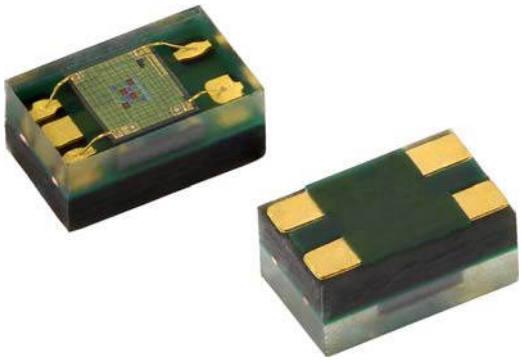
RGBW Color Sensor with I²C Interface



FEATURES

- Package type: surface mount
- Dimensions (L x W x H in mm): 2.0 x 1.25 x 1.0
- Integrated modules: color sensor (RGBW) and signal conditioning IC
- Filtron™ technology provides a spectrum matching real human eye responses
- Supports low transmittance (dark) lens design
- Fluorescent light flicker immunity
- Provides 16-bit resolution for each channel (R, G, B, W)
- Selectable maximum detection range (360, 721, 1442, 2883, 5767, or 11 796) lux with highest sensitivity 0.0056 lux/step
- Package: OPLGA
- Temperature compensation: -40 °C to +85 °C
- Low power consumption I²C (SMBus compatible) interface
- Output type: I²C bus
- Operation voltage: 2.5 V to 3.6 V
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free
e4
RoHS COMPLIANT
HALOGEN FREE
GREEN (5-2008)

DESCRIPTION

VEML6040 color sensor senses red, green, blue, and white light and incorporates photodiodes, amplifiers, and analog / digital circuits into a single chip using CMOS process. With the color sensor applied, the brightness, and color temperature of backlight can be adjusted base on ambient light source that makes panel looks more comfortable for end user's eyes. VEML6040's adoption of Filtron™ technology achieves the closest ambient light spectral sensitivity to real human eye responses.

VEML6040 provides excellent temperature compensation capability for keeping the output stable under changing temperature. VEML6040's function are easily operated via the simple command format of I²C (SMBus compatible) interface protocol. VEML6040's operating voltage ranges from 2.5 V to 3.6 V. VEML6040 is packaged in a lead (Pb)-free 4 pin OPLGA package which offers the best market-proven reliability.

APPLICATIONS

- Handheld device
- Notebook
- Consumer device
- Industrial and mechanical application

PRODUCT SUMMARY

PART NUMBER	OPERATING VOLTAGE RANGE (V)	I²C BUS VOLTAGE RANGE (V)	PEAK SENSITIVITY (nm)	RANGE OF SPECTRAL BANDWIDTH $\lambda_{0.5}$ (nm)	OUTPUT CODE
VEML6040	2.5 to 3.6	1.7 to 3.6	650, 550, 450 (R, G, B)	± 35, ± 35, ± 40 (R, G, B)	16 bit, I²C

Note

(1) Adjustable through I²C interface

ORDERING INFORMATION

ORDERING CODE	PACKAGING	VOLUME (1)	REMARKS
VEML6040A3OG	Tape and reel	MOQ: 2500 pcs	2.0 mm x 1.25 mm x 1.0 mm

Note

(1) MOQ: minimum order quantity

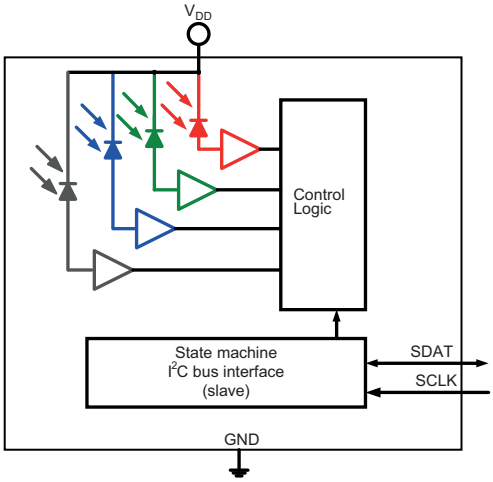
ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	TEST CONDITION	SYMBOL	MIN.	MAX.	UNIT
Supply voltage		V_{DD}	0	3.6	V
Operation temperature range		T_{amb}	-40	+85	°C
Storage temperature range		T_{stg}	-40	+85	°C

RECOMMENDED OPERATING CONDITIONS (T_{amb} = 25 °C, unless otherwise specified)					
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**MAX.**	**UNIT**
Supply voltage		V_{DD}	2.5	3.6	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	Ground
2	SDAT	I / O (open drain)	I^2C data bus data input / output
3	SCLK	I	I^2C digital bus clock input
4	V_{DD}	I	Power supply input

