Designing the VEML4031X00 Into an Application

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ABSTRACT

This application note provides an introduction to the functionality of the VEML4031X00 sensor, application circuits, and mechanical design considerations.

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Designing the VEML4031X00 Into an Application

CONTENTS

Designing the VEML4031X00 Into an Application

1. INTRODUCTION

The VEML4031X00 is a high accuracy digital ambient light sensor with 16-bit resolution in a miniature opaque 4.38 mm x 1.45 mm package. It includes a high sensitivity photodiode, low noise amplifier, and 16-bit A/D converter, and supports an easy to use I^2C bus communication interface and additional interrupt feature.

The ambient light read-out is available as a digital value, and the built-in photodiode response is near that of the human eye. The 16-bit dynamic range offers ambient light detection up to about 172 klx, with a resolution down to 0.0026 lx/counts.

Besides 100 Hz and 120 Hz flicker noise rejection and a low temperature coefficient, the device consumes just 0.5 µA in shutdown mode. The sensor is AEC-Q100 qualified and has an operating range from -40 °C to +110 °C.

The device's high senstivity of 0.0026 lx/counts allows the sensor to be placed behind very dark cover glasses that will dramatically reduce the total light reaching it. The sensor will also work behind clear cover glass, because even high illumination - such as daylight and all indoor lights - will not saturate the device and read-outs up to 172 klx are possible.

2. PIN DESCRIPTION AND BLOCK DIAGRAM

2.1 Pin Description

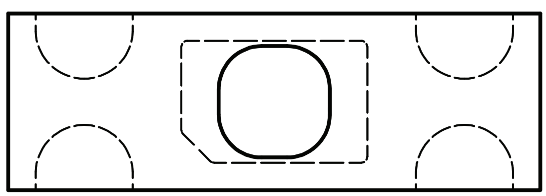


Fig. 1 - Pin Assignment (Top View) of the VEML4031X00

TABLE 1 - PIN DESCRIPTION

PIN NUMBER	PIN NAME	TYPE	DESCRIPTION
1	GND	I	Ground
2	SDA	I / O (open drain)	I^2C serial data
3	SCL	I / O (open drain)	I^2C serial clock
4	V_{DD}	I	Supply voltage

