

## RGBCIR Color Sensor With I<sup>2</sup>C Interface



### LINKS TO ADDITIONAL RESOURCES



### DESCRIPTION

VEML3328SL sensor senses red, green, blue, clear, and IR light by incorporating photodiodes, amplifiers, and analog / digital circuits into a single CMOS chip. With this sensor, the brightness and color temperature of a display backlight can be adjusted based on the ambient light source, and it can differentiate indoor from outdoor lighting environments.

### FEATURES

- Package type: surface-mount
- Dimensions (L x W x H in mm): 2.95 x 1.50 x 1.50
- Integrated modules: color sensor and signal conditioning IC
- Supports low transmittance (dark) lens design
- Provides 16-bit resolution for each channel (R, G, B, C, and IR)
- Package: OPLGA4 SV (side view)
- Temperature compensation: -40 °C to +85 °C
- Low power consumption I<sup>2</sup>C (SMBus compatible) interface
- Floor life: 168 h, MSL 3, according to J-STD-020
- Output type: I<sup>2</sup>C bus
- Operation voltage: 2.6 V to 3.6 V
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



### APPLICATIONS

- Automatic white balancing and color cast correction in digital cameras
- Automatic LCD backlight adjustment
- Maintaining consistent true color and ideal brightness levels on handheld displays as users move between indoor and outdoor environments
- On / off light switching in industrial and consumer applications
- Active monitoring of LED color output for IoT and smart lighting

### PRODUCT SUMMARY

| PART NUMBER | OPERATING VOLTAGE RANGE (V) | I <sup>2</sup> C BUS VOLTAGE RANGE (V) | PEAK SENSITIVITY (nm)                    | OUTPUT CODE              |
|-------------|-----------------------------|----------------------------------------|------------------------------------------|--------------------------|
| VEML3328SL  | 2.6 to 3.6                  | 1.7 to 3.6                             | 590, 610, 560, 470, 825 (C, R, G, B, IR) | 16 bit, I <sup>2</sup> C |

**ORDERING INFORMATION**

| ORDERING CODE | PACKAGING     | VOLUME <sup>(1)</sup> | REMARKS                     |
|---------------|---------------|-----------------------|-----------------------------|
| VEML3328SL    | Tape and reel | MOQ: 2500 pcs         | 2.95 mm x 1.50 mm x 1.50 mm |

**Note**

<sup>(1)</sup> MOQ: minimum order quantity

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

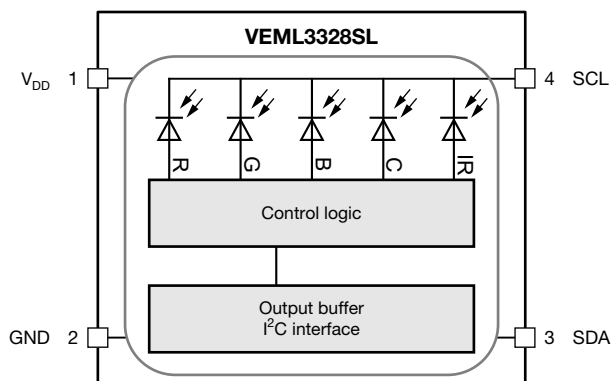
| PARAMETER                   | TEST CONDITION | SYMBOL    | MIN. | MAX. | UNIT               |
|-----------------------------|----------------|-----------|------|------|--------------------|
| Supply voltage              |                | $V_{DD}$  | 0    | 4    | V                  |
| Operation temperature range |                | $T_{amb}$ | -40  | +85  | $^{\circ}\text{C}$ |
| Storage temperature range   |                | $T_{stg}$ | -40  | +85  | $^{\circ}\text{C}$ |

**RECOMMENDED OPERATING CONDITIONS** ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified)

| PARAMETER                                | TEST CONDITION | SYMBOL         | MIN. | MAX. | UNIT               |
|------------------------------------------|----------------|----------------|------|------|--------------------|
| Supply voltage                           |                | $V_{DD}$       | 2.6  | 3.6  | V                  |
| Operation temperature range              |                | $T_{amb}$      | -40  | +85  | $^{\circ}\text{C}$ |
| I <sup>2</sup> C bus operating frequency |                | $f_{(I2CCLK)}$ | 10   | 400  | kHz                |

**PIN DESCRIPTIONS**

| PIN ASSIGNMENT | SYMBOL   | TYPE               | FUNCTION                                                |
|----------------|----------|--------------------|---------------------------------------------------------|
| 1              | $V_{DD}$ | -                  | Supply voltage                                          |
| 2              | GND      | -                  | Power supply ground; all voltages are referenced to GND |
| 3              | SDA      | I / O (open drain) | I <sup>2</sup> C digital bus data input / output        |
|                | SCL      | I                  | I <sup>2</sup> C digital bus clock input                |