BLOCK DIAGRAM



BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)							
PARAMETER		**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Supply voltage			V_{DD}	2.5		3.6	V
Supply current			I_{DD}		200		µA
I^2C signal input	Logic high	V_{DD} = 3.3 V	V_{IH}	1.5			V
	Logic low		V_{IL}			0.8	
	Logic high	V_{DD} = 2.6 V	V_{IH}	1.4			V
	Logic low		V_{IL}			0.6	
Peak sensitivity wavelength			λ_{PR}		650		nm
			λ_{PG}		550		nm
			λ_{PB}		450		nm
Irradiance responsivity		λ_{PR} = 630 nm			180		LSB/(µW/cm²)
		λ_{PG} = 530 nm			144		
		λ_{PB} = 467 nm			52		
Detectable intensity	Minimum	G channel, I_T = 1280 ms (1)(2)			0.0056		lx
	Maximum	G channel, I_T = 40 ms (1)(2)			11 796		
Dark offset		G channel, I_T = 80 ms (1)		0		3	
Operating temperature range			T_{amb}	-40		+85	°C
Shutdown current		Light condition = dark, V_{DD} = 3.6 V	I_{DD}		800		nA

Notes

(1) Test condition: V_{DD} = 3.3 V, temperature: 25°C

(2) Light source: white LED

I²C BUS 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	$t_{(HDDAT)}$	200		90		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

