# UV A Light Sensor with I$^2$C Interface

## FEATURES

- Package type: surface mount
- Dimensions (L x W x H in mm): 2.35 x 1.8 x 1.0
- Integrated modules: ultraviolet sensor (UV), and signal conditioning IC
- Converts solar UV light intensity to digital data
- Excellent UV sensitivity and linearity via Filtron$^{TM}$ technology
- Excellent performance of UV radiation measurement under long time solar UV exposure
- Excellent temperature compensation
- High dynamic detection resolution
- Standard I$^2$C protocol interface
- Support acknowledge feature (ACK)
- Immunity on fluorescent light flicker software shutdown mode control
- Package: OPLGA
- Temperature compensation: -40 °C to +85 °C
- Floor life: 168 h, MSL 3, according to J-STD-020
- Output type: I$^2$C bus
- Operation voltage: 2.7 V to 5.5 V
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

e4

RoHS COMPLIANT
HALOGEN FREE
GREEN (5-2008)

## APPLICATIONS

- Solar UV indicator
- Cosmetic / outdoor sport handheld product
- Consumer products
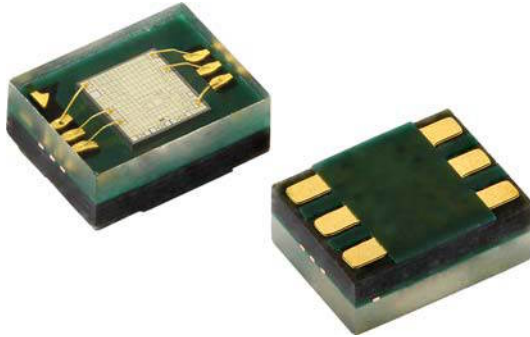
## DESCRIPTION

VEML6070 is an advanced ultraviolet (UV) light sensor with I$^2$C protocol interface and designed by the CMOS process. It is easily operated via a simple I$^2$C command. The active acknowledge (ACK) feature with threshold windows setting allows the UV sensor to send out a UVI alert message. Under a strong solar UVI condition, the smart ACK signal can be easily implemented by the software programming.

VEML6070 incorporates a photodiode, amplifiers, and analog / digital circuits into a single chip. VEML6070's adoption of Filtron$^{TM}$ UV technology provides the best spectral sensitivity to cover UV spectrum sensing. It has an excellent temperature compensation and a robust refresh rate setting that does not use an external RC low pass filter. VEML6070 has linear sensitivity to solar UV light and is easily adjusted by an external resistor. Software shutdown mode is provided, which reduces power consumption to be less than 1 µA. VEML6070's operating voltage ranges from 2.7 V to 5.5 V.

## PRODUCT SUMMARY

| PART NUMBER | OPERATING VOLTAGE RANGE (V) | I$^2$C BUS VOLTAGE RANGE (V) | PEAK SENSITIVITY (nm) | RANGE OF SPECTRAL BANDWIDTH $\lambda_{0.5}$ (nm) | OUTPUT CODE |
|---|---|---|---|---|---|
| VEML6070 | 2.7 to 5.5 | 1.7 to 5.5 | 355 | ± 20 | 16 bit, I$^2$C |

**Note**

[1] Adjustable through I$^2$C interface

## ORDERING INFORMATION

| ORDERING CODE | PACKAGING | VOLUME [1] | REMARKS |
|---|---|---|---|
| VEML6070 | Tape and reel | MOQ: 2500 pcs | 2.35 mm x 1.8 mm x 1.0 mm |

**Note**

[1] MOQ: minimum order quantity

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

| PARAMETER | TEST CONDITION | SYMBOL | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| Supply voltage | | $V_{DD}$ | 0 | 6.0 | V |
| Operation temperature range | | $T_{amb}$ | -40 | +85 | °C |

## RECOMMENDED OPERATING CONDITIONS ($T_{amb}$ = 25 °C, unless otherwise specified)

| PARAMETER | TEST CONDITION | SYMBOL | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| Supply voltage | | $V_{DD}$ | 2.7 | 5.5 | V |
| Operation temperature range | | $T_{amb}$ | -40 | +85 | °C |
| $I^2C$ bus operating frequency | | $f_{(I2CCLK)}$ | 10 | 400 | kHz |

## PIN DESCRIPTIONS

| PIN ASSIGNMENT | SYMBOL | TYPE | FUNCTION |
|---|---|---|---|
| 1 | GND | I | Power supply ground, all voltage are reference to GND |
| 2 | ACK | O (open drain) | Acknowledge pin |
| 3 | SDA | I / O (open drain) | $I^2C$ digital serial data output to the host |
| 4 | SET | | Light reading adjustment, connect a resistor to GND |
| 5 | SCL | I | $I^2C$ digital serial clock input from the host |
| 6 | $V_{DD}$ | I | Supply voltage |

