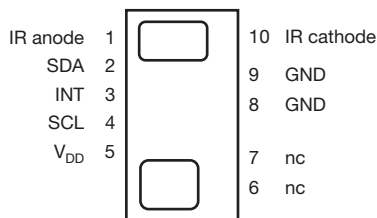


Fully Integrated Proximity Sensor With Infrared Emitter, I²C Interface, and Interrupt Function



DESCRIPTION

The VCNL3020 is a fully integrated proximity 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.
- Proximity / optical switch for consumer, computing and industrial devices and displays

FEATURES

- Package type: surface-mount
- Dimensions (L x W x H in mm): 4.90 x 2.40 x 0.83
- Integrated modules: infrared emitter (IRED), proximity sensor (PD), 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: 72 h, MSL 4, according to J-STD-020
- Low stand by current consumption: 1.5 μ A
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



PROXIMITY FUNCTION

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

PRODUCT SUMMARY

| PART NUMBER | OPERATING RANGE (mm) | OPERATING VOLTAGE RANGE (V) | I ² C BUS VOLTAGE RANGE (V) | LED PULSE CURRENT ⁽¹⁾ (mA) | OUTPUT CODE | ADC RESOLUTION PROXIMITY / AMBIENT LIGHT |
|-------------|----------------------|-----------------------------|--|---------------------------------------|--------------------------|--|
| VCNL3020 | 1 to 200 | 2.5 to 3.6 | 1.7 to 5 | 10 to 200 | 16 bit, I ² C | 16 bit / - |

Note

⁽¹⁾ Adjustable through I²C interface

ORDERING INFORMATION

| ORDERING CODE | PACKAGING | VOLUME ⁽¹⁾ | REMARKS |
|---------------|---------------|-----------------------|-----------------------------|
| VCNL3020-GS08 | Tape and reel | MOQ: 3300 pcs | 4.90 mm x 2.40 mm x 0.83 mm |
| VCNL3020-GS18 | | MOQ: 13 300 pcs | |

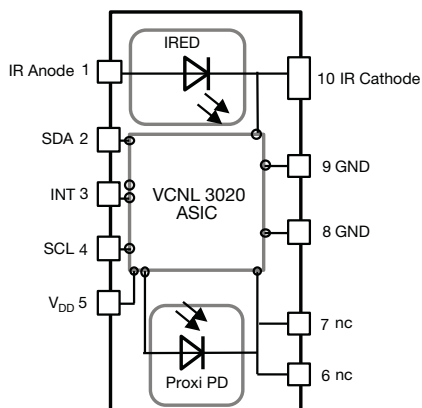
Note

⁽¹⁾ MOQ: minimum order quantity

| ABSOLUTE MAXIMUM RATINGS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified) | | | | | |
|--|---|-----------|------|------|--------------------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | MAX. | UNIT |
| Supply voltage | | V_{DD} | -0.3 | 5.5 | V |
| Operation temperature range | | T_{amb} | -25 | +85 | $^{\circ}\text{C}$ |
| Storage temperature range | | T_{stg} | -25 | +85 | $^{\circ}\text{C}$ |
| Total power dissipation | $T_{amb} \leq 25\text{ }^{\circ}\text{C}$ | P_{tot} | | 50 | mW |
| Junction temperature | | T_j | | 100 | $^{\circ}\text{C}$ |

| BASIC CHARACTERISTICS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified) | | | | | | |
|---|--|-----------|------|------|------|---------------|
| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
| Supply voltage V_{DD} | | | 2.5 | | 3.6 | V |
| Supply voltage IR anode | | | 2.5 | | 5 | V |
| I 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 | μA |
| Current consumption proximity mode incl. IRED (averaged) | 2 measurements per second, IRED current 20 mA | | | 5 | | μA |
| | 250 measurements per second, IRED current 20 mA | | | 520 | | μA |
| | 2 measurements per second, IRED current 200 mA | | | 35 | | μA |
| | 250 measurements per second, IRED current 200 mA | | | 4 | | mA |
| I ² C clock rate range | | f_{SCL} | | | 3400 | kHz |