**BLOCK DIAGRAM**



| <b>BASIC CHARACTERISTICS</b> ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified) |                               |                 |      |       |      |                                      |
|-----------------------------------------------------------------------------------------------------|-------------------------------|-----------------|------|-------|------|--------------------------------------|
| PARAMETER                                                                                           | TEST CONDITION                | SYMBOL          | MIN. | TYP.  | MAX. | UNIT                                 |
| Supply voltage                                                                                      |                               | $V_{DD}$        | 2.6  | 3.0   | 3.6  | V                                    |
| Supply current <sup>(1)</sup>                                                                       |                               | $I_{DD}$        | 500  | 580   | 1000 | $\mu\text{A}$                        |
| I <sup>2</sup> C signal input <sup>(1)</sup>                                                        | Logic high                    | $V_{IH}$        | 1.2  | -     | -    | V                                    |
|                                                                                                     | Logic low                     | $V_{IL}$        | -    | -     | 0.4  |                                      |
| Peak sensitivity wavelength                                                                         |                               | $\lambda_{PC}$  | -    | 590   | -    | nm                                   |
|                                                                                                     |                               | $\lambda_{PR}$  | -    | 610   | -    |                                      |
|                                                                                                     |                               | $\lambda_{PG}$  | -    | 560   | -    |                                      |
|                                                                                                     |                               | $\lambda_{PB}$  | -    | 470   | -    |                                      |
|                                                                                                     |                               | $\lambda_{PIR}$ | -    | 825   | -    |                                      |
| Irradiance responsivity                                                                             | 520 nm LED <sup>(1)(2)</sup>  | C               | -    | 57    | -    | counts/( $\mu\text{W}/\text{cm}^2$ ) |
|                                                                                                     | 850 nm LED <sup>(1)(2)</sup>  | IR              | -    | 25    | -    |                                      |
|                                                                                                     | 643 nm LED <sup>(1)(2)</sup>  | R               | -    | 41    | -    |                                      |
|                                                                                                     | 520 nm LED <sup>(1)(2)</sup>  | G               | -    | 39    | -    |                                      |
|                                                                                                     | 460 nm LED <sup>(1)(2)</sup>  | B               | -    | 34    | -    |                                      |
| Sensitivity                                                                                         | 5000 K WLED <sup>(1)(3)</sup> | G               | -    | 0.003 | -    | lx/count                             |
| Dark offset <sup>(1)(3)</sup>                                                                       |                               | R, G, B, C, IR  | 0    | -     | 3    | counts                               |
| Operating temperature range                                                                         |                               | $T_{amb}$       | -40  | -     | +85  | $^{\circ}\text{C}$                   |
| Shutdown current <sup>(1)</sup>                                                                     | Light condition = dark        | $I_{DD}$        | 0    | 800   | 1000 | nA                                   |

**Notes**

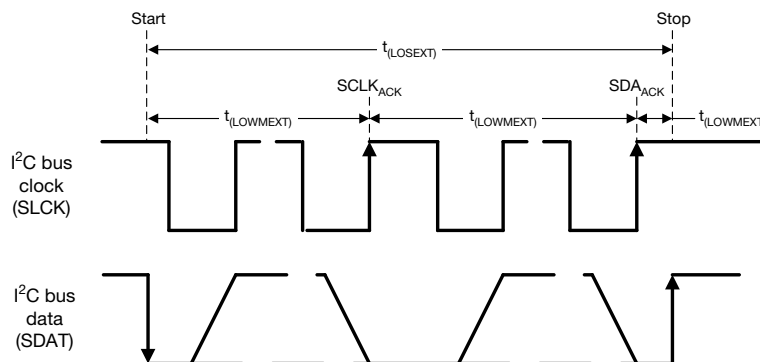
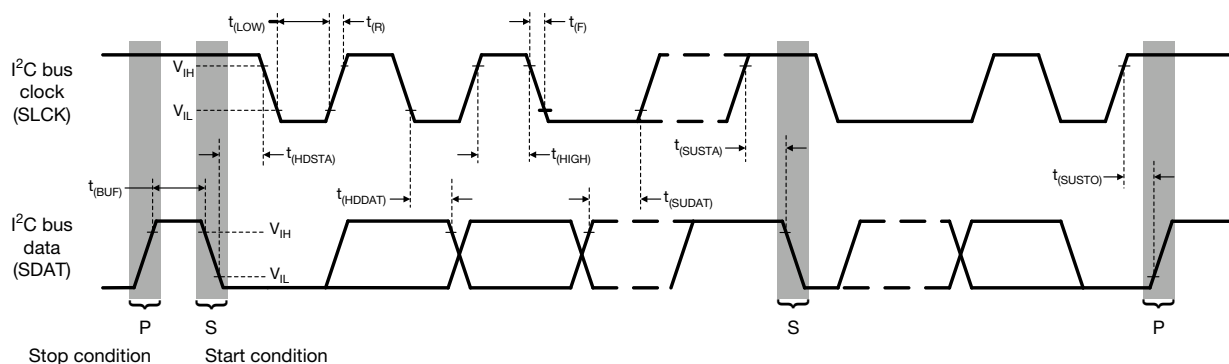
<sup>(2)</sup> Test condition:  $V_{DD} = 3\text{ V}$ , temperature:  $25\text{ }^{\circ}\text{C}$