## BLOCK DIAGRAM
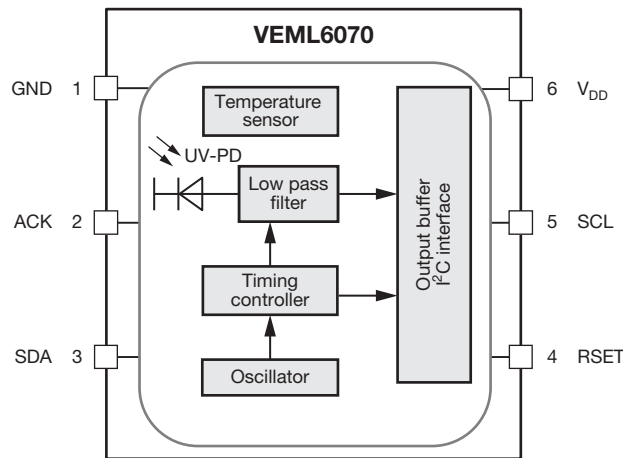


## BASIC CHARACTERISTICS ($T_{amb}$ = 25 °C, unless otherwise specified)

| PARAMETER | TEST CONDITION | | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|---|
| Supply operation voltage | | | $V_{DD}$ | 2.7 | - | 5.5 | V |
| Supply current | $R_{SET}$ = 240 kΩ [1][2] | | $I_{DD}$ | - | 100 | 250 | µA |
| $I^2C$ signal input | Logic high | [1][2] | $V_{IH}$ | 1.5 | - | $V_{DD}$ | V |
| | Logic low | | $V_{IL}$ | - | - | 0.8 | |
| Peak sensitivity wavelength | | | $\lambda_p$ | - | 355 | - | nm |
| Range of spectral sensitivity | | | $\lambda_{0.1}$ | 320 | - | 410 | nm |
| UVA sensitivity | $R_{SET}$ = 240 kΩ, $I_T$ = 1T [3] | | | - | 5 | - | µW/cm²/step |
| Maximum UVA detection power | $R_{SET}$ = 240 kΩ, $I_T$ = 1T [3] | | | - | - | 328 | mW/cm² |
| Dark offset | $R_{SET}$ = 240 kΩ, $I_T$ = 1T [1] | | | 0 | 1 | 5 | steps |
| Output offset | $R_{SET}$ = 240 kΩ, $I_T$ = 1T [1][4] | | | - | 2 | - | steps |
| Shutdown current | Light condition = dark [1] | | $I_{DD}$ | - | 1 | 15 | µA |

**Notes**
[1] Test condition: $V_{DD}$ = 3.3 V, temperature: 25°C
[2] Light source: solar light source
[3] Test using 365 nm UVA LED
[4] Ambient light intensity = 500 lx