Designing the VEML4031X00 Into an Application

2.2 Block Diagram

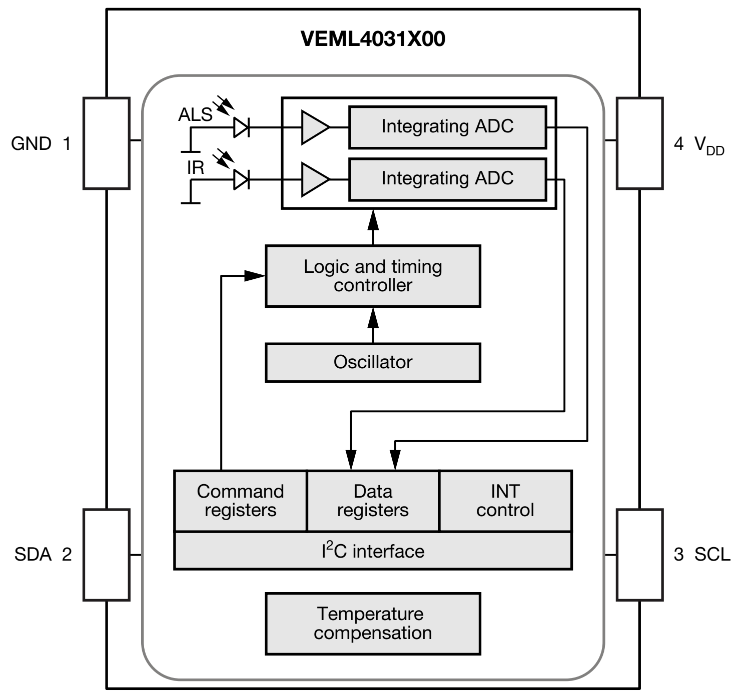


Fig. 2 - Block Diagram

TABLE 2 - BLOCK DIAGRAM DESCRIPTION	
COMPONENT	**DESCRIPTION**
Command registers	Memory storage for writing and reading I²C commands
I²C interface	I²C interface with active low open drain circuitry
Interrupt control	Interrupt control with active low open drain output
ALS, IR	The photodiode of the ALS and IR channels that is converting the received light into a photocurrent, which is then fed into the 16-bit ADC
Integrating ADC	16-bit analog to digital converter converts the analog signal to the digital signal (1); then, the input signal is amplified with an amplifier
Logic & timing controller	Control timer for the measurements
Temperature compensation	Internal temperature compensation structure
Oscillator	Generate internal clock signal

Note

(1) The actual bit resolution is 16 bit for integration times up to 6.25 ms. For 3.125 ms, the 16 bit can no longer be achieved. Please see the resolution table for more detailed information

Designing the VEML4031X00 Into an Application

3. APPLICATION CIRCUIT

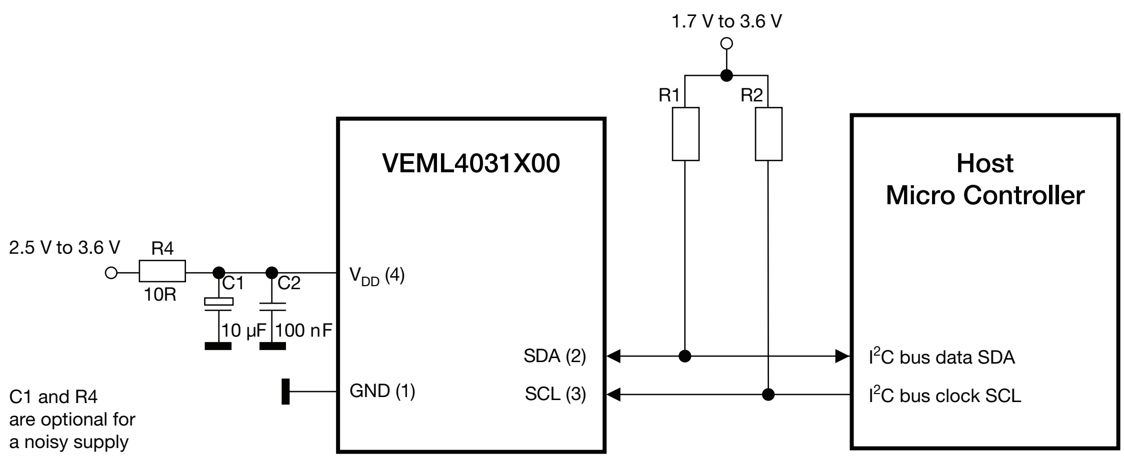


Fig. 3 - Application Circuity to Communicate With the VEML4031X00 via I^2C

TABLE 3 - APPLICATION CIRCUIT PARAMETERS

CIRCUIT PARAMETER	VALUE	DESCRIPTION
V_{DD}	2.5 V to 3.6 V	A stable power supply, such as a low dropout regulator or a switching regulator, is required; the power supply isolation can be further improved with a decoupling capacitor C_1
C_1 - C_2	100 nF to 1 µF	Decoupling capacitors are recommended to reduce the noise in the supply voltage
R_1 - R_2	2.2 kΩ to 4.7 kΩ	Pull-up resistors within the range of 2.2 kΩ to 4.7 kΩ are recommended; any increase in bus capacitance or resistance will increase the logic-high transition time
R_4	10 Ω	Decoupling resistor for noise rejection

Designing the VEML4031X00 Into an Application

4. REGISTER DESCRIPTION

4.1 DEVICE ADDRESS

The predefined 7-bit I^{2}C bus slave address of the VEML4031X00 is set to 0101001 = 0x29.

The 7-bit address can be converted into the 8-bit slave address by adding another bit to the 8-bit command. The least significant bit (LSB) then defines the read or write mode, which results in the 8-bit address of 0101 0010 = 0x52 for write and 0101 0011 = 0x53 for read.

