



Sensor Starter Kit User Guide

By Reinhard Schaar

INTRODUCTION

With the first digital sensors featuring the possibility to be controlled via the I²C-bus Vishay offered a demo kit that allowed for an easy connection to any Windows PC.

This demo kit was for the very first proximity / ambient light sensor (VCNL4000) and it looked as follows:



Fig. 1 - VCNL4000 Demo Kit

This VCNL4000 demo kit came with a mini-CD containing the USB driver and software, a USB dongle and the VCNL4000 sensor board.

This kit has now been replaced with the Sensor Starter Kit.



Fig. 2 - Sensor Starter Kit

The Sensor Starter Kit includes a USB dongle and mini-CD, which includes the needed USB driver and updated software. This is now the base for all of Vishay's sensor boards.

This kit (order name: **SensorStarterKit**) can be purchased from any of our catalogue distributors. It serves as the base for the VCNL4010, VCNL4020, VCNL4020X01, and VCNL3020 sensor boards and the VCNL4020 gesture demo board.

Every new digital sensor will also be available on a new sensor board, which can be connected to the USB dongle and operated with the Sensor Starter Kit software.

Sensor Starter Kit User Guide

For the sensor boards, please contact sensortechnsupport@vishay.com and we will send you the requested board absolutely free of charge. Software upgrades will be provided by e-mail and are also available as a download, under the “Software” section from the Sensor Starter Kit website:

www.vishay.com/moreinfo/vcnldemokit/

The VCNL4020 is the default sensor board attached to the Sensor Starter Kit because this is best starting point to learn about proximity and ambient light sensors.



Fig. 3 - VCNL4020 Sensor Board

The VCNL4010 and VCNL3020 are function and feature-wise the same as the VCNL4020, except the VCNL3020 does not include the ambient light sensor. The VCNL4020X01 is nearly identical to the VCNL4020, although it covers the higher temperature range required for automotive applications and comes with a bit higher internal emitter intensity.

For complete details on the VCNLs please read their datasheets

www.vishay.com/optical-sensors/reflective-outputis-16/

and corresponding application notes “Designing VCNLxyz into an Application”:

www.vishay.com/doc?84138 (VCNL4010)

www.vishay.com/doc?84136 (VCNL4020)

www.vishay.com/doc?84139 (VCNL3020)

There will soon be more digital sensors, an ambient light sensor, an RGB sensor and the next generation of proximity / ambient light sensors. This common base will be used for all these new devices. All available sensor boards that can be driven with the Sensor Starter Kit are shown here: www.vishay.com/moreinfo/vcnldemokit/

ESD WARNING

The VCNLs are sensitive to electrostatic discharge. Please take necessary precautions when handling the sensors and kit. For further information please read “Assembly Instructions” and “Packaging and Ordering”.

KIT COMPONENTS

There are three main components to the kit:

1. The blue sensor board, on which is soldered the VCNL4020, a decoupling capacitor, an additional IRED (VSMF2890GX01), some switching components, and the 2 x 8 pin connector
2. The USB dongle, which takes care of delivering the needed I²C-bus and supplies “clean” power to the sensor board (plus some GPIOs)
3. The development software found on the CD

The sensor board can be plugged into the USB dongle in the up or down orientation. An indicator light within the dongle will be illuminated when the sensor board is receiving power and the development software is started. The CD also contains a software license file. Note that the license file will be installed automatically by the installer. If for some reason this does not happen, the license folder is also included on the CD and should be saved to the C: drive before the software will run:

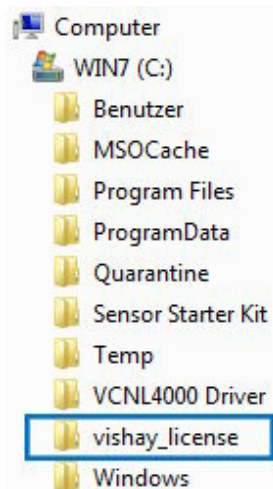


Fig. 4 - Vishay License in C:/ Directory

Please follow the Sensor Starter Kit installation guide, www.vishay.com/doc?84242



Fig. 5 - VCNL4010 Sensor Board



Sensor Starter Kit User Guide

VCNL Sensor Board Layout

The VCNL sensor boards, figure 3 and 5, have test points to allow simple evaluation and / or connection to the customer's application board. The boards also include an external emitter (VSMF2890GX01) to increase the measurement range to 500 mm and supporting FETs to use the integrated emitter and external emitter in series.

For more information on extending the detection range, please read www.vishay.com/doc?84225

Sensor Board Description, Functions, and Features, as well as a Schematic of the Board

For the VCNL4020 gesture control sensor board, this information can be found at: www.vishay.com/doc?84218

Every new sensor board can be connected to the Sensor Starter Kit. Please see:

www.vishay.com/moreinfo/vcnldemokit/

and the last page of this document.

Other Useful Links

I²C specification version 3.0:

www.nxp.com/documents/user_manual/UM10204.pdf

Male pin connector 2199SB-XXG-301523

Female pin connector 2200SB-XXG-A1

www.almita-connectors.com/connector/pcb-connectors.html

VCNL40x0 Development Software

After installing the software, run the following command: Rapid_VCNL40x0.exe. When executing the program, the Proximity Function screen is displayed. There are four tabbed files: Proximity Function, Ambient Light Function, Setup, and Register.

PROXIMITY FUNCTION

Proximity Mode

- select a single measurement, periodic measurement, or self-timed measurement. The periodic measurement rates are set in the Measurement Speed window within Setup menu. The default setting is "periodic measurement (on demand)." Selecting periodic measurement sets the 'prox_od' bit 3 of the command register #0 (80h) to "1." See screen shot 1.
- When chosen "selftimed mode" one additional window will appear what allows then the to program the proximity rate between 1.95 and 250 measurements per second as specified within datasheet: proximity rate register #2 (82h) bits 0 to 2.

Proximity Settings

- sets the infrared emitter current. The infrared emitter current determines the effective range of the sensor; higher current will translate to longer sensing range. This feature can also be used to determine the impact of the cover or window on the sensing range. To compensate for the infrared light absorbed by the window, the current can be increased. The current can be set by either toggling up or down or by left clicking in the window and a current select bar will pop-up. The default setting is 100 mA.

Proximity Results

- shows the chosen measurement rate, which is dependent on the delay time selected in conjunction with the measurement speed. The default is 10 ms ("10"), which results in about 30 measurements per second. So the time needed for one measurement is $1/30 \text{ s} = 0.033 \text{ s}$, which is shown within the "Measurement Time / Sample" field. The next four items show the actual proximity counts, their max., min., and mean values as well as the averaged peak to peak noise value.

Clear Display

- clears the upper and lower window graphs and resets the 'Data#' to zero.

Proximity Value

Changes the unit of measure for the proximity value. Click on the small blue letter on its left side. This letter indicates the selected format: b = binary, d = decimal, x = hexadecimal, o = octal, and p stands for SI notation.

Infinite Impulse Response (IIR) Filter

This low pass filter is activated with the "active" button and shows an average of the measurement results. The average value can be changed from 1 to 20 by clicking on the toggle arrow where 1 corresponds to no averaging and 20 to strong averaging. When active the button will be red.

Upper Window

Displays the entire 16-bit measured signal from 0 to 65 535 counts.