For technical questions, contact: sensorstechsupport@vishay.com

## I²C TIMING CHARACTERISTICS ($T_{amb}$ = 25 °C, unless otherwise specified)

| PARAMETER | SYMBOL | STANDARD MODE | | FAST MODE | | UNIT |
|---|---|---|---|---|---|---|
| | | MIN. | MAX. | MIN. | MAX. | |
| Clock frequency | $f_{(SMBCLK)}$ | 10 | 100 | 10 | 400 | kHz |
| Bus free time between start and stop condition | $t_{(BUF)}$ | 4.7 | - | 1.3 | - | µs |
| Hold time after (repeated) start condition; after this period, the first clock is generated | $t_{(HDSTA)}$ | 4.0 | - | 0.6 | - | µs |
| Repeated start condition setup time | $t_{(SUSTA)}$ | 4.7 | - | 0.6 | - | µs |
| Stop condition setup time | $t_{(SUSTO)}$ | 4.0 | - | 0.6 | - | µs |
| Data hold time | $t_{(HDDAT)}$ | | 3450 | - | 900 | ns |
| Data setup time | $t_{(SUDAT)}$ | 250 | - | 100 | - | ns |
| I²C clock (SCK) low period | $t_{(LOW)}$ | 4.7 | - | 1.3 | - | µs |
| I²C clock (SCK) high period | $t_{(HIGH)}$ | 4.0 | - | 0.6 | - | µs |
| Detect clock / data low timeout | $t_{(TIMEOUT)}$ | 25 | 35 | - | - | ms |
| Clock / data fall time | $t_{(F)}$ | - | 300 | - | 300 | ns |
| Clock / data rise time | $t_{(R)}$ | - | 1000 | - | 300 | ns |
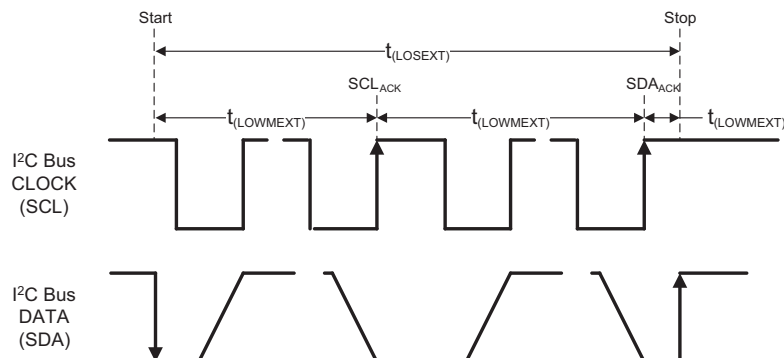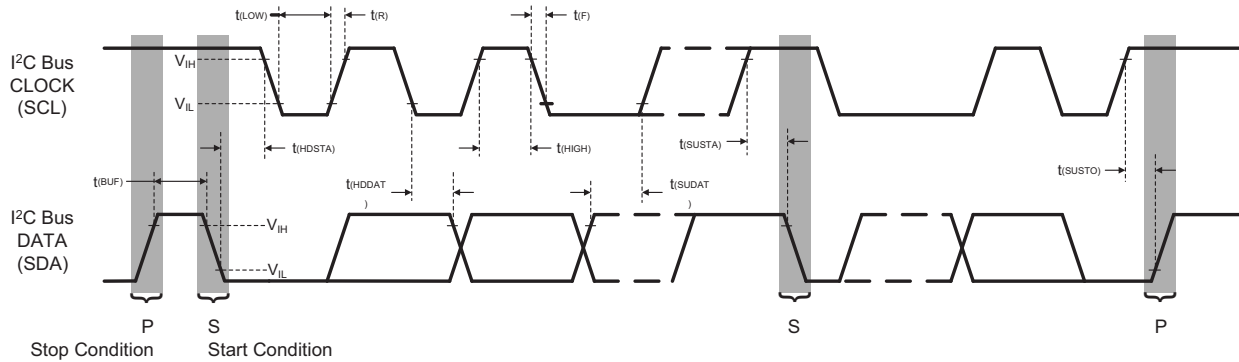


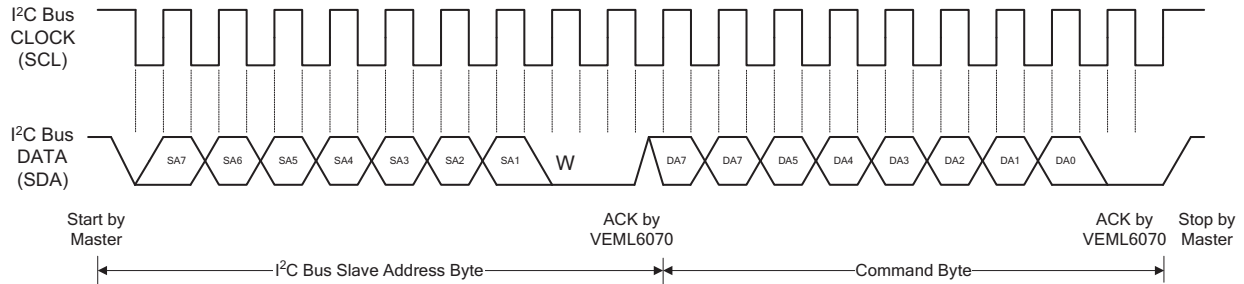Fig. 1 - I²C Timing Diagram

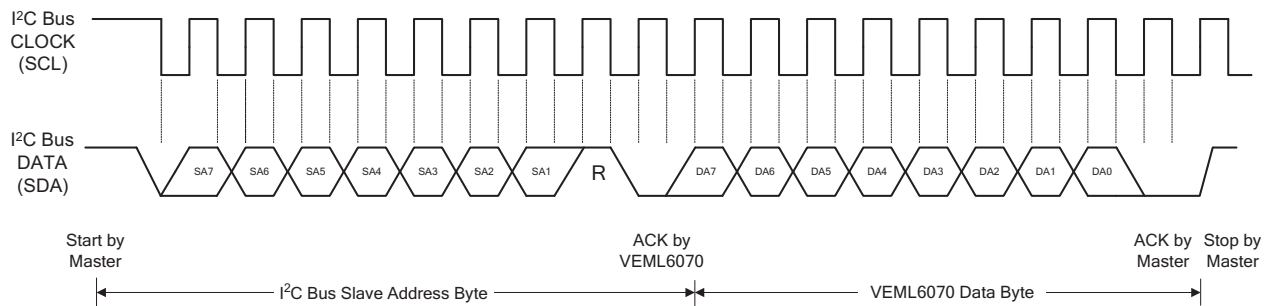## PARAMETER TIMING INFORMATION



Fig. 2 - Timing for Send Byte Command Format



Fig. 3 - I²C Timing for Receive Byte Command Format

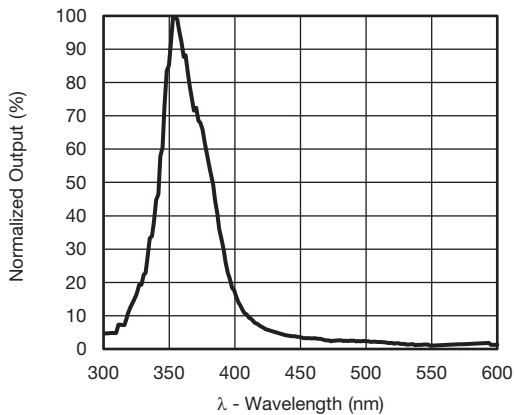## TYPICAL PERFORMANCE CHARACTERISTICS ($T_{amb}$ = 25 °C, unless otherwise specified)



