IRED side)
- Pin 6 - IRED anode to the power supply resp. FET
- Pin 7 - no connection
- Pin 8 - INT to microcontroller
- Pin 9 - SDA to microcontroller
- Pin 10 - SCL to microcontroller

The power supply for the ASIC (V_{DD}) has a defined range from 2.5 V to 3.6 V. It is best if V_{DD} is connected to a regulated power supply and pin 6, the anode of the built-in IRED, is connected - via a small FET - directly to the battery. This eliminates any influence of the high infrared emitter current pulses on the V_{DD} supply line.

If separate power supplies for the V_{DD} and the infrared emitter are used and there are no negative spikes below 2.5 V, a small 100 nF capacitor should be placed close to the V_{DD} pin and a 2.2 μF capacitor at the source of the external driver FET. This is sufficient at the supply voltage for the IRED, which needs to be between 3.3 V and 5 V. In addition, a 20 kΩ to 22 kΩ pull-up resistor is needed at the gate. At the cathode of the IRED (pin 5), a current-defining resistor is needed. This could be as low as 2.7 Ω, which would then lead to about 800 mA. The SCL and SDA, as well as the interrupt lines, need pull-up resistors. The resistor values depend on the application and on the I^2C bus speed. Common values are about 2.2 kΩ to 4.7 kΩ for the SDA and SCL, and about 8.2 kΩ to 22 kΩ for the interrupt line.

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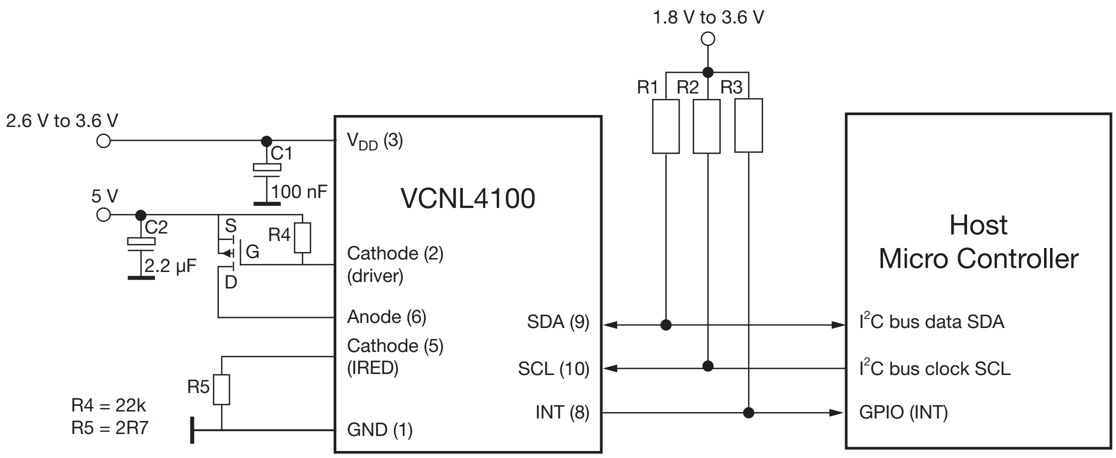

Fig. 6 - VCNL4100 Application Circuit

MECHANICAL DESIGN CONSIDERATIONS

The VCNL4100 is a fully integrated proximity and ambient light sensor. Competing sensors use a discrete infrared emitter, which leads to complex geometrical calculations to determine the position of the emitter.

The only dimensions that the design engineer needs to consider are the distance from the top surface of the sensor to the outside surface of the window, and the size of the window. These dimensions will determine the size of the detection zone.

The angle of half intensity of the emitter is about ± 15°, as shown in Fig. 7, and the sensitivity of the photodiodes is about ± 30°.

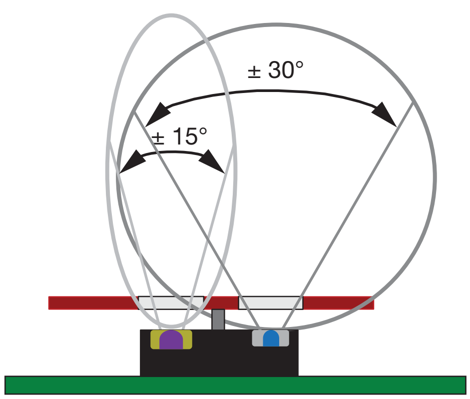

Fig. 7 - Emitter and Detector Angle

To achieve a good ambient light response, the diameter of the detector hole within the cover glass should not be too small. An angle of ± 30° will be sufficient in most applications. The package drawing shows the position of the IRED and photosensitive area. The +30° line should be set at the side of the photodiode, towards pin 1. The -30° line should be set no closer than 1 mm to that edge. The following are dimensions for the distance from the top surface of the sensor to the outside surface of the glass, a, and the width of the window, d.

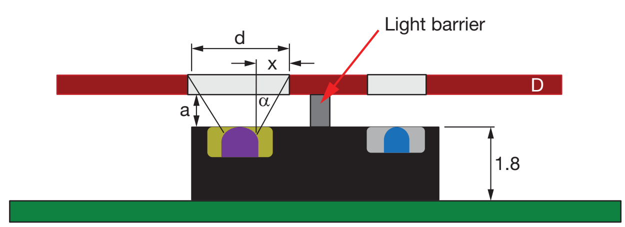

Fig. 8 - Window Diameter for Detector Hole

For the detector hole a diameter of ≥ 2 mm would be needed.

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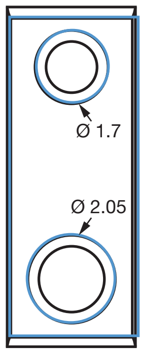

Fig. 9 - Light Holes Diameters

The diameter needs to be increased with distances between the sensor and cover glass according to the following calculation.