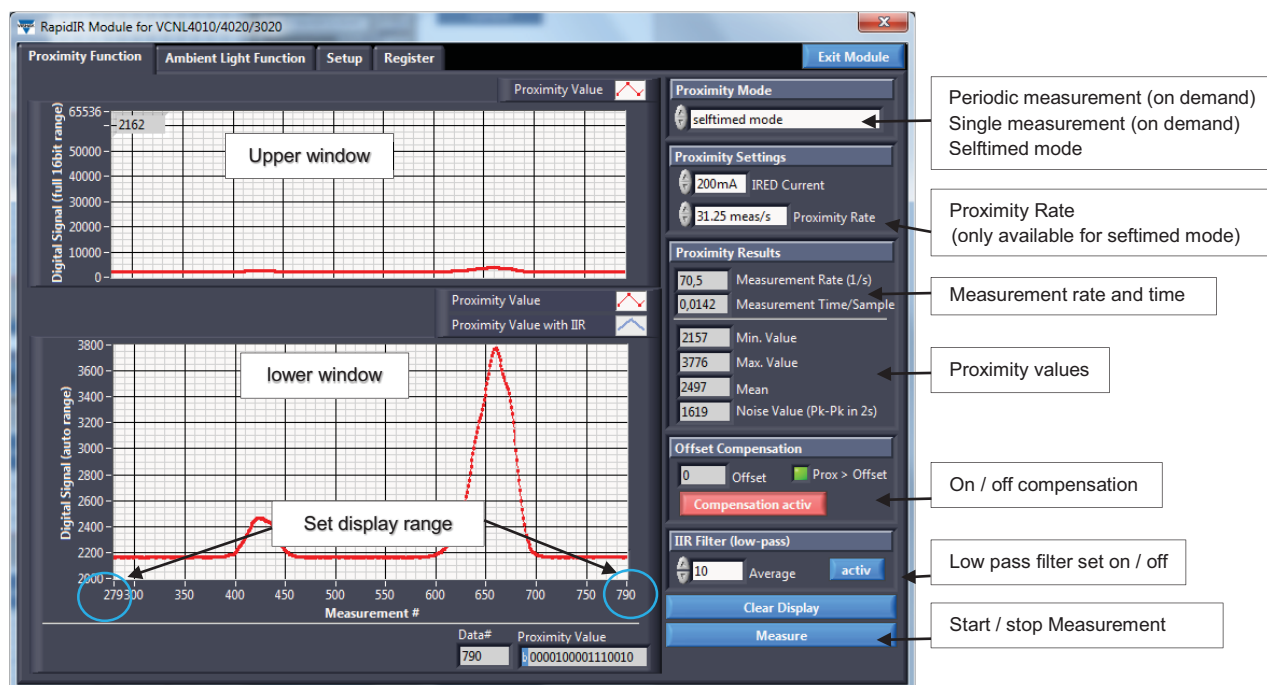
Lower Window

Displays only the active or dynamic range. The y-axis represents the number of counts and will change depending on the sensor reading.

Proximity Measurement

Click on the measure button to initiate a measurement.

Sensor Starter Kit User Guide



Screen Shot 1

Offset

Without an object in range, the upper window shows an offset of approximately 2000 counts. The lower windows shows the exact values. This offset is a result of optical crosstalk and digital noise. In an application where a window is placed over the top of the sensor, the offset value can be as high as 5000 to 20 000 counts.

For the kit, the offset value is calculated by averaging the last 2 seconds of counts. In a ready-made application the offset value should be subtracted from incoming proximity readings and the resultant used to determine object proximity.

Object with Range of 200 mm and 100 mm

Assuming the offset value is 2170 counts, at a range of 200 mm, the reflection from a hand results in an output count of 2190 counts. This is 20 counts higher than the offset or noise floor. At a range of 100 mm, the reflection of the object results in an output count of 2270 counts. This is 100 counts higher than the offset value. By clicking the "Compensate Offset" button, the software simulates this subtraction. When this function is active, the button will be red as in screen shot 1. With compensation offset active, the digital signal in the lower frame will display only the counts related to the reflected signal, effectively zeroing the offset. This is a feature of the kit only. In actual applications, the offset value should be subtracted to obtain actual proximity or ambient counts.

Object with Range of 10 mm and 5 mm

With compensation offset active, at a range of 10 mm, the reflection of the object (hand) results in an output count of approximately 8000 counts. At a range of 5 mm, the reflection results in an output count of approximately 30 000 counts. Again, with compensation offset active, the digital signal in the lower frame shows only the counts related to the reflected signal.

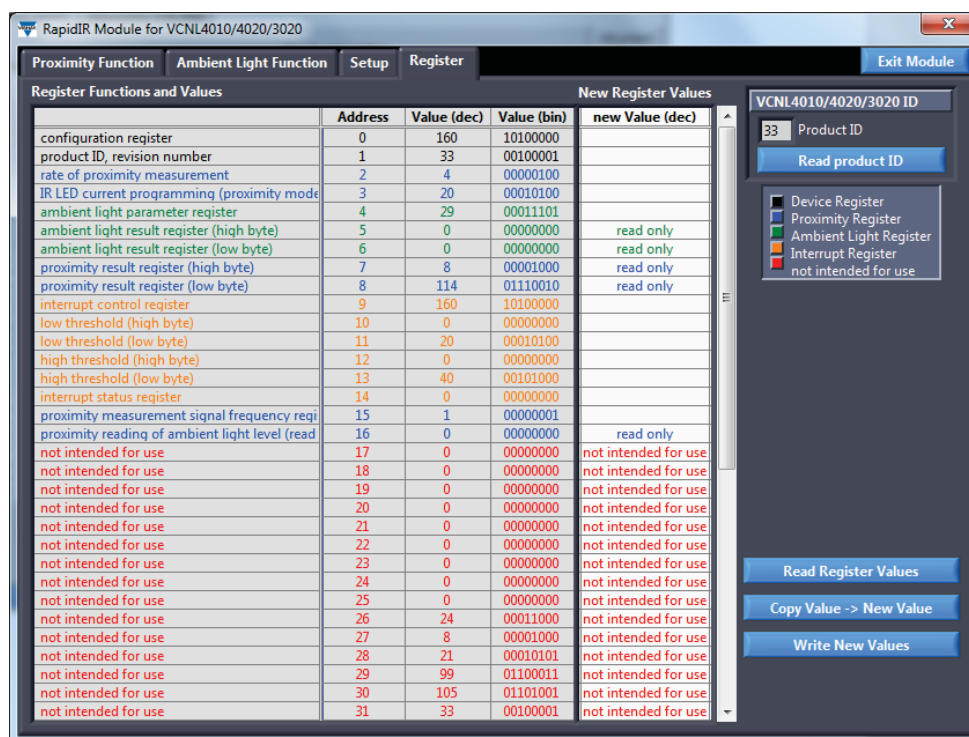
Display Range

Displays a specific range of readings by entering a minimum reading number on the right side of the x-axis and the maximum reading number on the left side of the x-axis. Type over the existing displayed value. This feature is only available when measurements have stopped.

Register Values

The actual proximity value is available by selecting the Register Value tab. The high 16-bit value is stored in register #7 and the low value is stored in register #8. Register #7 equals 8 (dec) [00001000] and register #8 equals 114 (dec) [01110010]. See screen shot 2.

Sensor Starter Kit User Guide



Screen Shot 2

FORMAT FEATURES - PROXIMITY

To Copy Graph

Right click within the upper or lower window and select "Copy Data" = "Daten kopieren."

To Change Line Color

Click inside the small white rectangle located between the upper and lower signal windows to change line colors, patterns, and other features.

AMBIENT LIGHT FUNCTION

Ambient Mode

Select a single, periodic, or selftimed measurement. The default setting is "periodic measurement (on demand)." Click 'Measure' to execute the measure function. See screen shot 3.

Upper Window

The upper window displays the entire 16-bit measured signal from 0 to 65 535 counts.

Lower Window

The lower window displays only the active or dynamic range. The y-axis represents the number of counts and will change depending on the sensor reading.

Ambient Light Settings

Defines the number of measurements used in the averaging function. Use the toggle button located left of the "Samples taken in 100 ms" title to scroll through available settings or click within the white value box and a pull down menu opens displaying all available values. The advantage of this function is that disturbance from 50 Hz / 60 Hz sources (100 Hz / 120 Hz) is significantly reduced by averaging. The default setting is 32 which sets bit 0, bit 1 and bit 2 of register #4 to 5(dec) (101); translated, 2⁵ or 32 measurements within 100 ms. These 32 measurements are averaged and the result is then available within Ambient Light Result register #5 and #6.