<sup>(3)</sup> IT: 100 ms, SENS = (0) = x 1, DG = (0 : 0) = x 1, GAIN = (0 : 0) = x 1

<sup>(4)</sup> IT: 400 ms, SENS = (0) = x 1, DG = (1 : 0) = x 4, GAIN = (1 : 0) = x 4

**I<sup>2</sup>C BUS TIMING CHARACTERISTICS** ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified)

| PARAMETER                                                                                   | SYMBOL         | STANDARD MODE |      | FAST MODE |      | UNIT          |
|---------------------------------------------------------------------------------------------|----------------|---------------|------|-----------|------|---------------|
|                                                                                             |                | MIN.          | MAX. | MIN.      | MAX. |               |
| Clock frequency                                                                             | $f_{(I2CCLK)}$ | 10            | 100  | 10        | 400  | kHz           |
| Bus free time between start and stop condition                                              | $t_{(BUF)}$    | 4.7           | -    | 1.3       | -    | $\mu\text{s}$ |
| Hold time after (repeated) start condition; after this period, the first clock is generated | $t_{(HDSTA)}$  | 4.0           | -    | 0.6       | -    | $\mu\text{s}$ |
| Repeated start condition setup time                                                         | $t_{(SUSTA)}$  | 4.7           | -    | 0.6       | -    | $\mu\text{s}$ |
| Stop condition setup time                                                                   | $t_{(SUSTO)}$  | 4.0           | -    | 0.6       | -    | $\mu\text{s}$ |
| Data hold time                                                                              | $t_{(HDDAT)}$  | -             | 3450 | -         | 900  | ns            |
| Data setup time                                                                             | $t_{(SUDAT)}$  | 250           | -    | 100       | -    | ns            |
| I <sup>2</sup> C clock (SCK) low period                                                     | $t_{(LOW)}$    | 4.7           | -    | 1.3       | -    | $\mu\text{s}$ |
| I <sup>2</sup> C clock (SCK) high period                                                    | $t_{(HIGH)}$   | 4.0           | -    | 0.6       | -    | $\mu\text{s}$ |
| Clock / data fall time                                                                      | $t_f$          | -             | 300  | -         | 300  | ns            |
| Clock / data rise time                                                                      | $t_r$          | -             | 1000 | -         | 300  | ns            |


