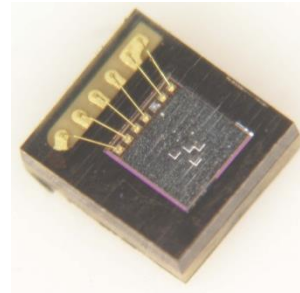


## Description

The ZOPT2202 Sensor integrates two types of ultra-violet optical sensors: one that is primarily sensitive in the UVA spectral range and one that is sensitive in the UVB spectral range.

The device is connected via an I<sup>2</sup>C interface to a microcontroller. Other I<sup>2</sup>C or SMBus devices can be connected to the same interface. The device has a programmable interrupt with hysteresis to respond to events and reduce the microcontroller tasks.

A major application of the device is in smart phones or other mobile devices to enable UVA and UVB energy level measurements in support of diverse health care applications or contextual awareness algorithms.



## Features

- Very high sensitivity for UVA and UVB energy levels
- Superior visible light and infrared energy suppression
- Very stable spectral response over angle of light incidence
- Large dynamic range
- Excellent temperature compensation
- Lowest conversion repeat noise
- Parallel operation of UVA and UVB sensor
- I<sup>2</sup>C interface capable of standard mode (100kHz) or fast mode (400kHz) communication; 1.8V logic compatible
- Programmable interrupt function for UVA or UVB sensor with upper and lower thresholds

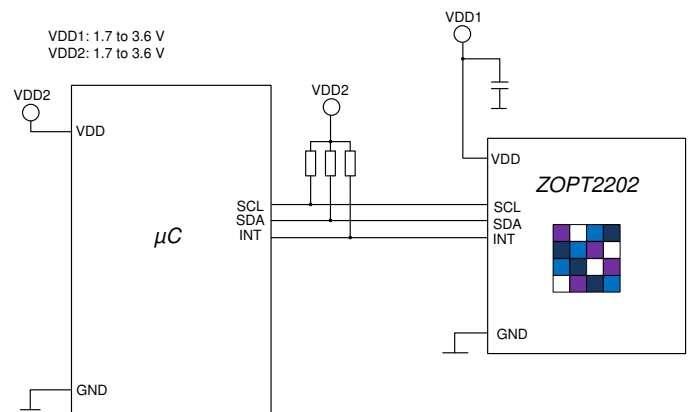
## Sensor Features

- UVA/UVB sensor in a matrix array arrangement
- Configurable output resolution: 13 to 20 bits
- Configurable analog gain: ×1 to ×18
- Linear output code
- Fluorescent light flicker immunity

## Physical Characteristics

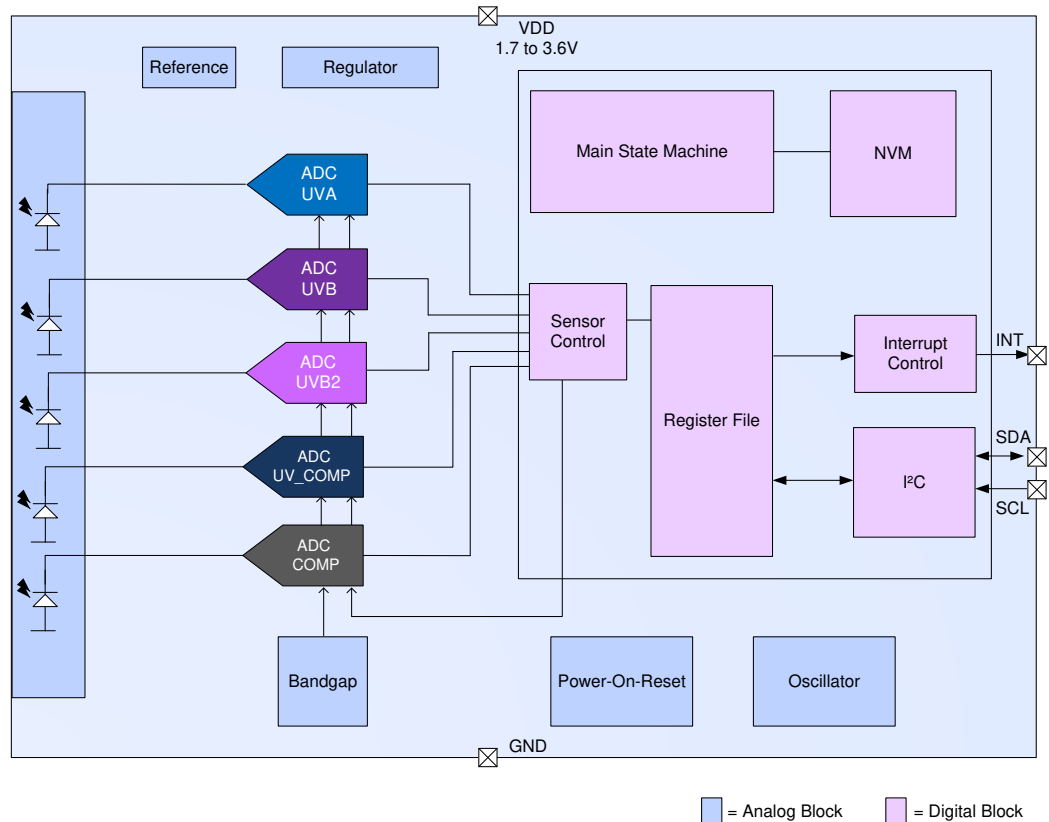
- Wide operation temperature: - 40°C to +90°C
- Wide supply voltage: 1.7V to 3.6V
- Minimum active current at maximum duty cycle:
  - Single channel: 110µA typical
  - Dual channel: 130µA typical
 Note: Average current is proportionally lower with lower measurement rates.
- Low standby current: 1µA typical
- Packages:
  - LGA6 (2.0 × 2.2 × 0.7 mm)
  - TSV (1.1 × 1.2 × 0.26 mm)

## ZOPT2202 Application Circuit



# ZOPT2202 Block Diagram

- Applications**
- Cellular phones
  - Notebooks
  - Consumer devices



## Ordering Information

Product Sales Code	Description	Package
ZOPT2202AC5R	ZOPT2202 LGA6 – Temperature range: -40 to +90°C	Reel
ZOPT2202AC9R	ZOPT2202 TSV – Temperature range: -40 to +90°C	Reel
ZOPT2202KIT V1.0	ZOPT2202 Evaluation Kit, including ZOPT Control Board, mini-USB cable, and 1 ZOPT2202 sample mounted on the LGA6 Sensor Board; kit software is available for free download – see the <i>ZOPT Evaluation Kit Quick Start-up Guide</i> included in the kit for instructions.	

## Contents

1.	Characteristics.....	6
1.1	Absolute Maximum Ratings.....	6
1.2	Operating Conditions.....	6
1.3	Electrical and Optical Parameters.....	7
2.	Typical Device Parameters.....	9
3.	Detailed Description.....	12
3.1	Block Diagram of ZOPT2202.....	12
3.2	Application Circuit.....	13
3.3	Pin Description.....	14
3.4	Device Operation Modes.....	15
3.5	Conversion Control State Machine.....	17
3.5.1	Start Up after Power-On or Software Reset.....	17
3.6	UV Sensor Sensitivity Configuration.....	18
3.6.1	Analog Gain Modes, Resolution, and Measurement Time.....	18
3.7	Interrupt Features.....	19
3.8	I <sup>2</sup> C Interface.....	20
3.8.1	I <sup>2</sup> C Address Decoding.....	20
3.8.2	I <sup>2</sup> C Register Read.....	20
3.8.3	Register Write.....	21
3.8.4	I <sup>2</sup> C Interface—Bus Timing.....	22
3.9	Summary of Internal Registers.....	23
3.10	Detailed Description of Registers.....	24
3.10.1	MAIN_CTRL.....	24
3.10.2	LS_MEAS_RATE.....	25
3.10.3	LS_GAIN.....	26
3.10.4	PART_ID.....	27
3.10.5	MAIN_STATUS.....	27
3.10.6	UVB2_DATA.....	28
3.10.7	UVA_DATA.....	29
3.10.8	UVB_DATA.....	30
3.10.9	UV_COMP_DATA.....	31
3.10.10	COMP_DATA.....	32
3.10.11	INT_CFG.....	33
3.10.12	INT_PST.....	33
3.10.13	LS_THRES_UP.....	34
3.10.14	LS_THRES_LOW.....	34
3.10.15	LS_THRES_VAR.....	35
3.10.16	DEVICE_CONFIG.....	35

4. Packages.....	36
4.1 LGA6 Package (2.0 × 2.2 × 0.7 mm) .....	36
4.1.1 Mechanical Dimensions.....	36
4.1.2 Pin Assignment (Top View) .....	36
4.1.3 Reflow Profile .....	37
4.1.4 LGA Tape Packaging Information .....	38
4.2 TSV Package (1.1 × 1.2 × 0.26 mm) .....	39
4.2.1 Mechanical Dimensions.....	39
5. Part Order Information.....	40
6. Glossary .....	40
7. Document Revision History .....	41

**List of Figures**

Figure 2.1 UVAS Spectral Response – Linear .....	9
Figure 2.2 UVAS Spectral Response – Logarithmic .....	9
Figure 2.3 UVBS Spectral Response – Linear .....	9
Figure 2.4 UVBS Spectral Response – Logarithmic .....	9
Figure 2.5 UVAS Spectral Response vs. AOI .....	10
Figure 2.6 UVBS Spectral Response vs. AOI .....	10
Figure 2.7 UVAS Field of View (375nm LED) .....	10
Figure 2.8 UVAS Field of View (Polar) (375nm LED) .....	10
Figure 2.9 UVBS Field of View (310nm LED) .....	10
Figure 2.10 UVBS Field of View (Polar) (310nm LED) .....	10
Figure 2.11 Conversion Repeat Noise .....	11
Figure 2.12 Active Current vs. Supply Voltage .....	11
Figure 2.13 Normalized Active Current vs. Temperature .....	11
Figure 2.14 Standby Current vs. Temperature.....	11
Figure 3.1 Simplified ZOPT2202 Block Diagram .....	12
Figure 3.2 Typical Application Circuit.....	13
Figure 3.3 Main State Machine .....	17
Figure 3.4 Interrupt Unit .....	19
Figure 3.5 I <sup>2</sup> C Register Read .....	21
Figure 3.6 I <sup>2</sup> C Register Write .....	21
Figure 3.7 Bus Timing .....	22

## List of Tables

Table 3.1	LGA Pin Description.....	14
Table 3.2	TSV Pin Description.....	14
Table 3.3	Mode Descriptions .....	15
Table 3.4	Channel Activation vs. Operation Mode.....	16
Table 3.5	UVAS Sensitivities .....	18
Table 3.6	UVBS Sensitivities .....	18
Table 3.7	Supported I <sup>2</sup> C Clock Frequencies .....	20
Table 3.8	I <sup>2</sup> C Address .....	20
Table 3.9	Bus Timing Characteristic .....	22
Table 3.10	Register Overview.....	23
Table 4.1	Reflow Profile Specifications.....	37

## 1. Characteristics

### 1.1 Absolute Maximum Ratings

The absolute maximum ratings are stress ratings only. The device might not function or be operable above the recommended operating conditions given in section 1.2. Stresses exceeding the absolute maximum ratings might damage the device. In addition, extended exposure to stresses above the recommended operating conditions might affect device reliability. IDT does not recommend designing to the "Absolute Maximum Ratings."

Parameter	Symbol	Conditions	Min.	Max.	Units
Maximum input supply voltage (VDD pin)	$V_{DD-GND}$			4.0	V
Maximum voltage on SCL, SDA and INT pins	$V_{I2C}$		-0.5	4.0	V
Maximum operating temperature range	$T_{AMB\_MAX}$		-40	90	°C
Storage temperature	$T_{STOR}$		-45	95	°C
Maximum input current into any pin except supply pins (latch-up)	$I_{IN}$		-100	100	mA
Electrostatic Discharge Protection <sup>[a]</sup>	$V_{HBM}$	Human Body Model, JESD22-A114	2000		V

[a] HBM: C = 100pF charged to  $V_{HBM}$  with resistor R = 1.5kΩ in series; valid for all pins.

### 1.2 Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Voltage supply on VDD pin	$V_{DD}$		1.7		3.6	V
Ambient operating temperature range	$T_{AMB}$		-40		90	°C

### 1.3 Electrical and Optical Parameters

$V_{DD} = 2.8V$ ,  $T_{AMB} = -40^{\circ}C$  to  $+90^{\circ}C$ , unless otherwise noted.