TABLE 4 - REGISTER NAME: DEVICE ADDRESS

ORDERING CODE	7-BIT SLAVE ADDRESS	8-BIT SLAVE ADDRESS	
VEML4031X00	0x29	0x52 (write)	0x53 (read)
VEML40311X00	0x10	0x20 (write)	0x21 (read)

4.2 REGISTER OVERVIEW

The sensor has fourteen user-accessible registers from 0x00 to 0x17 (0x02 and 0x03, 0x08 to 0x0F, and 0x16 are not defined / reserved with different functionalities). Note that due to the location of the two shutdown bits (SD_ON_0 in register 0x00 and SD_ON_1 in register 0x01), it is necessary to always write to both registers at once when configuring the device.

TABLE 5 - COMMAND CODE AND REGISTER DESCRIPTION

COMMAND CODE	DATA BYTE LOW / HIGH	REGISTER NAME	DEFAULT VALUE	FUNCTION	ACCESS
0x00	-	ALS_CONF_0	0x01	Set the integration time	Write and read
				Measurement mode of the sensor	
				Enable interupt function of the ALS channel	
				Switch the sensor on / off	
0x01	-	ALS_CONF_1	0x80	Switch the sensor on / off	
				GAIN and photodiode size setting	
				Interrupt persistance counter	
0x04	Low	ALS_THDH_L	0x00	ALS channel high threshold window setting (low byte)	
0x05	High	ALS_THDH_H	0x00	ALS channel high threshold window setting (high byte)	
0x06	Low	ALS_THDL_L	0x00	ALS channel low threshold window setting (low byte)	
0x07	High	ALS_THDL_H	0x00	ALS channel low threshold window setting (high byte)	
0x10	Low	ALS_DATA_L	0x00	Low byte of 16-bit ALS channel result data	Read only
0x11	High	ALS_DATA_H	0x00	High byte of 16-bit ALS channel result data	
0x12	Low	IR_DATA_L	0x00	Low byte of 16-bit IR channel result data	
0x13	High	IR_DATA_H	0x00	High byte of 16-bit IR channel result data	
0x14	Low	VEML4031X00_ID_L	0x01	ID code	
0x15	High	VEML4031X00_ID_H	0x00	ID code	
0x16	Low	INT_FLAG	0x00	Reserved	
0x17	High	INT_FLAG	0x00	Interrupt and active force mode event flag	

Notes

- Command code 0x00 default value is 0x01 = device is shutdown
- Command 0x00 and command 0x01 must be executed together, they cannot be executed independently

Designing the VEML4031X00 Into an Application

4.3 SENSETIVITY SETTINGS OF THE SENSOR

The resolution of the ALS and IR channels can be determined by the setting of the integration time, the gain factor, and the PD size. The IT, GAIN factor, and PD size cannot be set individually for each channel and is therefore applied to all channels simultaneously.

To achieve the highest resolution of 0.0026 lx/counts for the ALS channel, the max. integration time (400 ms), max. GAIN (gain x 2), and the complete photodiode size (ALS_PDDIV, 4/4 PD used) need to be applied. Accordingly, with the lowest resolution of 2.6296 lx/counts for the ALS channel, at the min. integration time (6.25 ms), min. GAIN (gain x 0.5), and one half of the photodiode size (ALS_PDDIV, 1/4 PD used), the max. illumination level of 172 klx is achievable.

Integration Time Setting

The integration time of the sensor determines its sensitivity, as well as its measurement rate. Hence an increase in the sampling rate can be achieved by decreasing the integration time of the sensor, but this will accordingly result in a reduction of the sensor's sensitivity. The bit ALS_IT in the command code ALS_CONF_0 (0x00) can be used to set the integration time.

