Fully Integrated Proximity and Ambient Light Sensor
with Infrared Emitter and \( \text{I}^2 \text{C} \) Interface

FEATURES

- Package type: surface mount
- Dimensions (L x W x H in mm): 3.95 x 3.95 x 0.75
- Integrated modules: infrared emitter (IRED), ambient light sensor (ALS-PD), proximity sensor (PD), and signal conditioning IC
- 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 \( \text{I}^2 \text{C} \) interface
- \( \text{I}^2 \text{C} \) 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 \( \mu \)A
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

PROXIMITY FUNCTION

- Built in infrared LED 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 characteristic
- 16 bit dynamic range for ambient light detection from 0.25 lx to 16 k lx
- 100 Hz and 120 Hz flicker noise rejection

DESCRIPTION

VCNL4000 is a fully integrated proximity and ambient light digital 16 bit resolution sensor in a miniature lead less package (LLP) for surface mounting. It includes a signal processing IC and supports an easy to use \( \text{I}^2 \text{C} \) bus communication interface.

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

PRODUCT SUMMARY

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>OPERATING RANGE (mm)</th>
<th>OPERATING VOLTAGE RANGE (V)</th>
<th>( \text{I}^2 \text{C} ) BUS VOLTAGE RANGE (V)</th>
<th>LED PULSE CURRENT (1) (mA)</th>
<th>AMBIENT LIGHT RANGE (lx)</th>
<th>AMBIENT LIGHT RESOLUTION (lx)</th>
<th>OUTPUT CODE</th>
<th>ADC RESOLUTION PROXIMITY / AMBIENT LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCNL4000</td>
<td>1 to 200</td>
<td>2.5 to 3.6</td>
<td>1.7 to 5</td>
<td>10 to 200</td>
<td>0.25 to 16 383</td>
<td>0.25</td>
<td>16 bit, ( \text{I}^2 \text{C} )</td>
<td>16 bit / 16 bit</td>
</tr>
</tbody>
</table>

Note
(1) Adjustable through \( \text{I}^2 \text{C} \) interface
ORDERING INFORMATION

<table>
<thead>
<tr>
<th>ORDERING CODE</th>
<th>PACKAGING</th>
<th>VOLUME (1)</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCNL4000-GS08</td>
<td>Tape and reel</td>
<td>MOQ: 1800 pcs</td>
<td>3.95 mm x 3.95 mm x 0.75 mm</td>
</tr>
<tr>
<td>VCNL4000-GS18</td>
<td></td>
<td>MOQ: 7000 pcs</td>
<td></td>
</tr>
<tr>
<td>VCNL4000demokit</td>
<td></td>
<td>MOQ: 1 pc</td>
<td></td>
</tr>
</tbody>
</table>

Note

(1) MOQ: minimum order quantity

ABSOLUTE MAXIMUM RATINGS \( (T_{amb} = 25 \, ^\circ C, \text{unless otherwise specified}) \)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITION</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>VDD</td>
<td></td>
<td>-0.3</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Operation temperature range</td>
<td>( T_{amb} )</td>
<td></td>
<td>-25</td>
<td>+85</td>
<td>(^\circ C )</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>( T_{stg} )</td>
<td></td>
<td>-40</td>
<td>+85</td>
<td>(^\circ C )</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>( T_{amb} \leq 25 , ^\circ C ) ( P_{tot} )</td>
<td></td>
<td>50</td>
<td></td>
<td>mW</td>
</tr>
<tr>
<td>Junction temperature</td>
<td>( T_j )</td>
<td></td>
<td>100</td>
<td></td>
<td>(^\circ C )</td>
</tr>
</tbody>
</table>