Note: See important table notes at the end of the table.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>Power On Reset</b>						
DC power-on reset level	POR <sub>LH</sub>	Slow variation of VDD	1.00	1.34	1.60	V
	POR <sub>HL</sub>					
<b>Current Consumption</b>						
UVAB_S Mode <sup>[a]</sup>	I <sub>UVA</sub>	Maximum duty cycle, VDD = 2.8V		110		μA
UVB_ONLY Mode <sup>[a]</sup>	I <sub>UVB</sub>	Maximum duty cycle, VDD = 2.8V		100		μA
UVAB_Raw Mode <sup>[a]</sup>	I <sub>UVA+B</sub>	Maximum duty cycle, VDD = 2.8V		130		μA
Standby Mode	I <sub>SBY</sub>	ZOPT2202 in Standby Mode, no active I <sup>2</sup> C communication		1	2	μA
<b>I<sup>2</sup>C Interface</b>						
I <sup>2</sup> C signal input high	V <sub>I2Chigh</sub>		1.5		VDD	V
I <sup>2</sup> C signal input low	V <sub>I2Clow</sub>		0		0.4	V
<b>UVAS Characteristics</b>						
Spectral response			See Figure 2.1 and Figure 2.2.			
Sensitivity at gain 1	G <sub>1</sub>	Specifications apply to the 20-bit resolution setting. Specifications change with resolution setting as given in Table 3.5.		0.106		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 3	G <sub>3</sub>			0.035		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 6 <sup>[b]</sup>	G <sub>6</sub>			0.018		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 9 <sup>[b]</sup>	G <sub>9</sub>			0.012		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 18 <sup>[b]</sup>	G <sub>18</sub>			0.006		$\frac{\mu W/cm^2}{count}$
Calibrated error at gain 18		Calibration done with UVA LED, 360nm, T <sub>AMB</sub> = +25°C			10	%

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>UVBS Characteristics</b>						
Spectral response			See Figure 2.3 and Figure 2.4.			
Sensitivity at gain 1	G <sub>1</sub>	Specifications apply to 20-bit resolution setting. Specifications change with resolution setting as given in Table 3.6		0.36		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 3	G <sub>3</sub>			0.12		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 6 [b]	G <sub>6</sub>			0.06		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 9 [b]	G <sub>9</sub>			0.04		$\frac{\mu W/cm^2}{count}$
Sensitivity at gain 18 [b]	G <sub>18</sub>			0.02		$\frac{\mu W/cm^2}{count}$
Calibrated error at gain 18		Calibration done with UVB LED, 310nm, T <sub>AMB</sub> = +25°C			10	%
<b>UVA / UVB Sensor Characteristics</b>						
UVA / UVB sensor output resolution	UVS <sub>RES</sub>	Programmable for 13, 16, 17, 18, 19, 20 Bit	13	18	20	Bit
UVA / UVB sensor dark level count	UVS <sub>DARK</sub>	No illumination 20-bit resolution Gain range x18 T <sub>AMB</sub> = -40 to +60°C		5	20	Count
<b>Conversion Timing</b>						
Minimum integration time [c]	t <sub>INTmin1</sub>			3.125		ms
	t <sub>INTmin2</sub>	With 50/60 Hz rejection		50		ms
Maximum integration time [c]	t <sub>INTmax</sub>	With 50/60 Hz rejection		400		ms
Wake-up time from Standby Mode	t <sub>WAKE-STB</sub>	From Standby to Active Mode (measurement can start)		500		μs
Measurement repeat rate [c]		Programmable	25		2000	ms
Timing accuracy [d]			-25		+25	%

[a] Maximum duty cycle is selected with a 100ms measurement time and 100ms repeat rate.

[b] Values valid up to 60°C.

[c] Typical timing accuracy applied.

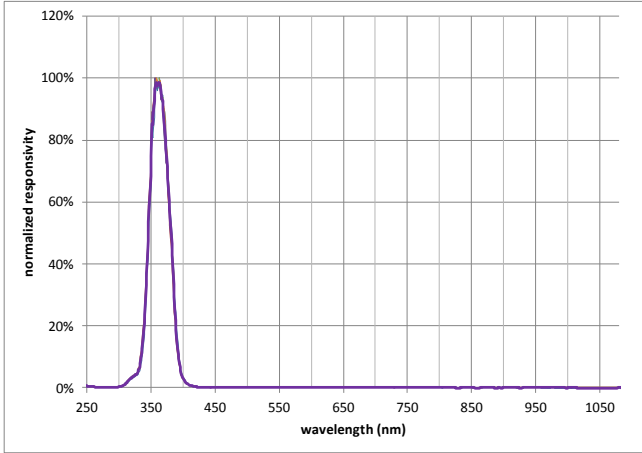
[d] All specifications related to timing can vary by this value; for example, a repeat rate of 50ms could vary up to 62.5ms.



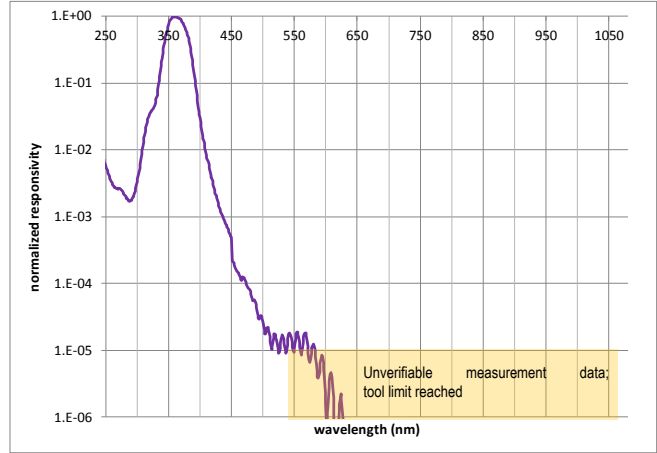
## 2. Typical Device Parameters

( $V_{DD} = 2.8V$ ; ZOPT2202 configuration: 20-bit resolution and gain range x18; other settings at default unless otherwise noted.)

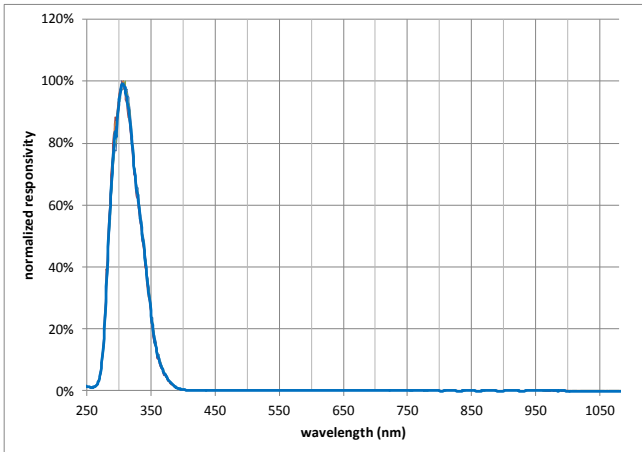
**Figure 2.1 UVAS Spectral Response – Linear**



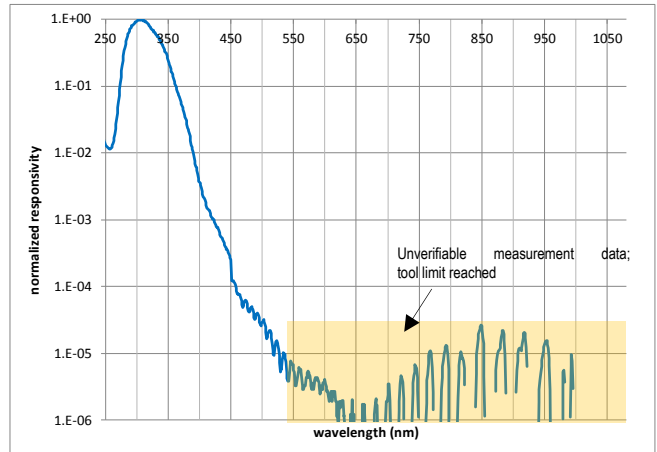
**Figure 2.2 UVAS Spectral Response – Logarithmic**



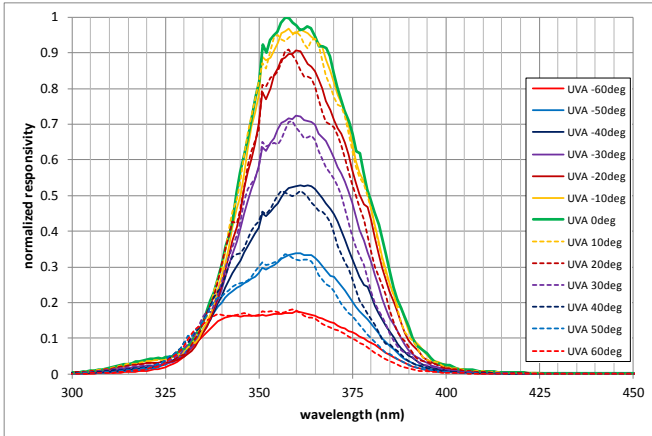
**Figure 2.3 UVBS Spectral Response – Linear**



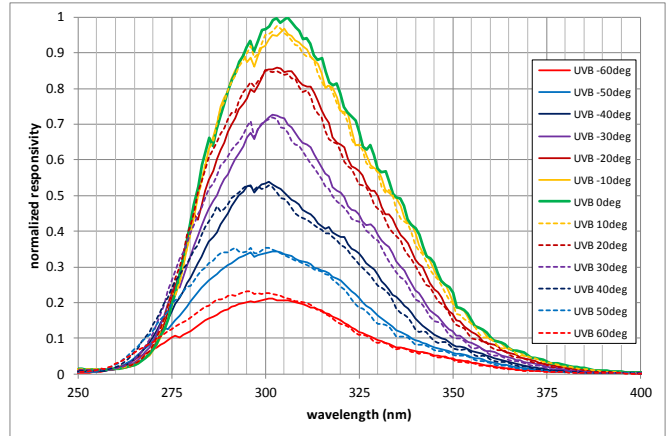
**Figure 2.4 UVBS Spectral Response – Logarithmic**



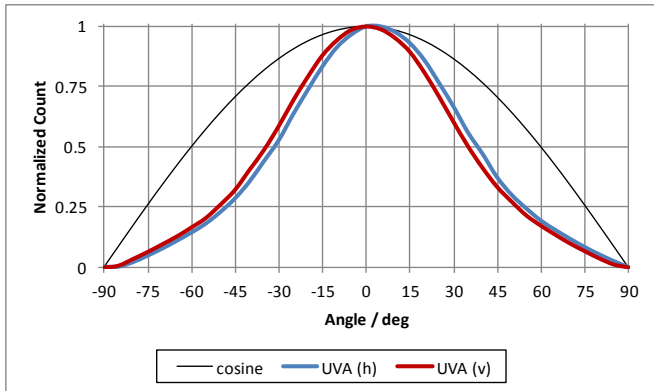
**Figure 2.5 UVAS Spectral Response vs. AOI**



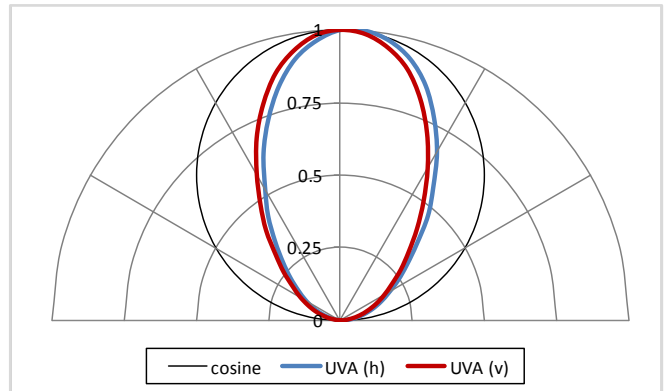
**Figure 2.6 UVBS Spectral Response vs. AOI**



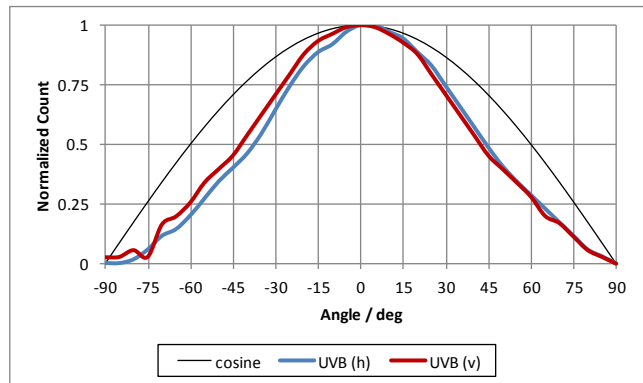
**Figure 2.7 UVAS Field of View (375nm LED)**



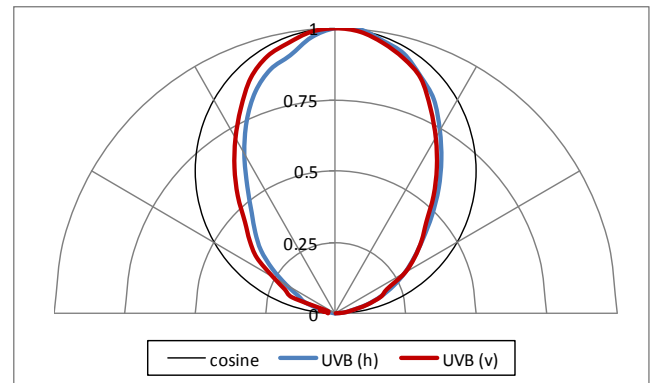
**Figure 2.8 UVAS Field of View (Polar) (375nm LED)**