TABLE 6 - INTEGRATION TIME

COMMAND CODE (ALS_CONF_0)			0x00	
BIT NAME	**FUNCTION**	**BIT**	**VALUE**	**DESCRIPTION**
ALS_IT	Set the integration time	6 : 4	0x0 (0b000)	3.125 ms (default)
			0x1 (0b001)	6.25 ms
			0x2 (0b010)	12.5 ms
			0x3 (0b011)	25 ms
			0x4 (0b100)	50 ms
			0x5 (0b101)	100 ms
			0x6 (0b110)	200 ms
			0x7 (0b111)	400 ms

Remark: For the integration time of 3.125 ms, the max. available resolution of the output channel is around 15 bit, which accordingly no longer leads to a doubling of the achievable illumination level.

GAIN and PD Size Setting

In command code ALS_CONF_1 (0x01), the bits ALS_PDDIV and ALS_GAIN can be used to adjust the GAIN settings of the VEML4031X00. The settings are irrespective of the channel and will be applied to all of them simultaneously. The ALS_PDDIV changes the effective size of the photodiode. This change will lead to a halving of the sensitivity when applied. The ALS_GAIN sets the internal gain factor and additionally can be used to further tune the sensitivity of the sensors. Please refer to Table 11 and Table 12 from the datasheet to get the best settings for the expected illumination level.

TABLE 7 - GAIN

COMMAND CODE (ALS_CONF_1)			0x01	
BIT NAME	**FUNCTION**	**BIT**	**VALUE**	**DESCRIPTION**
ALS_PDDIV	Set the effective photodiode size for the ALS and IR channel	6	0x0 (0b0)	2/2 PD used
			0x1 (0b1)	1/2 PD used
ALS_GAIN	Set the gain of the ALS and IR channel	4 : 3	0x0 (0b00)	Gain x1
			0x1 (0b01)	Gain x2
			0x2 (0b10)	Gain x0.66
			0x3 (0b11)	Gain x0.5

Remark: Possible saturation effects during the measurement start can be avoided if the application starts with the lowest gain setting: GAIN x 0.5, ALS_PDDIV = 1 (1/4 PD used). The setting GAIN x2 and ALS_PDDIV = 0 (4/4 PD used) should only be used if a high resolution is necessary. For example, if the sensor is placed under a dark cover glass where the illumination level is reduced to a low level.

Designing the VEML4031X00 Into an Application

4.4 BASIC INITZIALIZATION

Active Force and Selftimed Mode

The sensor can be configured in selftimed or active force mode. When the sensor is configured in selftimed mode the measurements are performed continuously until the measurement is stopped. Within the active force mode every measurement must be individually triggered via a software command. Unless not specifically needed due to the application requirements, the selftimed mode is the recommended operating mode. Per default, the sensor is operated in the selftimed mode.

The below figures show the basic initialization flow chart of both modes.