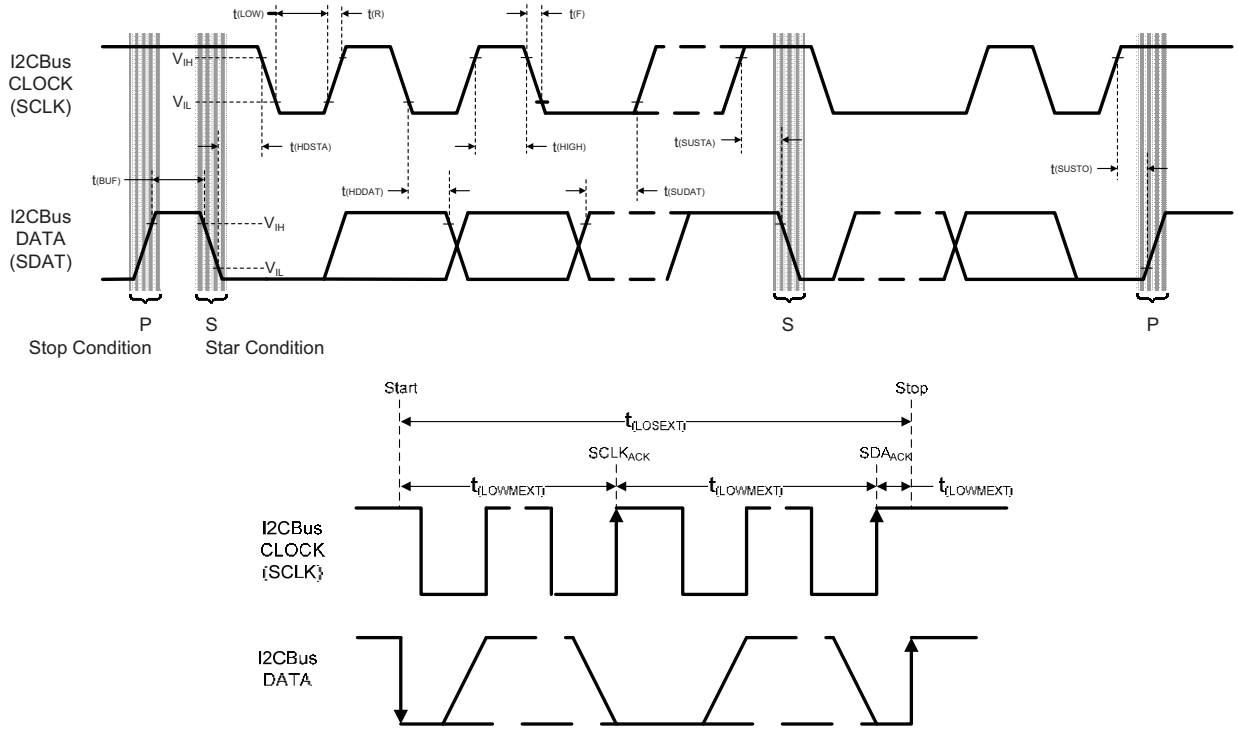


Fig. 1 - I²C Bus Timing Diagram

PARAMETER TIMING INFORMATION

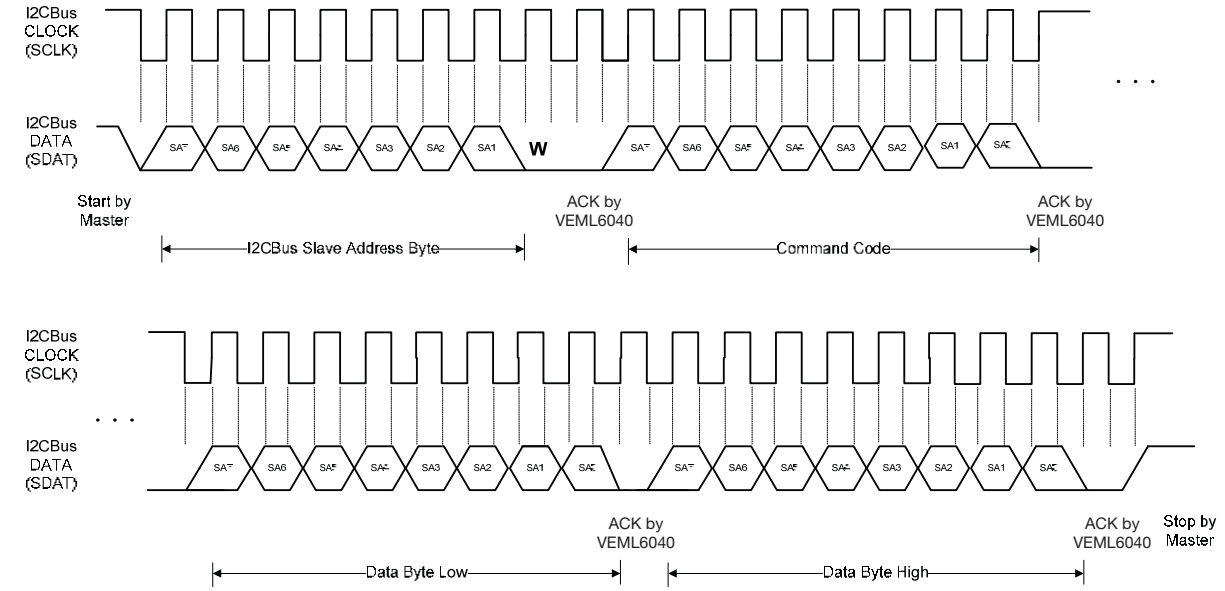


Fig. 2 - I²C Bus Timing for Sending Word Command Format

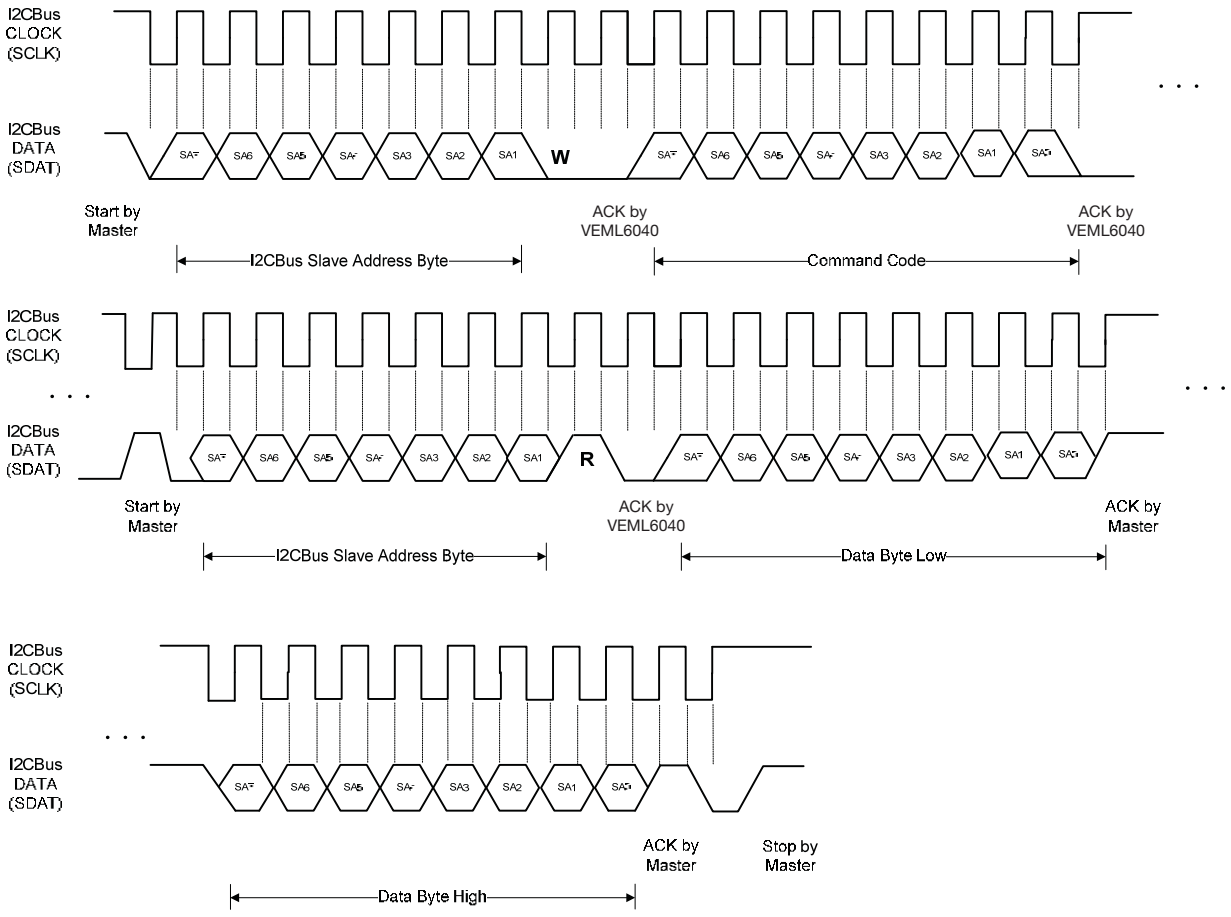


Fig. 3 - I²C Bus Timing for Receiving Word Command Format

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

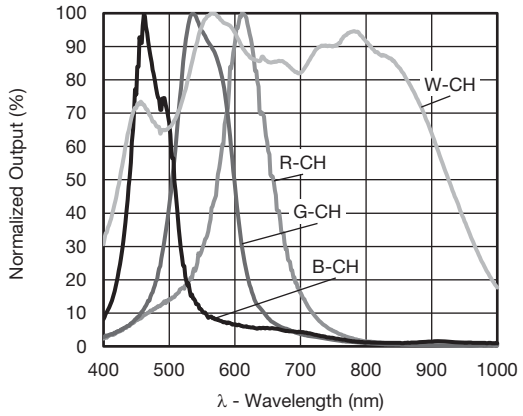


Fig. 4 - Normalized Spectral Response

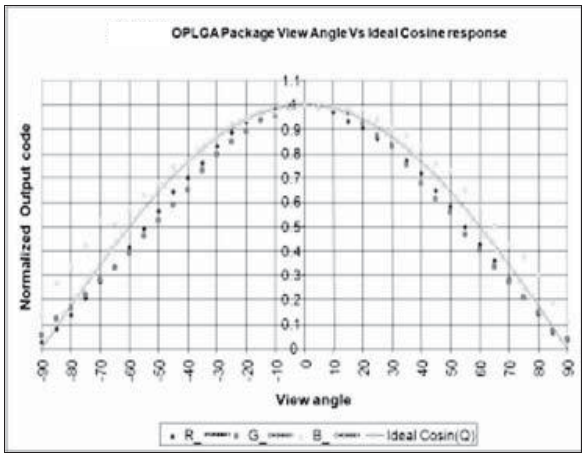


Fig. 5 - Normalized Output vs. View Angle

APPLICATION INFORMATION

Pin Connection with the Host

VEML6040 integrates R, G, B, and W sensor together with I²C interface. It is very easy for the baseband (CPU) to access VEML6040 output data via I²C interface without extra software algorithms. The hardware schematic is shown in the following diagram.

The 0.1 µF capacitor near the V_{DD} pin is used for power supply noise rejection. The 2.2 kΩs are suitable for the pull-up resistors of I²C.