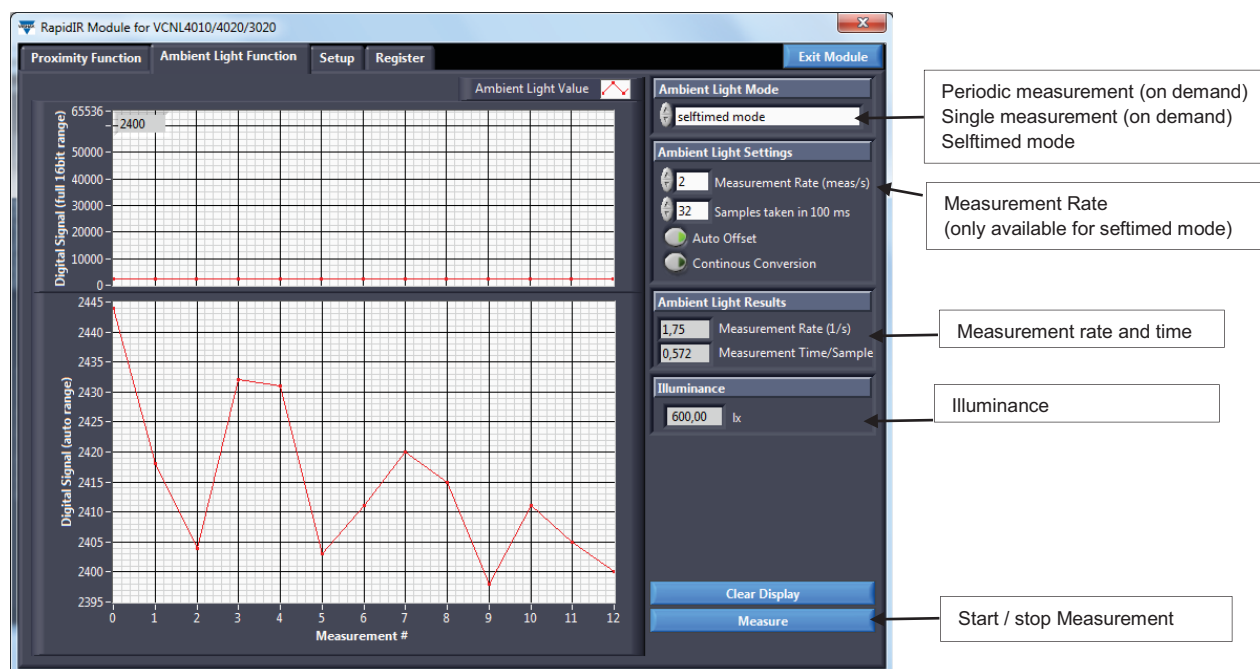
Auto Offset

Compensates for temperature related drift of the ambient light measurements. With auto offset active, the offset value is measured before each ambient light measurement and subtracted automatically from the actual reading. The default setting is "Auto Offset" active. "Auto Offset" is bit 3 of Ambient Light Parameter Register #4 (84h).

Continuous Conversion

Allows for faster measurements. With this selected, single conversions are made in a much shorter time.

Sensor Starter Kit User Guide



Screen Shot 3

Clear Display

Clears the upper and lower window graphs and resets the "Data#" to zero.

Illuminance

Displays the ambient light level in lux. It is calculated by dividing the number of counts by four. For example, there are 2400 counts which, when divided by four, results in 600 lx, see screen shot 3.

Figure of Merit

The ideal ambient light sensor will produce exactly the same output (counts) for the same brightness regardless of the source of light. In reality, silicon-based ambient light sensors will produce slightly different readings for halogen (2856 K CIE illuminant A), incandescent, fluorescent, and white LED sources. Figure 7 shows the average response for the VCNL40x0 ambient light sensors for all the above light sources and graphs the number of counts versus lux value for each light source. The halogen lamp shows a factor of 5.1 for digital counts versus lux, the fluorescent lamp shows a factor of 3.2 and white LEDs shows a factor of 4.1. The average response is a factor of 4 counts per lux. As shown in figure 6, a count of 1000 corresponds to 250 lx. This same count could be 200 lx for the halogen lamp or 310 lx for the fluorescent lamp. The overall tolerance for the VCNL40x0 ambient light sensor for different light sources is -22 % to +24 %.

The VCNL4010 and VCNL4020 have a sensitivity of 0.23 lux per count.

Sensor Starter Kit User Guide

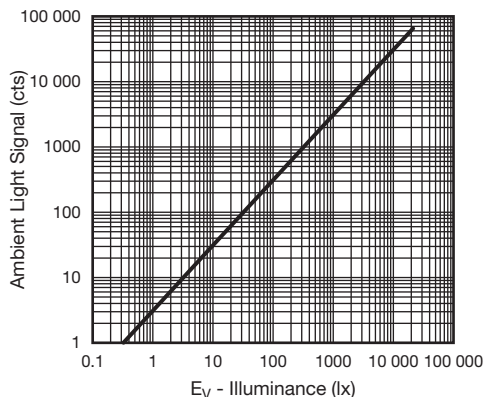


Fig. 6 - Ambient Light Signal (cts) vs. Illuminance E_V (lx)

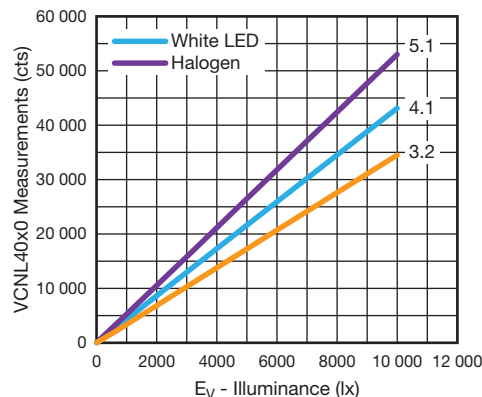
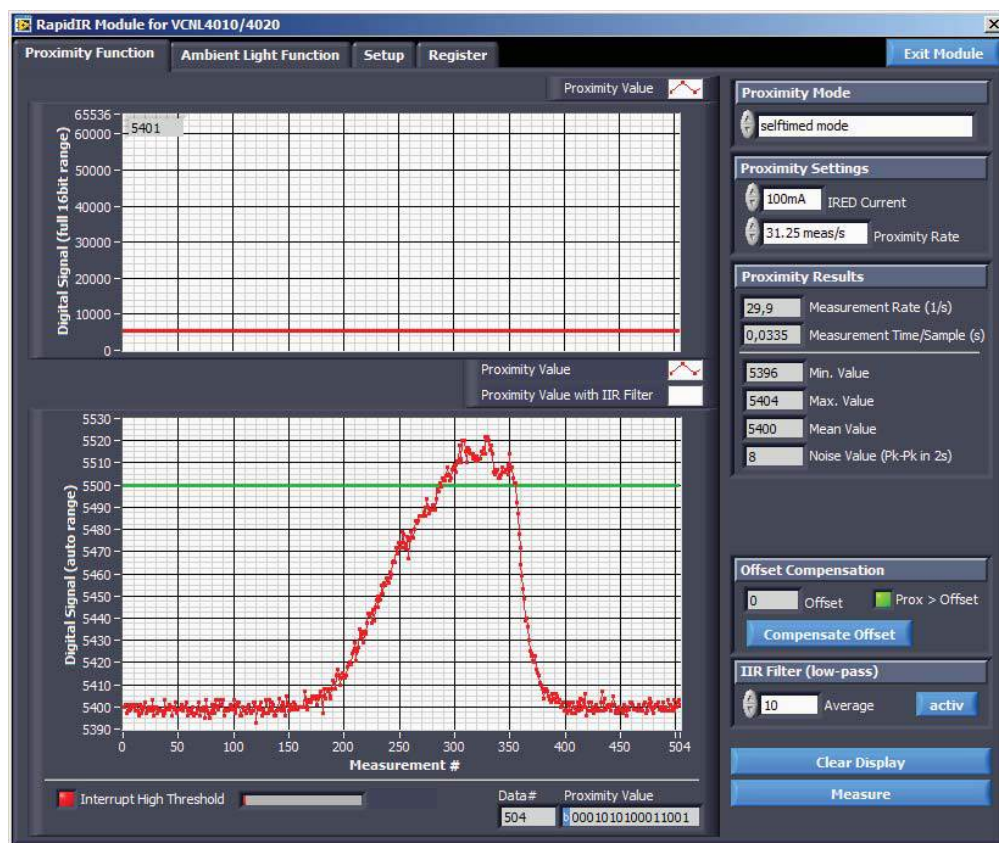


Fig. 7 - VCNL40x0 Measurements (cts) vs. Illuminance (lx)