For the detector hole, the width calculation for distances from 0 mm to 3 mm results in:

a = 0.0 mm → x = 0.0 → d = 2.0 mm + 0.00 = 2.00 mm
a = 0.5 mm → x = 0.29 → d = 2.0 mm + 0.58 = 2.58 mm
a = 1.0 mm → x = 0.58 → d = 2.0 mm + 1.16 = 3.16 mm
a = 1.5 mm → x = 0.87 → d = 2.0 mm + 1.74 = 3.74 mm
a = 2.0 mm → x = 1.16 → d = 2.0 mm + 2.32 = 4.32 mm
a = 2.5 mm → x = 1.45 → d = 2.0 mm + 2.90 = 4.90 mm
a = 3.0 mm → x = 1.74 → d = 2.0 mm + 3.48 = 5.48 mm

For the smaller IRED hole, the diameter can be as small as 1.7 mm.

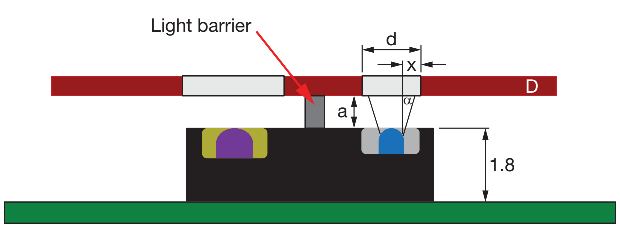

Fig. 10 - Window Diameters for IRED Hole

The width calculation for distances from 0 mm to 3 mm results in:

a = 0.0 mm → x = 0.00 → d = 1.7 mm + 0.0 = 1.7 mm
a = 0.5 mm → x = 0.15 → d = 1.7 mm + 0.3 = 2.0 mm
a = 1.0 mm → x = 0.30 → d = 1.7 mm + 0.6 = 2.3 mm
a = 1.5 mm → x = 0.45 → d = 1.7 mm + 0.9 = 2.6 mm
a = 2.0 mm → x = 0.60 → d = 1.7 mm + 1.2 = 2.9 mm
a = 2.5 mm → x = 0.75 → d = 1.7 mm + 1.5 = 3.2 mm
a = 3.0 mm → x = 0.90 → d = 1.7 mm + 1.8 = 3.5 mm

The mechanical design also needs the placement of a light barrier in between the IRED and detector to avoid any crosstalk.

PROXIMITY SENSOR

The main DC light sources found in the environment are sunlight and tungsten (incandescent) bulbs. These kinds of disturbance sources will cause a DC current in the detector inside the sensor, which in turn will produce noise in the receiver circuit. The negative influence of this DC light can be reduced by optical filtering, but is reduced much more efficiently by a so-called DC kill function. The proximity photodiode shows its best sensitivity at about 940 nm, as shown in Fig. 12.

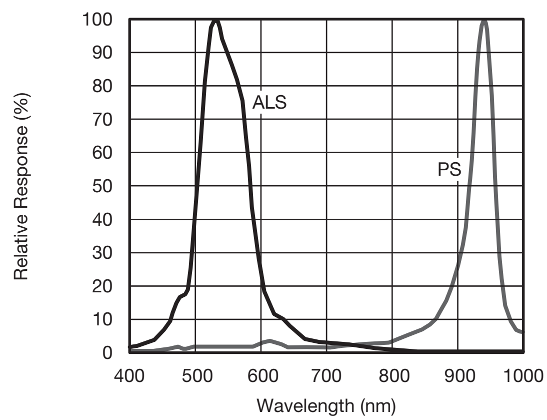

Fig. 11 - Spectral Sensitivity of ALS and Proximity Photodiode

The proximity sensor uses a short pulse signal of about 80 µs (PS_IT = 1T) up to 160 µs (PS_IT = 2T). The on / off duty ratio setting now defines which repetition rate to be used, which can be programmed from 1/20 up to 1/5120.

In addition to DC light source noise, there is some reflection of the infrared emitted light off the surfaces of the components surrounding the VCNL4100. The distance to the cover, proximity of surrounding components, tolerances of the sensor, ambient temperature, and type of window material used all contribute to this reflection. The result of the reflection and DC noise is the production of an output current on the proximity and light sensing photodiode. This current is converted into a count called the offset count.

In addition to the offset count, there could also be a small noise floor during the proximity measurement, which comes from the DC light suppression circuitry. This noise is typically just one or two counts. Only with light sources with strong infrared content could it be in the range from ± 5 counts to ± 10 counts.

The application should "ignore" this offset and small noise floor by subtracting them from the total proximity readings.

Results most often do not need to be averaged. If an object with very low reflectivity or at longer range needs to be detected, the sensor provides a register where the customer can define the number of consecutive measurements that the signal must exceed before producing an interrupt. This provides stable results without requiring averaging.

Designing the VCNL4100 into an Application

PROXIMITY CURRENT COSUMPTION

Both the ambient light sensor and the proximity sensor within the VCNL4100 offer a separate shutdown mode. Default values after start-up have them both disabled. The application may activate just the one wanted or both.

The VCNL4100's embedded LED driver drives the internal IRED via the "LED CATHODE" pin with a pulsed duty cycle. The IRED on / off duty ratio is programmable by an I²C command at register PS_Duty. Depending on this pulse / pause ratio, the overall proximity current consumption can be calculated. When higher measurement speed or faster response time is needed, PS_Duty may be selected to a maximum value of 1/20, which means one measurement will be made every 1.5 ms, but this will then also lead to the highest current consumption:

PS_Duty = 1/20: peak IRED current = 800 mA,
averaged current consumption is 800 mA/20 = 40 mA.

For proximity measurements executed just every 365 ms:
PS_Duty = 1/5120 peak IRED current = 800 mA,
averaged current consumption is 800 mA/5120 = 0.16 mA.

The above is always valid for the normal pulse width of T = 1T = 80 μs, as well as for 1.3T, 1.6T, and 2T. These pulse lengths are widened according to the factor, resulting in 160 μs for 2T, but the repetition time is also extended, ending in a period time of about 700 ms. Besides PS_IT, there are also two bits called PS_ITB.

These two bits offer the possibility to increase the pulse length from just 160 μs (for PS_IT = 2T and PS_ITB = 1/2) up to 1100 μs when programming PS_ITB with "4." This is already long enough that it could be needed to reduce the possible IRED current. The reduction is now also dependent on the duty ratio.