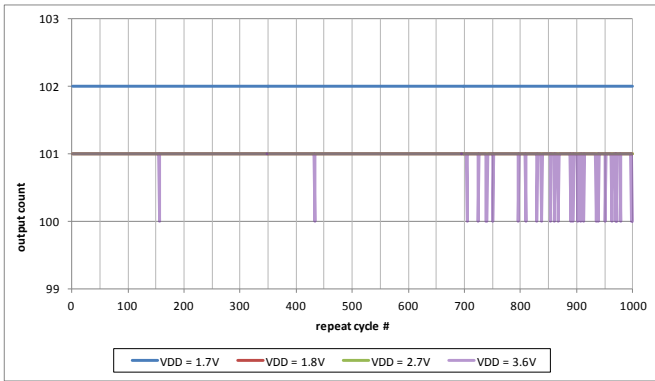
**Figure 2.9 UVBS Field of View (310nm LED)**



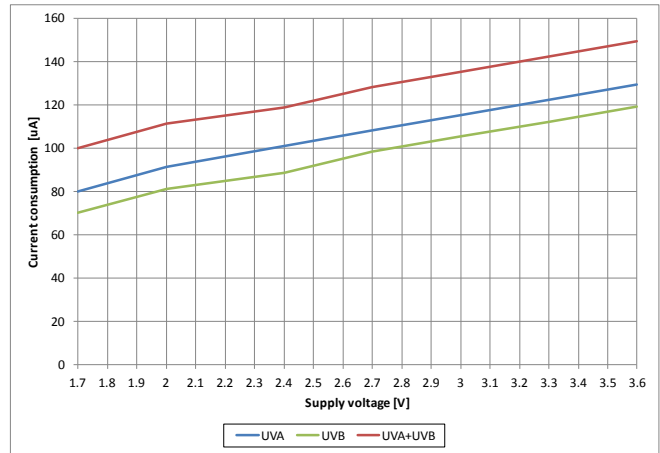
**Figure 2.10 UVBS Field of View (Polar) (310nm LED)**



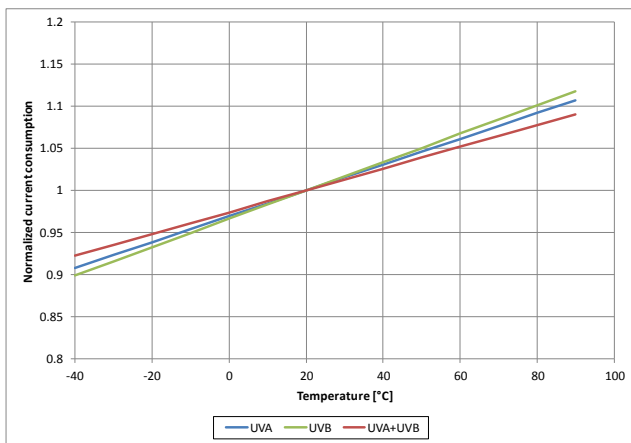
**Figure 2.11 Conversion Repeat Noise**



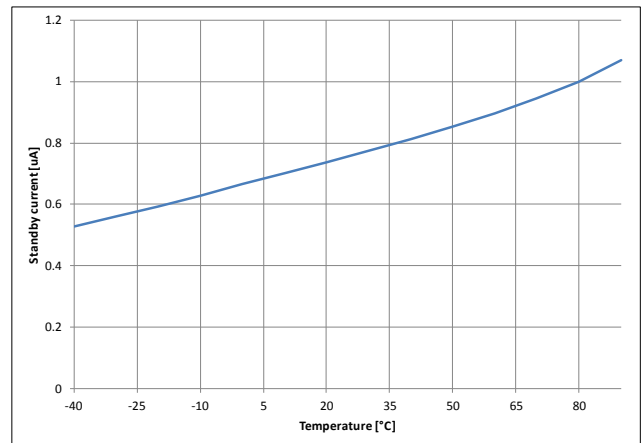
**Figure 2.12 Active Current vs. Supply Voltage**



**Figure 2.13 Normalized Active Current vs. Temperature**



**Figure 2.14 Standby Current vs. Temperature**

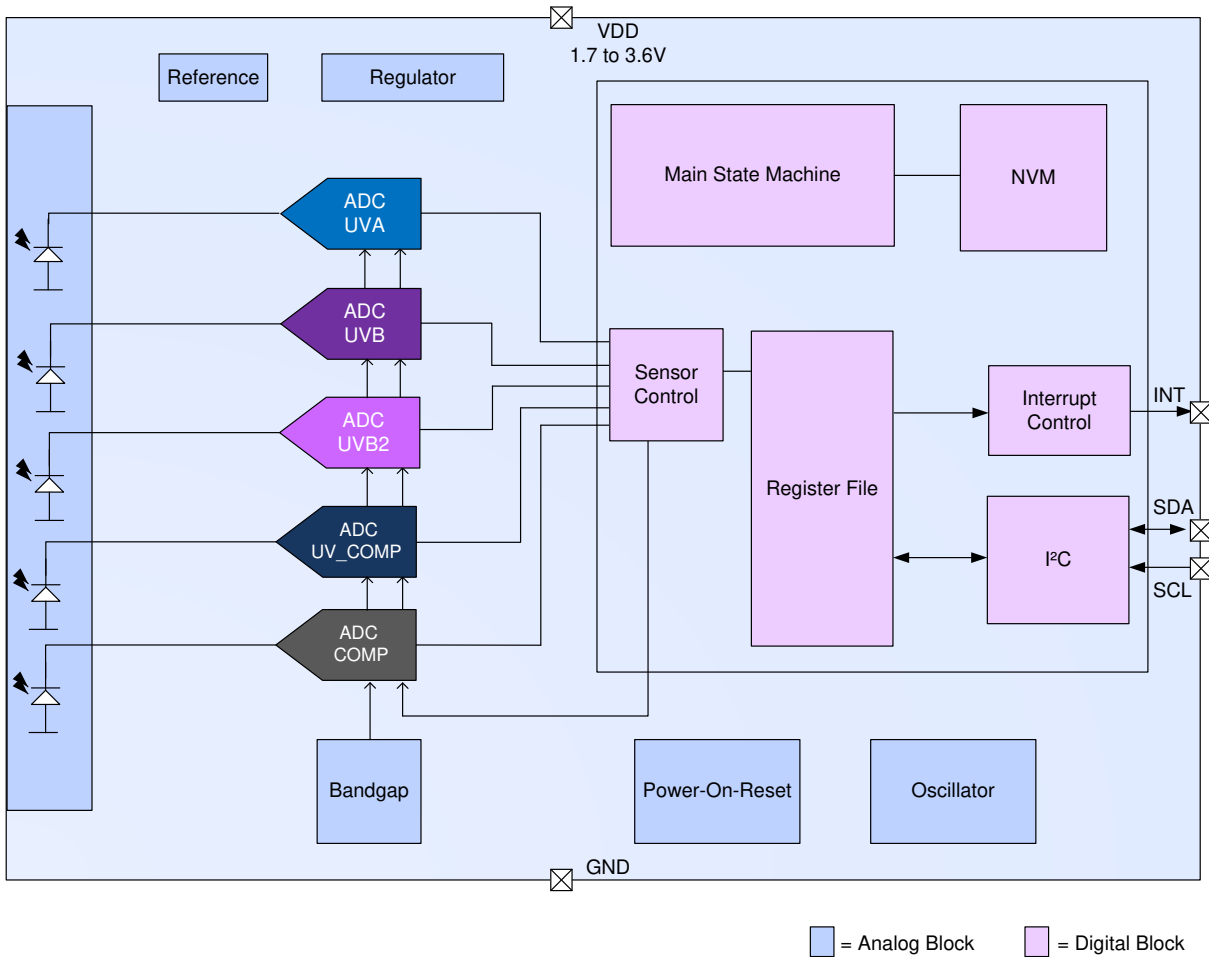


### 3. Detailed Description

The ZOPT2202 contains 5 different photodiode channels for UV energy level measurement, temperature compensation, and stray light compensation. The sensor diodes are arranged in a matrix array. The photodiode currents are converted to digital values by the ADCs. The ZOPT2202 includes some peripheral circuits such as internal oscillator, current source, voltage reference, and non-volatile memory (NVM) to store trimming information.

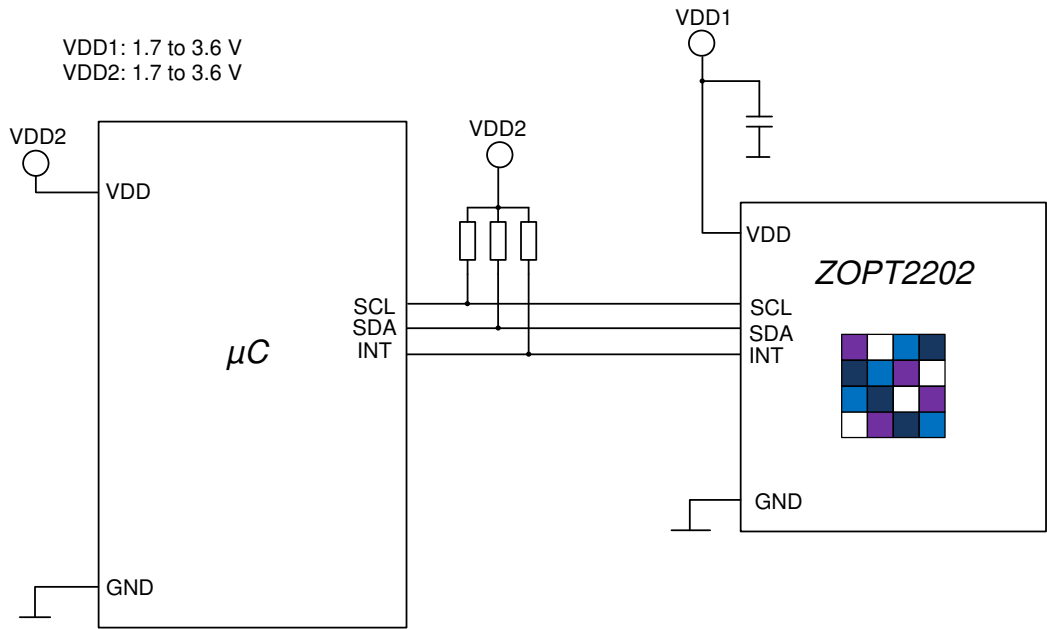
#### 3.1 Block Diagram of ZOPT2202

Figure 3.1 Simplified ZOPT2202 Block Diagram



### 3.2 Application Circuit

Figure 3.2 Typical Application Circuit



### 3.3 Pin Description

For pin layout and package dimensions, refer to sections 4.1 and 4.2 for the LGA6 and TSV packages respectively.

**Table 3.1 LGA Pin Description**

Number	Pin Name	I/O Type	Description
1	SCL	IN	I <sup>2</sup> C serial clock line
2	SDA	IN/OUT	I <sup>2</sup> C serial data line
3	VDD	SUPPLY	Digital/analog power supply
4	INT	OUT	Interrupt pin
5	GND	GROUND	Digital/analog ground
6	N.C.	-	Not connected

**Table 3.2 TSV Pin Description**

Number	Pin Name	I/O Type	Description
A1	INT	OUT	Interrupt pin
A2	SDA	IN/OUT	I <sup>2</sup> C serial data line
A3	N.C.	-	Not connected
B1	GND	GROUND	Digital/analog ground
B2	VDD	SUPPLY	Digital/analog power supply
B3	SCL	IN	I <sup>2</sup> C serial clock line