Fig. 1 - I<sup>2</sup>C Bus Timing Diagram

## PARAMETER TIMING INFORMATION

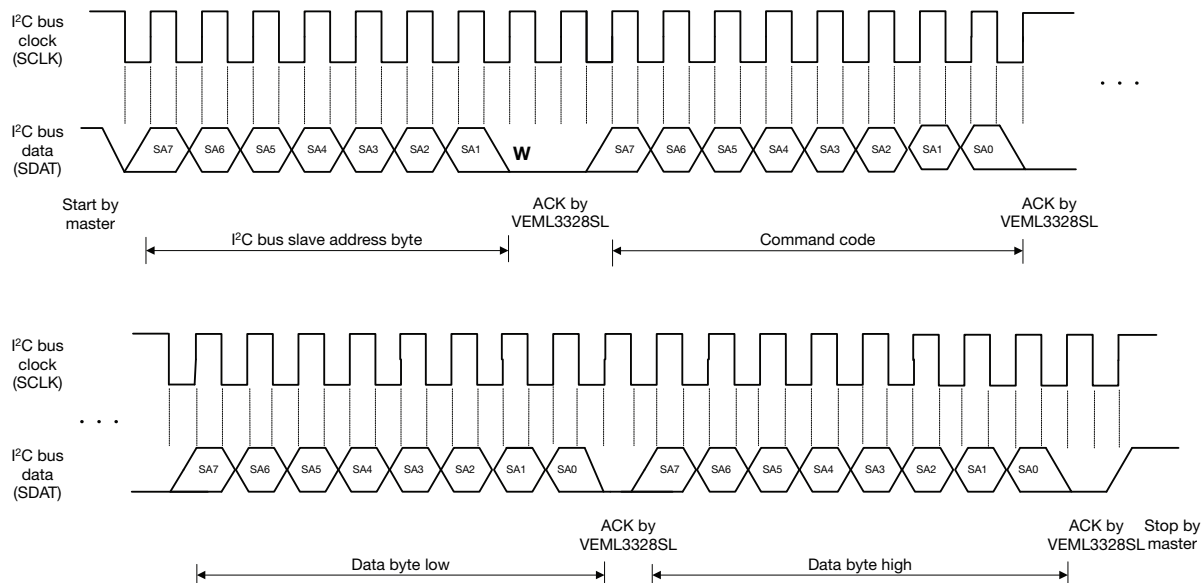


Fig. 2 - I²C Bus Timing for Sending Word Command Format

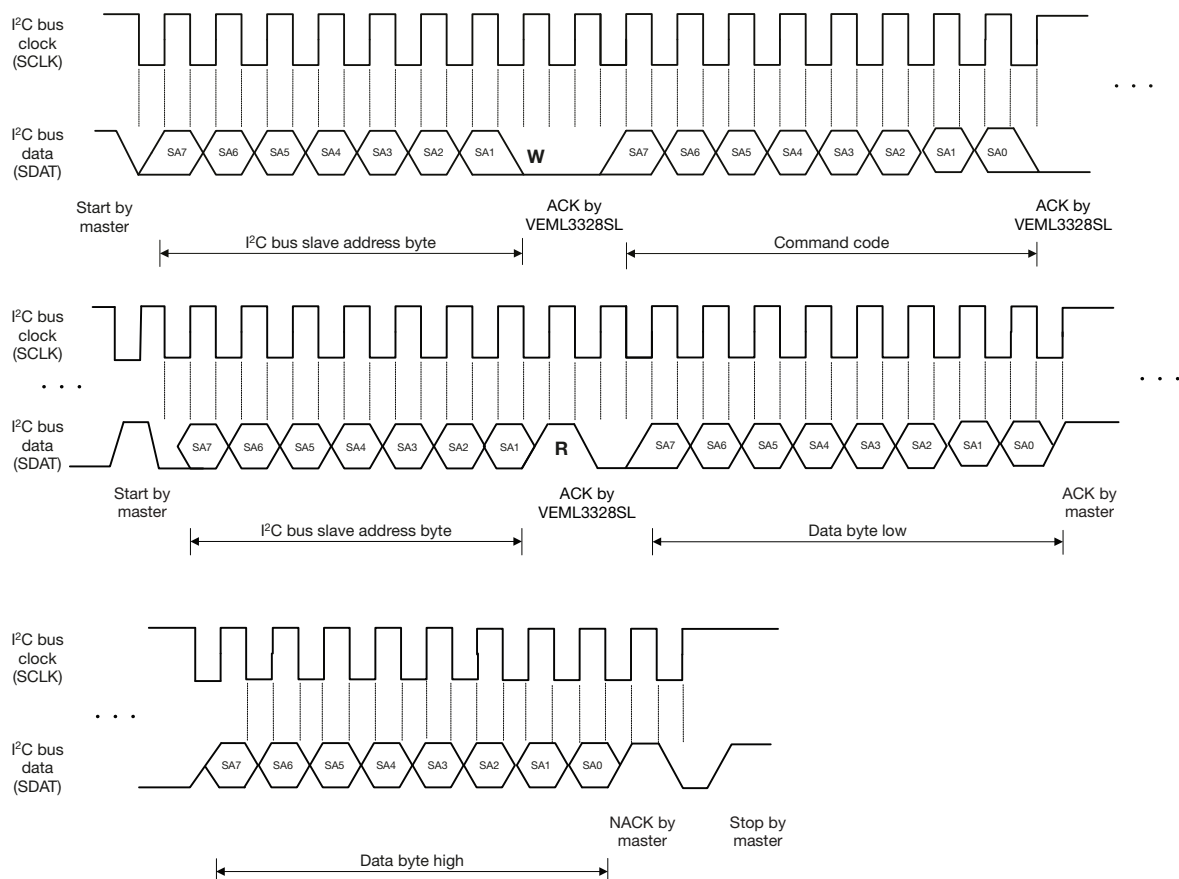


Fig. 3 - I²C Bus Timing for Receiving Word Command Format

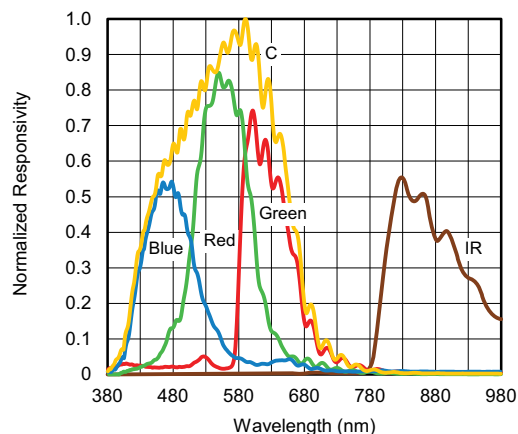
**TYPICAL PERFORMANCE CHARACTERISTICS** ( $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified)


Fig. 4 - Normalized Responsivity vs. Wavelength

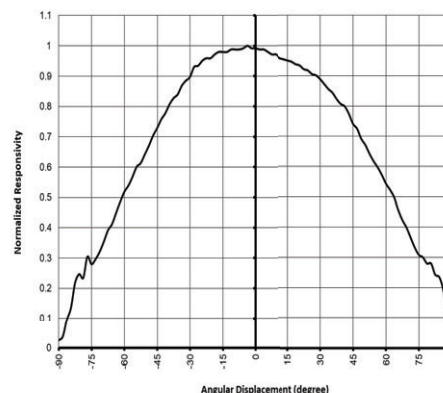


Fig. 5 - Normalized Responsivity vs. Angular Displacement

**APPLICATION INFORMATION**
**Pin Connection With the Host**

The VEML3328SL is a cost effective solution color and IR sensor with an I<sup>2</sup>C interface. All possible settings and result data can be accessed via the standard I<sup>2</sup>C interface.