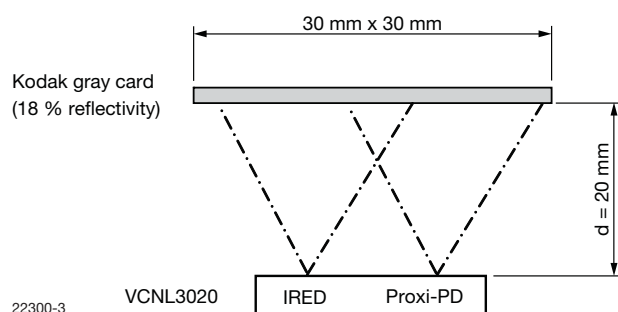
CIRCUIT BLOCK DIAGRAM



Note

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

TEST CIRCUIT



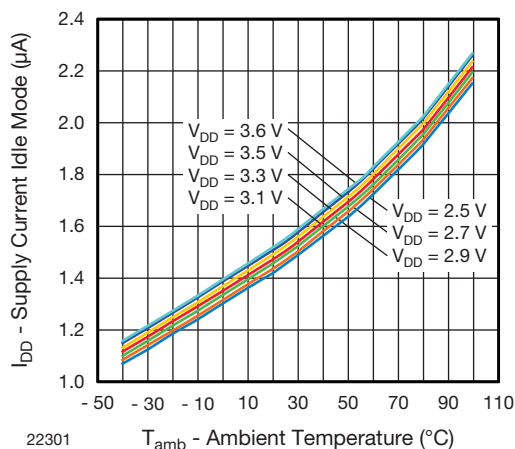
BASIC CHARACTERISTICS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified)


Fig. 1 - Idle Current vs. Ambient Temperature

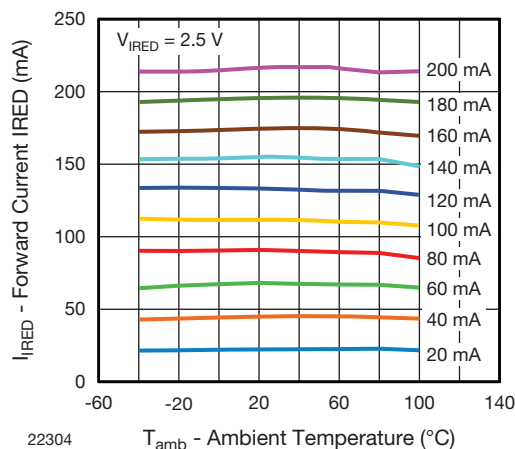


Fig. 4 - Forward Current vs. Temperature

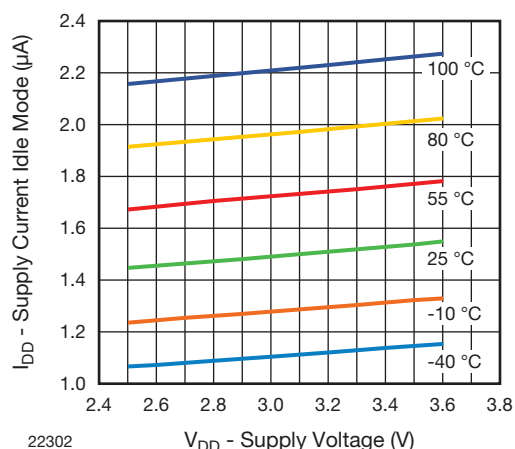
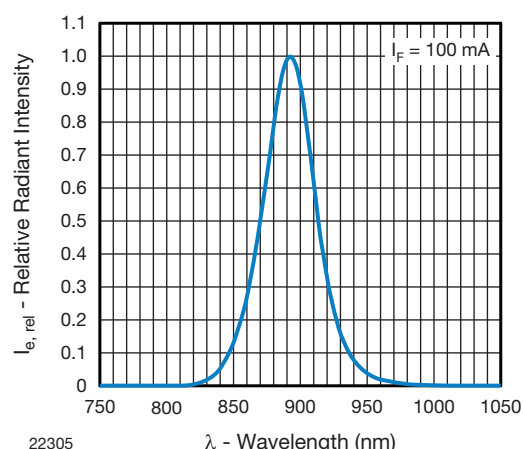