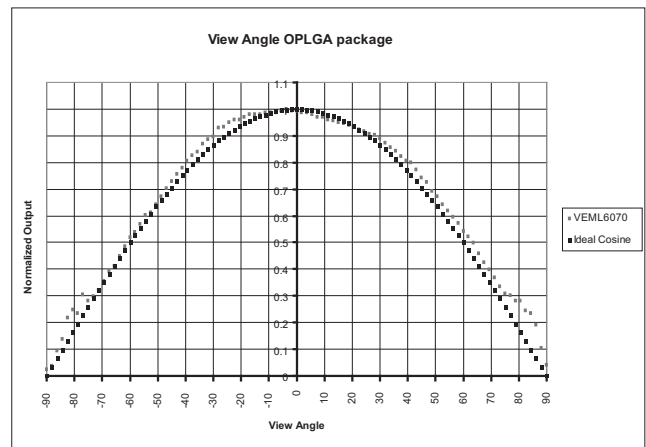Fig. 4 - Normalized Spectral Response



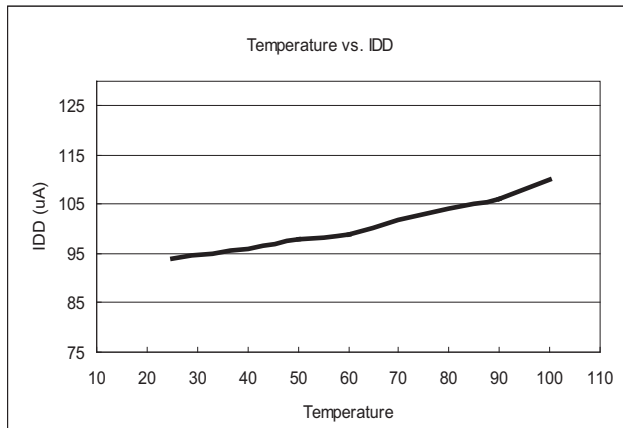Fig. 5 - Normalized Output vs. View Angle
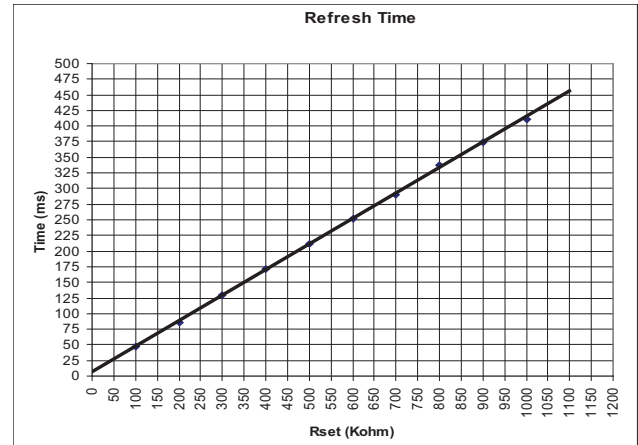
Fig. 6 - I$_{DD}$ vs.Temperature



Fig. 7 - Refresh Time

## APPLICATION INFORMATION

**Pin Connection with the Host**

VEML6070 is a cost effective solution for ultraviolet light sensing with I$^2$C interface. The standard serial digital interface easily accesses "UV light intensity" digital data.