A typical application circuit is shown in Fig. 6 below. The additional 0.1  $\mu\text{F}$  capacitor near the  $V_{DD}$  pin in the circuit is used for power supply noise rejection. Pull-up resistors for the I<sup>2</sup>C bus design are recommended to be 2.2  $\text{k}\Omega$ .

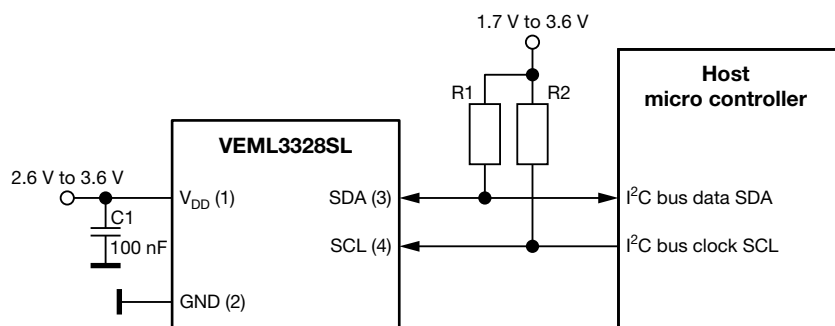
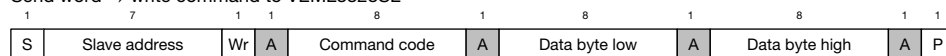


Fig. 6 - Hardware Pin Connection Diagram (Slave Address 0x10)

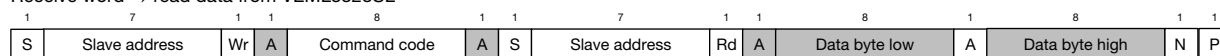
**Digital Interface**

The VEML3328SL contains a command register accessible via the I<sup>2</sup>C bus. All settings can be controlled via this register. The VEML3328SL's I<sup>2</sup>C command format description for read and write operations between VEML3328SL and the host is shown in Fig. 7. The white areas indicate the host activity and the gray areas indicate VEML3328SL's acknowledgement of the host access activity. Note that this protocol must be followed exactly to avoid false communication on the bus. Special care should be taken for the "Read Word" format, as here a repeated start condition is a must, as indicated.

Send word  $\rightarrow$  write command to VEML3328SL



Receive word  $\rightarrow$  read data from VEML3328SL



S = start condition

P = stop condition

A = acknowledge

N = not acknowledge

☐ Host action

☒ VEML3328SL acknowledge

Fig. 7 - Command Protocol Format

**Command Register Format**

VEML3328SL uses 0x10 slave address for 7-bit I<sup>2</sup>C addressing protocol. VEML3328SL has 16-bit resolution for each channel (R, G, B, C, and IR).

**TABLE 1 - COMMAND CODE DESCRIPTION**

| COMMAND CODE | REGISTER NAME | BIT     | FUNCTION DESCRIPTION                                                                                                                                                                                | R / W |
|--------------|---------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 0x00         | SD1           | 15      | Shutdown setting <sup>(1)</sup><br>SD1 = 0 power on; SD1 = 1 shutdown (default)                                                                                                                     | R / W |
|              | SD_ALS only   | 14      | 0 = power on all channels (default)<br>1 = power on G, C, and IR (R, B shutdown)                                                                                                                    |       |
|              | DG            | 13 : 12 | (0 : 0) = x 1 (default)<br>(0 : 1) = x 2<br>(1 : 0) = x 4<br>(1 : 1) = reserved                                                                                                                     |       |
|              | GAIN          | 11 : 10 | (1 : 1) = x 1/2<br>(0 : 0) = x 1 (default)<br>(0 : 1) = x 2<br>(1 : 0) = x 4                                                                                                                        |       |
|              | Reserved      | 9 : 8   | Set (0 : 0)                                                                                                                                                                                         |       |
|              | Reserved      | 7       | Set 0                                                                                                                                                                                               |       |
|              | SENS          | 6       | 0 = high sensitivity (default); 1 = low sensitivity (1/3)                                                                                                                                           |       |
|              | IT            | 5 : 4   | Integration time setting<br>(0 : 0) = 50 ms (default)<br>(0 : 1) = 100 ms<br>(1 : 0) = 200 ms<br>(1 : 1) = 400 ms                                                                                   |       |
|              | AF            | 3       | Auto / active force mode<br>0 = auto mode (default); 1 = active force mode                                                                                                                          |       |
|              | TRIG          | 2       | Trigger a single measurement when in active force mode. This bit resets to "0" automatically when the measurement cycle is complete.<br>0 = no trigger (default); 1 = trigger one measurement cycle |       |
|              | Reserved      | 1       | Set 0                                                                                                                                                                                               |       |
|              | SD0           | 0       | Shutdown setting <sup>(1)</sup><br>SD0 = 0 power on; SD0 = 1 shutdown (default)                                                                                                                     |       |