Fig. 2 - Idle Current vs. V_{DD}


Fig. 5 - Relative Radiant Intensity vs. Wavelength

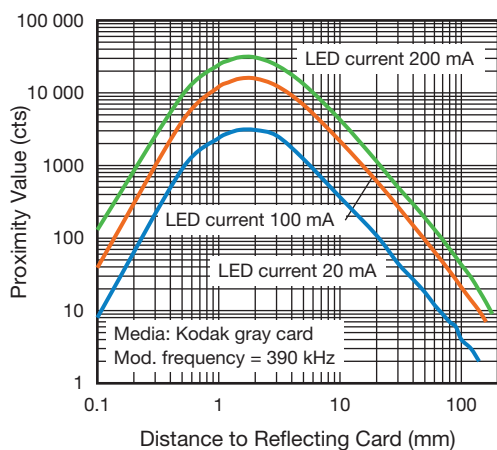


Fig. 3 - Proximity Value vs. Distance

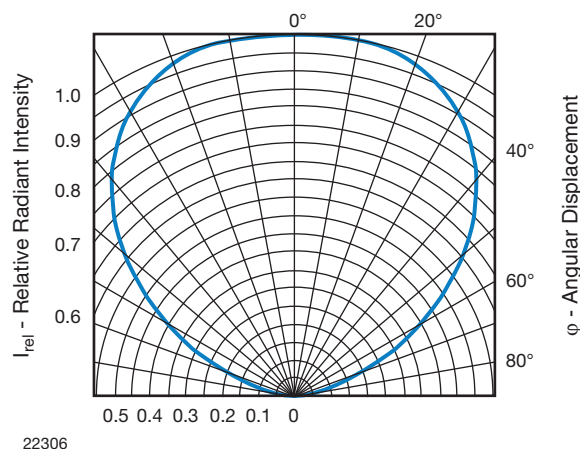


Fig. 6 - Relative Radiant Intensity vs. Angular Displacement

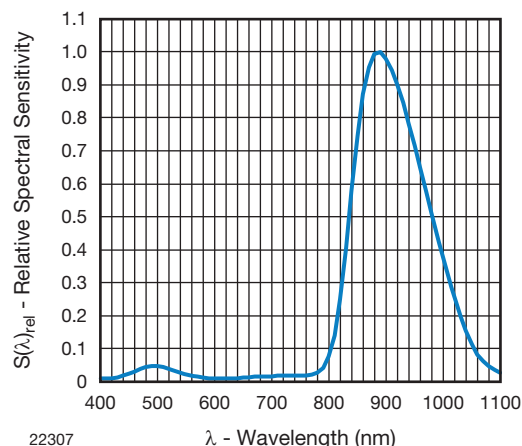


Fig. 7 - Relative Spectral Sensitivity vs. Wavelength (Proximity Sensor)

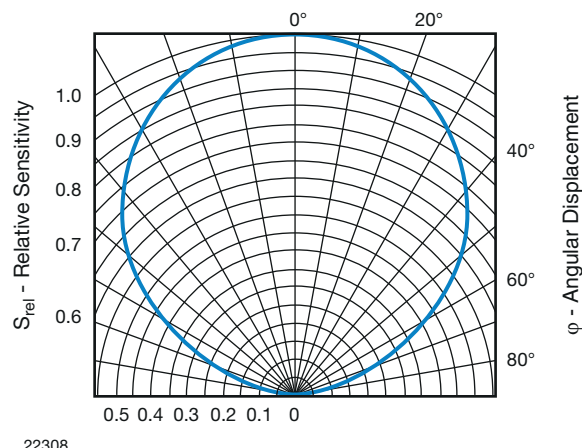


Fig. 8 - Relative Radiant Sensitivity vs. Angular Displacement (Proximity Sensor)

APPLICATION INFORMATION

VCNL3020 is a cost effective solution of proximity sensor with I²C bus interface. The standard serial digital interface is easy to access “Proximity Signal” without complex calculation and programming by external controller. Beside the digital output also a flexible programmable interrupt pin is available.

