# High Accuracy Ambient Light Sensor with I$^2$C Interface

## FEATURES

- Package type: surface mount
- Dimensions (L x W x H in mm): 2 x 2 x 0.85
- Integrated modules: ambient light sensor (ALS)
- Supply voltage range $V_{DD}$: 2.5 V to 3.6 V
- Communication via I$^2$C interface
- I$^2$C bus H-level range: 1.7 V to 3.6 V
- Floor life: 72 h, MSL 4, according to J-STD-020
- Low stand by current consumption: typ. 0.5 µA
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

e4

**RoHS**
COMPLIANT

HALOGEN
**FREE**
**GREEN**
(5-2008)

## DESCRIPTION

VEML6030 is a high accuracy ambient light digital 16-bit resolution sensor in a miniature transparent 2 mm x 2 mm package. It includes a high sensitive photodiode, a low noise amplifier, a 16-bit A/D converter and supports an easy to use I$^2$C bus communication interface and additional interrupt feature.

The ambient light result is as digital value available.

## AMBIENT LIGHT FUNCTION

- Filtron$^{TM}$ technology adaption: close to real human eye response
- O-Trim$^{TM}$ technology adoption: ALS output tolerance ≤ 10 %
- 16-bit dynamic range for ambient light detection from 0 lx to about 167 klx with resolution down to 0.005 lx/ct, supports low transmittance (dark) lens design
- 100 Hz and 120 Hz flicker noise rejection
- Excellent temperature compensation
- High dynamic detection resolution
- Software shutdown mode control

## APPLICATIONS

- Ambient light sensor for mobile devices (e.g. smart phones, touch phones, PDA, GPS) for backlight dimming
- Ambient light sensor for industrial on- / off-lighting operation
- Optical switch for consumer, computing, and industrial devices and displays

## PRODUCT SUMMARY

| PART NUMBER | OPERATING RANGE (mm) | OPERATING VOLTAGE RANGE (V) | I$^2$C BUS VOLTAGE RANGE (V) | AMBIENT LIGHT RANGE (lx) | AMBIENT LIGHT RESOLUTION (lx) | OUTPUT CODE | ADC RESOLUTION PROXIMITY / AMBIENT LIGHT |
|---|---|---|---|---|---|---|---|
| VEML6030 | n/a | 2.5 to 3.6 | 1.7 to 3.6 | 0 to 167 000 | 0.005 | 16 bit, I$^2$C | - / 0.005 |

## ORDERING INFORMATION

| ORDERING CODE | PACKAGING | VOLUME [1] | REMARKS |
|---|---|---|---|
| VEML6030 | Tape and reel | MOQ: 3000 | 2.0 mm x 2.0 mm x 0.85 mm |
| VEML6030-GS15 | | MOQ: 10 000 | |

**Note**

[1] MOQ: minimum order quantity

For technical questions, contact: sensorstechsupport@vishay.com

## ABSOLUTE MAXIMUM RATINGS ($T_{amb}$ = 25 °C, unless otherwise specified)

| PARAMETER | TEST CONDITION | SYMBOL | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| Supply voltage | | $V_{DD}$ | 0 | 4 | V |
| Operation temperature range | | $T_{amb}$ | -25 | +85 | °C |
| Storage temperature range | | $T_{stg}$ | -25 | +85 | °C |
| Total power dissipation | $T_{amb} \leq$ 25 °C | $P_{tot}$ | - | 50 | mW |
| Junction temperature | | $T_j$ | - | 110 | °C |

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

| PARAMETER | TEST CONDITION | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Supply voltage | | $V_{DD}$ | 2.5 | 3.3 | 3.6 | V |
| Shut down current [2] | $V_{DD}$ is 3.3 V | $I_{sd}$ | - | 0.5 | - | µA |
| Operation mode current [1] | $V_{DD}$ is 3.3 V, PSM = 11, refresh time 4100 ms | $I_{DD}$ | - | 2 | - | µA |
| | $V_{DD}$ is 3.3 V, PSM = 00, refresh time 600 ms | $I_{DD}$ | - | 8 | - | µA |
| | $V_{DD}$ is 3.3 V, PSM_EN = 0, refresh time 100 ms | $I_{DD}$ | - | 45 | - | µA |
| I²C clock rate range | | $f_{SCL}$ | 10 | - | 400 | kHz |
| I²C bus input H-level range | $V_{DD}$ is 3.3 V | $V_{ih}$ | 1.3 | - | 3.6 | V |
| I²C bus input L-level range | $V_{DD}$ is 3.3 V | $V_{il}$ | | - | 0.4 | V |
| Digital current out (low, current sink) | | $I_{ol}$ | 3 | - | - | mA |
| Digital resolution (LSB count) | with ALS_SM = "01" | | - | 0.005 | - | lx/step |
| Detectable minimum illuminance | with ALS_SM = "01" | $E_{V\ min.}$ | - | 0.01 | - | lx |
| Detectable maximum illuminance | with ALS_SM = "10" | $E_{V\ max.}$ | - | 167 000 | - | lx |
| Dark offset [1] | with ALS_SM = "01" | | - | 3 | - | step |