This duty ratio is always adapted. So, for doubling the pulse time the duty will also be doubled, ending with the fastest repetition time of "1/20," and for the longest pulse of 1.1 ms then: 20 x 1.1 ms = 22 ms and the pulse / pause ratio shows then: t_p/T = 0.05. This allows for ambient temperatures < 50 °C for an IRED current of up to 620 mA, but not 800 mA anymore. Also for duty ratio "1/80" t_p/T = 0.013 and even "1/640" t_p/T = 0.002, a small reduction is necessary (see also Fig. 12).

Also for half the maximum pulse length, for 0.56 ms with the fastest repetition time of 11 ms (duty = 1/20), a reduction to 700 mA is necessary.

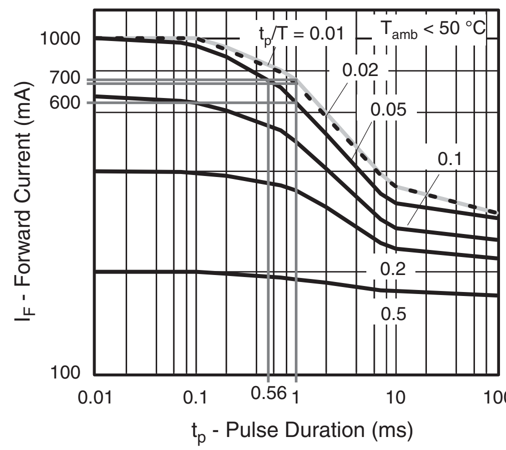

Fig. 12 - Pulse Forward Current vs. Pulse Duration

INITIALIZATION AND I²C TIMINGS

The VCNL4100 contains nine 16-bit command codes for operation control, parameter setup, and result buffering. All registers are accessible via I²C communication. The built-in I²C interface is compatible with the standard and high-speed I²C modes. The I²C H-level voltage range is from 2.5 V to 3.6 V.

There are only three registers out of the eight that typically need to be defined:

1. PS_Duty = 1/20 to 1/5120 (proximity duty ratio),
   PS_IT (proximity integration time = pulse length),
   PS_PERS (number of consecutive measurements above / below threshold), and PS_SD (PS power_on)
   PS_IT_Bank setting REGISTER PS_CONF1 #03 [0x03h]
2. ALS_IT (ALS_integration time)
   ALS_PERS (number of consecutive measurements above / below threshold), and
   ALS_SD (ALS power_on)
   REGISTER ALS_CONF #00 [0x00h]
3. Definition of the threshold value from the number of counts the detection of an object should be signaled:
   Proximity TOP Threshold REGISTER,
   PS_THDL_L in lower byte for #06, and
   PS_THDL_H in upper byte of #06.

To define the infrared emitter current, as well as the integration time (length of the proximity pulsing), evaluation tests should be performed using the least reflective material at the maximum distance specified.

Fig. 13 shows the typical digital counts output versus distance for three different emitter currents for integration time T1. The reflective reference medium is the Kodak Gray card. This card shows approximately 18 % reflectivity at 940 nm.

Designing the VCNL4100 into an Application

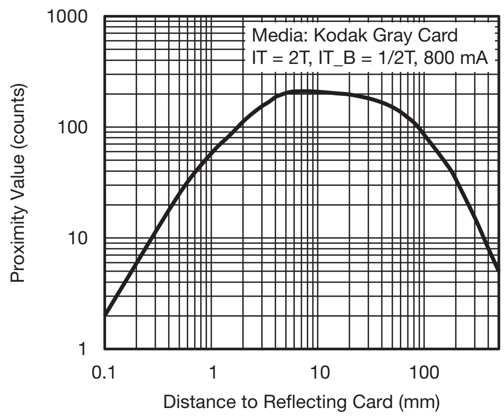

Fig. 13 - Proximity Value vs. Distance for IT= 2T and IT_B = 1/2T

The above diagram shows the possible detection counts with a pulse of 160 μs.

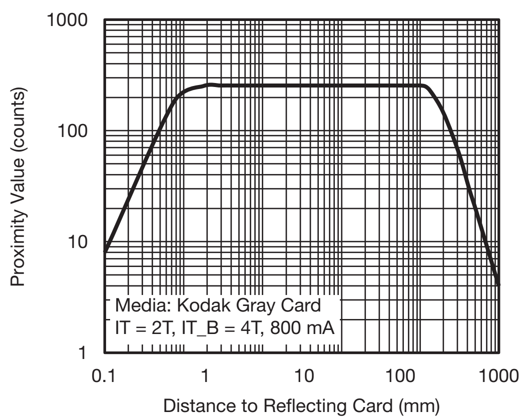

Fig. 14 - Proximity Value vs. Distance for IT = 2T and IT_B = 4T

Extending the pulse width up to 1100 μs will surely lead to saturation for low distances of an object, even for the Kodak Gray Card.

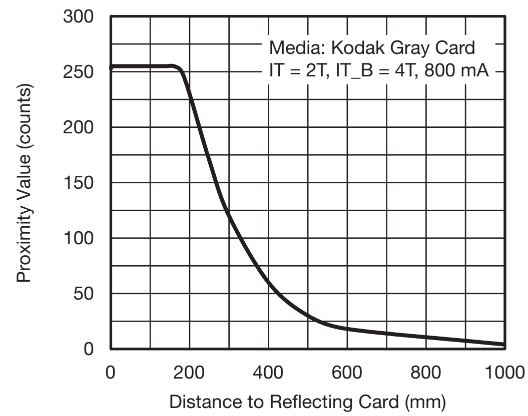

Fig. 15 - Proximity Value vs. Distance

Presenting the graph above in linear view shows data values between 20 cm to 1 m.

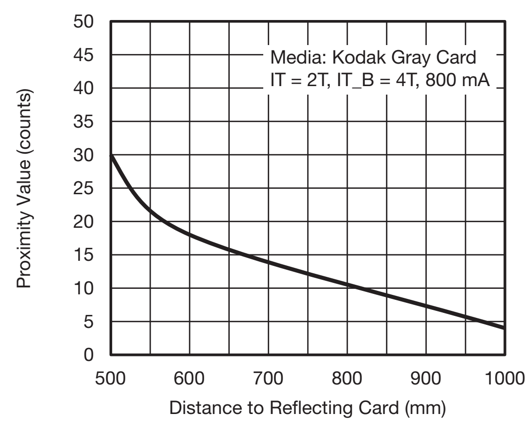

Fig. 16 - Proximity Counts vs. Distance

Reducing the graph above to just the upper half of the meter shows the remaining four counts at a distance of 1 m, even for the Kodak Gray Card.