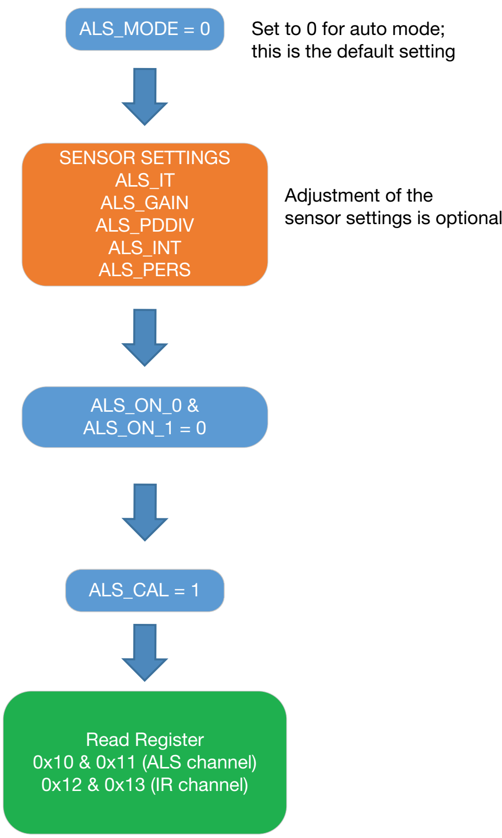


Fig. 4 - Basic Initialization for Selftimed Mode

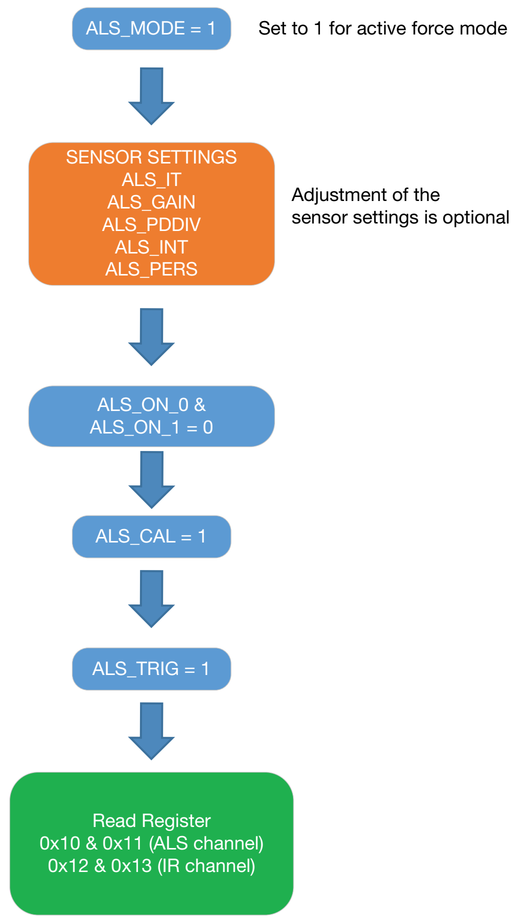


Fig. 5 - Basic Initialization for Active Force Mode

Designing the VEML4031X00 Into an Application

Automatic Gain Control

When the sensor is exposed to a wide range of illumination levels that cannot be covered with one set of sensitivity, the sensitivity of the sensor needs to be adjusted dynamically according to the received illumination level. This can be achieved by adjusting the GAIN and integration time settings of the sensor dynamically by implementing an automatic gain adjustment (AGC) into the software.