**Notes**

[1] Light source: white LED

[2] Light conditions: dark

## CIRCUIT BLOCK DIAGRAM
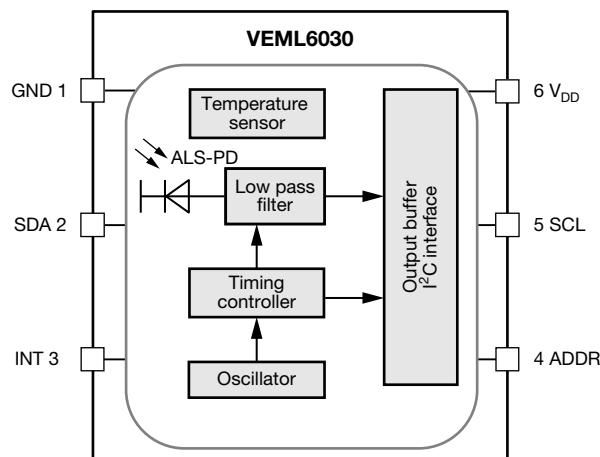


Fig. 1 - Block Diagram

**BASIC CHARACTERISTICS** ($T_{amb}$ = 25 °C, unless otherwise specified)
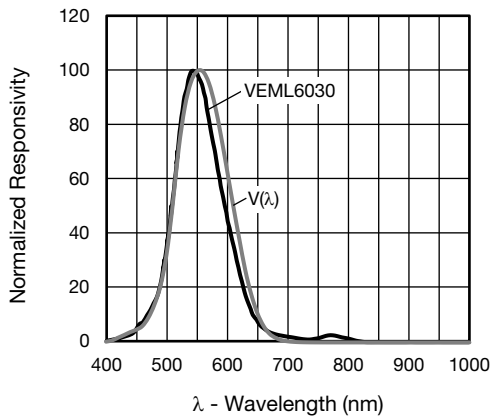
Fig. 2 - Spectral Response
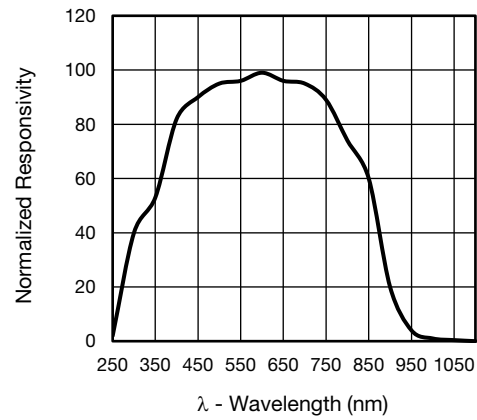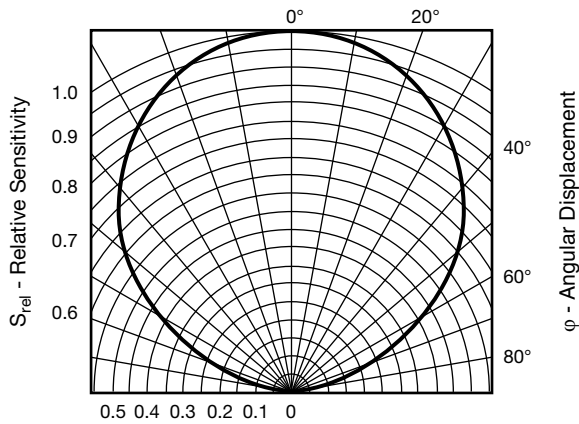
Fig. 3 - White Channel Responsivity

ALS sensitivity spectrum close to human eye photopic curve V(λ). Human eye curve adaption achieved by Filtron technology.

22308

Fig. 4 - Relative Radiant Sensitivity vs. Angular Displacement

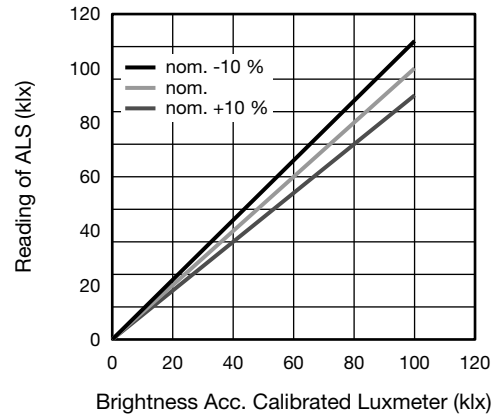Fig. 5 - ALS measurement deviation between different light sources: ≤ 10 %

## APPLICATION INFORMATION

VEML6030 is a cost effective solution of ambient light sensor with I2C bus interface. The standard serial digital interface is easy to access "Ambient Light Signal" without complex calculation and programming by external controller. Beside the digital output also a flexible programmable interrupt pin is available.