1. Application Circuit

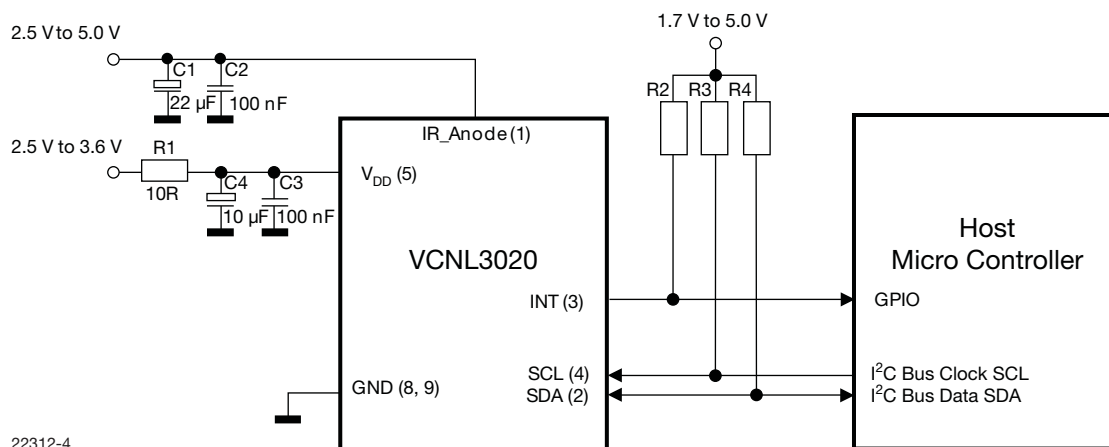


Fig. 9 - Application Circuit
(x) = Pin Number

Notes

- The interrupt pin is an open drain output. The needed pull-up resistor may be connected to the same supply voltage as the application controller and the pull-up resistors at SDA/SCL. Proposed value R2 should be >1 kΩ, e.g. 10 kΩ to 100 kΩ. Proposed value for R3 and R4, e.g. 2.2 kΩ to 4.7 kΩ, depend also on the I²C bus speed. For detailed description about set-up and use of the interrupt as well as more application related information see AN: “Designing VCNL3020 into an Application”.
- IR_Cathode needs no external connection. The needed connection to the driver is done internally.

2. I²C Interface

The VCNL3020 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 VCNL3020.

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.

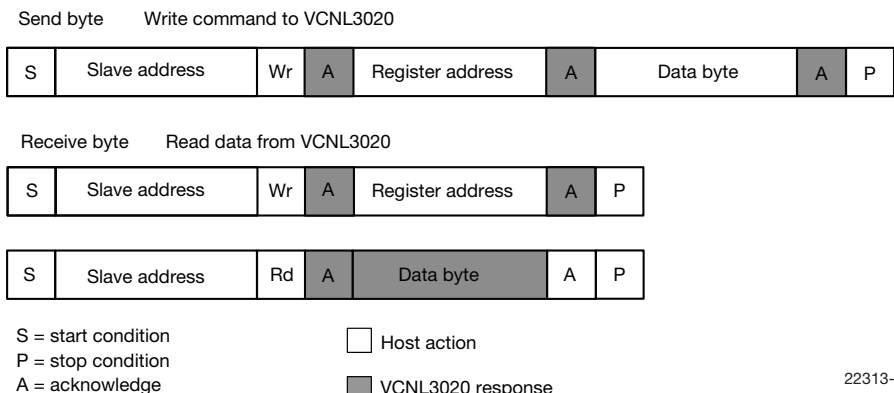


Fig. 10 - Send Byte/Receive Byte Protocol

Device Address

The VCNL3020 has a fix slave address for the host programming and accessing selection. The predefined 7 bit I²C 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

VCNL3020 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 proximity measurements. This register contains a flag bit 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 | n/a | prox_data_rdy | n/a | prox_od | n/a | prox_en | selftimed_en |
| Description | | | | | | | |
| config_lock | Read only bit. Value = 1 | | | | | | |
| 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. | | | | | | |
| 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). | | | | | | |
| prox_en | 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 | | | | | | |

Note

- Beside prox_en first selftimed_en needs to be set. On-demand measurement mode is disabled if selftimed_en bit is set. For the selftimed_en mode changes in reading rates (reg #2) can be made only when b0 (selftimed_en bit) = 0.