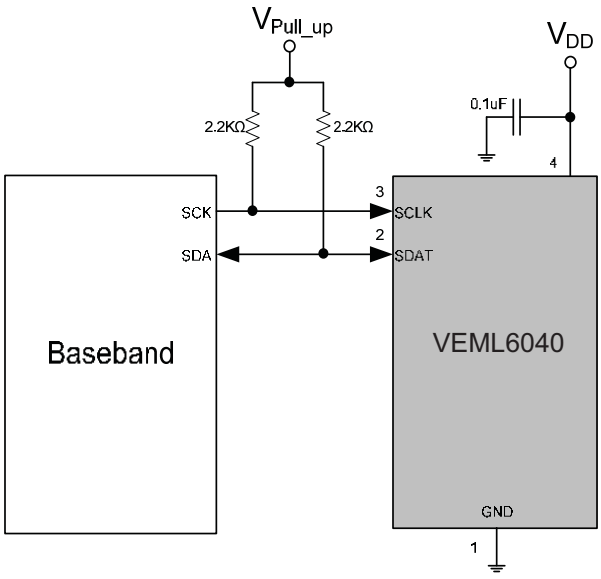


Fig. 6 - Hardware Pin Connection Diagram

Digital Interface

VEML6040 apply slave address 0x10 of 7 bit addressing protocol for I²C. VEML6040 contains an 8-bit command register following each of slave address as shown in figure 7. All operations can be controlled by the command register. The simple command structure helps users easily program the operation setting and latch the light data from VEML6040. Following I²C command format is simple for read and write operations between VEML6040 and the host as shown in figure 7. The white sections indicate host activity and the gray sections indicate VEML6040's acknowledgement of the host access activity. Based on write word protocol, 8-bit command codes can be written by the host under the same slave address. For data reading, VEML6040 apply read word protocol.