### 1. Application Circuit



1.7 V to 3.6 V

R1 R2 R3

GND (1)

2.5 V to 3.6 V
R4
10R
C1 10 µF
C2 100 nF
V_DD (6)

VEML6030

C1 and R4 are optional for very disturbed supply

ADDR (4)

SDA (2)
SCL (5)
INT (3)

Host Micro Controller

I2C bus data SDA
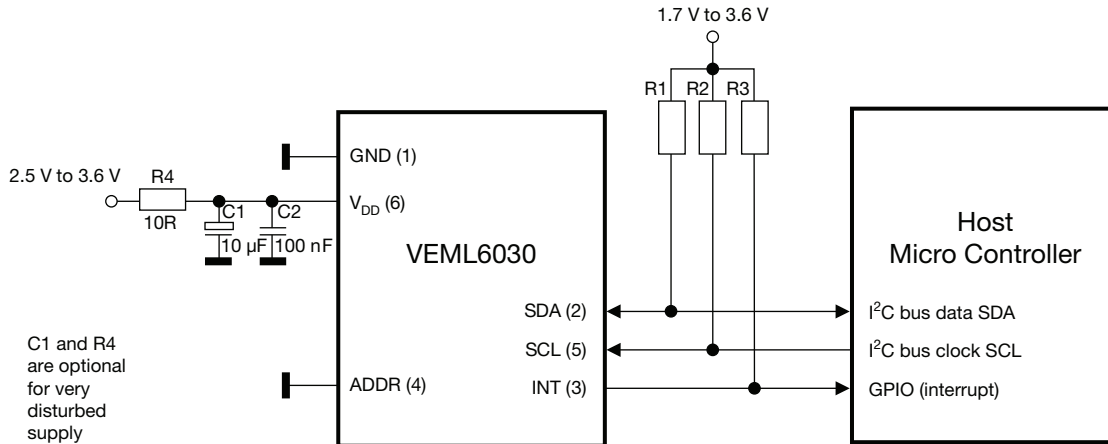I2C bus clock SCL
GPIO (interrupt)

Fig. 6 - Application Circuit
(x) = Pin Number

**Notes**

- The interrupt pin is an open drain output. Proposed values for the pull-up resistors should be > 1 kΩ, e.g. 2.2 kΩ to 4.7 kΩ for the R1 and R2 (at SDA and SCL) and 10 kΩ to 100 kΩ for R3 (at interrupt).
  Normally just one decoupling capacitor is needed. This should be ≥ 100 nF and placed close to the $V_{DD}$ pin.
  Pin ADDR allows for the device addresses: pin 4 = high ($V_{DD}$) = 0x48, pin 4 = low (GND) = 0x10

  For detailed description about set-up and use of the interrupt as well as more application related information see AN: "Designing VEML6030 into an Application".

### 2. I2C Interface

The VEML6030 contains actual six 16 bit command codes for operation control, parameter setup, and result buffering. All registers are accessible via I2C communication. Figure 7 shows the basic I2C communication with VEML6030.

The built in I2C interface is compatible with I2C modes "standard" and "fast": 10 kHz to 400 kHz.

I2C H-level range = 1.3 V to 3.6 V.

Please refer to the I2C specification from NXP for details.

Send byte        Write command to VEML6030

| S | Slave address | Wr | A | Command code | A | Data byte (LSB) | A | Data byte (MSB) | A | P |

Receive byte        Read data from VEML6030

| S | Slave address | Wr | A | Command code | A | S | Slave address | Rd | A | Data byte (LSB) | A | Data byte (MSB) | N | P |

S = start condition
P = stop condition
A = acknowledge
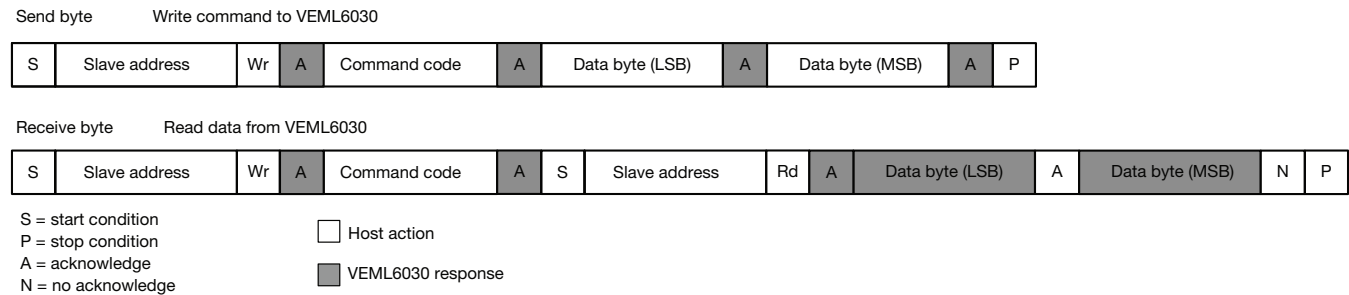N = no acknowledge

☐ Host action

▦ VEML6030 response

Fig. 7 - Send Byte / Receive Byte Protocol

### Device Address

The VEML6030 has two fix slave addresses for the host programming and accessing selection.