The additional capacitor near the V$_{DD}$ pin is used for power supply noise rejection. For the I$^2$C bus design, the pull-up voltage refers to the I/O of the baseband due to the "open drain" design. The pull-up resistors for the I$^2$C bus design are recommended to be 2.2 kΩ. The circuit diagram as an example is shown in figure 8.
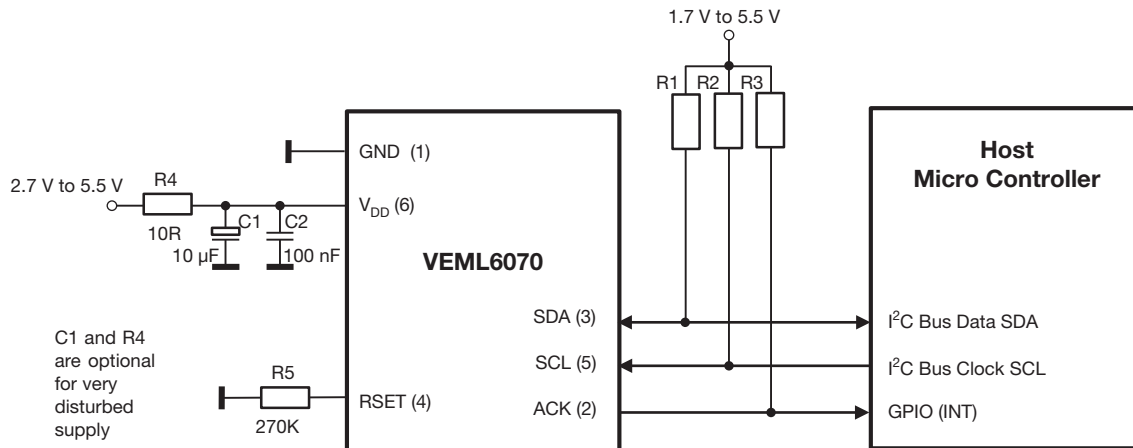


Fig. 8 - Hardware Pin Connection Diagram

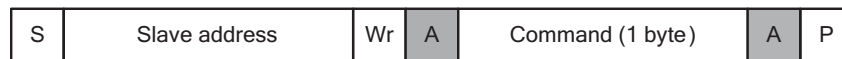For technical questions, contact: sensorstechsupport@vishay.com

## Digital Interface

VEML6070 contains a 8-bit command register written via the I²C bus. All operations can be controlled by the command register. The simple command structure enables users to easily program the operation setting and latch the light data from VEML6070. In figure 9, VEML6070 I²C command format description for reading and writing operation between the host and VEML6070 are shown. The white sections indicate host activity and the gray sections indicate VEML6070's acknowledgement of the host access activity.

Receive byte → read data from UVS

| S | Slave address | Rd | A | Light data (1 byte) | A | P |
|---|---|---|---|---|---|---|

Send byte → write command to UVS

| S | Slave address | Wr | A | Command (1 byte) | A | P |
|---|---|---|---|---|---|---|

S = start condition
P = stop condition
A = acknowledge
Shaded area = VEML6070 acknowledge

Fig. 9 - VEML6070 Command Protocol

## Slave Address and Function Description

The VEML6070 has one slave address used for write functions (command) and two slave addresses used for read functions (UV data LSB and MSB).

The 7-bit address for write functions is 38h = 0111000**x** resulting in a 70h = 0111000**0** 8-bit address. The 7-bit addresses for read functions are 38h = 0111000**x** for the UV Data LSB and 39h = 0111001**x** for the UV data MSB. This results in a 71h = 0111000**1** and 73h = 0111001**1** 8-bit address, respectively. The 7-bit address 39h should not be used for a write function.

## Command Register Format

VEML6070 provides a command to set device operations and sensitivity adjustment. This command is 8-bit long and includes 4 parameter groups for programming. The command format descriptions and register setting explanations are shown in tables 1 and 2.

| TABLE 1 - COMMAND REGISTER BITS DESCRIPTION | | | | | | | |
|---|---|---|---|---|---|---|---|
| COMMAND FORMAT | | | | | | | |
| Reserved | | ACK | ACK_THD | IT | | Reserved | SD |
| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 0 | 0 | ACK | THD | IT1 | IT0 | 1 | SD |
| DESCRIPTION | | | | | | | |
| Reserved | | Reserved | | | | | |
| ACK | | Acknowledge activity setting | | | | | |
| ACK_THD | | Acknowledge threshold window setting for byte mode usage | | | | | |
| IT | | Integration time setting | | | | | |
| SD | | Shutdown mode setting | | | | | |

## TABLE 2 - REGISTER TABLE SETTING

| BITS SETTING | DESCRIPTION | | BITS SETTING | DESCRIPTION |
|---|---|---|---|---|
| Reserved | Set initial value to (0 : 0) | | (IT1 : IT0) [1] | (0 : 0) = ½T (0 : 1) = 1T (1 : 0) = 2T (1 : 1) = 4T |
| ACK | 0 = disable | | Reserved | Set initial value to 1 |
| ACK | 1 = enable | | | |
| ACK_THD | 0 = 102 steps | | SD | 0 = disable |
| ACK_THD | 1 = 145 steps | | SD | 1 = enable |

**Note**

[1] Please refer to table 4, "Example of Refresh Time and $R_{SET}$ Value Relation"

## Data Access

VEML6070 has 16-bit resolution to give high resolution for light intensity sensing. Examples of the application setting are shown in table 3.