Note

- PS_IT_B ≥ 2 should only be used if the application is not used in direct sunlight

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With defining the duty time (PS_Duty), the repetition rate = the number of proximity measurements per second (speed of proximity measurements) is defined. This is possible between 1.44 ms (more than 600 measurements/s) by programming PS_Duty with 1/20 and 700 ms (about 0.7 measurements/s) with programming PS_Duty with 1/5120. It ends up at about 5.6 s duty time when programmed to the longest possible pulse of 1.1 ms (PS_IT = 2T and PS_IT_B = 4T).

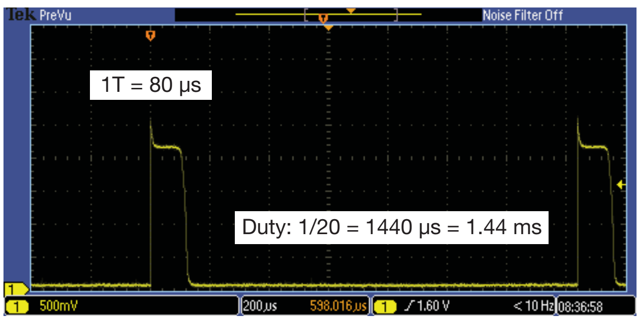


Fig. 17 - Proximity Measurements with PS_Duty = 1/20 and PS_IT = 1T (PS_IT_B = 1/2)

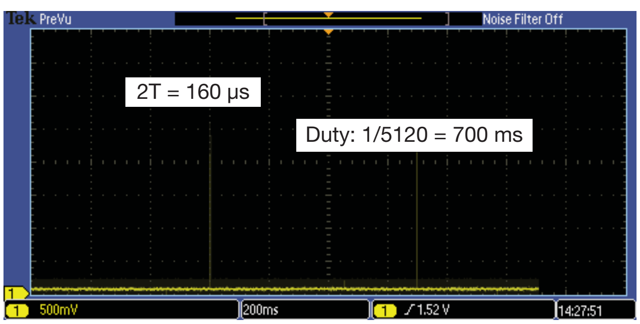


Fig. 18 - Proximity Measurements with PS_Duty = 1/5120 and PS_IT = 2T (PS_IT_B = 1/2)

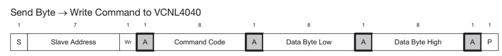
This duty cycle also determines how fast the application reacts when an object appears in, or is removed from, the proximity zone.

Reaction time is also determined by the number of counts that must be exceeded before an interrupt is set. This is possible to define with proximity persist: PS_PERS. Possible values are from 1 to 4.

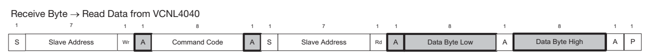
To define all these register values, an evaluation test should be performed. The sensor starter kit allows you to perform evaluation tests and properly set the registers for your application. The kit is available from any of Vishay's distributors. It comes with the VCNL4020 sensor board. The VCNL4100 sensor board can be requested by sending an e-mail to sensorstechsupport@vishay.com.

Timing

For an I²C bus operating at 100 kHz, to write or read an 8-bit byte, plus start (or stop) and bit acknowledgement, takes 100 µs. Together with the slave address byte and the 8-bit command code byte, plus the 16-bit data, this results in a total of 400 µs. When the device is powered on, the initialization with just these five registers needs 5 x 4 bytes (slave address, command register, and 16-bit data) for a total of 20 bytes. So, 20 x 100 µs = 2000 µs = 2 ms.



The read-out of 16-bit data would take a total of five bytes (slave address, command code, slave address with read bit set) and 16-bit data sent from the VCNL4100. So, 500 µs:



Power Up

The release of the internal reset, the start of the oscillator, and the signal processor need **2.5 ms**

Initialize Registers

Write to three registers **1200 µs**

- Proximity duty ratio
- ALS integration time
- Proximity interrupt TOP threshold

After programming command code 06 with the evaluated threshold values, command code 04 with the provided and proposed value, and command code 00 with the needed ALS integration time, the command code 03 will power up the sensor with the needed proximity pulse and in wanted duty cycle.

Asking for one forced proximity measurement	**400 µs**
For (active forced, PS_IT = 2)	
Time to trigger [0.5 x PS_IT]	**500 µs**
DC-kill ambient light [3 x PS_IT]	**3000 µs**
Proximity measurement [1 x PS_IT]	**1000 µs**
IRED shutdown [1 x PS_IT]	**1000 µs**
Read out of the proximity data	**500 µs**
total:	**6400 µs**

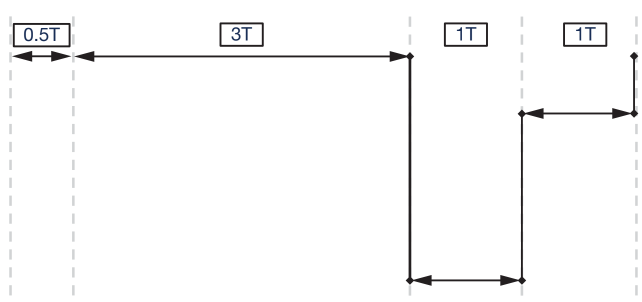


Fig. 19 - Timing Specification for Active Forced Mode

APPLICATION NOTE

Designing the VCNL4100 into an Application

AMBIENT LIGHT SENSING

Ambient light sensors are used to detect light or brightness in a manner similar to the human eye. They allow settings to be adjusted automatically in response to changing ambient light conditions. By turning on, turning off, or adjusting features, ambient light sensors can conserve battery power or provide extra safety by eliminating the need for manual adjustments.

Illuminance is the measure of the intensity of a light incident on a surface and can be correlated to the brightness perceived by the human eye. In the visible range, it is measured in units called “lux.” Light sources with the same lux measurement appear to be equally bright. In Fig. 19, the incandescent light and sunlight have been scaled to have the same lux measurement.