With ADDR pin plugged to power supply = high = $V_{DD}$, the predefined 7 bit I2C bus address is set to 1001000 = 0x48. The least significant bit (LSB) defines read or write mode. Accordingly the bus address is set to 1001 0000 = 90h for write and 1001 0001 = 91h for read.

With ADDR pin plugged to ground = low, the slave address (7 bit) is set to 0010000 = 0x10. According 8 bit the bus address is then 0010 0000 = 20h for write and 0010 0001 = 21h for read.

## Register Addresses

VEML6030 has actual six user accessible 16 bit command codes.

The addresses are 00h to 06h (03h not defined / reserved).

## Auto-Memorization

VEML6030 can memorize the last ambient data before shutdown and keep this data before waking up.

When VEML6030 is in shutdown mode, the host can freely read this data via read command directly.

When VEML6030 wakes up, the data will be refreshed by new detection.

| COMMAND REGISTER FORMAT | | | | |
|---|---|---|---|---|
| **COMMAND CODE** | **REGISTER NAME** | **BIT** | **FUNCTION / DESCRIPTION** | **R / W** |
| 00 | reserved | 15 : 13 | Set 000b | W |
| | ALS_SM | 12 : 11 | Sensitivity mode selection<br>00 = ALS sensitivity x 1<br>01 = ALS sensitivity x 2<br>10 = ALS sensitivity x (1/8)<br>11 = ALS sensitivity x (1/4) | W |
| | reserved | 10 | Set 0b | W |
| | ALS_IT | 9 : 6 | ALS integration time setting<br>1100 = 25 ms<br>1000 = 50 ms<br>0000 = 100 ms<br>0001 = 200 ms<br>0010 = 400 ms<br>0011 = 800 ms | W |
| | ALS_PERS | 5 : 4 | ALS persistence protect number setting<br>00 = 1<br>01 = 2<br>10 = 4<br>11 = 8 | W |
| | reserved | 3 : 2 | Set 00b | W |
| | ALS_INT_EN | 1 | ALS interrupt enable setting<br>0 = ALS INT disable<br>1 = ALS INT enable | W |
| | ALS_SD | 0 | ALS shut down setting<br>0 = ALS power on<br>1 = ALS shut down | W |
| 01 | ALS_WH | 15 : 8 | ALS high threshold window setting (MSB) | W |
| | | 7 : 0 | ALS high threshold window setting (LSB) | W |
| 02 | ALS_WL | 15 : 8 | ALS low threshold window setting (MSB) | W |
| | | 7 : 0 | ALS low threshold window setting (LSB) | W |
| 03 | reserved | 15 : 3 | Set 0000 0000 0000 0b | |
| | PSM | 2 : 1 | Power saving mode; see table "Refresh time"<br>00 = mode 1<br>01 = mode 2<br>10 = mode 3<br>11 = mode 4 | W |
| | PSM_EN | 0 | Power saving mode enable setting<br>0 = disable<br>1 = enable | W |
| 04 | ALS | 15 : 8 | MSB 8 bits data of whole ALS 16 bits | R |
| | | 7 : 0 | LSB 8 bits data of whole ALS 16 bits | R |
| 05 | WHITE | 15 : 8 | MSB 8 bits data of whole WHITE 16 bits | R |
| | | 7 : 0 | LSB 8 bits data of whole WHITE 16 bits | R |
| 06 | ALS_IF_L | 15 | ALS crossing low threshold INT trigger event | R |
| | ALS_IF_H | 14 | ALS crossing high threshold INT trigger event | R |
| | reserved | 13 : 0 | | |

**Note**
- Command code 0 default value is 01 = devices is shut down

**Command Code #0: Configuration Register**

Register address = 00h
The command code #0 is for configuration of the ambient light measurements.

| TABLE 1 - CONFIGURATION REGISTER #0 | | | | |
|---|---|---|---|
| REGISTER NAME | BIT | FUNCTION / DESCRIPTION | R / W |
| reserved | 15 : 13 | Set 000b | W |
| ALS_SM | 12 : 11 | Sensitivity mode selection<br>00 = ALS sensitivity x 1<br>01 = ALS sensitivity x 2<br>10 = ALS sensitivity x (1/8)<br>11 = ALS sensitivity x (1/4) | W |
| reserved | 10 | Set 0b | W |
| ALS_IT | 9 : 6 | ALS integration time setting<br>1100 = 25 ms<br>1000 = 50 ms<br>0000 = 100 ms<br>0001 = 200 ms<br>0010 = 400 ms<br>0011 = 800 ms | W |
| ALS_PERS | 5 : 4 | ALS persistence protect number setting<br>00 = 1<br>01 = 2<br>10 = 4<br>11 = 8 | W |
| reserved | 3 : 2 | Set 00b | W |
| ALS_INT_EN | 1 | ALS interrupt enable setting<br>0 = ALS INT disable<br>1 = ALS INT enable | W |
| ALS_SD | 0 | ALS shut down setting<br>0 = ALS power on<br>1 = ALS shut down | W |

**Note**

• Light level [lx] is (ALS OUTPUT DATA [dec.] / ALS sensitivity) x (10 / IT [ms]). Please study also the application note.