## TABLE 3 - DATA ACCESS DESCRIPTION

| | VEML6070 16-BIT DATA BUFFER | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Sequence 1 | ← | | | | | | | → | | | | | | | | |
| Sequence 2 | | | | | | | | | ← | | | | | | | → |

**Notes**

- Slave addresses (8 bits) for data read: 0x71 and 0x73
- Data reading sequence for the host:
  - Set read command to 0x73, read MSB 8 bits of 16 bits light data (sequence 1)
  - Set read command to 0x71, read LSB 8 bits of 16 bits light data for completing data structure (sequence 2)

## Initialization

VEML6070 needs to be initialized while the system's power is on. The initialization includes two major steps: (1) clear ACK state of UVS and (2) fill the initial value, 06 (HEX), into the 0x70 addresses. After the initialization is completed, VEML6070 can be programmable for operation by write command setting from the host. VEML6070 initialization is recommended to be completed within 150 ms.

## Acknowledge Activity

VEML6070 provides a function for sending an acknowledge signal (ACK) to the host when the value of sensed UV light is over the programmed threshold (ACK_THD) value. The purpose of the ACK signal is similar to the interrupt feature which informs the host once the sensed data level goes beyond the interrupt threshold setting. VEML6070 has two ACK threshold values, 102 steps and 145 steps.

There are two methods of driving acknowledge condition and read / write command to VEML6070:

(1) If the host implements the INT function, it performs a modified received byte operation to disengage VEML6070's acknowledge signal and acknowledge alert response address (ARA), 0x18 (Hex). A command format for responses to an ARA is shown in figure 10.

| S | ARA (0x18) | Rd | A | UVS Slave Address | A | P |
|---|---|---|---|---|---|---|

Fig. 10 - Command Format for Responds to an ARA

(2) If the host does not implement this feature, it should periodically access the ARA or read ARA before setting each read / write command.

The behavior of an ACK signal is similar to the INT definition in I²C specification. For the hardware circuit design, this pin connects to an INT pin or GPIO pin of the MCU. The threshold ACK_THD definition is based on the sensitivity setting of VEML6070.

The ACK or UVI interrupt function allows the UVI sensing system to perform data pooling based on the interrupt event. The system sensor manager does not need to do continual data pooling and this significantly reduced the MCU loading. The ACK signal can also be used as a trigger event for popping up a warning UVI message.

**Refresh Time Determination**

VEML6070's refresh time can be determined by the $R_{SET}$ value. Cooperating with the command register setting, the designer has a flexible way of defining the timing for light data collection. The default refresh time is 1T, (IT1 : IT0) = (0 : 1). If the $R_{SET}$ value is changed, the default timing changes and the other parts in the register table also change by comparing itself with the default timing (refer to figure 7).

Table 4 is an example of two $R_{SET}$ resistors that show the timing table that the system designer can use a flexible way to determine the desired refresh time.

| TABLE 4 - EXAMPLE OF REFRESH TIME AND $R_{SET}$ VALUE RELATION | | | |
|---|---|---|---|
| REGISTER | SETTING | REFRESH TIME | |
| | | $R_{SET}$ = 300 kΩ | $R_{SET}$ = 600 kΩ |
| (IT1 : IT0) | (0 : 0) = ½T | 62.5 ms | 125 ms |
| | (0 : 1) = 1T | 125 ms | 250 ms |
| | (1 : 0) = 2T | 250 ms | 500 ms |
| | (1 : 1) = 4T | 500 ms | 1000 ms |

The designer can decide the refresh timing range requirement first, then choose an appropriate $R_{SET}$ value for the timing range, and then write the correct value for the system application via I$^2$C protocol.