**Note**

<sup>(1)</sup> For power on, both SD0 and SD1 have to be set to 0. For shutdown, both SD0 and SD1 have to be set to 1

**TABLE 2 - DATA REGISTERS**

| COMMAND CODE | REGISTER NAME | DATE BYTE LOW / HIGH | BIT   | FUNCTION DESCRIPTION      | R / W |
|--------------|---------------|----------------------|-------|---------------------------|-------|
| 0x04         | C_LSB         | Low                  | 7 : 0 | Clear channel LSB data    | R     |
|              | C_MSB         | High                 | 7 : 0 | Clear channel MSB data    |       |
| 0x05         | R_LSB         | Low                  | 7 : 0 | Red channel LSB data      |       |
|              | R_MSB         | High                 | 7 : 0 | Red channel MSB data      |       |
| 0x06         | G_LSB         | Low                  | 7 : 0 | Green channel LSB data    |       |
|              | G_MSB         | High                 | 7 : 0 | Green channel MSB data    |       |
| 0x07         | B_LSB         | Low                  | 7 : 0 | Blue channel LSB data     |       |
|              | B_MSB         | High                 | 7 : 0 | Blue channel MSB data     |       |
| 0x08         | IR_LSB        | Low                  | 7 : 0 | Infrared channel LSB data |       |
|              | IR_MSB        | High                 | 7 : 0 | Infrared channel MSB data |       |
| 0x0C         | ID_L          | Low                  | 7 : 0 | Device ID 0x28            |       |
|              | Reserved      | High                 | 7 : 0 |                           |       |

**Note**

- Command codes 0x01 to 0x03 and 0x09 to 0x0B are reserved



### Data Access

Each of the C, R, G, B, and IR result registers has a 16-bit resolution (2 bytes). One byte is the LSB and the other byte is the MSB. The host needs to follow the read word protocol as shown in Fig. 7. The data format shows as below.

| TABLE 2 - 16-BIT DATA FORMAT  |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
|-------------------------------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| VEML3328SL 16-BIT DATA FORMAT |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
| Data bit                      | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Data byte low                 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
| Data byte high                |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |

### Note

|   |               |    |   |              |   |   |               |    |   |               |   |                |   |   |
|---|---------------|----|---|--------------|---|---|---------------|----|---|---------------|---|----------------|---|---|
| S | Slave address | Wr | A | Command code | A | S | Slave address | Rd | A | Data byte low | A | Data byte high | N | P |
|---|---------------|----|---|--------------|---|---|---------------|----|---|---------------|---|----------------|---|---|