Screen Shot 4

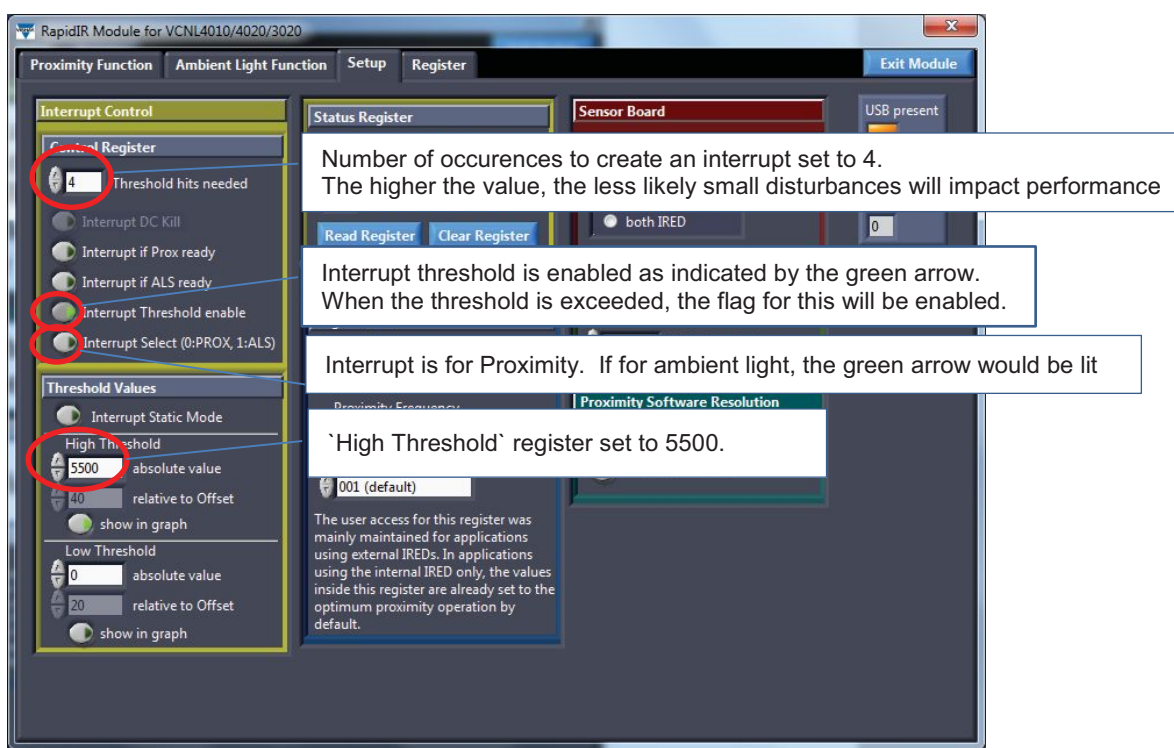
Sensor Starter Kit User Guide

Interrupt

In order to set interrupt thresholds, it is necessary to determine the offset counts for the sensor. The offset count is application specific so it can only be determined by assembling the sensor with surrounding components with the cover or window above it. Offset counts are initially determined during development and may again be measured during assembly or final test of the end product. To determine the offset counts, the sensor's proximity performance must be determined using the worst-case reflective object required to be detected at the desired distance it is to be detected. By adjusting the current of the infrared emitter, the range can be established. By adjusting the measurement speed, the response rate desired can be established. All these parameters together yield the total offset counts of the sensor without an object in range.

Example:

The sensor without any cover and close surrounding of other objects / components delivers about 2300 counts with an infrared emitter current of 100 mA. With some higher components close by and with a less transmissive cover this easily could rise up to 5000 or even 20 000 counts, depending on the distance and reflectivity of the cover used. As shown in screen shot 4, the offset counts are 5400. As an example, the application needs to detect an object at a distance of 5 cm. After some development trials, the sensor measures 5500 counts when the object is 5 cm distance and the forward current is 100 mA. For the application, the upper threshold will be set to 5500 counts, the green line in screen shot 4. When the counts exceed this threshold, in other words when an object is at 5 cm distance or less, an interrupt will be generated.



Screen Shot 5

Screen shot 5 shows the Setup page where the Interrupt Control variables are set or defined:

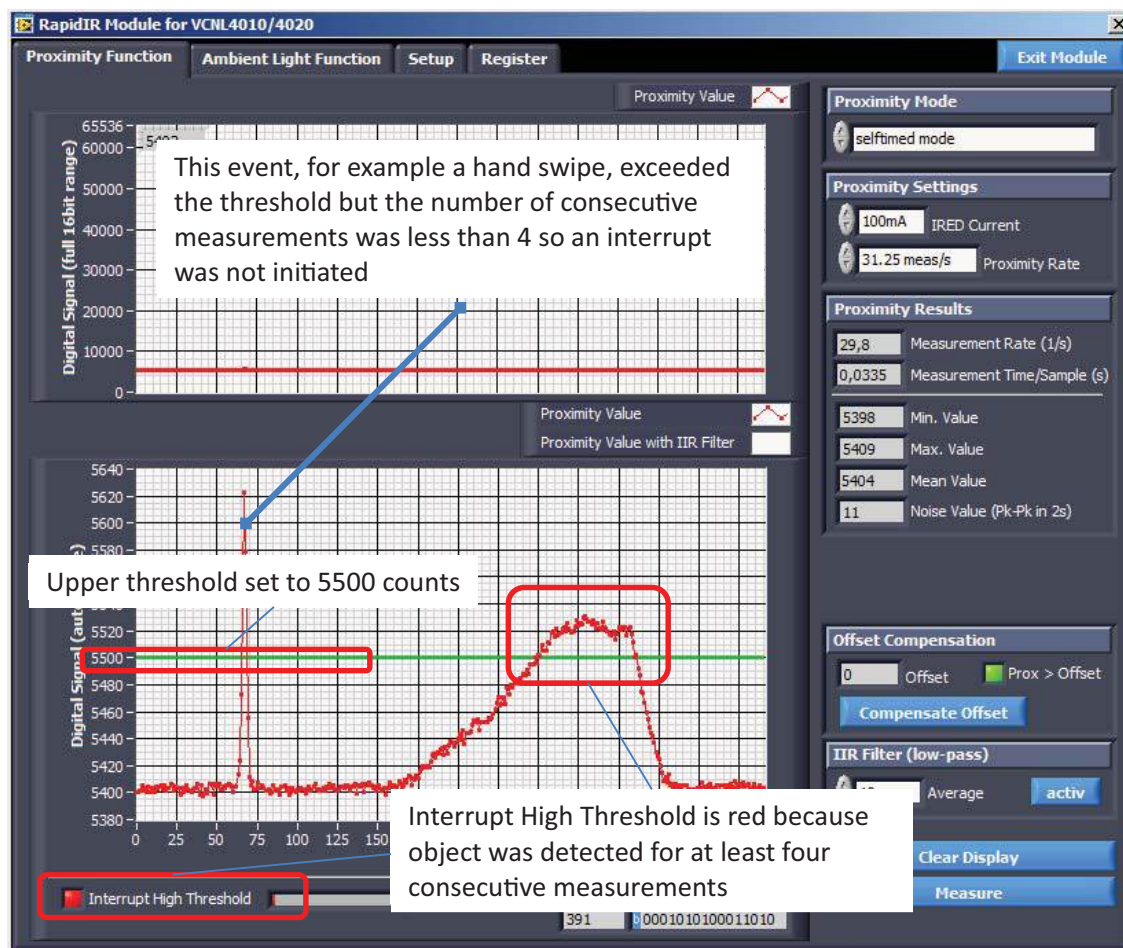
- Upper threshold val
- Lower threshold value
- Number of measurements above or below a threshold needed to generate an interrupt
- Enable interrupt threshold function
- Threshold applies to proximity or ambient light

To avoid reacting to momentary object proximity, some applications will want to wait until several measurements are taken indicating an object is present or has been removed before generating an interrupt. The "Threshold hits needed" value is set to 4 in screen shot 5. The upper threshold is set to 5500 counts as discussed above. There is no lower threshold. The interrupt is enabled as indicated by the green arrow on the toggle button. Finally, the interrupt is for

Sensor Starter Kit User Guide

proximity because the green arrow is not illuminated. If it were for ambient light, the green arrow would be illuminated. Note that by clicking on the “show in graph” button under

each threshold value, the user will graphically be shown the threshold value in relation to the offset and current readings.