Fig. 7 - Command Protocol Format

Slave Address and Function Description

VEML6040 uses 0x10 slave address for 7-bit I²C addressing protocol. VEML6040 has 16-bit resolution for each channel (R, G, B, and W) that provides sensitivity up to 0.0056 lux/step for G, which is advantageous under a low transmittance lens design (dark lens).

TABLE 1 - SLAVE ADDRESS AND COMMAND CODE DESCRIPTION

SLAVE ADDRESS 0x10										
COMMAND CODE	REGISTER NAME	R / W	BIT							
			7	6	5	4	3	2	1	0
00H_L	CONF	R / W	0	IT (2 : 0)			0	TRIG	AF	SD
00H_H	Reserved	R / W	Reserved							
01H to 07H	Reserved	R / W	Reserved							
08H_L	R_DATA_L	R	R_Data (7 : 0)							
08H_H	R_DATA_M	R	R_Data (15 : 8)							
09H_L	G_DATA_L	R	G_Data (7 : 0)							
09H_H	G_DATA_M	R	G_Data (15 : 8)							
0AH_L	B_DATA_L	R	B_Data (7 : 0)							
0AH_H	B_DATA_M	R	B_Data (15 : 8)							
0BH_L	W_DATA_L	R	W_Data (7 : 0)							
0BH_H	W_DATA_M	R	W_Data (15 : 8)							

Note

- Slave address is 7-bit addressing protocol

Command Register Format

VEML6040 provides an 8-bit command register for controlling. The description of each command format is shown in the following tables. Color sensor is function compatible with ambient light sensor when apply color sensor at green channel.

Color Sensor Command

TABLE 2-1 - COMMAND CODE 00H BITS DESCRIPTION

SLAVE ADDRESS: 0x10; REGISTER NAME: CONF; COMMAND CODE: 00H / DATA BYTE LOW							
X	IT			X	TRIG	AF	SD
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
0	IT2	IT1	IT0	0	TRIG	AF	SD

DESCRIPTION	
IT	Integration time setting
TRIG	Proceed one detecting cycle at manual force mode
AF	Auto / manual force mode
SD	Chip shutdown setting

TABLE 2-2 - COMMAND CODE 00H REGISTER SETTING

BITS SETTING	DESCRIPTION	BITS SETTING	DESCRIPTION
BIT 7	Default = 0	BIT 3	Default = 0
BIT 6, 5, 4 IT (2 : 0)	(0 : 0 : 0) = 40 ms	BIT 2 TRIG	0 = no trigger
	(0 : 0 : 1) = 80 ms		1 = trigger one time detect cycle
	(0 : 1 : 0) = 160 ms	BIT 1 AF	0 = auto mode
	(0 : 1 : 1) = 320 ms		1 = force mode
	(1 : 0 : 0) = 640 ms	BIT 0 SD	0 = enable color sensor
	(1 : 0 : 1) = 1280 ms		1 = disable color sensor

TABLE 3-1 - RESERVE COMMAND CODE DESCRIPTION

RESERVED		COMMAND CODE: 00H / DATA BYTE HIGH
Command	Bit	Description
Reserved	7 : 0	Default = 00H

TABLE 3-2 - RESERVE COMMAND CODE DESCRIPTION

RESERVED		COMMAND CODE: 01H TO 07H
Command	Bit	Description
Reserved	7 : 0	Default = 00H

TABLE 4 - READ OUT COMMAND CODE DESCRIPTION

COMMAND CODE	REGISTER	BIT	DESCRIPTION
08H_L (08H data byte low)	R_DATA_L	7 : 0	00H to FFH, R channel LSB output data
08H_H (08H data byte high)	R_DATA_M	7 : 0	00H to FFH, R channel MSB output data
09H_L (09H data byte low)	G_DATA_L	7 : 0	00H to FFH, G channel LSB output data
09H_H (09H data byte high)	G_DATA_M	7 : 0	00H to FFH, G channel MSB output data
0AH_L (0AH data byte low)	B_DATA_L	7 : 0	00H to FFH, B channel LSB output data
0AH_H (0AH data byte high)	B_DATA_M	7 : 0	00H to FFH, B channel MSB output data
0BH_L (0BH data byte low)	W_DATA_L	7 : 0	00H to FFH, W channel LSB output data
0BH_H (0BH data byte high)	W_DATA_M	7 : 0	00H to FFH, W channel MSB output data

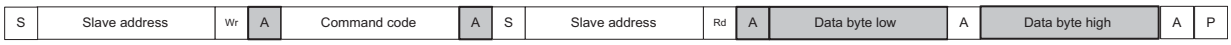
Data Access

VEML6040 has 16-bit high resolution sensitivity for each channel of color sensor (R,G,B, and W). To represent the 16-bit data, it has to apply two bytes. One byte is for LSB and the other byte is for MSB. The host needs to follow the read word protocol as shown in figure 7. The data format shows as below.