### 3.4 Device Operation Modes

**Table 3.3 Mode Descriptions**

Mode Number	Mode Name	Comment
1	Standby	Default mode after power-up. In this mode, the oscillator, all internal support blocks, and the ADCs are switched off but I <sup>2</sup> C communication is fully supported.
2	UVAB_S	<p><u>Active ADC Channels:</u> UVA, UVB2, COMP</p> <p>UVAB_S Mode provides the ZOPT2202's internal temperature and stray light compensation for the UVA and UVB2 sensor output data.</p> <ul style="list-style-type: none"> <li>• UVAB_S Mode is a standard operation mode of the ZOPT2202 that is available for activation after power-up or any ZOPT2202 reset. It does not require additional initialization commands to be sent before activation.</li> <li>• Note: Internal temperature and stray light compensation is based on COMP channel data.</li> <li>• Note: The COMP channel is located aside from the sensor matrix. Hence, stray light compensation is not perfectly matched to the UVA and UVB2 sense elements.</li> <li>• Temperature compensation is optimum.</li> <li>• UVAB_S Mode is activated by setting the <i>LS_EN</i> bit to 1 and set the <i>RawMode_SEL</i> bit to 0 in the <i>MAIN_CTRL</i> register (see section 3.10.1) <ul style="list-style-type: none"> <li>○ Write 02<sub>HEX</sub> to register 00<sub>HEX</sub></li> </ul> </li> <li>• Internal temperature and stray light compensation is performed following the calculation before sensor data is stored in the output register: <ul style="list-style-type: none"> <li>○ UVA = UVA<sub>raw</sub> – COMP</li> <li>○ UVB2 = UVB2<sub>raw</sub> – COMP</li> </ul> </li> </ul>
3	UVB_ONLY	<p><u>Active ADC Channels:</u> UVB, UV_COMP</p> <p>UVB_ONLY Mode allows high precision measurements of UVB energy intensity. The sensor response is chosen such that it can be used to calculate the UV index directly.</p> <p>Temperature and stray light compensation for the sensor channel is performed internally via the UV_COMP channel.</p> <ul style="list-style-type: none"> <li>• UVB_ONLY Mode is a standard operation mode of the ZOPT2202 that is available for activation after power-up or any ZOPT2202 reset. It does not require additional initialization commands to be sent before activation.</li> <li>• Note: Internal temperature and stray light compensation is based on the UV_COMP channel data.</li> <li>• Note: The UV_COMP channel is located within sensor matrix. Hence, this mode provides optimum temperature and stray light compensation for UVB channel.</li> <li>• UVB Mode is activated by setting the <i>LS_EN</i> and <i>UVB_ONLY</i> bits to 1 in the <i>MAIN_CTRL</i> register (see section 3.10.1) <ul style="list-style-type: none"> <li>○ Write 0A<sub>HEX</sub> to register 00<sub>HEX</sub></li> </ul> </li> <li>• Internal temperature and stray light compensation is performed following the calculation before sensor data is stored in the output register: <ul style="list-style-type: none"> <li>○ UVB = UVB<sub>raw</sub> – UV_COMP</li> </ul> </li> </ul>

Mode Number	Mode Name	Comment
4	UVAB_Raw	<p><u>Active ADC Channels:</u> UVA, UVB, UVB2, UV_COMP, COMP</p> <p>UVAB_Raw Mode allows optimum temperature and stray light compensation for UVA and UVB sensor output data by external post-processing.</p> <ul style="list-style-type: none"> <li>UVAB_Raw Mode uses a special operation mode of the ZOPT2202. It requires a specific sequence to initialize after power up.</li> <li>The following commands must be sent via I<sup>2</sup>C <i>single byte</i> access to activate the special operation mode of ZOPT2202: <ul style="list-style-type: none"> <li>Write B5<sub>HEX</sub> to register 31<sub>HEX</sub></li> <li>Write DF<sub>HEX</sub> to register 30<sub>HEX</sub></li> <li>Write 04<sub>HEX</sub> to register 31<sub>HEX</sub></li> </ul> </li> <li>UVAB_Raw operation is activated (after the sequence above has been sent) by setting the <i>LS_EN</i> and <i>RawMode_SEL</i> bits to 1 and setting the <i>UVB_Only</i> bit to 0 in the <i>MAIN_CTRL</i> register (see section 3.10.1) <ul style="list-style-type: none"> <li>Write 06<sub>HEX</sub> to register 00<sub>HEX</sub></li> </ul> </li> <li>No internal temperature and stray light compensation is carried out. All channel data registers carry the <i>uncompensated raw data</i> as received from ADCs</li> <li>Important: Proper temperature and stray light <i>compensation must be done on the application level</i> applying following formulas: <ul style="list-style-type: none"> <li><math>UVA = UVA\_raw - UV\_COMP</math></li> <li><math>UVB = UVB\_raw - UV\_COMP</math></li> </ul> </li> </ul> <p>Important: The internal digital trimming factors are not applied to the output data in the UVAB_Raw Mode. If this mode is used, contact IDT for the related application note (see contact information on last page).</p>

**Table 3.4 Channel Activation vs. Operation Mode**

Mode Number	Mode Name	UVA		UVB		UVB2		UV_COMP		COMP	
		Inactive	Active	Inactive	Active	Inactive	Active	Inactive	Active	Inactive	Active
1	Standby	✓		✓		✓		✓		✓	
2	UVAB_S		✓	✓			✓	✓			✓
3	UVB_ONLY	✓			✓	✓			✓	✓	
4	UVAB_Raw		✓		✓		✓		✓		✓



### 3.5 Conversion Control State Machine

#### 3.5.1 Start Up after Power-On or Software Reset

The main state machine is set to “Start State” during power-on or software reset. As soon as the reset is released, the internal oscillator is started and the programmed I<sup>2</sup>C address and the trim values are read from the internal NVM trimming data block. The ZOPT2202 enters Standby Mode as soon as the Idle State is reached as shown in Figure 3.3.

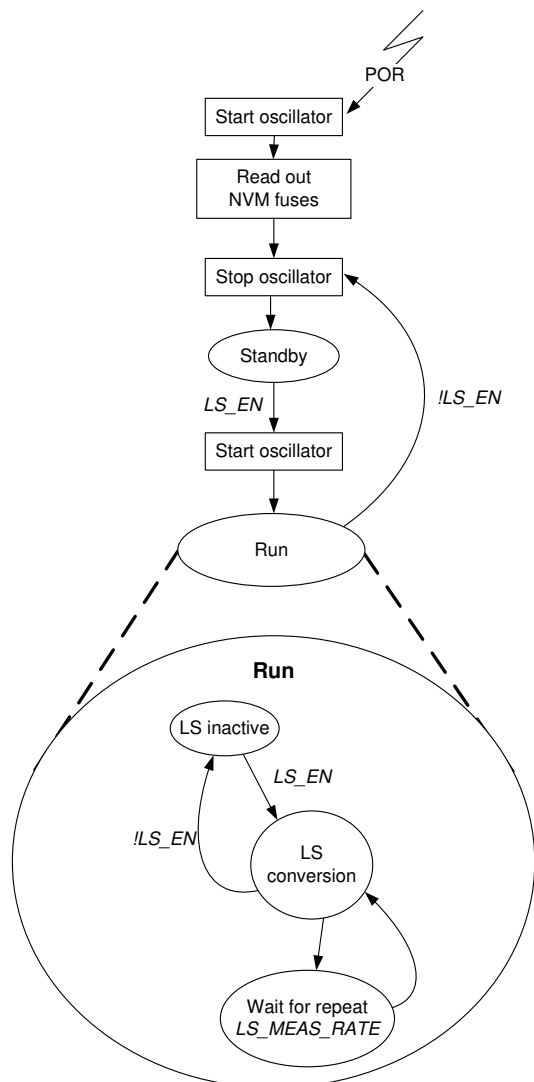
NOTE: If the I<sup>2</sup>C address has not yet been read, the device will respond with NACK to any I<sup>2</sup>C command and ignore any request to avoid responding to an incorrect I<sup>2</sup>C address.

If any of the UV operation modes become activated through an I<sup>2</sup>C command (i.e., the *LS\_EN* bit is set to 1 and the UV mode is selected with the respective bits in the *MAIN\_CTRL* register), the internal support blocks are immediately powered on. Once the voltages and currents are settled (typical after 500μs), the state machine checks for trigger events from a measurement scheduler to start conversions according to the selected measurement repeat rates (see section 3.10.2).

When the user resets the *LS\_EN* bit to 0, a running conversion will be completed and the relevant ADCs and support blocks will move to Standby Mode thereafter.

**Figure 3.3 Main State Machine**

Note: See Table 3.4 for a list of the light sensor channels that are active for the configured LS mode.



## 3.6 UV Sensor Sensitivity Configuration

### 3.6.1 Analog Gain Modes, Resolution, and Measurement Time

There are five analog gain modes to adjust sensitivity of the ZOPT2202 device to the needs of the application. The microcontroller can calculate the received UV energy by multiplying the sensor output data with the appropriate output-scaling coefficients.

If UVAB\_Raw Mode is used, temperature and stray light compensation shall be carried out in the microcontroller before output scaling coefficients are applied (see section 3.4. for the UVAB\_Raw Mode description).

Selected analog gain settings as well as resolution and measurement time settings are valid for all ADC converter channels at the same time. The gain, resolution, and measurement time cannot be simultaneously set to different settings for different channels. If different gain or resolution settings are required for different channels, conversions have to be carried out with modified settings one after another.

**Table 3.5 UVAS Sensitivities**

Effective Output Resolution [Bits]	Measurement Time [ms]	Gain Mode 1	Gain Mode 3	Gain Mode 6	Gain Mode 9	Gain Mode 18
		Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$
13	3.125	0.074	0.221	0.443	0.664	1.328
16	25	0.590	1.771	3.542	5.313	10.625
17	50	1.181	3.542	7.083	10.625	21.250
<b>18 (default)</b>	<b>100</b>	<b>2.361</b>	<b>7.083</b>	<b>14.167</b>	<b>21.250</b>	<b>42.500</b>
19	200	4.722	14.167	28.333	42.500	85.000
20	400	9.444	28.333	56.667	85.000	170.000

**Table 3.6 UVBS Sensitivities**

Effective Output Resolution [Bits]	Measurement Time [ms]	Gain Mode 1	Gain Mode 3	Gain Mode 6	Gain Mode 9	Gain Mode 18
		Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$	Sensitivity $\left[ \frac{\text{counts}}{\mu\text{W}/\text{cm}^2} \right]$
13	3.125	0.022	0.065	0.130	0.195	0.391
16	25	0.174	0.521	1.042	1.563	3.125
17	50	0.347	1.042	2.083	3.125	6.250
<b>18 (default)</b>	<b>100</b>	<b>0.694</b>	<b>2.083</b>	<b>4.167</b>	<b>6.250</b>	<b>12.500</b>
19	200	1.389	4.167	8.333	12.500	25.000
20	400	2.778	8.333	16.667	25.000	50.000

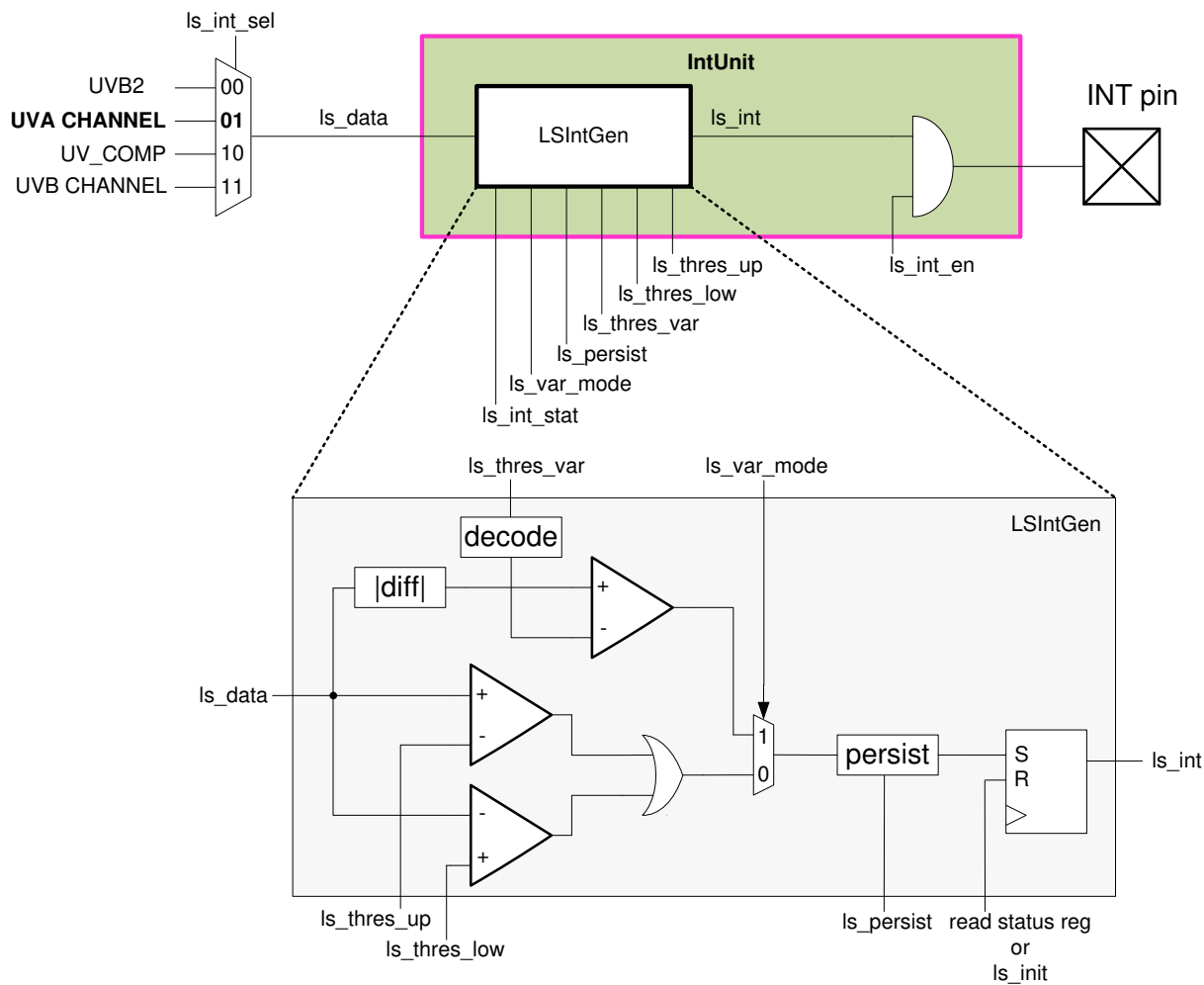
### 3.7 Interrupt Features

The ZOPT2202 can generate an interrupt signal on a user selectable sensor channel. Interrupts will be triggered if upper or lower threshold values are crossed or if output count variation of consecutive conversions has exceeded a defined limit.