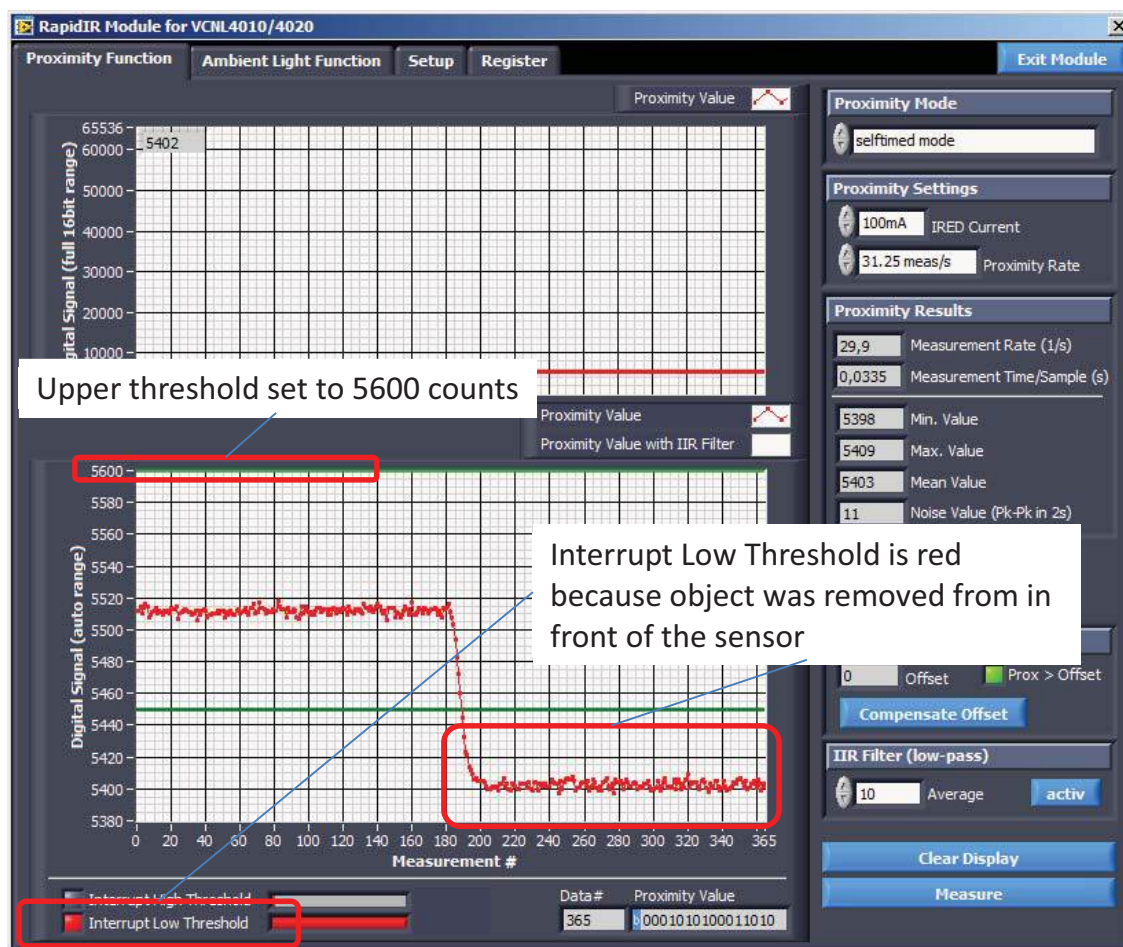


Screen Shot 6

Screen shot 6 demonstrates how a brief event, for example a quick swipe of a hand, exceeded the threshold but the number of consecutive measurements was less than 4 so an interrupt was not generated. Following this event, an object is within 5 cm for long enough for an interrupt to be generated. The “Interrupt High Threshold” indicator in the lower left corner is illuminated (red). Once an object

is detected, there are a number of possible actions an application can take. Continuous polling can be initiated to monitor the object’s proximity. Or, the current interrupt could be cleared, threshold values reprogrammed and the microcontroller freed to perform other activities or to sleep until an event occurs that generates a new interrupt.

Sensor Starter Kit User Guide

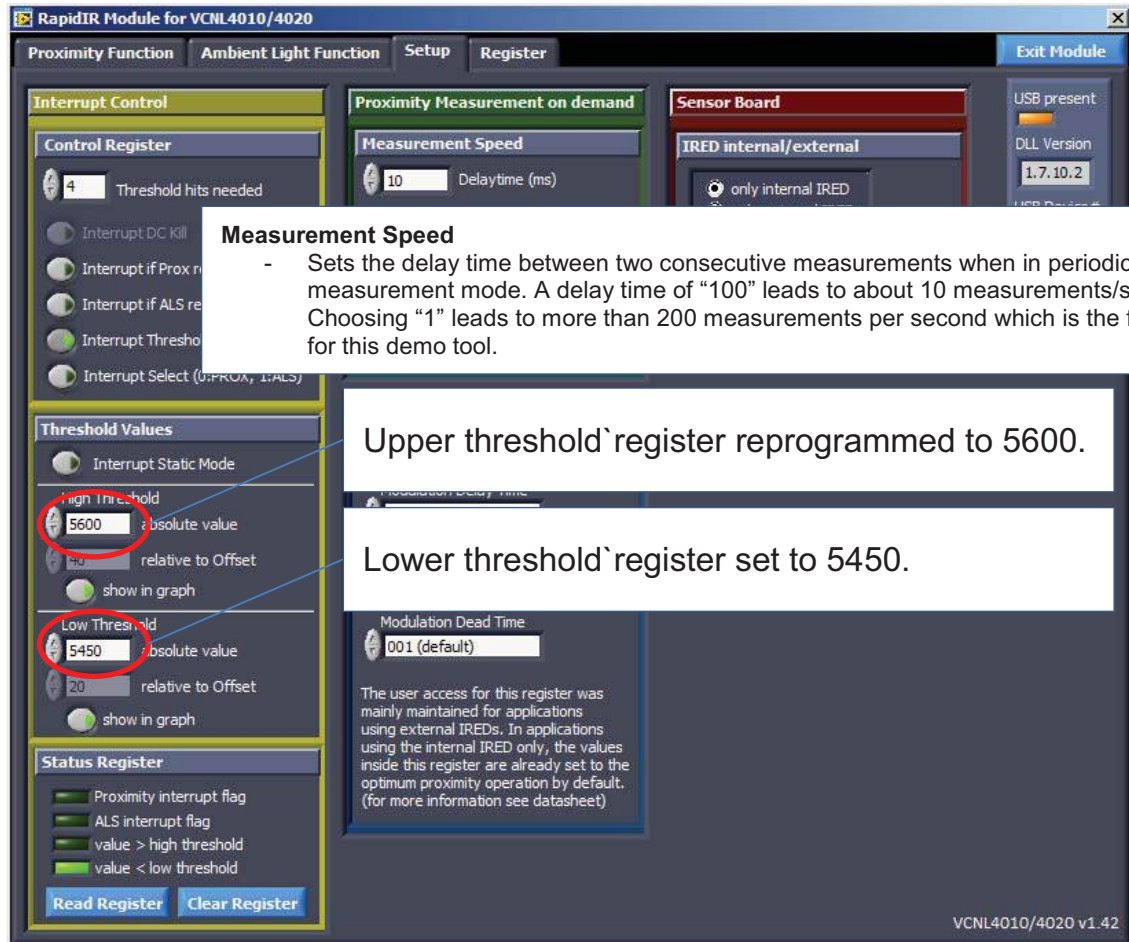


Screen Shot 7

Screen shot 7 shows how the upper threshold is reprogrammed to be high enough so that it will not “be in play” anymore, for example 65 535 counts. To be able to show it in the lower window, the value has been set to 5600 for this example. The application needs to now initiate an action when the object is no longer present. In a smart phone application for example, the screen backlight and touch function is turned off when the phone is brought to the users ear (upper threshold) and should turn back on

when the phone is removed from being near the user’s ear (lower threshold). The lower threshold should be above the offset counts but below the present proximity counts. In this example, the lower threshold is set to 5450 counts. Screen shot 7 also shows that the object is removed and the signal goes below the lower threshold. The “Interrupt Low Threshold” indicator in the lower left corner is illuminated (red).