In the infrared region, the intensity of the incandescent light is significantly higher. A standard silicon photodiode is much more sensitive to infrared light than visible light. Using it to measure ambient light will result in serious deviations between the lux measurements of different light sources and human eye perception. Using Vishay’s ambient light sensors will solve this problem because they are most sensitive to the visible part of the spectrum.

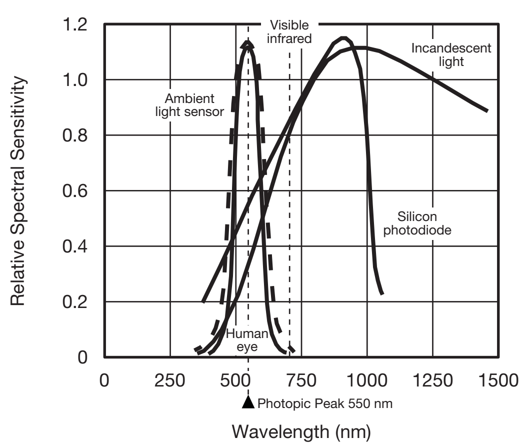


Fig. 20 - Relative Spectral Sensitivity vs. Wavelength

The human eye can see light with wavelengths from 400 nm to approximately 700 nm. The ambient light sensor array in the VCNL4100 closely matches this range of sensitivity and provides a digital output based on a 16-bit signal.

AMBIENT LIGHT MEASUREMENT, RESOLUTION, AND CALCULATION

The ambient light sensor’s measurement resolution is defined to about 0.01 lux/count for the highest sensitivity with a 640 ms integration time. The 16-bit digital resolution is equivalent to 65 536 counts. This yields a measurement range from 0.01 lux to 655 lux. For higher illuminance, shorter integration time needs to be selected, which results in lower resolution.

ALS RESOLUTION AND MAXIMUM DETECTION RANGE			
ALS_IT		SENSITIVITY (lx/step)	MAXIMUM DETECTION RANGE (lx)
ALS_IT (7 : 6)	INTEGRATION TIME		
(0, 0)	80 ms	0.08	5243
(0, 1)	160 ms	0.04	2621
(1, 0)	320 ms	0.02	1311
(1, 1)	640 ms	0.01	655

The sensitivity curve below shows the behavior of this ALS photodiode.

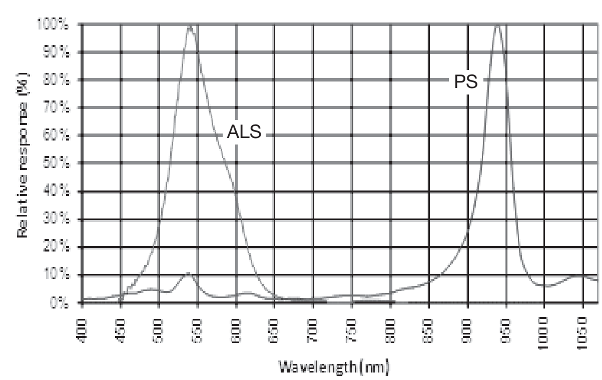


Fig. 21 - Normalized Spectral Response

AMBIENT LIGHT SENSOR CURRENT CONSUMPTION

The ambient light sensor can operate with four selectable integration times from 80 ms to 640 ms.

During ALS measurements, the device consumes approximately 180 μA.

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AMBIENT LIGHT INITIALIZATION AND I²C INTERFACE

For ambient light sensing, only the low byte of command code #0 needs to be initialized:

- ALS_SD (bit 0 = 0 = ALS Power_on)
- ALS_INT_EN (bit 1 = 1 = ALS interrupt enable)
- ALS_PERS (bit 2, 3: no. of interrupt persistence)
- ALS_IT (bit 6, 7: integration time)

The rate for self-timed measurements is dependent on the integration time.

For unknown brightness conditions, it should always be started with the shortest integration time. This avoids possible overload / saturation. Only if ambient light result register values are very low, e.g. no content within the high byte of the 16-bit register (#9), should the next more sensitive integration time be used.

Calculating the available lux level is done by multiplying the ambient light result value from register 9 (L and H byte) with the integration time / resolution.

Example: integration time is at 80 ms and 0x09H and 0x09L show 01010100 and 01110110, expressed in decimals: 21 622 counts leading to 21 622 x 0.08 to 1729 lx.

Within the ready-made application, this factor should be fine-tuned, as cover glass and the size of the opening will also impact the result.

Interrupt

The VCNL4100 features a very intelligent interrupt function. The interrupt function enables the sensor to work independently until a predefined proximity or ambient light event or threshold occurs. It then sets an interrupt which requires the microcontroller to awaken. This helps customers reduce their software effort, and reduces power consumption by eliminating polling communication traffic between the sensor and microcontroller.

The interrupt pin, pin 8, of the VCNL4100 should be connected to a dedicated GPIO of the controller. A pull-up resistor is added to the same power supply that the controller is connected to. This INT pull-up resistor may be in the range of 8.2 kΩ to 100 kΩ.

The events that can generate an interrupt include:

1. A lower and an upper threshold for the proximity value can be defined. If the proximity value falls below the lower limit or exceeds the upper limit, an interrupt event will be generated. In this case, an interrupt flag bit in the read-out register 0x0B will be set and the interrupt pad of the VCNL will be pulled to low by an open drain pull-down circuit. In order to eliminate false triggering of the interrupt by noise or disturbances, it is possible to define the number of consecutive measurements that have to occur before the interrupt is triggered.
2. A lower and an upper threshold for the ambient light value can be defined. If the ambient light value falls below the lower limit or exceeds the upper limit, an interrupt event will be generated. There are two sets of high and low threshold registers, so both thresholds for proximity and ambient light can be observed in parallel.

Besides this “normal” interrupt mode, an automatic mode is also available, which is called the logic output mode.

This mode automatically pulls the interrupt pin low when an object exceeds the programmed upper threshold and also resets it if the lower threshold is exceeded. So no actions from the controller are needed if, for example, a smartphone is held close to an ear but quickly taken away (e.g. for a short look at the display).