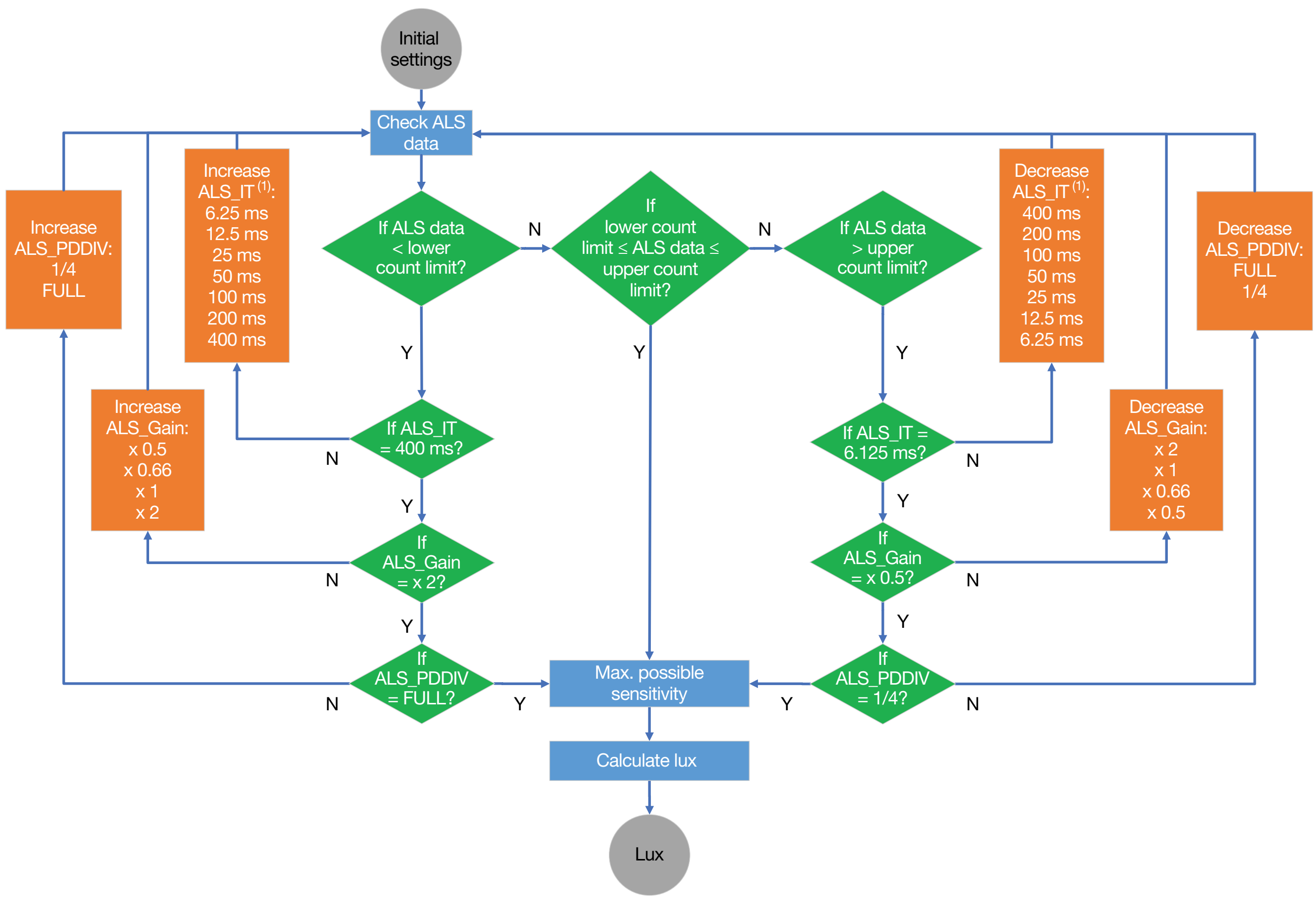


Fig. 6 - VEML4031X00 AGC

Note

- The integration time of 3.125 ms should not be used in the AGC algorithm because the data is no longer 16 bit

Designing the VEML4031X00 Into an Application

4.5 INTERRUPT HANDLING

The interrupt feature of the VEML4031X00 focuses on the ambient light channel results of the sensor only, and is not available for the IR channel. The interrupt can be used to reduce the interactions between the sensor and the microcontroller. The interrupt mode can be enabled with the ALS_INT bit in register ALS_CONF_0 (0x00).

TABLE 8 - INTERRUPT

COMMAND CODE (ALS_CONF_1)			0x01	
BIT NAME	**FUNCTION**	**BIT**	**VALUE**	**DESCRIPTION**
ALS_INT	Enable / disable the interrupt function of the ALS channel	1	0x0 (0b0)	Disable (default)
			0x1 (0b1)	Enable

Persistence Settings

The persistence function ALS_PERS determines the number of consecutive measurements that have to remain above or below the chosen threshold level to activate the interrupt pin.

TABLE 9 - PERSISTANCE

COMMAND CODE (ALS_CONF_1)			0x01	
BIT NAME	**FUNCTION**	**BIT**	**VALUE**	**DESCRIPTION**
ALS_PERS	Set the amount of consecutive threshold crossing events necessary to trigger the interrupt	2 : 1	0x0 (0b00)	1 time (default)
			0x1 (0b01)	2 times
			0x2 (0b10)	4 times
			0x3 (0b11)	8 times

Interrupt Thresholds

The high and low threshold levels for the interrupt can be set individually. In register ALS_THDH - 0x04, the 0x05 high threshold window can be determined.