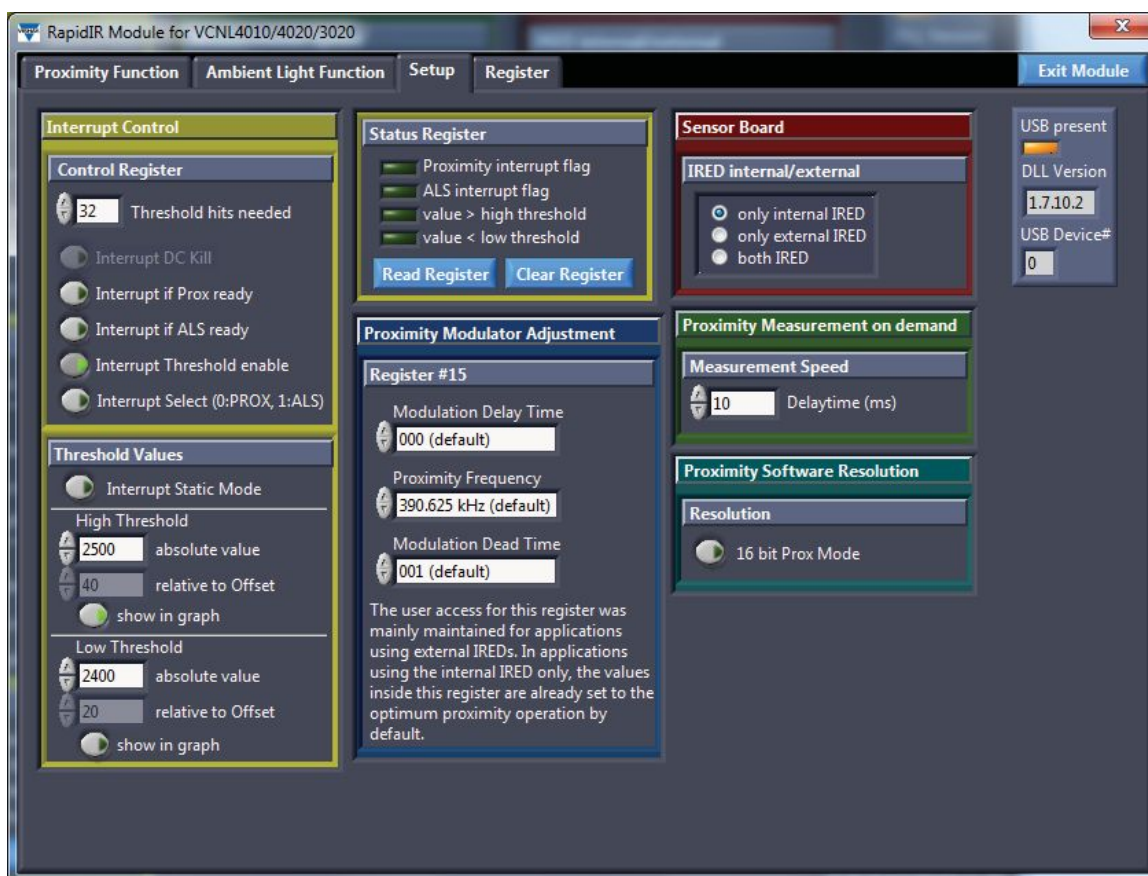
Sensor Starter Kit User Guide



Screen Shot 8

Screen shot 8 shows that the status bit indicator for low threshold, "value < low threshold," has been illuminated (**int_th_lo = 1**).

Sensor Starter Kit User Guide



Screen Shot 9

External Emitter Settings

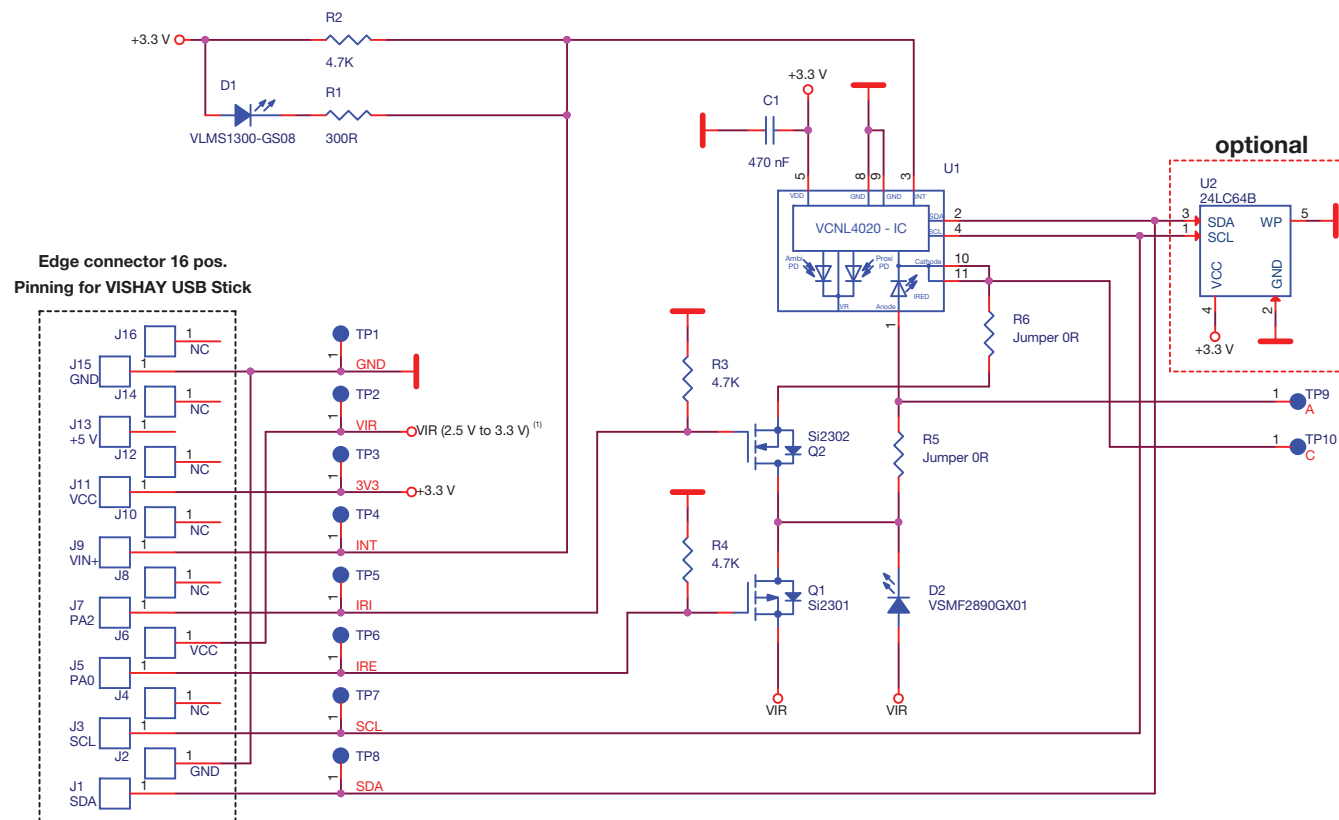
In screen shot 9 the Setup screen for the VCNL4010 and VCNL4020 is shown. For the VCNL4020X01 and also for the VCNL3020 - which comes without the ambient light sensor - the same demo software is used. Under the red Sensor Board section, the default “internal emitter” indicator is illuminated. Users have the option of selecting the use of an external emitter or using both internal and external emitter. The supply voltage for the external emitter is called VIR and connected via the USB controller board to a 3.3 V power supply, see figure 8 and 9. It can be connected to a separate power supply. If internal and external infrared emitters will be driven in series, they need to be connected to a higher voltage.

The blue Proximity Modulator Adjustment section of the Setup screen shows default values for the use of the integrated infrared emitter. When using external emitters or a combination of an internal and external emitter, the modulation delay time, modulation dead time, and proximity frequency may need to be adjusted. Please refer to the VCNL4010, VCNL4020, or VCNL3020 Application Notes for further details.

The green Proximity Measurement On Demand section of the Setup screen allows users to adjust the delay between two consecutive measurements. Any value between 0 and 10 000 can be entered in the field. A value of 0 results in 1 ms between measurements (200 measurement per second) while a value of 10 000 results in about 10 seconds between measurements.

Sensor Starter Kit User Guide

SCHEMATIC



IRI	IRE	IREd operating
L or open	L or open	only internal IREd
L or open	H	both IREdS
H	L or open	forbidden
H	H	only external IREd

When using the VCNL4020 sensor board without VISHAY USB stick, an additional pullup resistors (2.4 to 10K) on SDA and SCL is necessary

Note

(1) VIR may be set > 3.3 V (< 5 V), however then Q1 will no longer short circuit the external emitter D2