**PACKAGE INFORMATION** in millimeters

TOP VIEW

SIDE VIEW

BOTTOM VIEW



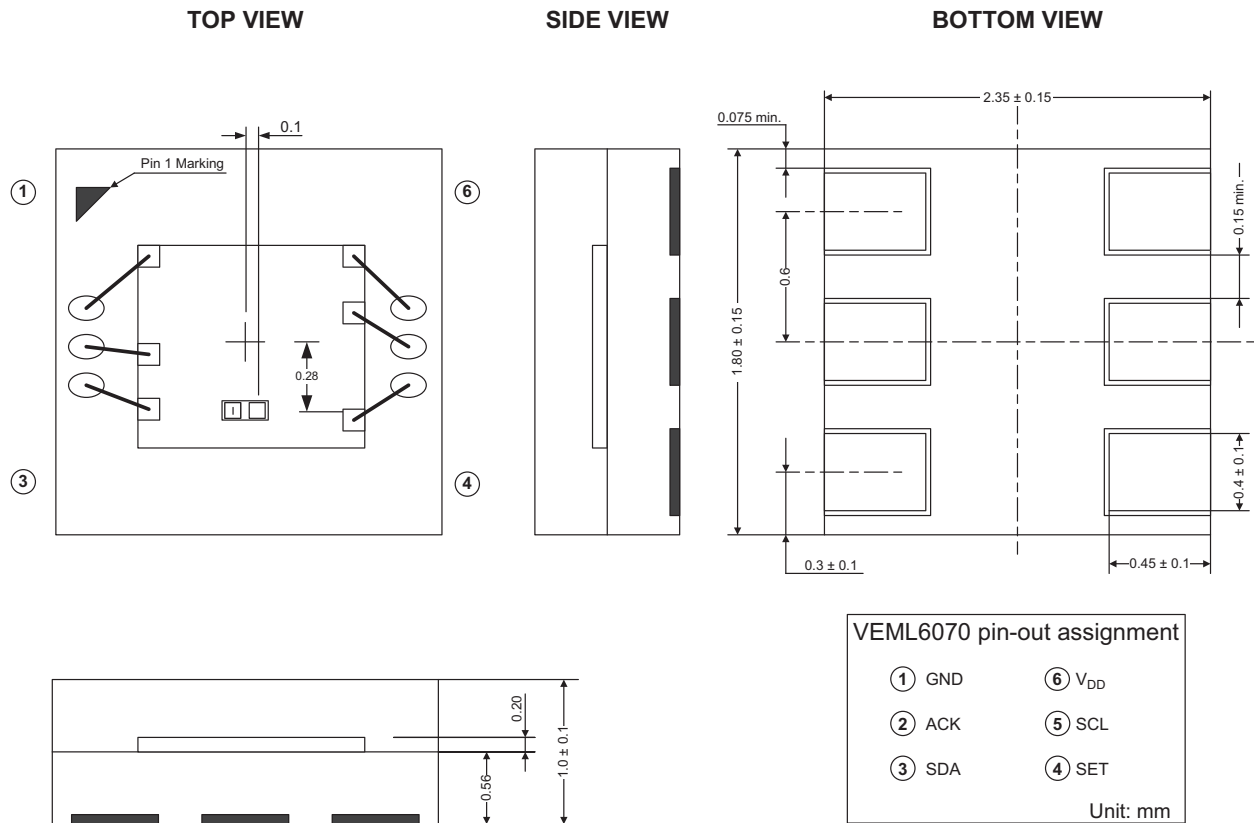| VEML6070 pin-out assignment | |
|---|---|
| ① GND | ⑥ V_DD |
| ② ACK | ⑤ SCL |
| ③ SDA | ④ SET |
| | Unit: mm |

Fig. 11 - VEML6070 A3OP Package Dimensions
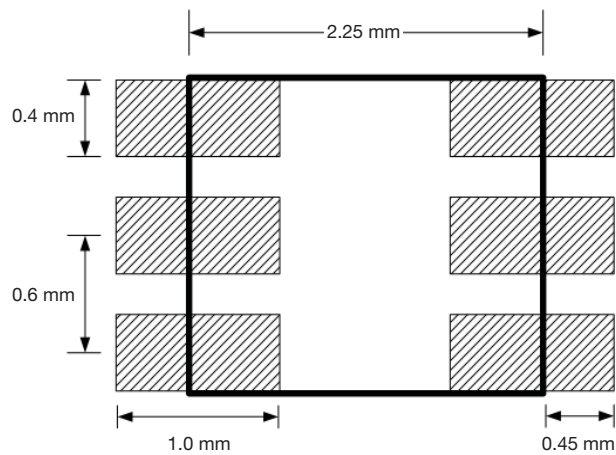
**LAYOUT NOTICE**
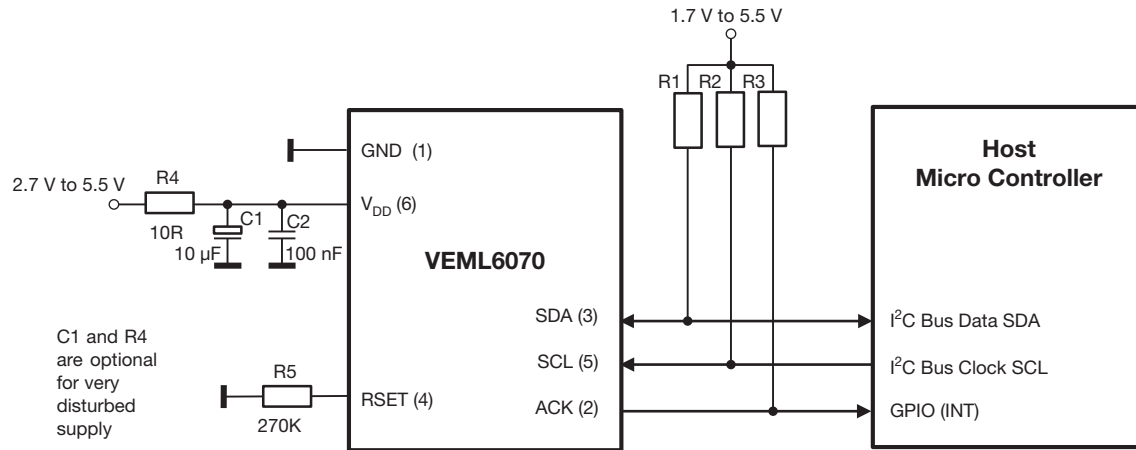