BASIC CHARACTERISTICS \( (T_{amb} = 25 \, ^\circ C, \text{unless otherwise specified}) \)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITION</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage ( V_{DD} )</td>
<td></td>
<td></td>
<td>2.5</td>
<td>3.6</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Supply voltage IR anode</td>
<td></td>
<td></td>
<td>2.5</td>
<td>5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>I2C Bus H-level range</td>
<td></td>
<td></td>
<td>1.7</td>
<td>5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Current consumption</td>
<td>Standby current, no IRED-operation</td>
<td></td>
<td>1.5</td>
<td>2</td>
<td>( \mu A )</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>2 measurements per second, IRED current 20 mA</td>
<td></td>
<td>4</td>
<td></td>
<td>( \mu A )</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>250 measurements per second, IRED current 20 mA</td>
<td></td>
<td>500</td>
<td></td>
<td>( \mu A )</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>2 measurements per second, IRED current 200 mA</td>
<td></td>
<td>31</td>
<td></td>
<td>( \mu A )</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>250 measurements per second, IRED current 200 mA</td>
<td></td>
<td>3.8</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Ambient light resolution</td>
<td>Digital resolution (LSB count)</td>
<td></td>
<td>0.25</td>
<td></td>
<td>lx</td>
<td></td>
</tr>
<tr>
<td>Ambient light output</td>
<td>( E_V = 100 , lx ) averaging = 64</td>
<td></td>
<td>400</td>
<td></td>
<td>counts</td>
<td></td>
</tr>
<tr>
<td>I2C clock rate range</td>
<td></td>
<td></td>
<td>( f_{SCL} )</td>
<td>3400</td>
<td>kHz</td>
<td></td>
</tr>
</tbody>
</table>
CIRCUIT BLOCK DIAGRAM

TEST CIRCUIT

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

BASIC CHARACTERISTICS ($T_{amb} = 25 \degree C$, unless otherwise specified)

Fig. 1 - Idle Current vs. Ambient Temperature

Fig. 2 - Idle Current vs. $V_{DD}$

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

Fig. 8 - Relative Radiant Sensitivity vs. Angular Displacement

Fig. 9 - Ambient Light Value vs. Illuminance

Fig. 10 - Relative Spectral Sensitivity vs. Wavelength
APPLICATION INFORMATION

VCNL4000 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.

1. Application Circuit

![Application Circuit Diagram]

**Fig. 12 - Application Circuit**

(x) = Pin Number

**Legend:**
- IR Anode (1)
- VDD (7)
- GND (6, 12)
- SCL (5)
- SDA (4)
- I2C Bus Clock SCL
- I2C Bus Data SDA

**Component Values:**
- C1: 22 μF
- C2: 100 nF
- C3: 100 nF
- C4: 22 μF
- C5: 100 nF
- R1: 10R

**Input Voltage Ranges:**
- 2.5 V to 5 V
- 2.5 V to 3.6 V
2. I2C Interface

The VCNL4000 contains twelve 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 VCNL4000.

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

I2C H-level range = 1.7 V to 5 V.

Please refer to the I2C specification from NXP for details.

---

**Table 1 - Command Register #0**

<table>
<thead>
<tr>
<th>Bit 0</th>
<th>Bit 1</th>
<th>Bit 2</th>
<th>Bit 3</th>
<th>Bit 4</th>
<th>Bit 5</th>
<th>Bit 6</th>
<th>Bit 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>config_lock</td>
<td>als_od</td>
<td>prox_data_rdy</td>
<td>als_data_rdy</td>
<td>prox_data_rdy</td>
<td>N/A</td>
<td>N/A</td>
<td>config_lock</td>
</tr>
</tbody>
</table>

**Description**

- config_lock  Read only bit. Value = 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_data_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  R/W bit. Starts a single on-demand measurement for ambient light. If averaging is enabled, starts a sequence of readings and stores the averaged result. Result is available at the end of conversion for reading in the registers #5(HB) and #6(LB).
- prox_od  R/W bit. Starts a single on-demand measurement for proximity. Result is available at the end of conversion for reading in the registers #7(HB) and #8(LB).

**Notes**

- After a proximity start command [prox_od] a WAIT time of ≥ 400 μs should be inserted before any read out commands.
- With setting bit 3 and bit 4 at the same write command, a simultaneously measurement of ambient light and proximity is done.
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 = 11h.

<table>
<thead>
<tr>
<th>TABLE 2 - PRODUCT ID REVISION REGISTER #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
</tr>
<tr>
<td>Product ID</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Product ID</td>
</tr>
<tr>
<td>Revision ID</td>
</tr>
</tbody>
</table>

Register #2 without Function in Current Version
Register address = 82h.

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>
<thead>
<tr>
<th>TABLE 3 - IR LED CURRENT REGISTER #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
</tr>
<tr>
<td>Fuse prog ID</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Fuse prog ID</td>
</tr>
<tr>
<td>IR LED current value</td>
</tr>
</tbody>
</table>

Register #4 Ambient Light Parameter Register
Register address = 84h.