TABLE 5 - 16-BIT DATA FORMAT

	VEML6040 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	◄	—	—	—	—	—	—	►								

Notes



- Data byte low represents LSB and data byte high represents MSB.
- To read color data, for example, R channel the following should be written: 10H-08H-11H and then the 16 bit result is available. Command code for R, G, B, and W channel data is 08H, 09H, 0AH, and 0BH respectively.

The integration time settings result in the corresponding resolutions that are shown in table 6.

TABLE 6 - G CHANNEL RESOLUTION AND MAXIMUM DETECTION RANGE

IT SETTING		G SENSITIVITY
IT (2 : 0)	INTEGRATION TIME	
(0 : 0 : 0)	40 ms	0.18
(0 : 0 : 1)	80 ms	0.09
(0 : 1 : 0)	160 ms	0.045
(0 : 1 : 1)	320 ms	0.0225
(1 : 0 : 0)	640 ms	0.01125
(1 : 0 : 1)	1280 ms	0.005625
G integration time = 40 ms		11 796 lux

Data Auto-Memorization

VEML6040 can memorize the last ambient light data before shutting down and keeps this data before waking up again. When VEML6040 is in shutdown mode, the host can freely read this data directly via read command. When VEML6040 wakes up, the data is refreshed by a newly acquired detection.