Fig. 12 - VEML6070 OPLGA PCB Layout Footprint

## APPLICATION CIRCUIT BLOCK REFERENCE



Fig. 13 - VEML6070 Application Circuit

**Notes**

- $V_{DD}$ range: 2.7 V to 5.5 V
- The pull-up voltage for I2C bus is referring to the I/O specification of baseband

### RECOMMENDED STORAGE AND REBAKING CONDITIONS

| PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|
| Storage temperature | | 5 | 50 | °C |
| Relative humidity | | - | 60 | % |
| Open time | Rebaking process should be done when aluminized envelope reopened | - | - | |
| Total time | From the date code on the aluminized envelope (unopened) | - | 6 | months |
| Rebaking | Tape and reel: 60 °C | - | 22 | h |
| | Tube: 60 °C | - | 22 | h |

### RECOMMENDED INFRARED REFLOW

Soldering conditions are based on J-STD-020 C definition.

1. After opening the tape and reel, IR reflow process should be done

2. IR reflow profile conditions

### 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.) | - |

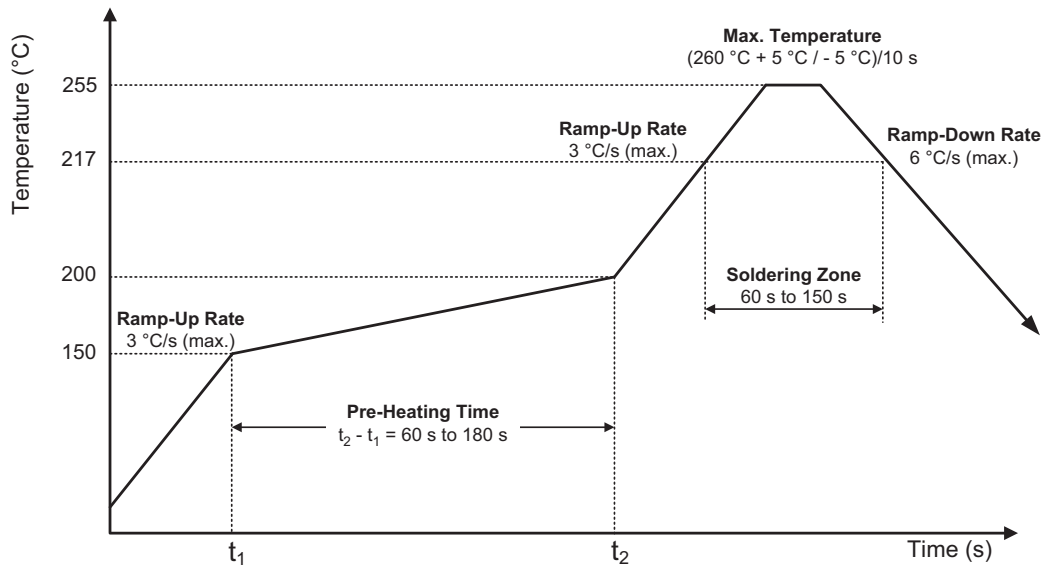3. Recommend Normal Solder Reflow is 235 °C to 255 °C

Fig. 14 - VEML6070 A3OP 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.)

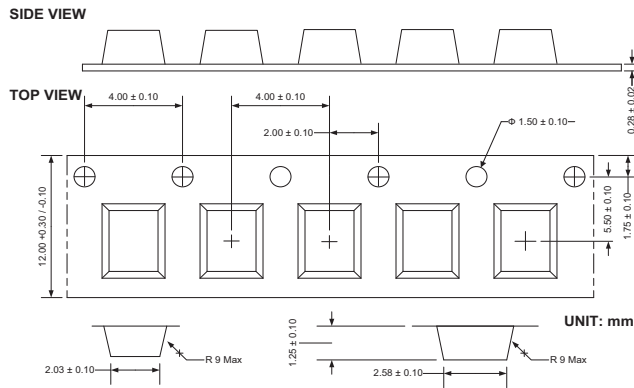## TAPE PACKAGING INFORMATION in millimeters

### DIMENSION OF CARRIER TAPE

**SIDE VIEW**

**TOP VIEW**

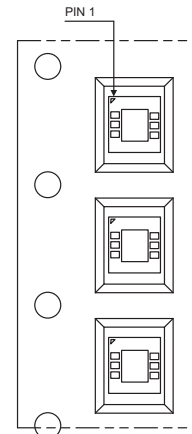UNIT: mm

Fig. 15 - VEML6070 A3OP Package Carrier Tape

PIN 1

Fig. 16 - Taping Direction

Fig. 17 - Reel Dimension

For technical questions, contact: sensorstechsupport@vishay.com