**Command Code #1: High Threshold Windows Setting**

Command code address = 01h. Once enable INT function and use high / low windows threshold, bit 15:0 provides 16 bit register for high bound threshold windows setting.

| TABLE 2 - HIGH THRESHOLD WINDOWS SETTING #1 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| Description | | | | | | | | | | | | | | | |
| ALS high threshold window setting (15:8 MSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |
| ALS high threshold window setting (7:0 LSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |

**Command Code #2: Low Threshold Windows Setting**

Command code address = 02h. Once enable INT function and use high / low windows threshold, bit 15:0 provides 16 bit register for low bound threshold windows setting.

| TABLE 3 - LOW THRESHOLD WINDOWS SETTING #2 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| Description | | | | | | | | | | | | | | | |
| ALS low threshold window setting (15:8 MSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |
| ALS low threshold window setting (7:0 LSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |

**Command Code #3: Power Saving Mode: PSM**

Command code address = 03h. Bits 2 and 1 define the power saving modes. Bits 15 : 3 are reserved.

| TABLE 4 - POWER SAVING MODES | | | | |
|---|---|---|---|---|
| **COMMAND CODE** | **REGISTER NAME** | **BIT** | **FUNCTION / DESCRIPTION** | **R / W** |
| 03 | PSM | 2 : 1 | Power saving mode; see table "Refresh time"<br>00 = mode 1<br>01 = mode 2<br>10 = mode 3<br>11 = mode 4 | W |
| | PSM_EN | 0 | Power saving mode enable setting<br>0 = disable<br>1 = enable | W |

**Command Code #4: ALS High Resolution Output Data**

Command code address = 04h. To access 16 bit high resolution ALS output, it is suitable to follow read protocol to read from command code #04 16 bits register.

| TABLE 5 - ALS HIGH RESOLUTION OUTPUT DATA #4 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| **Description** | | | | | | | | | | | | | | | |
| ALS high resolution output data (15 : 8 MSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |
| ALS high resolution output data (7 : 0 LSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |

**Command Code #5: White Channel Output Data**

Command code address = 05h. To access 16 bit WHITE output, it is suitable to follow read protocol to read from command code #05 16 bits register.

| TABLE 6 - WHITE CHANNEL OUTPUT DATA #5 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| **Description** | | | | | | | | | | | | | | | |
| WHITE output data (15 : 8 MSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |
| WHITE output data (7 : 0 LSB 8 bits of whole 16 bits) | | | | | | | | | | | | | | | |

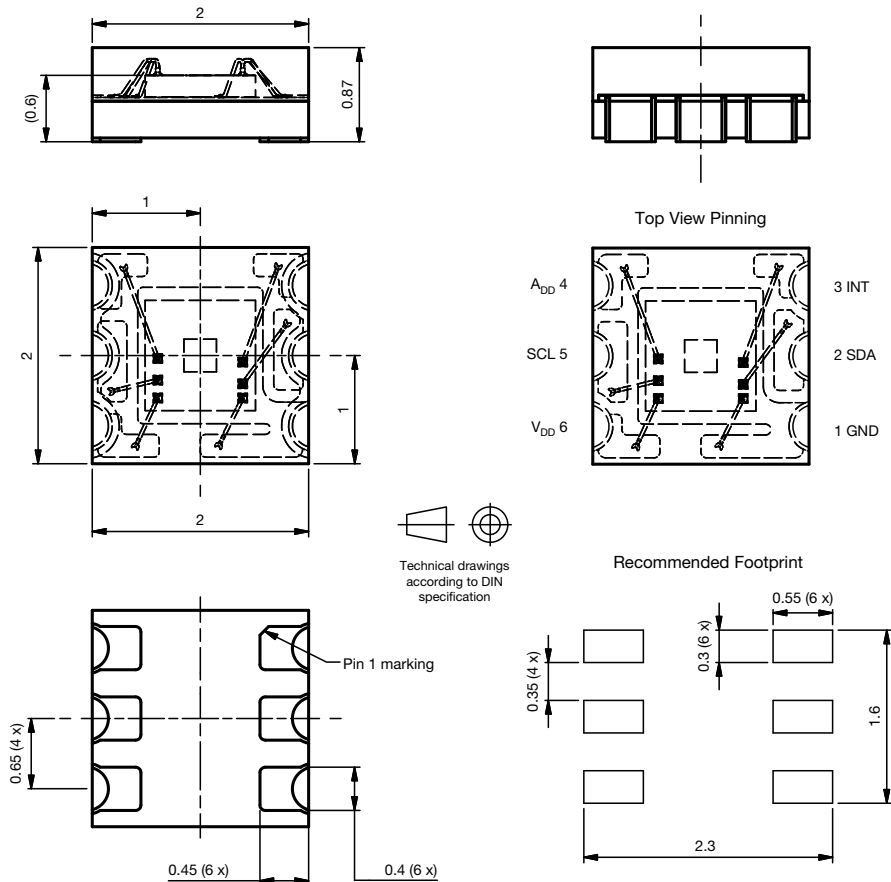**Command Code #6: Interrupt Status**

Command code address = 06h. Bit 15 defines interrupt flag while trigger occurred due to data crossing low threshold windows. Bit 14 defines interrupt flag while trigger occurred due to data crossing high threshold windows.