PACKAGE INFORMATION in millimeters

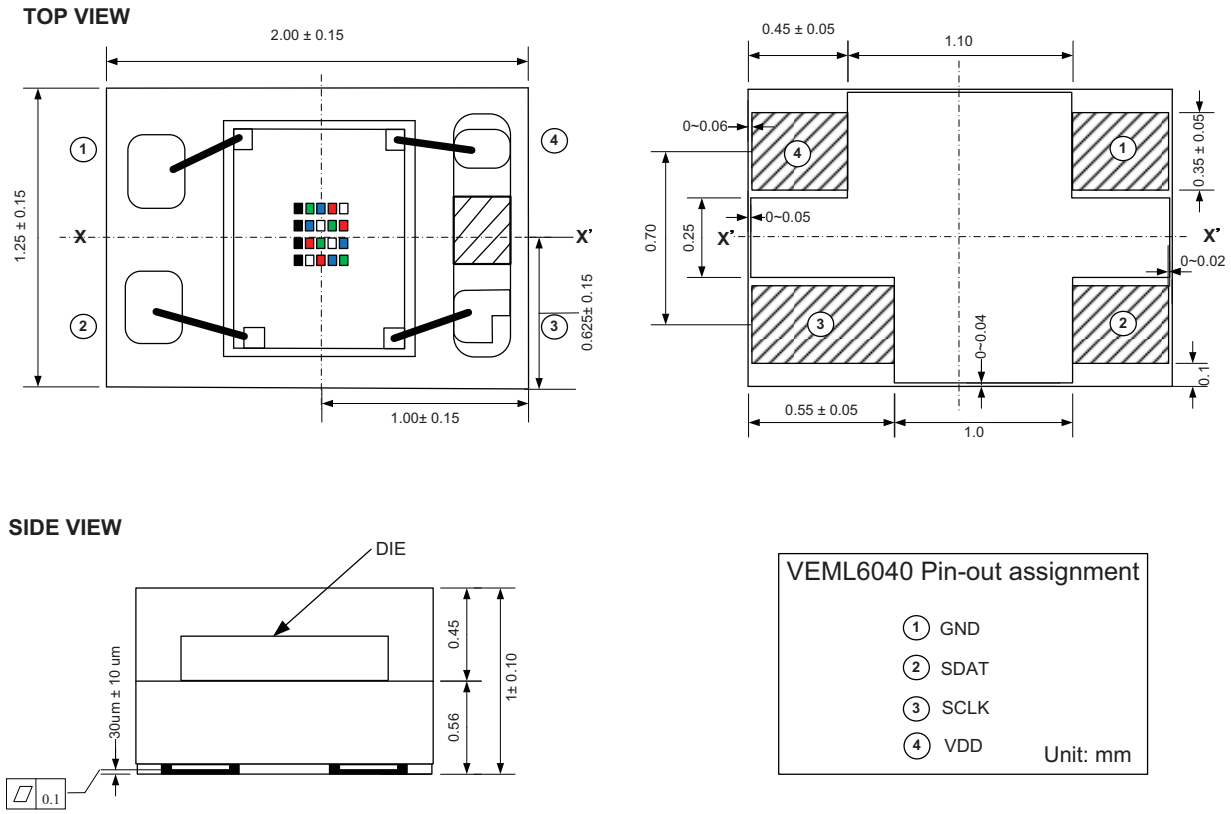


Fig. 8 - VEML6040 A3OG Package Dimensions

LAYOUT NOTICE AND REFERENCE CIRCUIT in millimeters

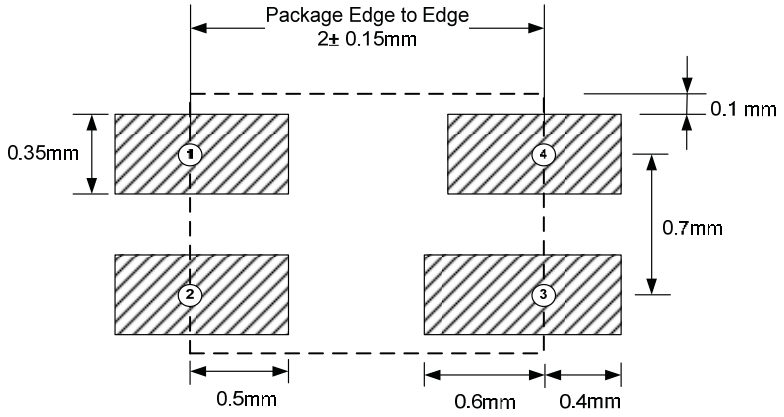


Fig. 9 - VEML6040 PCB Layout Footprint

APPLICATION CIRCUIT BLOCK REFERENCE

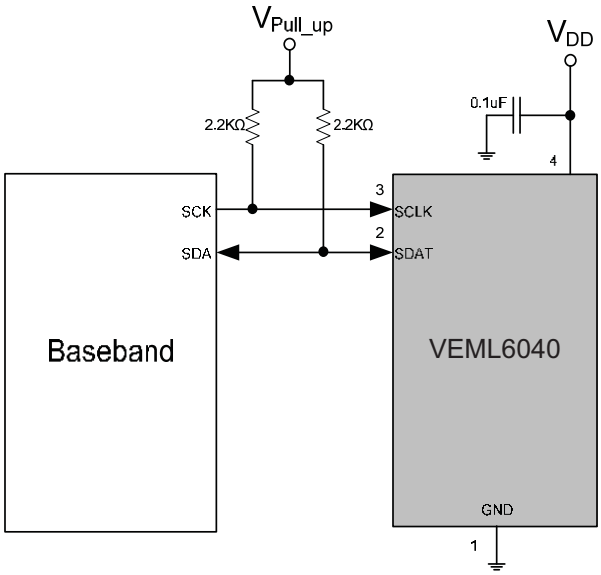


Fig. 10 - VEML6040 Application Circuit

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	h

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