**Register #1 Product ID Revision Register**

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

Register data value of current revision = 21h.

TABLE 2 - PRODUCT ID REVISION REGISTER #1

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-------------|-------|---------------------------|-------|-------------|-------|-------|-------|
| Product ID | | | | Revision ID | | | |
| Description | | | | | | | |
| Product ID | | Read only bits. Value = 2 | | | | | |
| Revision ID | | Read only bits. Value = 1 | | | | | |

Register #2 Rate of Proximity Measurement

Register address = 82h.

TABLE 3 - PROXIMITY RATE REGISTER #2

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

Note

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

Register #3 LED Current Setting for Proximity Mode

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

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

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

TABLE 4 - IR LED CURRENT REGISTER #3

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

**Register #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 5 - 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 measurement result | | | | | | | |

TABLE 6 - PROXIMITY RESULT REGISTER #8

| 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.

TABLE 7 - INTERRUPT CONTROL REGISTER #9

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

| 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 9 - LOW THRESHOLD REGISTER #11

| 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 10 - HIGH THRESHOLD REGISTER #12

| 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 11 - HIGH THRESHOLD REGISTER #13

| 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 indicates if high or low going threshold exceeded.

TABLE 12 - 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 | n/a | int_th_low | int_th_hi |
| Description | | | | | | | |
| int_prox_ready | | R/W bit. Indicates a generated interrupt for proximity | | | | | |
| int_th_low | | R/W bit. Indicates a low threshold exceed | | | | | |
| int_th_hi | | R/W bit. Indicates a high threshold exceed | | | | | |

Note

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

Register #15 Proximity Modulator Timing Adjustment

Register address = 8Fh.

| TABLE 13 - PROXIMITY MODULATOR TIMING ADJUSTMENT #15 | | | | | | | |
|--|-------|--|---------------------|-------|----------------------|-------|-------|
| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| Modulation delay time | | | Proximity frequency | | Modulation dead time | | |
| Description | | | | | | | |
| 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 to the possibility for setting different proximity signal frequency. Correct adjustment is optimizing measurement signal level. (DEFAULT = 0) | | | | | |
| Proximity frequency | | 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 = 390.625 kHz (DEFAULT) 01 = 781.25 kHz 10 = 1.5625 MHz 11 = 3.125 MHz | | | | | |
| Modulation dead time | | R/W bits. Setting a dead time in evaluation of IR signal at the slopes of the IR signal. (DEFAULT = 1) This function is for reducing of possible disturbance effects. This function is reducing signal level and should be used carefully. | | | | | |

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 proximity 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 proximity measurement demands 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.

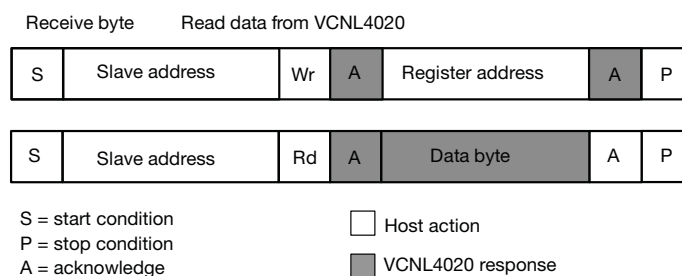


Fig. 11 - Send Byte/Receive Byte Protocol

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.

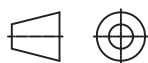
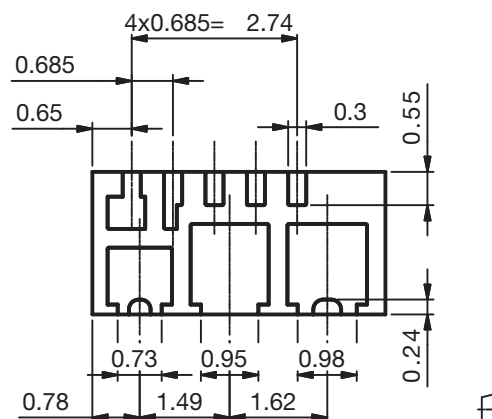
Example: read register “Proximity Result Register” #7 and #8:

Addressing:command: 26h, 87h (VCNL3020_I2C_Bus_Write_Adv., Proximity Result Register #7 [87])