- Data byte low represents LSB and data byte high represents MSB



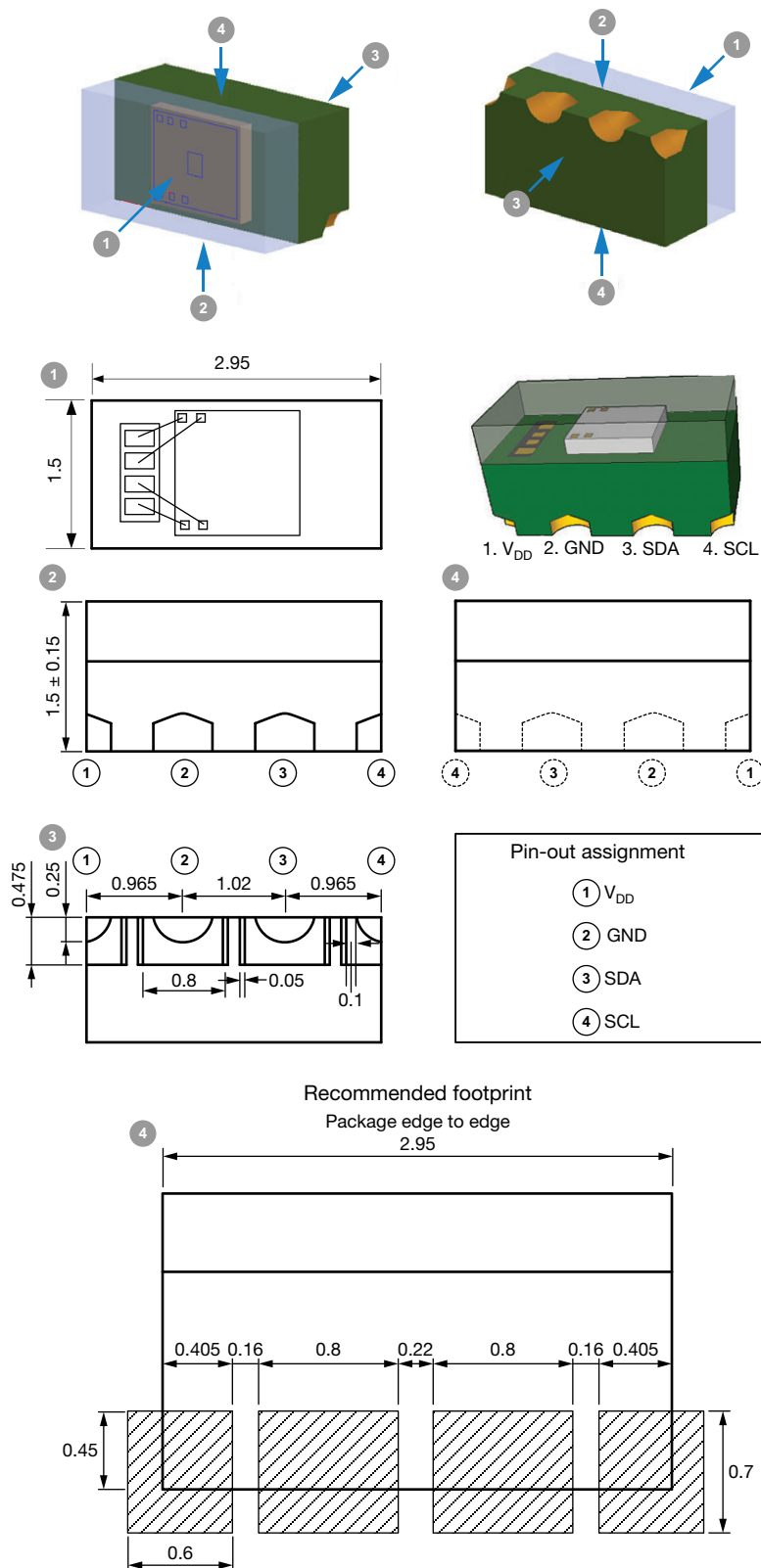
**PACKAGE INFORMATION** in millimeters


Fig. 8 - VEML3328SL Package Dimensions

**RECOMMENDED STORAGE AND REBAKING CONDITIONS**

| PARAMETER           | CONDITIONS                                               | MIN. | MAX. | UNIT   |
|---------------------|----------------------------------------------------------|------|------|--------|
| Storage temperature |                                                          | 5    | 50   | °C     |
| Relative humidity   |                                                          | -    | 60   | %      |
| Open time           |                                                          | -    | 168  | h      |
| Total time          | From the date code on the aluminized envelope (unopened) | -    | 12   | months |
| Rebaking            | Tape and reel: 60 °C                                     | -    | 22   | h      |
|                     | Tube: 60 °C                                              | -    | 22   |        |

**RECOMMENDED INFRARED REFLOW**

Soldering conditions which are based on J-STD-020 C

**IR REFLOW PROFILE CONDITION**

| PARAMETER                                  | CONDITIONS | TEMPERATURE                           | TIME          |
|--------------------------------------------|------------|---------------------------------------|---------------|
| Peak temperature                           |            | 255 °C + 0 °C / - 5 °C (max.: 260 °C) | 10 s          |
| Preheat temperature range and timing       |            | 150 °C to 200 °C                      | 60 s to 180 s |
| Timing within 5 °C to peak temperature     |            | -                                     | 10 s to 30 s  |
| Timing maintained above temperature / time |            | 217 °C                                | 60 s to 150 s |
| Timing from 25 °C to peak temperature      |            | -                                     | 8 min (max.)  |
| Ramp-up rate                               |            | 3 °C/s (max.)                         | -             |
| Ramp-down rate                             |            | 6 °C/s (max.)                         | -             |