Application Example

The following example will demonstrate the ease of using the VCNL4100 sensor. Customers are strongly encouraged to purchase a sensor starter kit and request a VCNL4100 sensor board from sensorstechsupport@vishay.com.

Offset

During development, the application-specific offset counts for the sensor were determined. As previously mentioned, the offset count is affected by the components surrounding the VCNL4100, the window or cover being used, the distance from the sensor to the cover, and emitter intensity, defined by the forward current, which is dependent on the value of the series resistor used.

In the following example, with a cover over the sensor and choosing a 2.7 Ω series resistor, about 800 mA peak current flows through the sensor’s internal IRED and the offset counts are seven counts (Fig. 18). Offset counts vary by application and can be anywhere from 0 counts to several tens of counts. It is important to note that the offset count may change slightly over time due to, for example, the window becoming scratched or dirty, or being exposed to high-temperature changes. If possible, the offset value should occasionally be checked and, if necessary, modified.

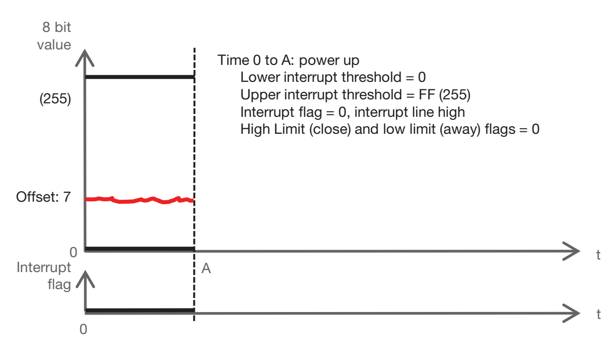

Fig. 22

Designing the VCNL4100 into an Application

Power Up

As mentioned, there are three variables for proximity measurement that need to be set in the register when the sensor is powered up: the number of occurrences that must exceed a threshold to generate an interrupt, the threshold values, and the number of proximity measurements per second.

The sensor should detect persons at a distance of 100 cm. Development testing determined that a current of 800 mA produces adequate counts for detection. The proximity measurement rate is set so that about 10 measurements are done within a second and the number of occurrences to trigger an interrupt is set to four. Based on development testing, with a person wearing quite dark clothes at about a 100 cm distance, the resulting total count is 10. This will be used as the upper threshold (high threshold).

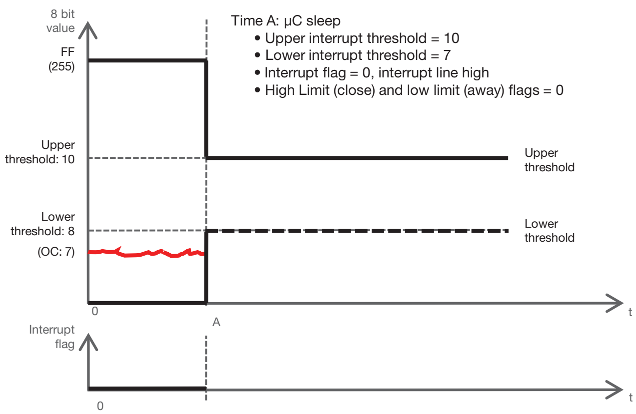

Fig. 23

By setting the number of occurences before generating an interrupt to four, a single proximity value above or below the thresholds will have no effect, as shown in Fig. 24.

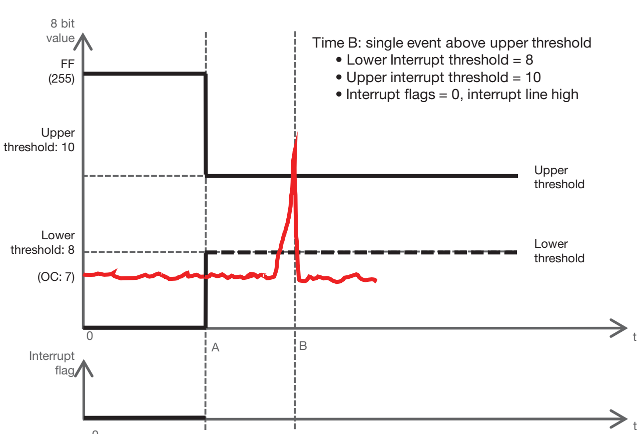

Fig. 24

Home appliance applications such as intelligent coffee machines and ovens and others will wake up when a person comes close and turns on their display. For other applications, such as automatic dispensing, the soap or towel will be dispensed.

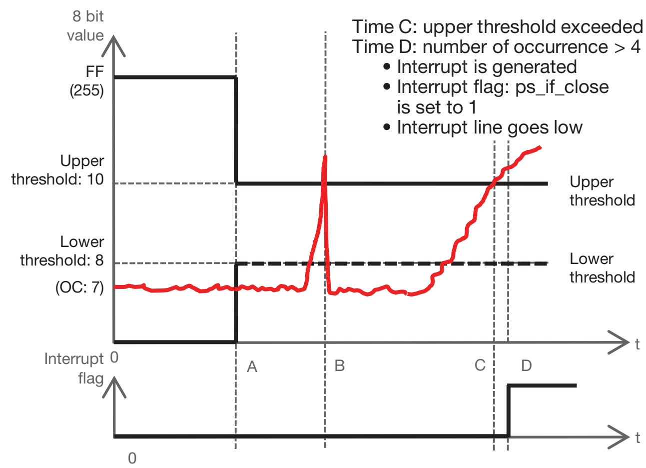

Fig. 25

In some applications, the bottom threshold will also be programmed and wait for an interrupt signal. The ps_if_away is also set to "1" and the ps_if_close cleared by reading it, since the object is close to the sensor. A lower threshold will occur when the object (person) is no longer that close before the sensor and the display and / or light will no longer be illuminated.

For this example, the lower threshold is also set to a defined level, here just eight counts, which is just one count more than typical offset count.