Fig. 8 - Circuit Diagram of VCNL4020 Sensor Board

Sensor Starter Kit User Guide

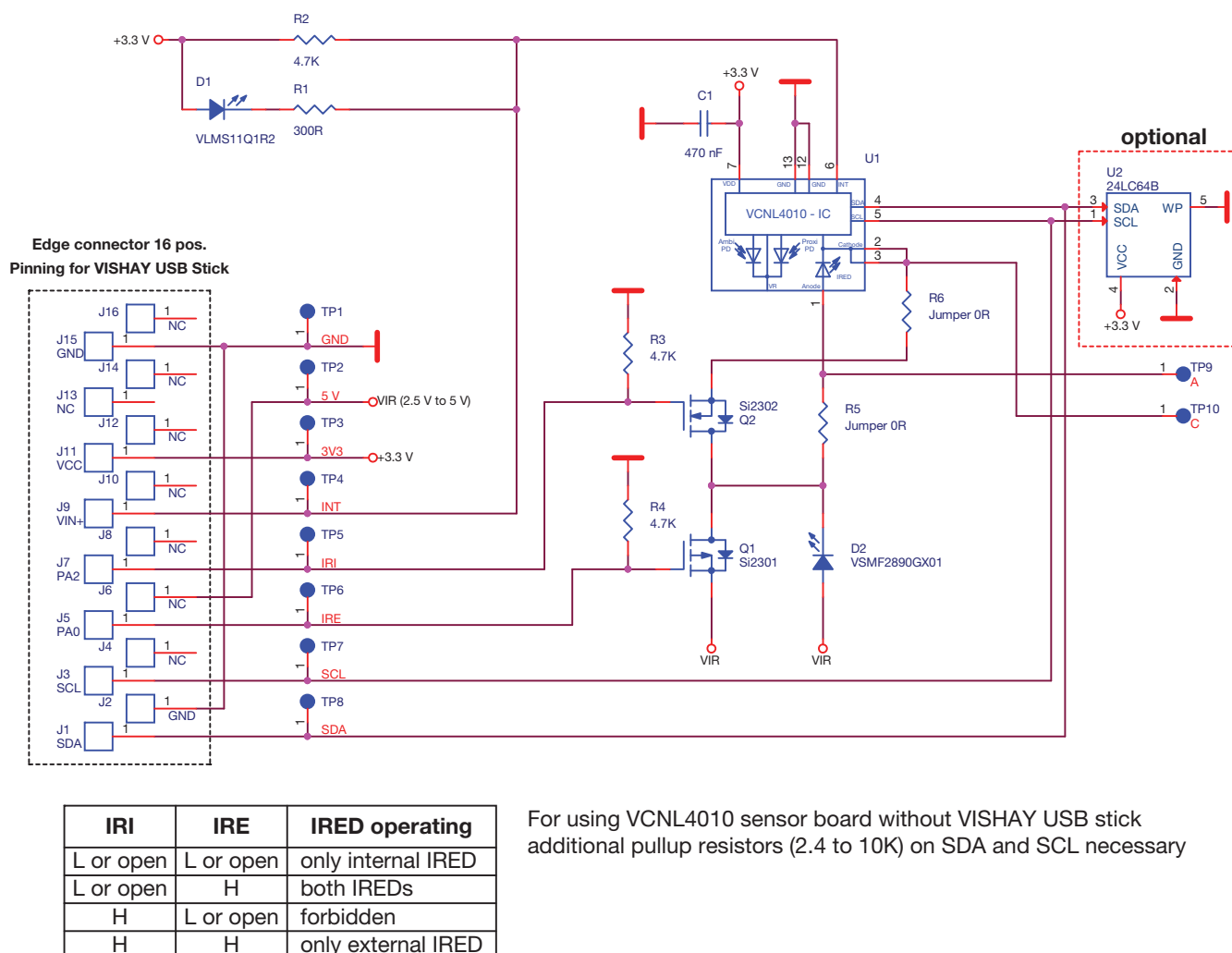


Fig. 9 - Circuit Diagram of VCNL4010 Sensor Board

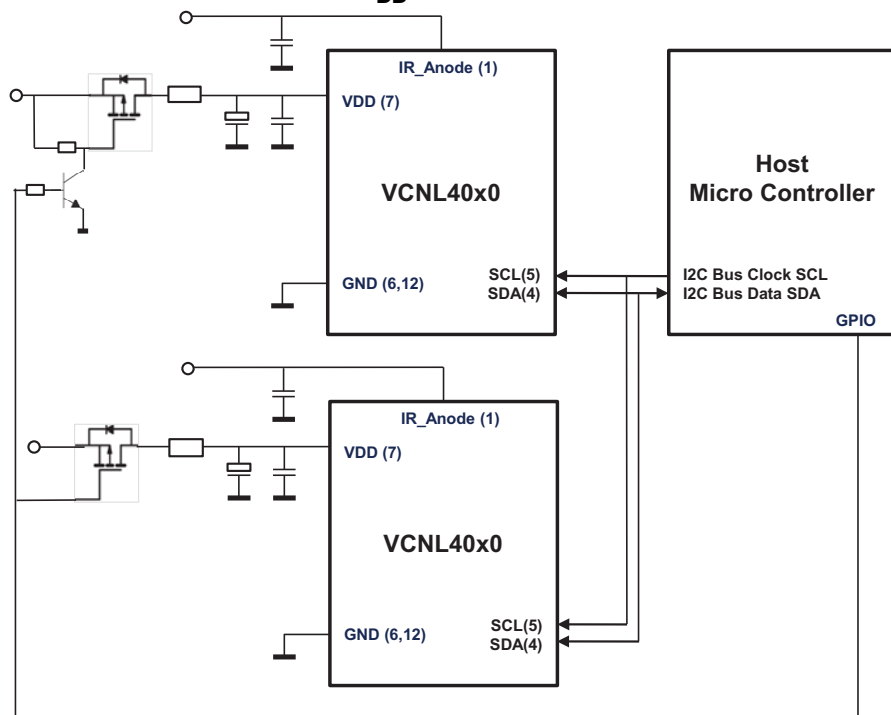
The switching information (IRI and IRE) is delivered from the USB controller and the specification given above.

ADDITIONAL REMARKS

1. The demo software behind this Sensor Starter Kit is LabVIEW based. Due to licensing issues we cannot provide the LabVIEW source code.
2. The controller within the USB dongle is a Cypress CY7C68013.
3. The nominal I²C-bus speed is about 100 kHz.
4. The required pull-up resistors at the SDA and SCL lines are within the dongle and connected to 3.3 V.
5. A small regulator provides all sensor boards with 3.3 V. Eventually the needed 2.5 V are created on the corresponding boards.
6. For additional handling of analog voltages, an A/D converter (MCP3421) is included within this dongle. Its address is "A0."
7. These added rows of "test pins" shown in figures 3 and 5) allow a connection to your own application. Do not forget to add the needed SDA / SCL pull-up resistors in this case. For all VCNL40x0 and VCNL3020 sensor boards it should also be noted, that the anode side of the available external IRED needs to be connected to a supply voltage between 2.5 V and 5 V. This is done within the USB dongle.
8. All VCNLs come with one and the same I²C-bus address: 26h for write and 27h for read. If more than one VCNL is used within an application, a switch for the I²C-bus lines is needed. Please see some proposals on next pages.