An interrupt can be indicated at the INT pin as an active low signal or via a status register flag. Interrupt conditions are always evaluated after completion of a new conversion on the selected sensor channel.

The *ls\_int* signal (output of LSIntGen in Figure 3.4) is also stored in the *MAIN\_STATUS* register as the *LS interrupt status* (see section 3.10.5) flag. The flag is cleared by reading the *MAIN\_STATUS* register. A cleared *LS interrupt status* flag will also clear the interrupt signal on the INT pin.

**Figure 3.4 Interrupt Unit**



The interrupt is configured by the bits in the *INT\_CFG* register (see section 3.10.11). The interrupt is enabled by setting the bit *LS\_INT\_EN* = 1. It can function as either threshold-triggered (*LS\_VAR\_MODE* = 0) or variance-triggered (*LS\_VAR\_MODE* = 1).

The interrupt source generator is configurable to be one of the following input channels: UVA, UVB, UVB2, or UV\_COMP. The interrupt source is selected by the *LS\_INT\_SEL* bits.

The threshold interrupt is enabled with  $LS\_INT\_EN = 1$  and  $LS\_VAR\_MODE = 0$ . The interrupt is set when the respective  $\ast\_DATA$  register value of the selected interrupt source channel is above the upper or below the lower threshold configured in the  $LS\_THRES\_UP$  and  $LS\_THRES\_LOW$  registers (see sections 3.10.13 and 3.10.14 respectively) for a specified number of consecutive measurements as configured in the  $INT\_PST$  register ( $1+LS\_PERSIST$ ; see section 3.10.12).

The variance interrupt is enabled with  $LS\_INT\_EN = 1$  and  $LS\_VAR\_MODE = 1$ . It is set when the absolute value difference between the preceding and the current output data of the selected interrupt source channel is above the decoded variance threshold (see section 3.10.15) for a specified number of consecutive measurements ( $1+LS\_PERSIST$ ).

### 3.8 I<sup>2</sup>C Interface

The ZOPT2202 is equipped with an I<sup>2</sup>C interface for control and data communication. The chip always operates as a slave. The device offers two different 7-bit slave addresses that are selectable via NVM programming. A read/write bit must be appended to the slave address by the master device to properly communicate with the device.

The interface is compatible with Standard Mode (100kHz) and Fast Mode (400kHz) I<sup>2</sup>C communication.

**Table 3.7 Supported I<sup>2</sup>C Clock Frequencies**

Mode	Frequency	Transient Noise Filter
Standard	100kHz	50ns
Fast	400kHz	50ns

The I<sup>2</sup>C circuitry is always active (Standby or Active Mode of the ZOPT2202). If the I<sup>2</sup>C address has not yet been read from the memory block, the device will respond with “NACK” to any request and ignore the possible commands. An attempt to read or write to non-existing addresses will be answered with “NACK.”

#### 3.8.1 I<sup>2</sup>C Address Decoding

The I<sup>2</sup>C address decoding is done during start up after power-on-reset or software reset. Two different I<sup>2</sup>C addresses can be selected through NVM programming (see Table 3.8).

**Table 3.8 I<sup>2</sup>C Address**

Address NVM Level	I <sup>2</sup> C Address		
	7 Bits	Write	Read
0 – default	1010 011 <sub>XBIN</sub>	A6 <sub>HEX</sub>	A7 <sub>HEX</sub>
1 – programmed	1010 010 <sub>XBIN</sub>	A4 <sub>HEX</sub>	A5 <sub>HEX</sub>

#### 3.8.2 I<sup>2</sup>C Register Read

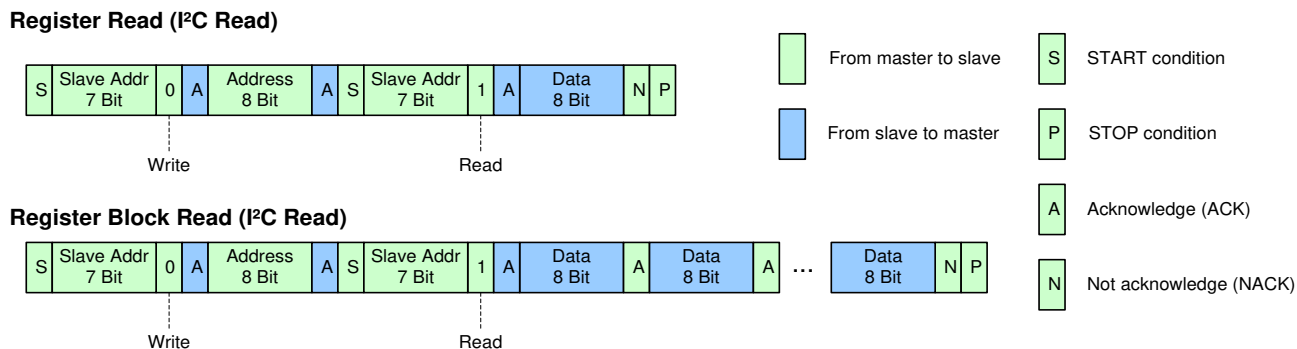
The ZOPT2202 registers can be read individually or in block read mode. When two or more bytes are read in block read mode, reserved register addresses are skipped and the next valid address is referenced. If the last valid address has been reached, but the master continues with the block read, the address counter in the ZOPT2202 will not roll over and the ZOPT2202 returns 00<sub>HEX</sub> for every subsequent byte read.

The block read operation is the only way to ensure correct data read out of multi-byte registers and to avoid splitting of results with HIGH and LOW bytes originating from different conversions. During block read access on the sensor  $\ast\_DATA$  registers, the result update is blocked.

If a read access is started on an address of a non-readable register, the ZOPT2202 will return NACK until the I<sup>2</sup>C operation is ended.

Read operations must follow the timing diagram in Figure 3.5.

**Figure 3.5 I<sup>2</sup>C Register Read**



**3.8.3 Register Write**

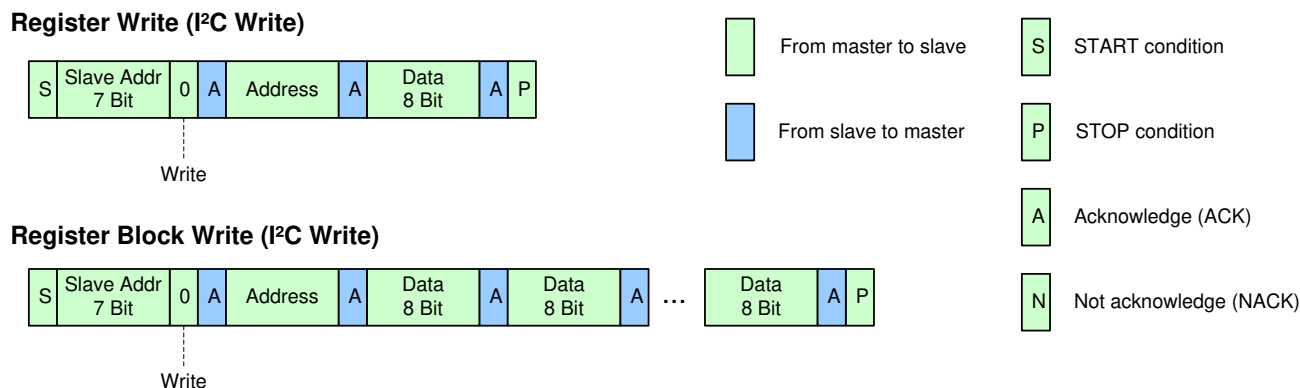
The ZOPT2202 registers can be written to individually or in block write mode. When two or more bytes are written in block write mode, reserved registers and read-only registers are skipped. The transmitted data is automatically applied to the next writable register. If a register includes read (R) and read/write (RW) bits, the register is not skipped. Data written to read-only bits are ignored.

If the last valid address of the ZOPT2202's address range is reached but the master attempts to continue the block write operation, the address counter of the ZOPT2202 will not roll over. The ZOPT2202 will return NACK for every following byte sent by the master until the I<sup>2</sup>C operation is ended.

If a write access is started on an address of a non-writeable register, the ZOPT2202 will return NACK until the I<sup>2</sup>C operation is ended.

Write operations must follow the timing diagram in Figure 3.6.

**Figure 3.6 I<sup>2</sup>C Register Write**



3.8.4 I<sup>2</sup>C Interface—Bus Timing

Figure 3.7 Bus Timing

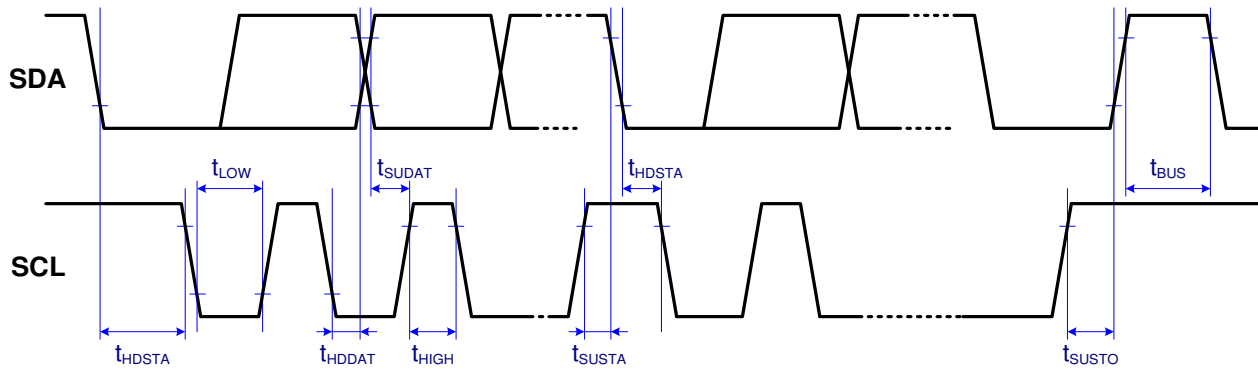


Table 3.9 Bus Timing Characteristic

PARAMETER	SYMBOL	Standard Mode	Fast Mode	UNITS
Maximum SCL clock frequency	$f_{SCL}$	100	400	kHz
Minimum START condition hold time relative to SCL edge	$t_{HDSTA}$	4		$\mu$ S
Minimum SCL clock low width	$t_{LOW}$	4.7		$\mu$ S
Minimum SCL clock high width	$t_{HIGH}$	4		$\mu$ S
Minimum START condition setup time relative to SCL edge	$t_{SUSTA}$	4.7		$\mu$ S
Minimum data hold time on SDA relative to SCL edge	$t_{HDDAT}$	0		$\mu$ S
Minimum data setup time on SDA relative to SCL edge	$t_{SUDAT}$	0.1	0.1	$\mu$ S
Minimum STOP condition setup time on SCL	$t_{SUSTO}$	4		$\mu$ S
Minimum bus free time between stop condition and start condition	$t_{BUS}$	4.7		$\mu$ S