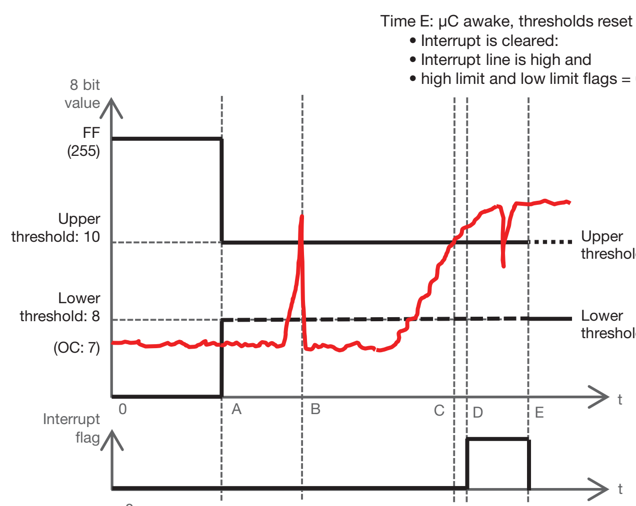

Fig. 26

Designing the VCNL4100 into an Application

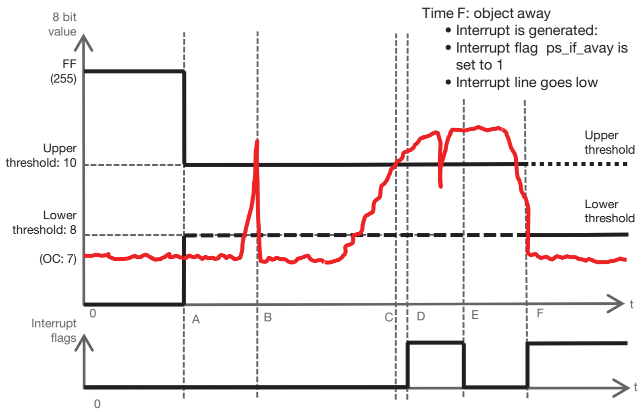

Fig. 27

Some measurements and features are shown with the demo tool and demo software with a cover glass at about a 1 mm distance.

1. Proximity set-up with 2T wide pulses, 800 mA emitter current, and a duty cycle of 1/640, which results in about six measurements per second (PS_IT_B = 1).

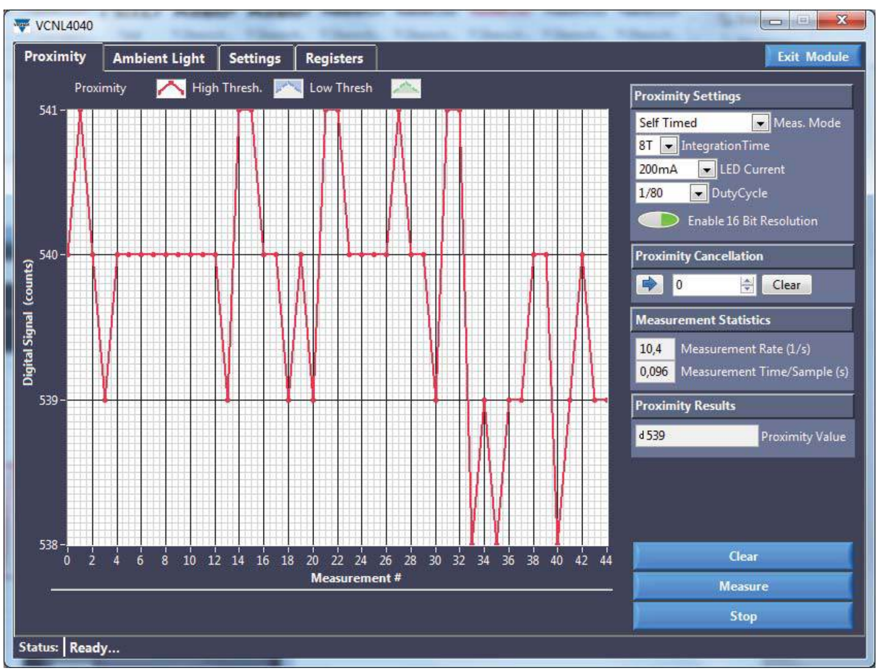

Fig. 28

Designing the VCNL4100 into an Application

2. If a hand or skin now comes as close as 50 cm, these seven counts rise up to more than 10 counts.

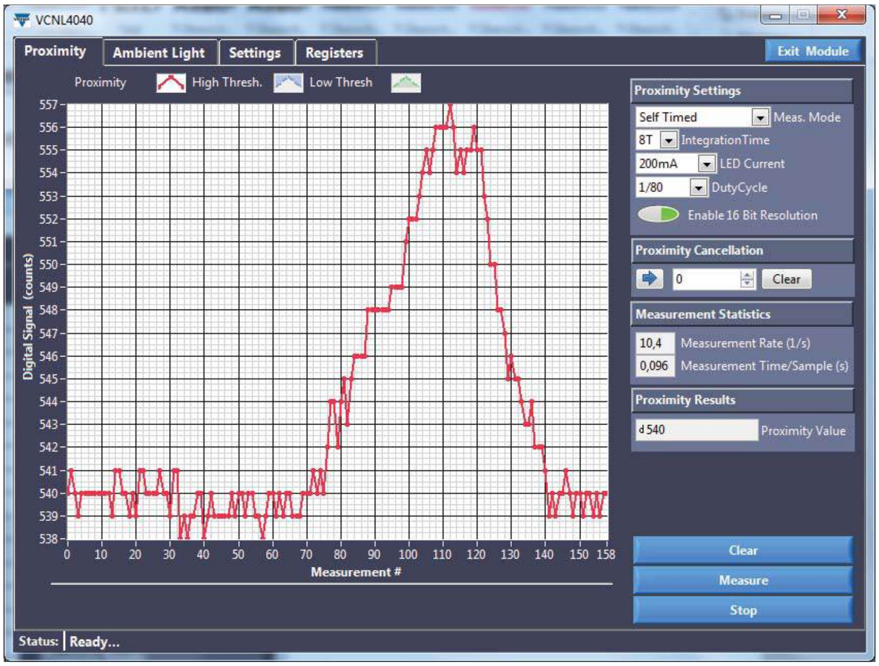

Fig. 29

3. Here the thresholds are programmed as 10 for the upper and eight for the lower. To see these, both "Show" buttons are activated. The presence of an object should only be recognized when four consecutive measurements are above that threshold.