| TABLE 7 - INTERRUPT STATUS #6 | | |
|---|---|---|
| Bit 15 | Bit 14 | Bit 13 to 0 |
| int_th_low | int_th_high | reserved |
| **Description** | | |
| int_th_low | Read bit. Indicated a low threshold exceed | |
| int_th_high | Read bit. Indicated a high threshold exceed | |

## REFRESH TIME DETERMINATION OF PSM

VEML6030's refresh time can be determined by PSM and ALS_IT setting in power saving mode (PSM). Cooperating with the command register setting, the designer has a flexible method in defining the timing, power consumption, and sensitivity for light data collection.

### REFRESH TIME, $I_{DD}$, AND SENSITIVITY RELATION

| ALS_SM | PSM | ALS_IT | REFRESH TIME (ms) | $I_{DD}$ (µA) | SENSITIVITY (lx/bit) |
|---|---|---|---|---|---|
| 01 | 00 | 0000 | 600 | 8 | 0.042 |
| 01 | 01 | 0000 | 1100 | 5 | 0.042 |
| 01 | 10 | 0000 | 2100 | 3 | 0.042 |
| 01 | 11 | 0000 | 4100 | 2 | 0.042 |
| 01 | 00 | 0001 | 700 | 13 | 0.021 |
| 01 | 01 | 0001 | 1200 | 8 | 0.021 |
| 01 | 10 | 0001 | 2200 | 5 | 0.021 |
| 01 | 11 | 0001 | 4200 | 3 | 0.021 |
| 01 | 00 | 0010 | 900 | 20 | 0.010 |
| 01 | 01 | 0010 | 1400 | 13 | 0.010 |
| 01 | 10 | 0010 | 2400 | 8 | 0.010 |
| 01 | 11 | 0010 | 4400 | 5 | 0.010 |
| 01 | 00 | 0011 | 1300 | 28 | 0.005 |
| 01 | 01 | 0011 | 1800 | 20 | 0.005 |
| 01 | 10 | 0011 | 2800 | 13 | 0.005 |
| 01 | 11 | 0011 | 4800 | 8 | 0.005 |

## PACKAGE DIMENSIONS in millimeters



Top View Pinning

$A_{DD}$ 4    3 INT

SCL 5    2 SDA

$V_{DD}$ 6    1 GND

Technical drawings according to DIN specification

Pin 1 marking

Recommended Footprint

Drawing No.: 6.550-5348.01-4
Issue: 1; 19.02.16

Not indicated tolerances ± 0.1

For technical questions, contact: sensorstechsupport@vishay.com
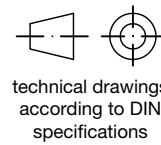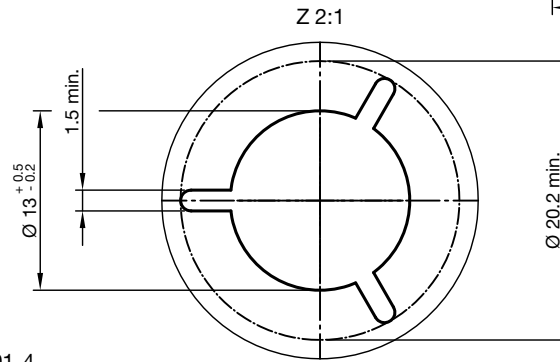
**TAPE AND REEL DIMENSIONS** in millimeters



Form of the leave open of the wheel is supplier specific.