### 3.9 Summary of Internal Registers

**Table 3.10 Register Overview**

Address	Type	Name	Default Value	Description
00 <sub>HEX</sub>	RW	MAIN_CTRL	00 <sub>HEX</sub>	Operation mode control, software (SW) reset
04 <sub>HEX</sub>	RW	LS_MEAS_RATE	22 <sub>HEX</sub>	Measurement rate and resolution setting
05 <sub>HEX</sub>	RW	LS_GAIN	01 <sub>HEX</sub>	Analog gain range setting
06 <sub>HEX</sub>	R	PART_ID	B2 <sub>HEX</sub>	Part number ID and revision ID
07 <sub>HEX</sub>	R	MAIN_STATUS	20 <sub>HEX</sub>	Power-on status, interrupt status, data status
0A <sub>HEX</sub>	R	UVB2_DATA_0	00 <sub>HEX</sub>	UVB2 - ADC measurement data, LSB
0B <sub>HEX</sub>	R	UVB2_DATA_1	00 <sub>HEX</sub>	UVB2 - ADC measurement data
0C <sub>HEX</sub>	R	UVB2_DATA_2	00 <sub>HEX</sub>	UVB2 - ADC measurement data, MSB
0D <sub>HEX</sub>	R	UVA_DATA_0	00 <sub>HEX</sub>	UVA - ADC measurement data, LSB
0E <sub>HEX</sub>	R	UVA_DATA_1	00 <sub>HEX</sub>	UVA - ADC measurement data
0F <sub>HEX</sub>	R	UVA_DATA_2	00 <sub>HEX</sub>	UVA - ADC measurement data, MSB
10 <sub>HEX</sub>	R	UVB_DATA_0	00 <sub>HEX</sub>	UVB - ADC measurement data, LSB
11 <sub>HEX</sub>	R	UVB_DATA_1	00 <sub>HEX</sub>	UVB - ADC measurement data
12 <sub>HEX</sub>	R	UVB_DATA_2	00 <sub>HEX</sub>	UVB - ADC measurement data, MSB
13 <sub>HEX</sub>	R	UV_COMP_DATA_0	00 <sub>HEX</sub>	UV_COMP - ADC measurement data, LSB
14 <sub>HEX</sub>	R	UV_COMP_DATA_1	00 <sub>HEX</sub>	UV_COMP - ADC measurement data
15 <sub>HEX</sub>	R	UV_COMP_DATA_2	00 <sub>HEX</sub>	UV_COMP - ADC measurement data, MSB
16 <sub>HEX</sub>	R	COMP_DATA_0	00 <sub>HEX</sub>	COMP - ADC measurement data, LSB
17 <sub>HEX</sub>	R	COMP_DATA_1	00 <sub>HEX</sub>	COMP - ADC measurement data
18 <sub>HEX</sub>	R	COMP_DATA_2	00 <sub>HEX</sub>	COMP - ADC measurement data, MSB
19 <sub>HEX</sub>	RW	INT_CFG	10 <sub>HEX</sub>	Interrupt configuration
1A <sub>HEX</sub>	RW	INT_PST	00 <sub>HEX</sub>	Interrupt persist setting
21 <sub>HEX</sub>	RW	LS_THRES_UP_0	FF <sub>HEX</sub>	Interrupt upper threshold, LSB
22 <sub>HEX</sub>	RW	LS_THRES_UP_1	FF <sub>HEX</sub>	Interrupt upper threshold, intervening bits
23 <sub>HEX</sub>	RW	LS_THRES_UP_2	0F <sub>HEX</sub>	Interrupt upper threshold, MSB
24 <sub>HEX</sub>	RW	LS_THRES_LOW_0	00 <sub>HEX</sub>	Interrupt lower threshold, LSB
25 <sub>HEX</sub>	RW	LS_THRES_LOW_1	00 <sub>HEX</sub>	Interrupt lower threshold, intervening bits
26 <sub>HEX</sub>	RW	LS_THRES_LOW_2	00 <sub>HEX</sub>	Interrupt lower threshold, MSB

Address	Type	Name	Default Value	Description
27 <sub>HEX</sub>	RW	LS_THRES_VAR	00 <sub>HEX</sub>	Interrupt variance threshold
2F <sub>HEX</sub>	RW	DEVICE_CONFIG	00 <sub>HEX</sub>	Control bit for I <sup>2</sup> C address
30 <sub>HEX</sub>	RW	SPECIAL_MODE_1		Special operation mode register 1
31 <sub>HEX</sub>	RW	SPECIAL_MODE_2		Special operation mode register 2

### 3.10 Detailed Description of Registers

#### 3.10.1 MAIN\_CTRL

Address                   00<sub>HEX</sub>  
 Default value           00<sub>HEX</sub>  
 Register access        RW

Bit	7	6	5	4	3	2	1	0
00 <sub>HEX</sub>	0	0	0	SW reset	UVB_ONLY	RawMode_SEL	LS_EN	0

Bit[4]       *SW reset* If bit is set to 1, a software reset will be triggered.

Bit[3]       *UVB\_ONLY* This bit is only checked if *LS\_EN* is active.  
 0 (default)       UVAB Modes:       Further UVAB sub-mode selection by Bit[2]  
 1                   UVB\_ONLY:       UVB, UV\_COMP channels activated,  
   UVA, UVB2, COMP channels deactivated  
   Mode takes precedence over other operation modes

Bit[2]       *RawMode\_SEL* This bit selects the respective UVAB sub-mode  
 0 (default)       UVAB\_S            UVA, UVB2, COMP channels activated  
   UVB, UV\_COMP channels deactivated  
 1                   UVAB\_Raw        UVA, UVB, UVB2, UV\_COMP, and COMP channels activated

Bit[1]       *LS\_EN*  
 1                   Light sensor active  
 0 (default)       Light sensor standby

Bit[0]       Reserved

Writing to this register stops the ongoing measurements and starts new measurements (depending on the respective enable bits).



### 3.10.2 LS\_MEAS\_RATE

Address 04<sub>HEX</sub>  
 Default value 22<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
04 <sub>HEX</sub>	0	LS Resolution / Bit Width			0	LS Measurement Rate		

Bit[6:4] *Light Sensor Resolution/ Bit Width.* The resolution selected via this register will have an effect on the measurement time and the accuracy of the measurement.

- 000<sub>BIN</sub> 20-Bit – 400ms
- 001<sub>BIN</sub> 19-Bit – 200ms
- 010<sub>BIN</sub> 18-Bit – 100ms **(default)**
- 011<sub>BIN</sub> 17-Bit – 50ms
- 100<sub>BIN</sub> 16-Bit – 25ms
- 101<sub>BIN</sub> 13-Bit – 3.125ms
- 110<sub>BIN</sub> Reserved
- 111<sub>BIN</sub> Reserved

Bit[2:0] *LS Measurement Rate.* This bit field controls the timing of the periodic measurements of the light sensor in Active Mode.

- 000<sub>BIN</sub> 25ms
- 001<sub>BIN</sub> 50ms
- 010<sub>BIN</sub> 100ms **(default)**
- 011<sub>BIN</sub> 200ms
- 100<sub>BIN</sub> 500ms
- 101<sub>BIN</sub> 1000ms
- 110<sub>BIN</sub> 2000ms
- 111<sub>BIN</sub> 2000ms



**Note:** When the measurement repeat rate is programmed to be faster than possible for the specified ADC measurement time, the repeat rate will be lower than programmed (maximum speed).

Writing to this register stops the ongoing measurements and starts new measurements (depending on the respective enable bits).

### 3.10.3 LS\_GAIN

Address 05<sub>HEX</sub>  
 Default value 01<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
05 <sub>HEX</sub>	0	0	0	0	0	LS Gain Range		

Note: The following UVA / UVB detection ranges apply to the 20-bit resolution setting (measurement time = 400ms); see Table 3.5 and Table 3.6 for further details.

*LS Detection Ranges:*

Bit[2:0]	UVA Sensor (temperature and stray light compensated):			
	000 <sub>BIN</sub>	Gain: 1	0.106 to 111026	μW/cm <sup>2</sup>
	001 <sub>BIN</sub>	Gain: 3 ( <b>default</b> )	0.035 to 37009	μW/cm <sup>2</sup>
	010 <sub>BIN</sub>	Gain: 6	0.018 to 18504	μW/cm <sup>2</sup>
	011 <sub>BIN</sub>	Gain: 9	0.012 to 12336	μW/cm <sup>2</sup>
	100 <sub>BIN</sub>	Gain: 18	0.006 to 6168	μW/cm <sup>2</sup>

Bit[2:0]	UVB Sensor (temperature and stray light compensated):			
	000 <sub>BIN</sub>	Gain: 1	0.36 to 377487	μW/cm <sup>2</sup>
	001 <sub>BIN</sub>	Gain: 3 ( <b>default</b> )	0.086 to 125829	μW/cm <sup>2</sup>
	010 <sub>BIN</sub>	Gain: 6	0.043 to 62915	μW/cm <sup>2</sup>
	011 <sub>BIN</sub>	Gain: 9	0.029 to 41943	μW/cm <sup>2</sup>
	100 <sub>BIN</sub>	Gain: 18	0.014 to 20972	μW/cm <sup>2</sup>

Writing to this register stops the ongoing measurements and starts new measurements (depending on the respective enable bits).

### 3.10.4 PART\_ID

Address 06<sub>HEX</sub>  
 Default value B2<sub>HEX</sub>  
 Register access R

Bit	7	6	5	4	3	2	1	0
06 <sub>HEX</sub>	Part Number ID				Revision ID			

Bit[7:4] Part number ID

Bit[3:0] Revision ID of the component. The value increases by one each time a new silicon revision is manufactured

### 3.10.5 MAIN\_STATUS

Address 07<sub>HEX</sub>  
 Default value 20<sub>HEX</sub>  
 Register access R

Bit	7	6	5	4	3	2	1	0
07 <sub>HEX</sub>	0	0	Power-On status	LS interrupt status	LS data status	0	0	0

Bit[5] *Power-On status*. If set to 1, the part went through a power-up event, either because the part was turned on or because there was a power-supply voltage disturbance

**A value of 1 is the default at first register read after power-on reset.**

**Note:** All interrupt threshold settings in the registers have been reset to power-on default states and should be examined if the *Power-On status* flag is set.

The special operation mode needed for UVAB\_Raw Mode is turned off if a power-up event occurs and the mode must be initialized before UVAB\_Raw Mode activation.

**The flag is cleared after the register is read.**

Bit[4] *LS interrupt status* (updated even when the interrupt pin is disabled)

- 0 interrupt condition has not occurred (**default**)
- 1 interrupt condition has occurred (cleared after read)

Bit[3] *LS data status*

- 0 old data, already read (**default**)
- 1 new data, not yet read (cleared after read)

Bit[2:0] Reserved

### 3.10.6 UVB2\_DATA

Address                0A<sub>HEX</sub> and 0B<sub>HEX</sub> and 0C<sub>HEX</sub>  
 Default value        00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access      R

Bit	7	6	5	4	3	2	1	0
0A <sub>HEX</sub>	UVB2_DATA_0[7:0]							
0B <sub>HEX</sub>	UVB2_DATA_1[15:8]							
0C <sub>HEX</sub>	0	0	0	0	UVB2_DATA_2[19:16]			

UVB2 channel digital output data (unsigned integer, 13 to 20 bit, LSB aligned).

Applied temperature and stray light compensation depends on operation mode. See section 3.4 for details.

When an I<sup>2</sup>C read operation is active and points to an address in the range 07<sub>HEX</sub> to 18<sub>HEX</sub>, all registers in this range are locked until the I<sup>2</sup>C read operation is completed or this address range is left.

This guarantees that the data in the registers belongs to the same measurement cycle. New measurement data is stored into temporary registers and the actual \*\_DATA registers are updated as soon as there is no on-going I<sup>2</sup>C read operation in the address range 07<sub>HEX</sub> to 18<sub>HEX</sub>.

Register 0A<sub>HEX</sub>    Bit[7:0]        UVB2 diode data least significant data byte  
 Register 0B<sub>HEX</sub>    Bit[7:0]        UVB2 diode data intervening data byte  
 Register 0C<sub>HEX</sub>    Bit[3:0]        UVB2 diode data most significant data byte

### 3.10.7 UVA\_DATA

Address            0D<sub>HEX</sub> and 0E<sub>HEX</sub> and 0F<sub>HEX</sub>  
 Default value    00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access   R

Bit	7	6	5	4	3	2	1	0
0D <sub>HEX</sub>	UVA_DATA_0[7:0]							
0E <sub>HEX</sub>	UVA_DATA_1[15:8]							
0F <sub>HEX</sub>	0	0	0	0	UVA_DATA_2[19:16]			

UVA channel digital output data (unsigned integer, 13 to 20 bit, LSB aligned).

Applied temperature and stray light compensation depends on operation mode. See section 3.4 for details.

When an I<sup>2</sup>C read operation is active and points to an address in the range 07<sub>HEX</sub> to 18<sub>HEX</sub>, all registers in this range are locked until the I<sup>2</sup>C read operation is completed or this address range is left.

This guarantees that the data in the registers belongs to the same measurement cycle. New measurement data is stored into temporary registers and the actual \*\_DATA registers are updated as soon as there is no on-going I<sup>2</sup>C read operation in the address range 07<sub>HEX</sub> to 18<sub>HEX</sub>.

Register 0D <sub>HEX</sub>	Bit[7:0]	UVA diode data least significant data byte
Register 0E <sub>HEX</sub>	Bit[7:0]	UVA diode data intervening data byte
Register 0F <sub>HEX</sub>	Bit[3:0]	UVA diode data most significant data byte

### 3.10.8 UVB\_DATA

Address                10<sub>HEX</sub> and 11<sub>HEX</sub> and 12<sub>HEX</sub>  
 Default value        00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access      R

Bit	7	6	5	4	3	2	1	0
10 <sub>HEX</sub>	UVB_DATA_0[7:0]							
11 <sub>HEX</sub>	UVB_DATA_1[15:8]							
12 <sub>HEX</sub>	0	0	0	0	UVB_DATA_2[19:16]			

UVB channel digital output data (unsigned integer, 13 to 20 bit, LSB aligned).

Applied temperature and stray light compensation depends on operation mode. See section 3.4 for details.

When an I<sup>2</sup>C read operation is active and points to an address in the range 07<sub>HEX</sub> to 18<sub>HEX</sub>, all registers in this range are locked until the I<sup>2</sup>C read operation is completed or this address range is left.