Recommend Normal Solder Reflow is 235 °C to 255 °C

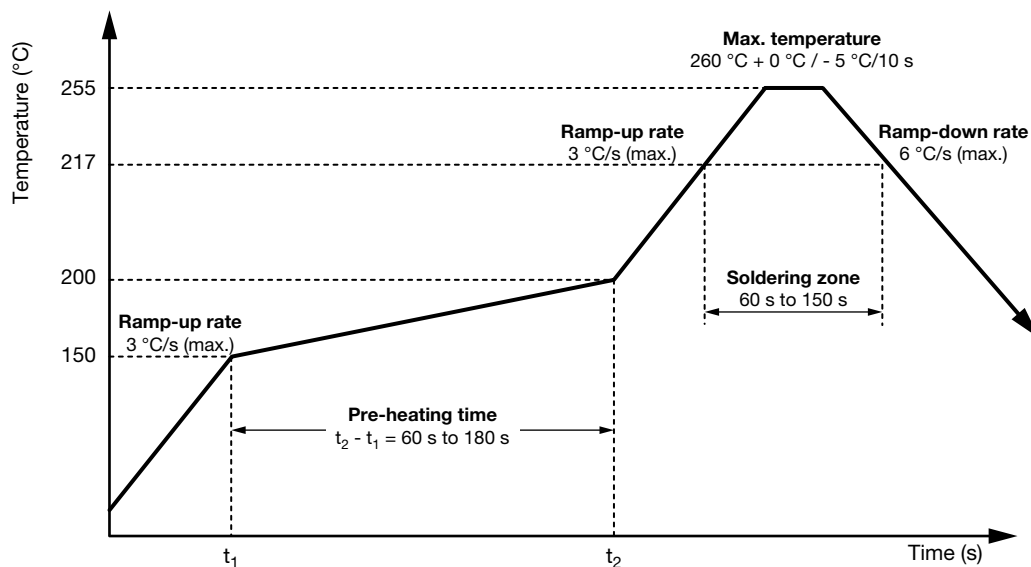


Fig. 9 - VEML3328SL OPLGA Solder Reflow Profile Chart

## RECOMMENDED IRON TIP SOLDERING CONDITION AND WARNING HANDLING

1. Solder the device with the following conditions:
  - 1.1. Soldering temperature: 400 °C (max.)
  - 1.2. Soldering time: 3 s (max.)
2. If the temperature of the method portion rises in addition to the residual stress between the leads, the possibility that an open or short circuit occurs due to the deformation or destruction of the resin increases
3. The following methods: VPS and wave soldering, have not been suggested for the component assembly
4. Cleaning method conditions:
  - 4.1. Solvent: methyl alcohol, ethyl alcohol, isopropyl alcohol
  - 4.2. Solvent temperature < 45 °C (max.)
  - 4.3. Time: 3 min (min.)

## TAPE PACKAGING INFORMATION in millimeters

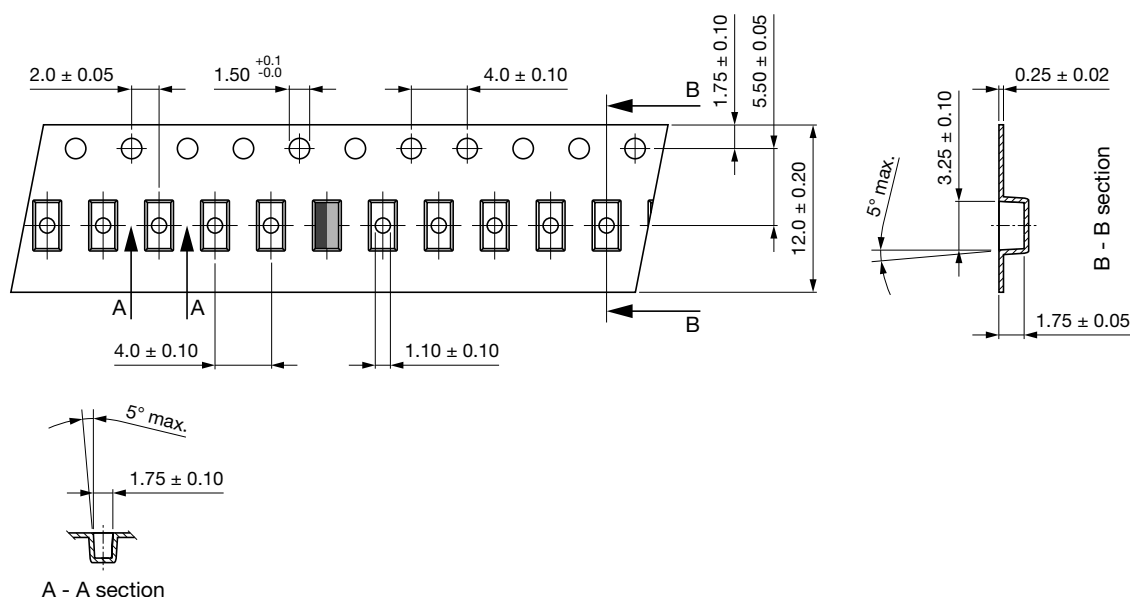


Fig. 10 - VEML3328SL Package Carrier Tape

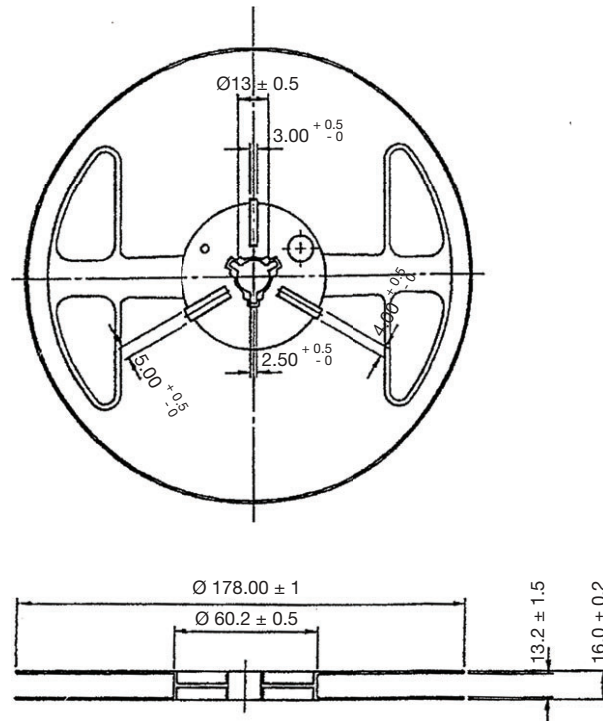


Fig. 11 - Reel Dimensions



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