technical drawings
according to DIN
specifications
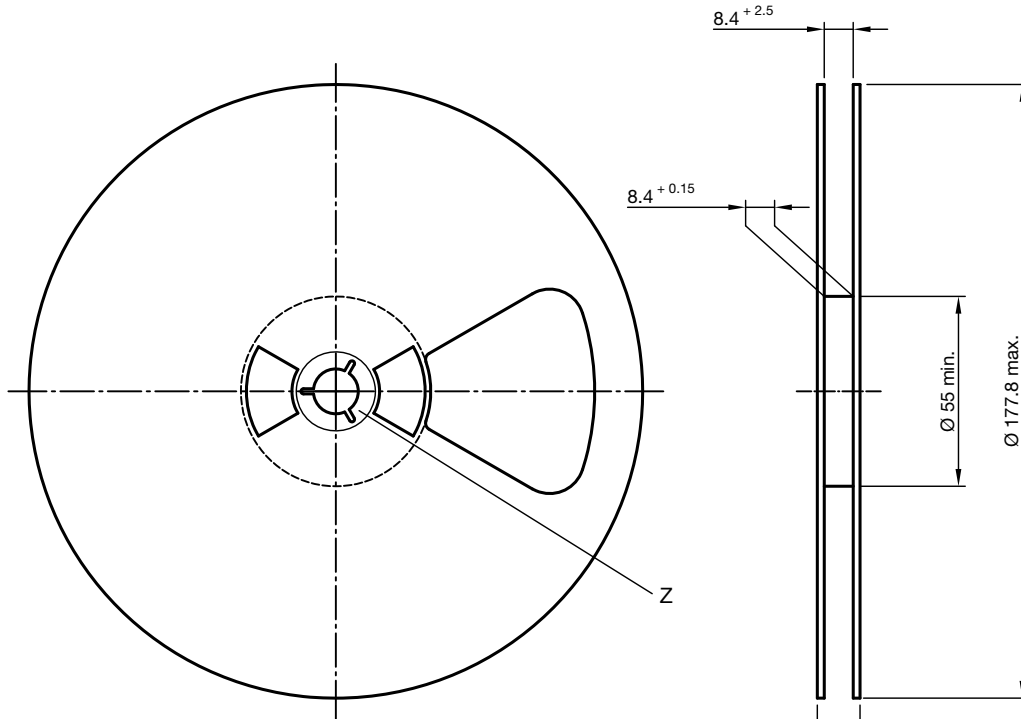
Drawing-No.: 9.800-5096.01-4
Issue: 4;  08.03.2016

Fig. 8 - 7" Reel, 3000 Pieces

Label

Z

Form of the leave open
of the wheel is supplier specific.

unreel direction

Y

100 min.

330 max.

14.4 max.

8.4 $^{+2.5}_{-0}$

Z ( 2 : 1 )

Y ( 1 : 1 )

Ø 20.2 min.

Ø 13 $^{+0.5}_{-0.2}$

1.5 min.

8.4 $^{+0.15}_{-0}$
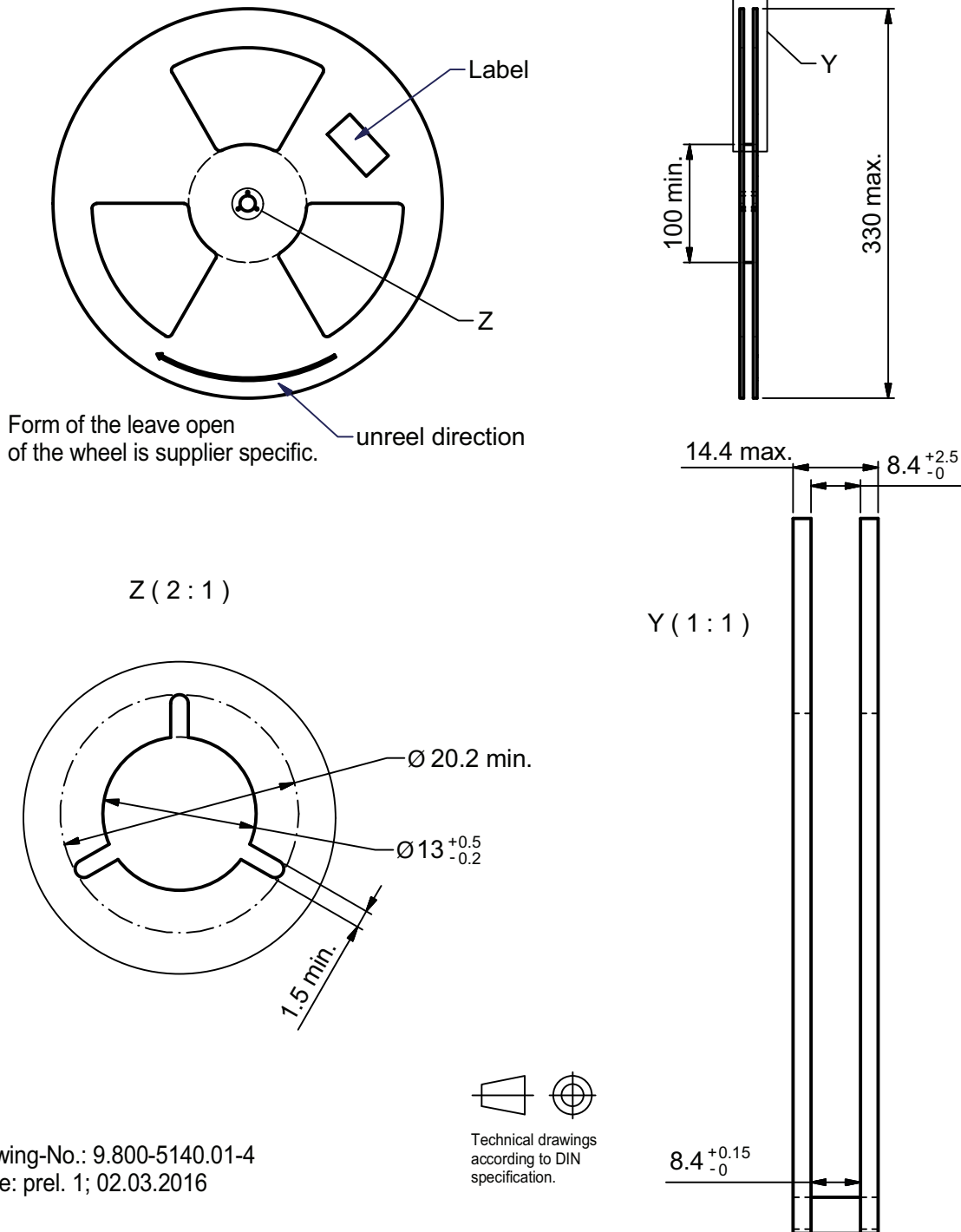
Drawing-No.: 9.800-5140.01-4
Issue: prel. 1; 02.03.2016