This guarantees that the data in the registers belongs to the same measurement cycle. New measurement data is stored into temporary registers and the actual \*\_DATA registers are updated as soon as there is no on-going I<sup>2</sup>C read operation in the address range 07<sub>HEX</sub> to 18<sub>HEX</sub>.

Register 10 <sub>HEX</sub>	Bit[7:0]	UVB diode data least significant data byte
Register 11 <sub>HEX</sub>	Bit[7:0]	UVB diode data intervening data byte
Register 12 <sub>HEX</sub>	Bit[3:0]	UVB diode data most significant data byte

### 3.10.9 UV\_COMP\_DATA

Address                13<sub>HEX</sub> and 14<sub>HEX</sub> and 15<sub>HEX</sub>  
 Default value        00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access      R

Bit	7	6	5	4	3	2	1	0
13 <sub>HEX</sub>	UV_COMP_DATA_0[7:0]							
14 <sub>HEX</sub>	UV_COMP_DATA_1[15:8]							
15 <sub>HEX</sub>	0	0	0	0	UV_COMP_DATA_2[19:16]			

Digital output data from the temperature and stray light compensation channel for UVB data (UV\_COMP) (unsigned integer, 13 to 20 bit, LSB aligned).

Applied compensation depends on operation mode. See section 3.4 for details.

When an I<sup>2</sup>C read operation is active and points to an address in the range 07<sub>HEX</sub> to 18<sub>HEX</sub>, all registers in this range are locked until the I<sup>2</sup>C read operation is completed or this address range is left.

This guarantees that the data in the registers belongs to the same measurement cycle. New measurement data is stored into temporary registers and the actual \*\_DATA registers are updated as soon as there is no on-going I<sup>2</sup>C read operation in the address range 07<sub>HEX</sub> to 18<sub>HEX</sub>.

Register 13 <sub>HEX</sub>	Bit[7:0]	UV_COMP diode data least significant data byte
Register 14 <sub>HEX</sub>	Bit[7:0]	UV_COMP diode data intervening data byte
Register 15 <sub>HEX</sub>	Bit[3:0]	UV_COMP diode data most significant data byte

**3.10.10 COMP\_DATA**

Address 16<sub>HEX</sub> and 17<sub>HEX</sub> and 18<sub>HEX</sub>  
 Default value 00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access R

Bit	7	6	5	4	3	2	1	0
16 <sub>HEX</sub>	COMP_DATA_0[7:0]							
17 <sub>HEX</sub>	COMP_DATA_1[15:8]							
18 <sub>HEX</sub>	0	0	0	0	COMP_DATA_2[19:16]			

Digital output data from the temperature and stray light compensation channel for UVA and UVB2 data (COMP) (unsigned integer, 13 to 20 bit, LSB aligned).

Applied compensation depends on operation mode. See section 3.4 for details.

When an I<sup>2</sup>C read operation is active and points to an address in the range 07<sub>HEX</sub> to 18<sub>HEX</sub>, all registers in this range are locked until the I<sup>2</sup>C read operation is completed or this address range is left.

This guarantees that the data in the registers belongs to the same measurement cycle. New measurement data is stored into temporary registers and the actual \*\_DATA registers are updated as soon as there is no on-going I<sup>2</sup>C read operation in the address range 07<sub>HEX</sub> to 18<sub>HEX</sub>.

Register 16<sub>HEX</sub> Bit[7:0] COMP diode data least significant data byte  
 Register 17<sub>HEX</sub> Bit[7:0] COMP diode data intervening data byte  
 Register 18<sub>HEX</sub> Bit[3:0] COMP diode data most significant data byte



**3.10.11 INT\_CFG**

Address 19<sub>HEX</sub>  
 Default value 10<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
19 <sub>HEX</sub>	0	0	LS_INT_SEL		LS_VAR_MODE	LS_INT_EN	0	0

Bit[5:4] *LS\_INT\_SEL* Light sensor interrupt source select  
 00 UVB2 channel  
 01 UVA channel **(default)**  
 10 UV\_COMP channel  
 11 UVB channel

Bit[3] *LS\_VAR\_MODE* Light sensor variation interrupt mode  
 0 Threshold Interrupt Mode **(default)**  
 1 Variation Interrupt Mode

Bit[2] *LS\_INT\_EN* Light sensor interrupt enable  
 0 Interrupt disabled **(default)**  
 1 Interrupt enabled

**3.10.12 INT\_PST**

Address 1A<sub>HEX</sub>  
 Default value 00<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
1A <sub>HEX</sub>	LS_PERSIST				0	0	0	0

Bit[7:4] This register sets the number of similar consecutive light sensor (LS) interrupt events that must occur before the interrupt is asserted.  
 0000<sub>BIN</sub> Every LS value out of threshold range **(default)** asserts an interrupt.  
 0001<sub>BIN</sub> 2 consecutive LS values out of threshold range assert an interrupt.  
 ...  
 1111<sub>BIN</sub> 16 consecutive LS values out of threshold range assert an interrupt.

Bit[3:0] Reserved.

### 3.10.13 LS\_THRES\_UP

Address 21<sub>HEX</sub> and 22<sub>HEX</sub> and 23<sub>HEX</sub>  
 Default value FF<sub>HEX</sub> and FF<sub>HEX</sub> and 0F<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
21 <sub>HEX</sub>	LS_THRES_UP_0							
22 <sub>HEX</sub>	LS_THRES_UP_1							
23 <sub>HEX</sub>	0	0	0	0	LS_THRES_UP_2			

LS\_THRES\_UP\_x sets the upper threshold value for the LS interrupt.

The interrupt controller compares the value in LS\_THRES\_UP\_x against measured data in the \*\_DATA\_x registers of the selected LS interrupt channel. It generates an interrupt event if \*\_DATA\_x exceeds the threshold level.

The data format for LS\_THRES\_UP\_x must match that of the \*\_DATA\_x registers.

Register 21<sub>HEX</sub> Bit[7:0] LS upper interrupt threshold value, LSB  
 Register 22<sub>HEX</sub> Bit[7:0] LS upper interrupt threshold value, intervening byte  
 Register 23<sub>HEX</sub> Bit[3:0] LS upper interrupt threshold value, MSB

### 3.10.14 LS\_THRES\_LOW

Address 24<sub>HEX</sub> and 25<sub>HEX</sub> and 26<sub>HEX</sub>  
 Default value 00<sub>HEX</sub> and 00<sub>HEX</sub> and 00<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
24 <sub>HEX</sub>	LS_THRES_LOW_0							
25 <sub>HEX</sub>	LS_THRES_LOW_1							
26 <sub>HEX</sub>	0	0	0	0	LS_THRES_LOW_2			

LS\_THRES\_LOW\_x sets the lower threshold value for the LS interrupt. The interrupt controller compares the value in LS\_THRES\_LOW\_x against measured data in the \*\_DATA\_x registers of the selected LS interrupt channel. It generates an interrupt event if the \*\_DATA\_x is below the threshold level.

The data format for LS\_THRES\_LOW\_x must match that of the \*\_DATA\_x registers.

Register 24<sub>HEX</sub> Bit[7:0] LS lower interrupt threshold value, LSB  
 Register 25<sub>HEX</sub> Bit[7:0] LS lower interrupt threshold value, intervening byte  
 Register 26<sub>HEX</sub> Bit[3:0] LS lower interrupt threshold value, MSB

**3.10.15 LS\_THRES\_VAR**

Address 27<sub>HEX</sub>  
 Default value 00<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
27 <sub>HEX</sub>	0	0	0	0	0	LS_THRES_VAR		

Bit[2:0] LS variance threshold

**Code** Interrupt generated when

000<sub>BIN</sub> new DATA\_x varies by **8 counts** compared to previous result (**default**)

001<sub>BIN</sub> new DATA\_x varies by **16 counts** compared to previous result

010<sub>BIN</sub> new DATA\_x varies by **32 counts** compared to previous result

011<sub>BIN</sub> new DATA\_x varies by **64 counts** compared to previous result

100<sub>BIN</sub> new DATA\_x varies by **128 counts** compared to previous result

101<sub>BIN</sub> new DATA\_x varies by **256 counts** compared to previous result

110<sub>BIN</sub> new DATA\_x varies by **512 counts** compared to previous result

111<sub>BIN</sub> new DATA\_x varies by **1024 counts** compared to previous result

**3.10.16 DEVICE\_CONFIG**

Address 2F<sub>HEX</sub>  
 Default value 00<sub>HEX</sub>  
 Register access RW

Bit	7	6	5	4	3	2	1	0
2F <sub>HEX</sub>	0	0	0	0	Reserved	Reserved	I <sup>2</sup> C Address	Reserved

Bit[1] I<sup>2</sup>C Address

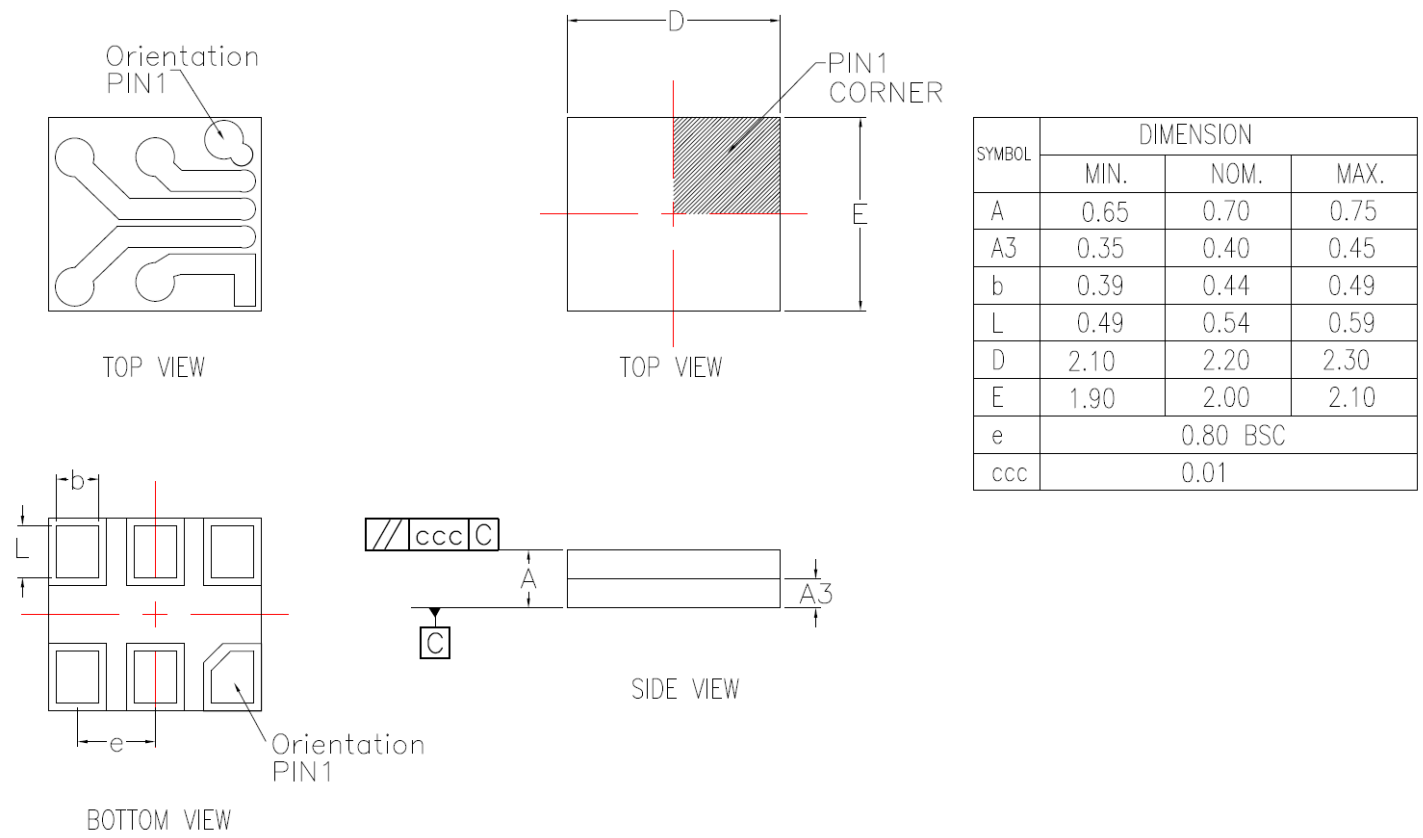
0 (**default**) 7-bit format (no R/W bit consideration): 53<sub>HEX</sub>  
 8-bit format (with R/W bit consideration): A6<sub>HEX</sub> / A7<sub>HEX</sub>

1 7-bit format (no R/W bit consideration): 52<sub>HEX</sub>  
 8-bit format (with R/W bit consideration): A4<sub>HEX</sub> / A5<sub>HEX</sub>