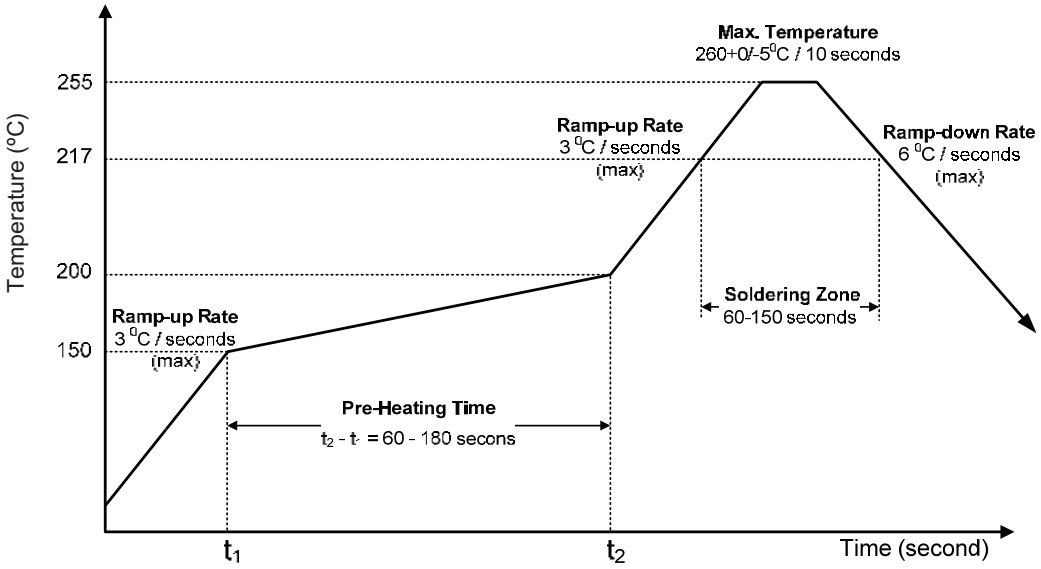


Fig. 11 - VEML6040 OPLGA Solder Reflow Profile Chart

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

DIMENSION OF CARRIER TAPE

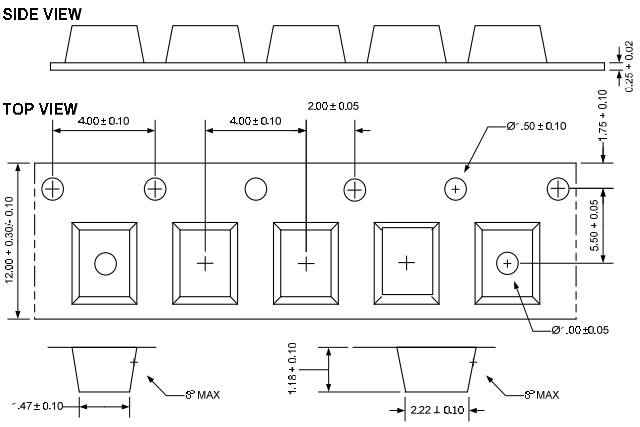


Fig. 12 - VEML6040 A3OG Package Carrier Tape

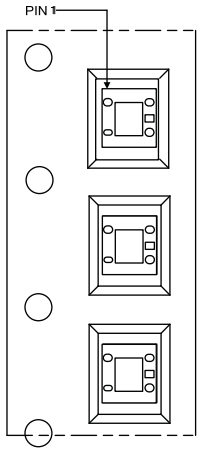


Fig. 13 - Taping Direction

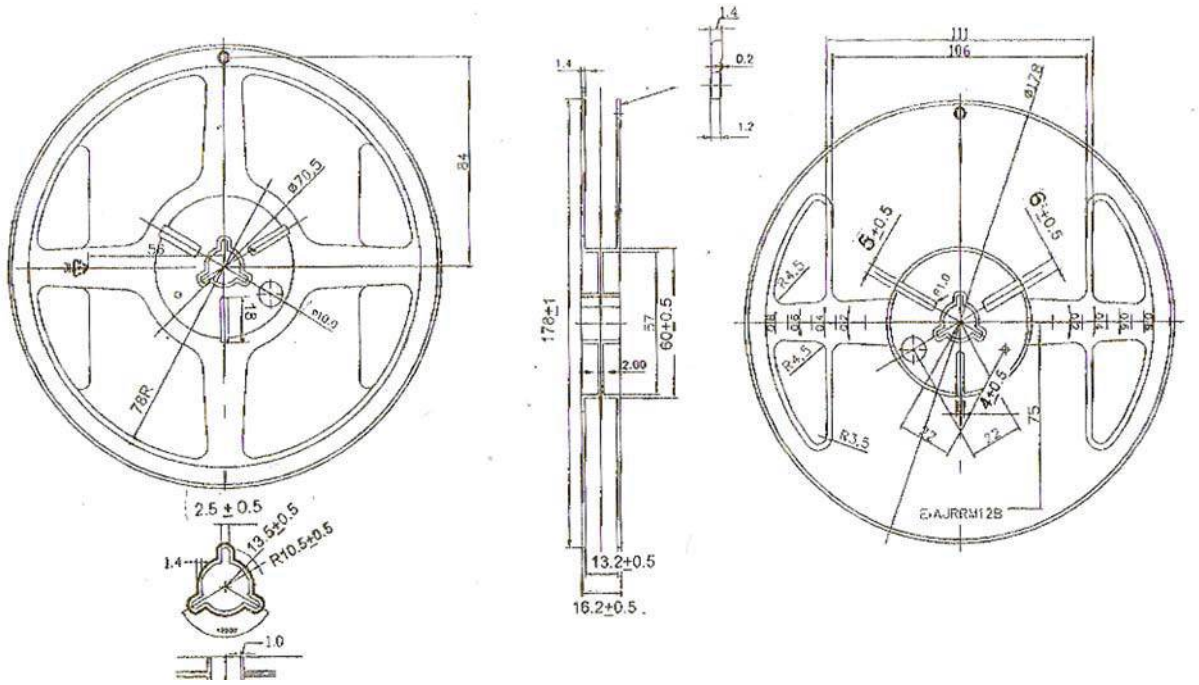


Fig. 14 - Reel Dimensions

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