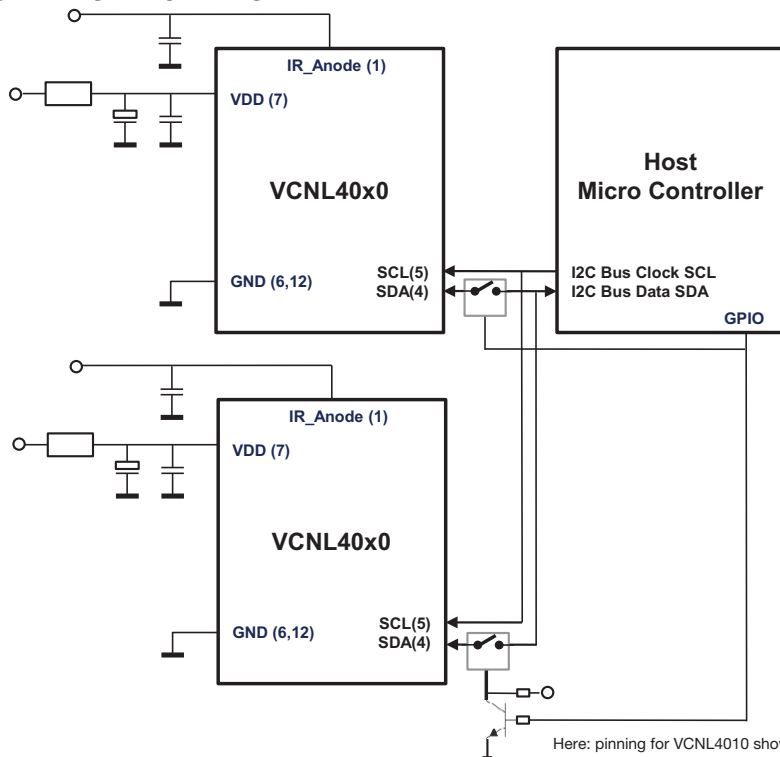
Sensor Starter Kit User Guide

PROPOSAL 1: SWITCHED V_{DD}



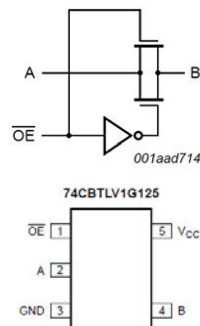
Here: pinning for VCNL4010 shown

PROPOSAL 2: SWITCHED SDA



Here: pinning for VCNL4010 shown

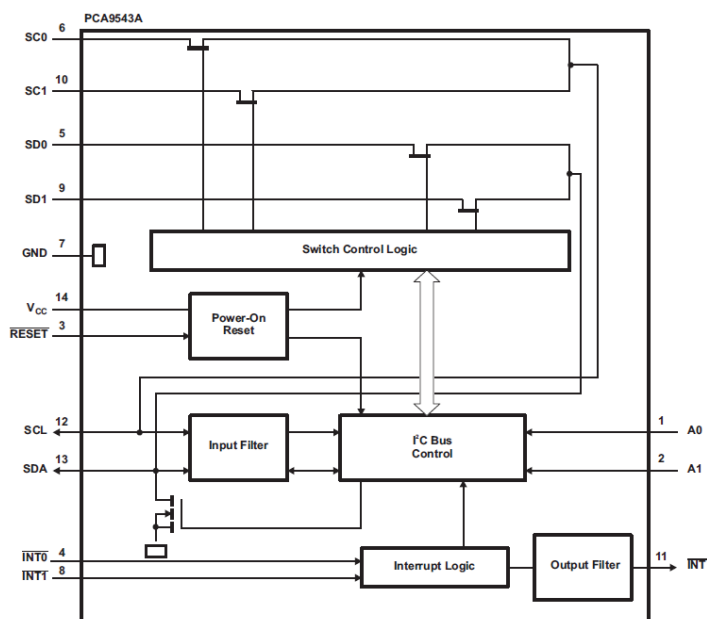
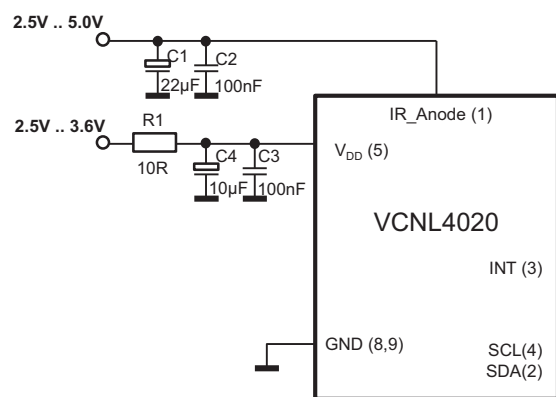
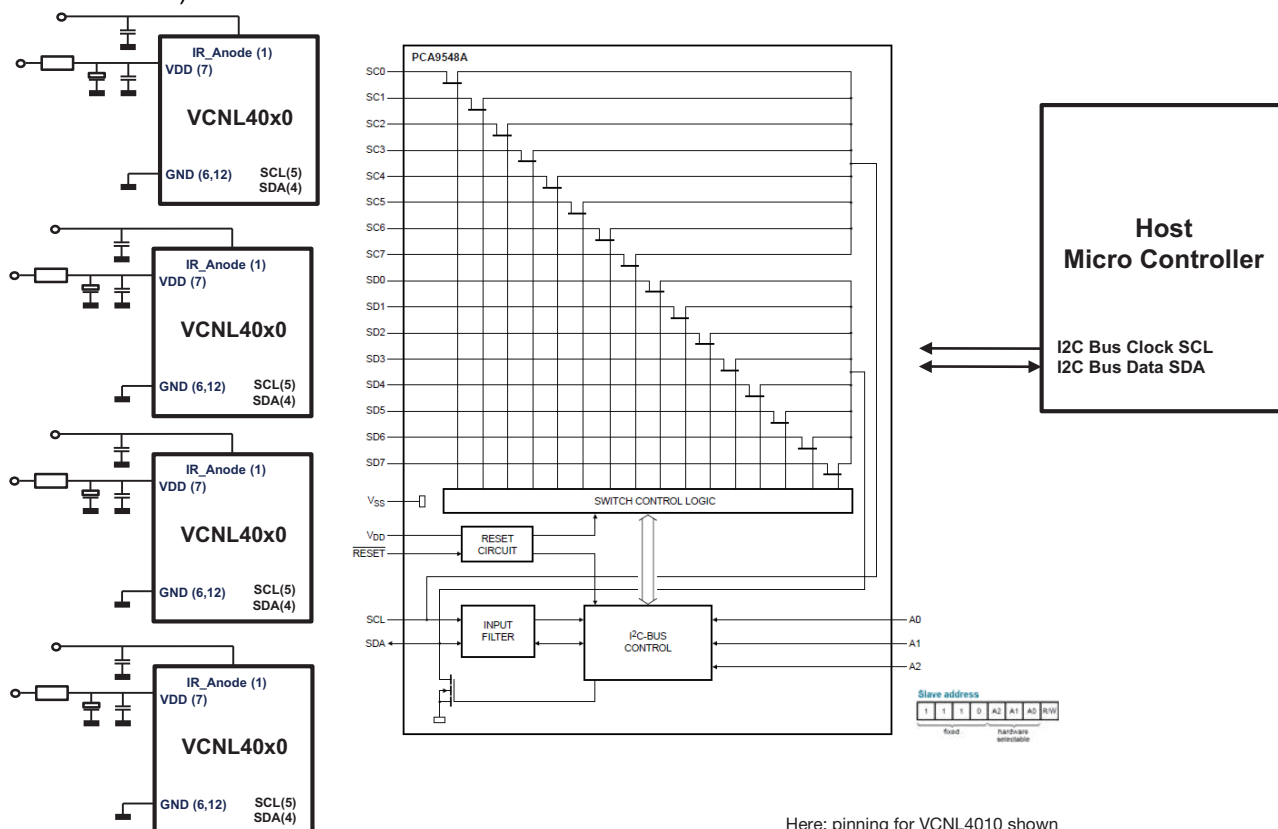
switching the SDA line,
e.g. With single bus switch as
74CBTLV1G125



Sensor Starter Kit User Guide

PROPOSAL 3: VIA A DEDICATED I²C-BUS SWITCH IC, E.G. PCA9548 OR PCA9543A

(for two channels)



Sensor Starter Kit User Guide

A web page shows all available sensor boards that can be used with the Sensor Starter Kit:



Build **Vishay** into your **Design**

Language ▼

Part #/Keyword Search
Go

Cross-Reference Search
Go

-- Parametric Search --

PRODUCTS

APPLICATIONS

COMPANY INFO

QUALITY AND ENVIRONMENTAL

More Info » VCNL Family demo kit and software downloads

SENSOR STARTER KIT DOWNLOADS

Will one of our VCNL-sensors work in your application? Find out by purchasing the SensorStarterKit. The starter kit comes with the VCNL4020 sensor board, the USB connector, and all the necessary software, license and driver files needed to have you testing in no time. The starter kit is available from any Vishay distributor. If you want to try the VCNL4010, -4020X01, or -3020, just send us an e-mail to sensorstechsupport@vishay.com with your contact information, a brief description of the application, and the sensor board you want. We will send you the requested add-on board free of charge.

Sensor Starter Kit



Add-On Boards



VCNL40x0 base software, license files, and USB driver	Vishay USB Dongle	VCNL4020	VCNL4010	VCNL3020	VCNL4020 Gesture Control	VCNL4020X01
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CONTACT US

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Check Distributor Stock: [Go](#)

Enter Part Number

CURRENT ESTIMATOR

Determine how much current is required for your application
VCNL4010, VCNL3020
VCNL4020, VCNL4020X01

SOFTWARE

VCNL4020 Gesture Demo Board Software Download
- http://images.vishay.com/books/VCNL4020_Gesture_Sensor_Board_Installer.zip
Upgrade from VCNL4000DemoKit
- http://images.vishay.com/books/Vishay_SensorStarterKit.zip
VCNL4010/4020 Demo Software Download
- <http://www.vishay.com/doc?84144>

DOCUMENTS

VCNL4020 Gesture Demo Board Installation Guide
- <http://www.vishay.com/doc?84226>
Sensor Starter Kit Installation Guide
- <http://www.vishay.com/doc?84242>
Sensor Starter Kit User Guide
- <http://www.vishay.com/doc?84264>

TOOLS

Current Estimator Tool
- <http://www.vishay.com/optoelectronics/opto-sensors-calculator/>

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