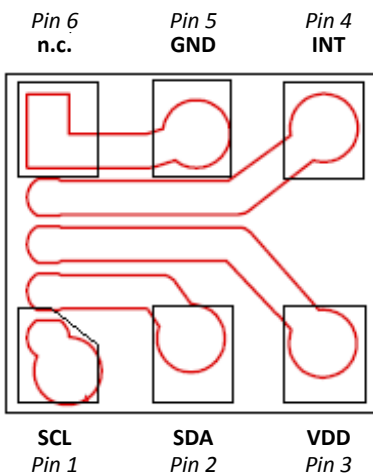
## 4. Packages

### 4.1 LGA6 Package (2.0 × 2.2 × 0.7 mm)

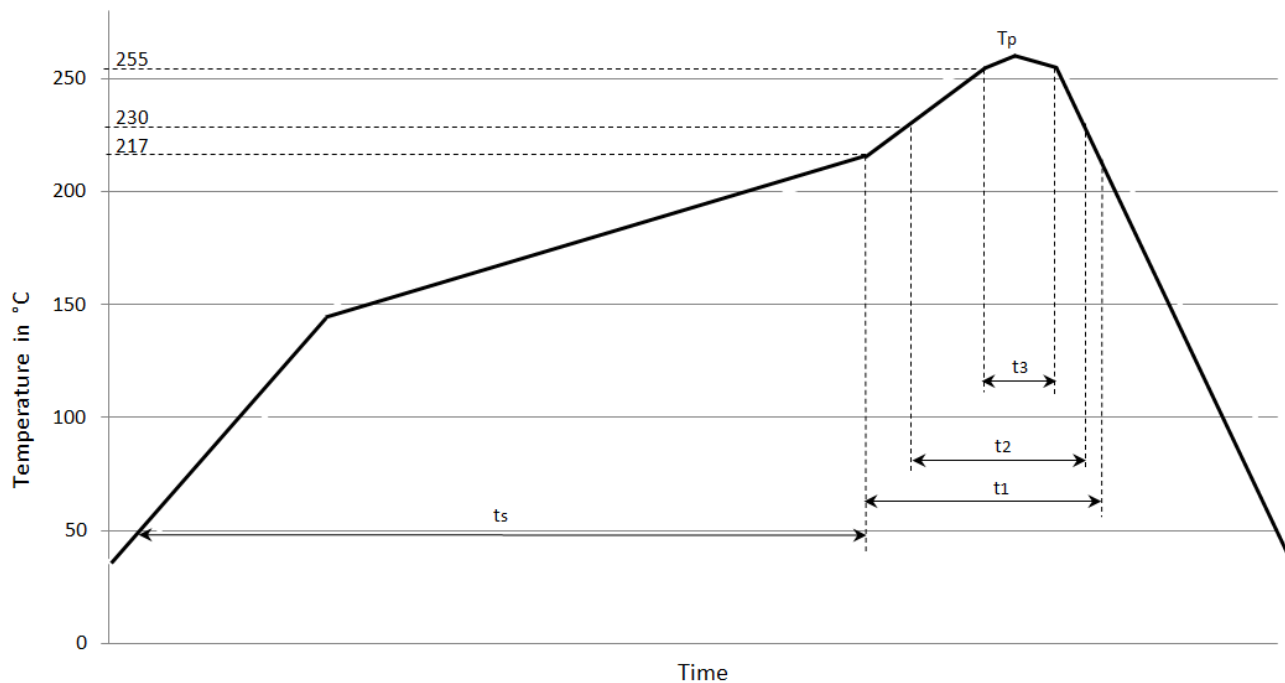
#### 4.1.1 Mechanical Dimensions



#### 4.1.2 Pin Assignment (Top View)



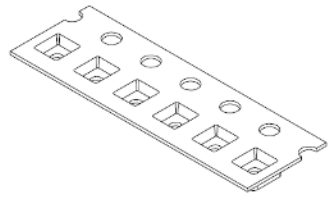
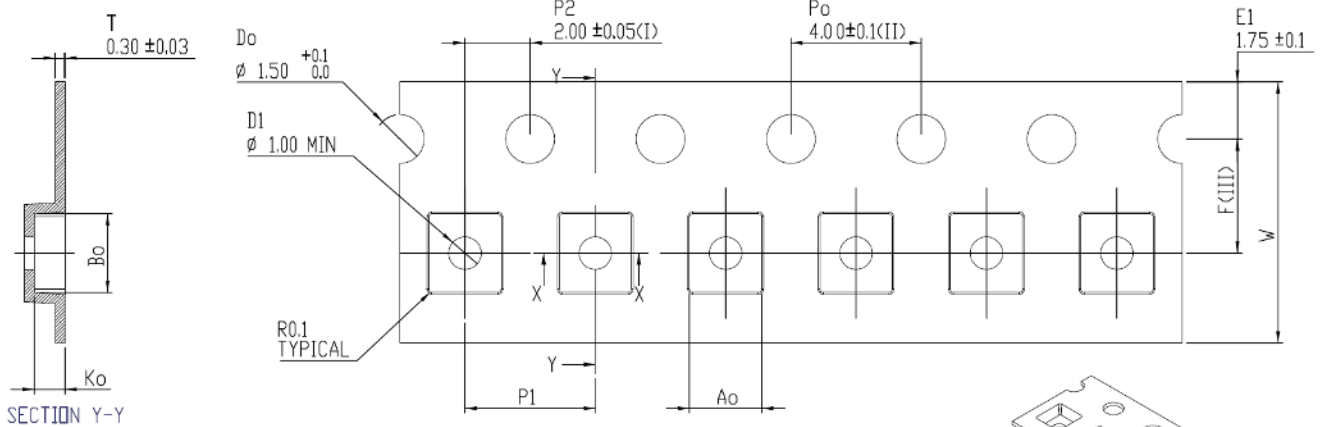
### 4.1.3 Reflow Profile



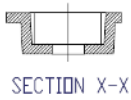
**Table 4.1 Reflow Profile Specifications**

Parameter	Legend	Component
Time above 217°C	$t_1$	$\leq 60$ sec
Time above 230°C	$t_2$	$\leq 50$ sec
Time above 255°C	$t_3$	$\leq 15$ sec
Peak Temp	$T_p$	$\leq 260^\circ\text{C}$
Soak Time (50°C – 217°C)	$t_s$	$\leq 180$ sec
Temperature Gradient Preheating		$< 3$ °C/sec
Temperature Gradient Cooling		$< 5$ °C/sec

4.1.4 LGA Tape Packaging Information



Ao	2.22 +/- 0.1
Bo	2.42 +/- 0.1
Ko	0.95 +/- 0.1
F	3.50 +/- 0.05
P1	4.00 +/- 0.1
W	8.00 +0.3/-0.1



NOTES : (UNLESS OTHERWISE SPECIFIED)

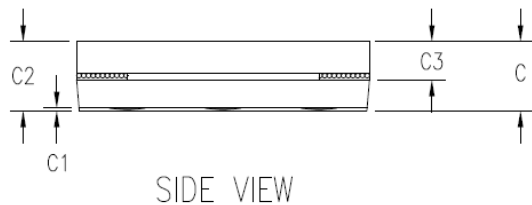
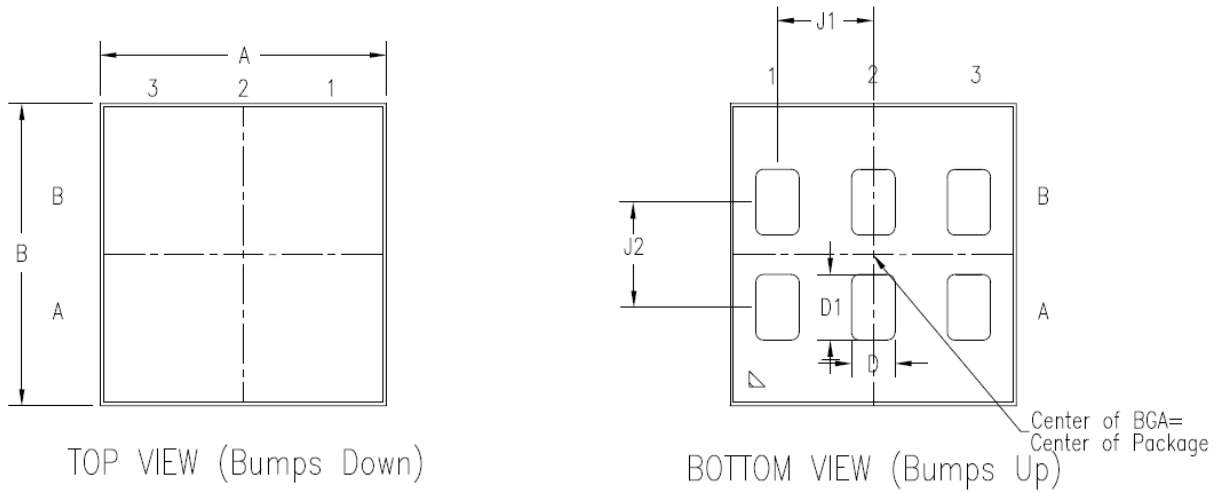
1. SUPPLIER : C-PAK
2. SUPPLIER PART NUMBER : ODFN-2x2.2x0.7 (EM1089-16)
3. Po 10 PITCHES CUMULATIVE TOLERANCE ON TAPE : ±0.20 mm
4. REFER TO MSA-3018 FOR THE ALLOWABLE CAMBER REQUIREMENT.
5. MATERIAL : BLACK CONDUCTIVE POLYSTYRENE.
6. Ao AND Bo MEASURED FROM THE BOTTOM OF THE POCKET.
7. Ko MEASURED FROM A PLANE ON THE INSIDE BOTTOM OF THE POCKET TO THE TOP SURFACE OF THE CARRIER.
8. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE.
9. POCKET CENTER AND POCKET HOLE CENTER MUST BE SAME POSITION.
10. REFER TO MAA-3092 & MSA-3018 FOR THE IDT STANDARD REQUIREMENT FOR CARRIER TAPE.
11. ALL THE DIMENSIONS ARE IN MILLIMETERS (MM).
12. LENGTH PER ROLL = 500 METERS.
13. ALLOWABLE CAMBER TO BE 2/250 MM MAXIMUM.

## 4.2 TSV Package (1.1 × 1.2 × 0.26 mm)

Note: In the following mechanical diagram, the symbol N refers to the number of pins, N1 refers to the number of pin columns, and N2 refers to the number of rows.

### 4.2.1 Mechanical Dimensions

Mechanical Diagram



SYMBOL	PACKAGE DIMENSIONS		
	MIN	NOM	MAX
A	1065	1090	1115
B	1125	1150	1175
C	203	263	323
C1	5	10	15
C2	218	263	308
C3	125	145	165
D	135	165	195
D1	250	280	310
N	6 (INC)		
N1	3		
N2	2		
J1		365	
J2		400	

**NOTE:**

1. DIMENSIONS in  $\mu\text{m}$ .
2. The thickness of Bond-1 glass is 100  $\mu\text{m}$  (green glass x 1pcs).
3. The material of solder printing is SAC305.

## 5. Part Order Information

Product Sales Code	Description	Package
ZOPT2202AC5R	ZOPT2202 LGA6 – Temperature range: -40 to +90°C	Reel
ZOPT2202AC9R	ZOPT2202 TSV – Temperature range: -40 to +90°C	Reel
ZOPT2202KIT V1.0	ZOPT2202 Evaluation Kit, including ZOPT Control Board, mini-USB cable, and 1 ZOPT2202 sample mounted on the LGA6 Sensor Board; kit software is available for free download – see the ZOPT Evaluation Kit Quick Start-up Guide included in the kit for instructions.	

## 6. Glossary

Term	Description
ADC	Analog-to-Digital Converter
LGA	Land-Grid Array (package type)
LS	Light Sensor (can be UVAS, UVBS, or UVB2S depending on ZOPT2202 configuration)
NVM	Non-volatile Memory
PWM	Pulse Width Modulation
SDA	Serial Data
SCL	Serial Clock
SW	Software
TVS	Through-Silicon Vias (package type)
UVA	Ultra violet energy in spectral range of 315nm to 400nm wavelength
UVB	Ultra violet energy in spectral range of 280nm to 315nm wavelength



## 7. Document Revision History

Release Date	Description
September 21, 2016	<ul style="list-style-type: none"> <li>▪ Added new package type TSV and its package information (see new section 4.2).</li> <li>▪ Update for part codes.</li> <li>▪ Addition of note about trimming factors for the UVAB_Raw Mode in Table 3.3.</li> <li>▪ Addition of Table 3.1 for LGA pin descriptions and Table 3.2 for TVS package.</li> <li>▪ Updates for Table 3.5 and Table 3.6.</li> <li>▪ Updates for Figure 3.3 and Figure 3.4.</li> <li>▪ Update for section 3.10.3</li> <li>▪ Added new section 4.1.3 for the reflow profile.</li> <li>▪ Added new section 4.1.4 for tape packaging information.</li> <li>▪ Minor edits for clarity and formatting.</li> </ul>
April 20, 2016	Rebranding for IDT. Revision number is replaced with release date.
January 6, 2016 (Revision 1.00)	First release.

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