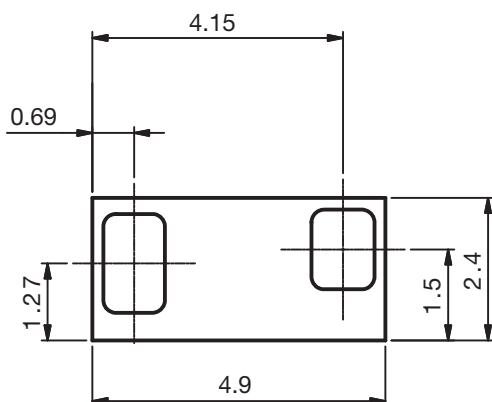
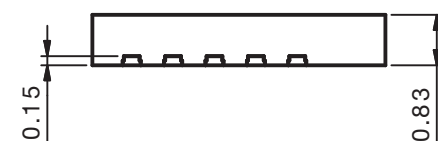
Read register #7: command: 27h, data (VCNL3020_I²C_Bus_Read_Adr., {High Byte Data of Proximity Result register #7 [87]})

Read register #8: command: 27h, data (VCNL3020_I²C_Bus_Read_Adr., {Low Byte Data of Proximity Result register #8 [88]})

PACKAGE DIMENSIONS in millimeters



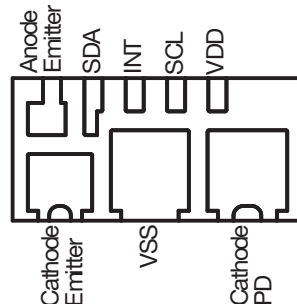
technical drawings
according to DIN
specifications



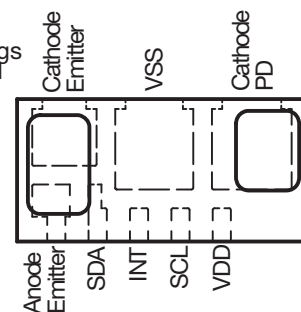
Drawing refers to following types: VCNL3020
Drawing-No.: 6.550-5319 Issue: prel. 14. MAY 2012