Technical drawings
according to DIN
specification.

Fig. 9 - 13" Reel, 10 000 Pieces
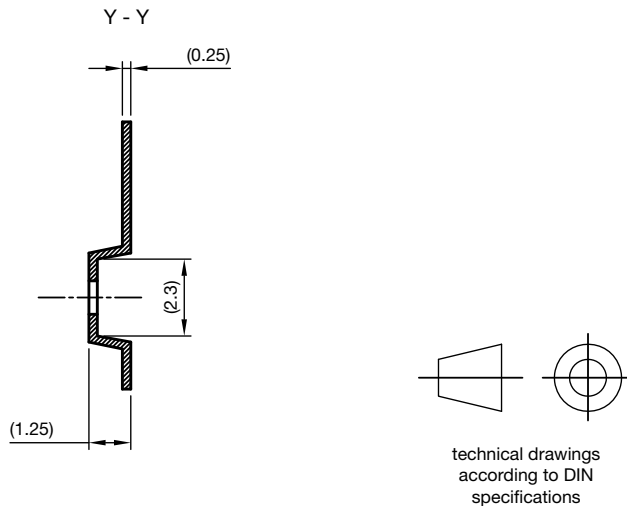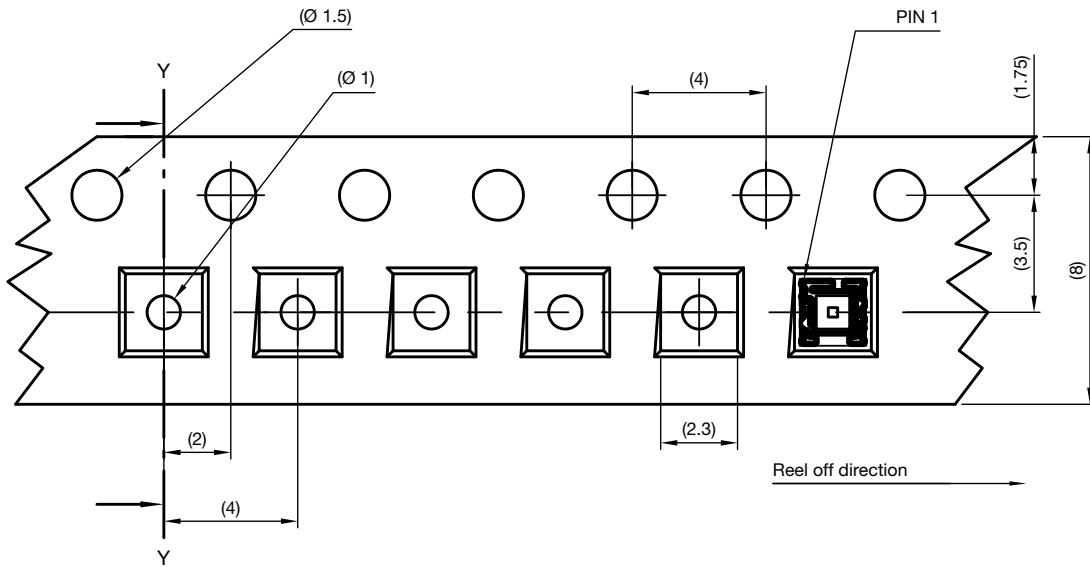
Drawing-No.: 9.700-5397.01-4
Issue: 1; 19.02.16
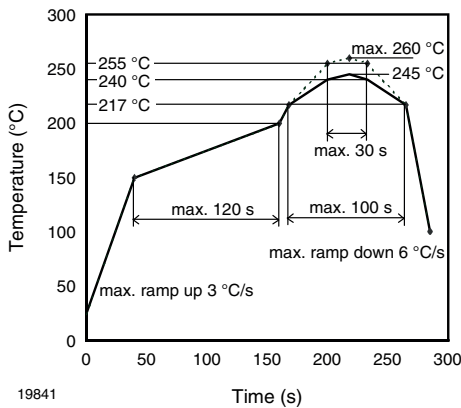
Fig. 10 - Taping

## REFLOW SOLDER PROFILE



19841

Fig. 11 - 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 °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 °C (+ 5 °C), RH < 5 %.

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