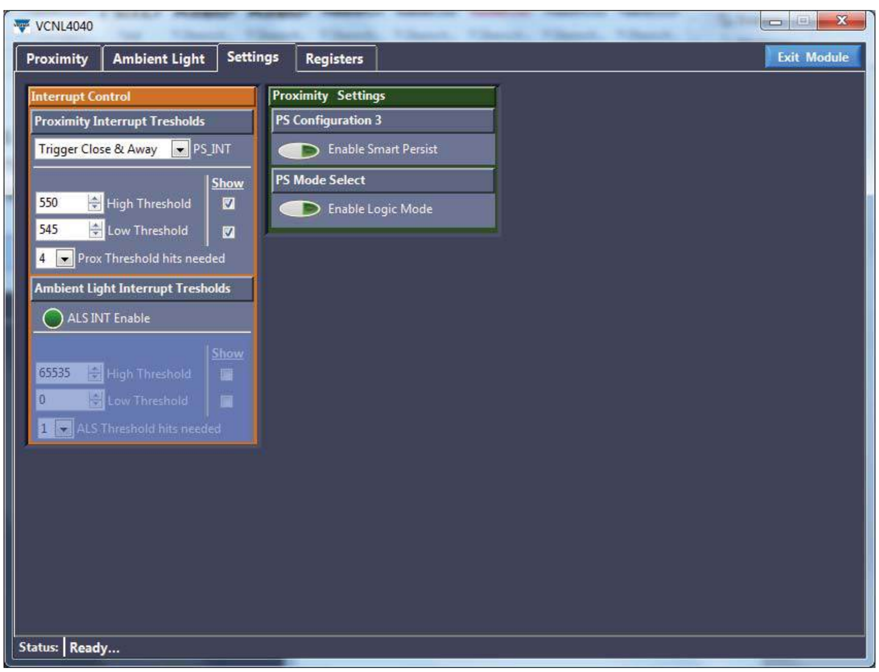

Fig. 30

Designing the VCNL4100 into an Application

4. Just one or two measurements above the threshold will not activate the interrupt.

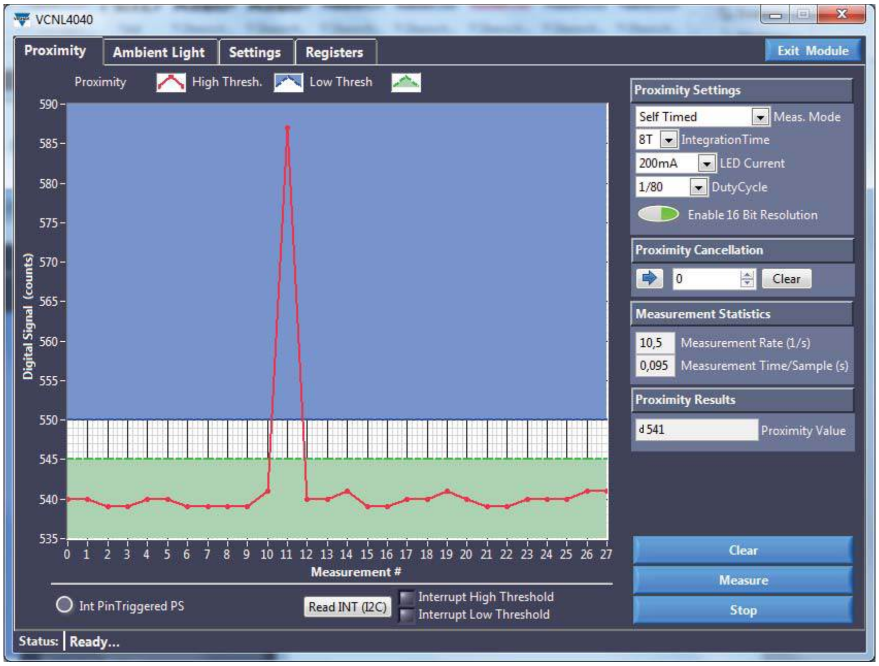

Fig. 31

5. With more than four measurements above the threshold, however, the interrupt is pulled low, as indicated by the red LED on the demo board and the red light: "Int Pin Triggered PS."

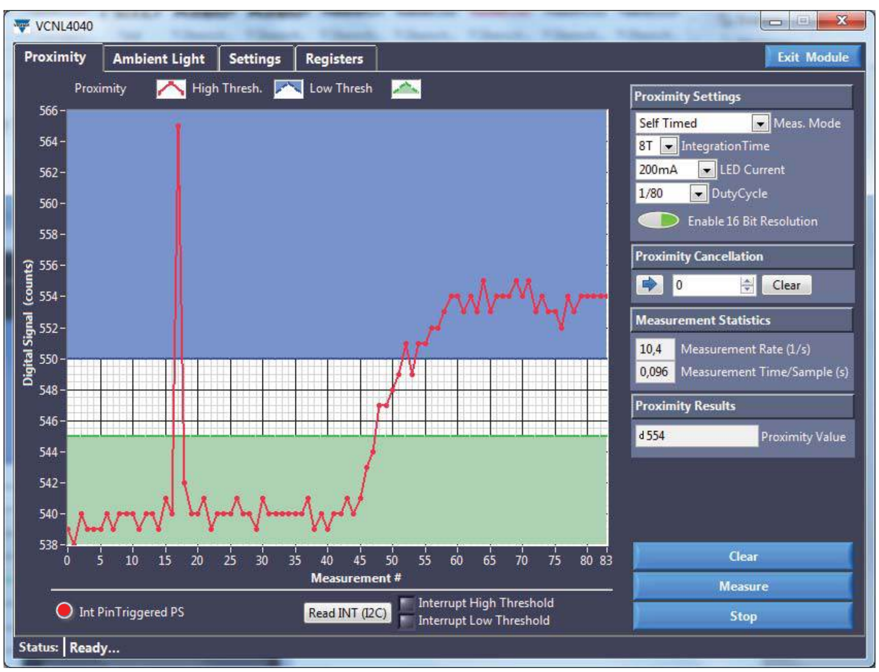

Fig. 32