Not indicated tolerances ± 0.1

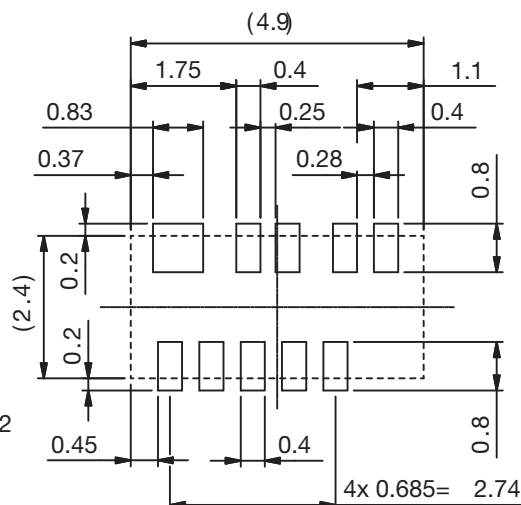
Pinning Bottom view

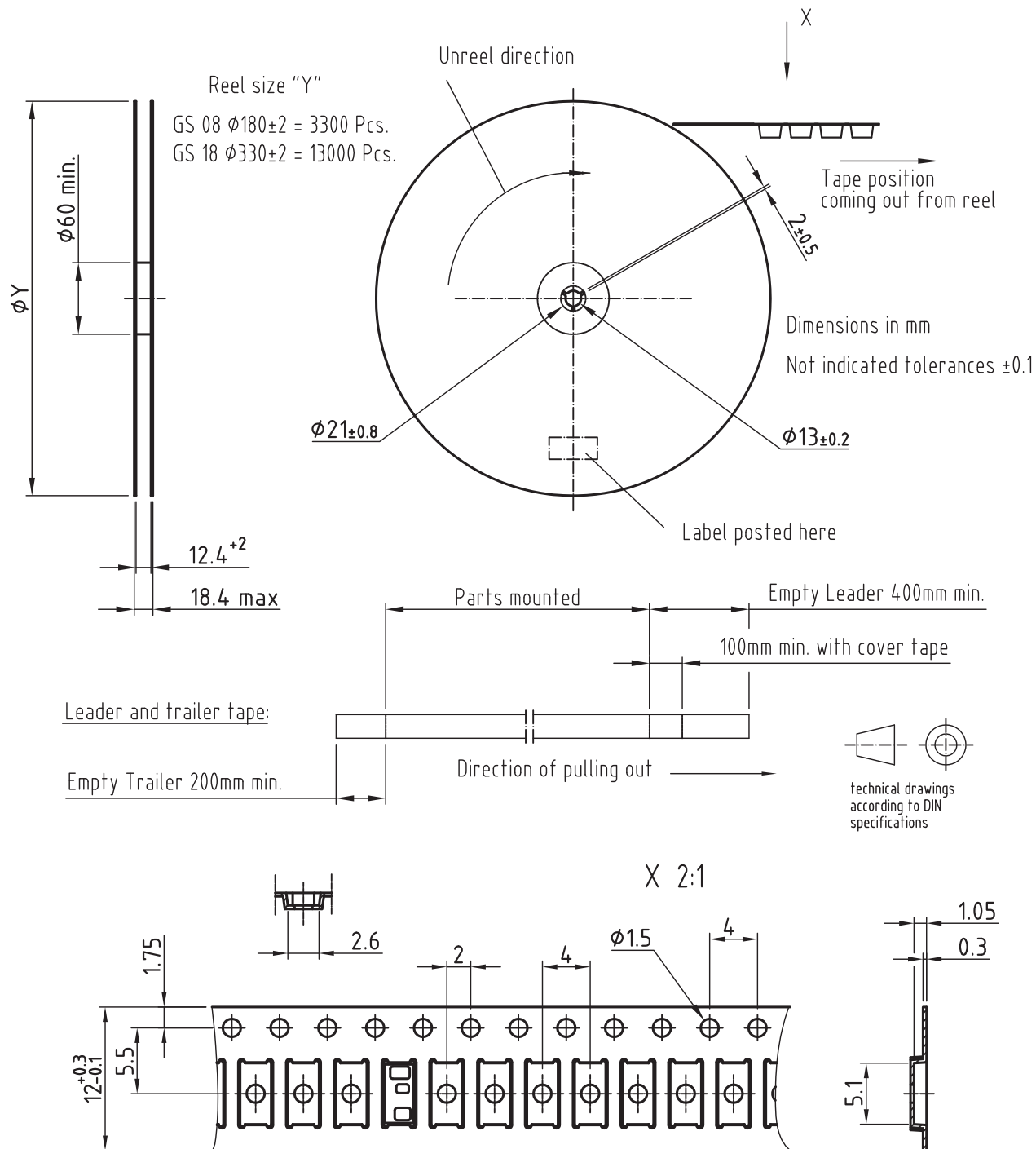


Pinning Top view



Proposed PCB Footprint



TAPE AND REEL DIMENSIONS in millimeters


Drawing-No.: 9.700-5387.01-4

Issue: prel; 22.11.11

SOLDER PROFILE

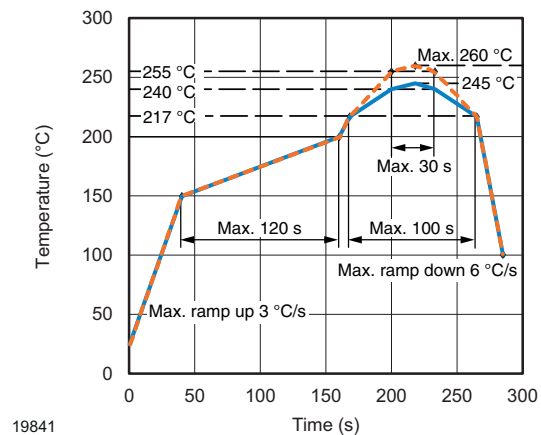


Fig. 12 - Lead (Pb)-free Reflow Solder Profile
According to J-STD-020

DRYPACK

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

FLOOR LIFE

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

Floor life: 72 h

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

Moisture sensitivity level 4, 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 $40\text{ °C} (+ 5\text{ °C})$, $RH < 5\%$.



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