<table>
<thead>
<tr>
<th>TABLE 4 - AMBIENT LIGHT PARAMETER REGISTER #4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
</tr>
<tr>
<td>Cont. conv. mode</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Cont. conversion mode</td>
</tr>
<tr>
<td>Auto offset compensation</td>
</tr>
<tr>
<td>Averaging function</td>
</tr>
</tbody>
</table>
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 5 - AMBIENT LIGHT RESULT REGISTER #5

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

- Read only bits. High byte (15:8) of ambient light measurement result

### TABLE 6 - AMBIENT LIGHT RESULT REGISTER #6

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 7 - PROXIMITY RESULT REGISTER #7

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

- Read only bits. High byte (15:8) of proximity measurement result

### TABLE 8 - PROXIMITY RESULT REGISTER #8

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

- Read only bits. Low byte (7:0) of proximity measurement result

Register #9 Proximity Measurement Signal Frequency
Register address = 89h.

### TABLE 9 - PROXIMITY MEASUREMENT SIGNAL FREQUENCY #9

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

- R/W bits. Setting the proximity IR test signal frequency. The proximity measurement is using a square IR signal as measurement signal. Four different values are possible:
  - 00 = 3.125 MHz
  - 01 = 1.5625 MHz
  - 02 = 781.25 kHz (DEFAULT)
  - 03 = 390.625 kHz

- Bit 0 and 1
  - Proximity frequency
Register #10 Proximity Modulator Timing Adjustment
Register address = 8Ah.

<table>
<thead>
<tr>
<th>TABLE 10 - PROXIMITY MODULATOR TIMING ADJUSTMENT #10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit 7</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Modulation delay time</td>
</tr>
</tbody>
</table>

Description
- The settings for best performance will be provided by Vishay. With first samples this is evaluated to: delay time = 4 and dead time = 1, with that register #10 should be programmed with: 129 (dez.)

Register #11 Ambient IR Light Level Register
Register address = 8Bh.
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 μA. 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](image)

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.

Example: read register "Ambient Light Result Register" #5 and #6:
Addressing:command: 26h, 85h (VCNL4000_I²C_Bus_Write_Adr., Ambient Light Result Register #5 [85])
Read register #5:command: 27h, data (VCNL4000_I²C_Bus_Read_Adr., (High Byte Data of Ambient Light Result Register #5 [85]))
Read register #6:command: 27h, data (VCNL4000_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).

![Fig. 15 - Ambient Light Measurement with Averaging = 2](image1)

![Fig. 16 - Ambient Light Measurement with Averaging = 8](image2)

**Note**

- ≥ Independent of setting of averaging the result is available only after 100 ms.

**Continuous conversion mode (bit7 of reg #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](image3)

![Fig. 18 - Ambient Light Measurement with Averaging = 8; using Continuous Conversion Mode](image4)
**PACKAGE DIMENSIONS** in millimeters

Drawing-No.: 6.550-5302.01-4  
Issue: prel; 16.02.10

Not indicated tolerances ± 0.1

Pad must not be electrical connected

Anode Emitter

Cathode Emitter

Pinning

Top view

Bottom view

Proposed PCB Footprint

0.35 (10x)

0.2

0.4

0.2

0.805

0.4

1.26

0.805

0.75

0.35 ± 0.05

0.935

0.47 ± 0.05

0.175 ± 0.05

0.985

0.75

0.75 ± 0.05

0.475

0.75 ± 0.05

0.35 ± 0.05

0.475

0.75 ± 0.05

0.35 ± 0.05

0.475

0.75 ± 0.05

0.935

0.4 ± 0.05

0.175 ± 0.05

0.75

4 x 0.75 = 3

0.75 ± 0.05

0.15

2.615

3.95

0.965

0.95

2.615

3.95
TAPE AND REEL DIMENSIONS in millimeters

Reel size "Y"
GS 08 Ø 180 ± 2 = 1800 pcs.
GS 18 Ø 330 ± 2 = 7000 pcs.

Ø 60 min.
12.4 ± 2
18.4 max.

Ø 21 ± 0.8
Ø 13 ± 0.2

Label posted here
Tape position coming out from reel
Not indicated tolerances ± 0.1

Parts mounted
100mm min. with cover tape

Leader and trailer tape:
Empty Trailer 200mm min.
Empty Leader 400mm min.

Technical drawings according to DIN specifications

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

22319
**SOLDER PROFILE**

![Solder Profile Diagram](image)

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


**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 %.
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Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.

Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.