TABLE 10 - INTERRUPT HIGH THRESHOLD

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_THDH_L							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_THDH_H							

COMMAND	BIT NAME	FUNCTION	BIT	VALUE	DESCRIPTION
0x04	ALS_THDH_L	Set the high threshold interrupt value	7 : 0	0 to 65 535	Low byte
0x05	ALS_THDH_H		7 : 0		High byte

In register ALS_THDL - 0x06, the 0x07 low threshold window can be determined.

TABLE 11 - INTERRUPT LOW THRESHOLD

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_THDL_L							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_THDL_H							

COMMAND	BIT NAME	FUNCTION	BIT	VALUE	DESCRIPTION
0x06	ALS_THDL_L	Set the low threshold interrupt value	7 : 0	0 to 65 535	Low byte
0x07	ALS_THDL_H		7 : 0		High byte

Designing the VEML4031X00 Into an Application

Interrupt Results

With the bits ALS_IF_L and ALS_IF_H in register 0x17, the interrupt flags for the high and low thresholds can be monitored. The interrupt flag is triggered as soon as the required number of consecutive measurements, determined by the persistence counter, is exceeded. The reading of the interrupt flag automatically clears the interrupt function. The next activation of the interrupt happens as soon as the applied threshold is exceeded again. When the interrupt is cleared and still remains within the limits of the determined threshold, no consecutive activation is triggered. At first the measurement must cross the threshold again to be able to trigger the interrupt flag again.

TABLE 12 - INTERRUPT FLAG

COMMAND CODE	BIT NAME	FUNCTION	BIT	VALUE	DESCRIPTION
0x17	ALS_IF_L	Low threshold interupt flag	2	0x0 (0b0)	No low threshold crossing
				0x1 (0b1)	Low threshold crossing interrupt event flag for the green channel
	ALS_IF_H	High threshold interupt flag	1	0x0 (0b0)	No high threshold crossing
				0x1 (0b1)	High threshold crossing interrupt event flag for the green channel

4.6 READ-OUT MEASUREMENT RESULTS

The output values of the ALS and IR channels are stored in the dedicated output registers. The raw value always consists of two bytes. The values can be read out as soon as the measurement cycle is completed. The VEML4031X00 stores the last results of all the channels before the device is shut down, keeping the data accessible. When the VEML4031X00 is in shutdown mode, the host can freely read this data via the read command directly. The sensor will lose the data as soon as it is disconnected from the V_{DD}.

Ambient Light Measurement Results

The command codes 0x10 and 0x11 (ALS_DATA) contain the ambient light measurement results. The low byte is stored in the command code 0x10 (ALS_DATA_L), while the command code 0x11 (ALS_DATA_H) accesses the high byte of the ALS channel results. The combination of both bytes provides the 16-bit output value.

TABLE 14 - REGISTER NAME: G_DATA

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_DATA_L							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ALS_DATA_H							

COMMAND	BIT NAME	FUNCTION	BIT	VALUE	DESCRIPTION
0x10	ALS_DATA_L	Read the green channel output data	7 : 0	0 to 65 535	Low byte
0x11	ALS_DATA_H		7 : 0		High byte

Designing the VEML4031X00 Into an Application

IR Channel Measurement Results

The command codes 0x12 and 0x13 (IR_DATA) contain the IR channel measurement results. The low byte is stored in the command code 0x12 (IR_DATA_L), while the command code 0x13 (IR_DATA_H) accesses the high byte of the IR measurement results. The combination of both bytes provides the 16-bit output value.

TABLE 16 - REGISTER NAME: IR_DATA							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IR_DATA_L							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IR_DATA_H							
COMMAND	**BIT NAME**	**FUNCTION**		**BIT**	**VALUE**	**DESCRIPTION**	
0x12	IR_DATA_L	Read the IR channel output data		7 : 0	0 to 65 535	Low byte	
0x13	IR_DATA_H			7 : 0		High byte	

5. I²C AND TIMING

5.1 I²C WRITE AND READ PROTOCOL

The communication with the VEML4031X00 can be performed via the I²C interface of the sensor. The I²C write and read protocol when communicating with the sensor is shown in Fig. 7.

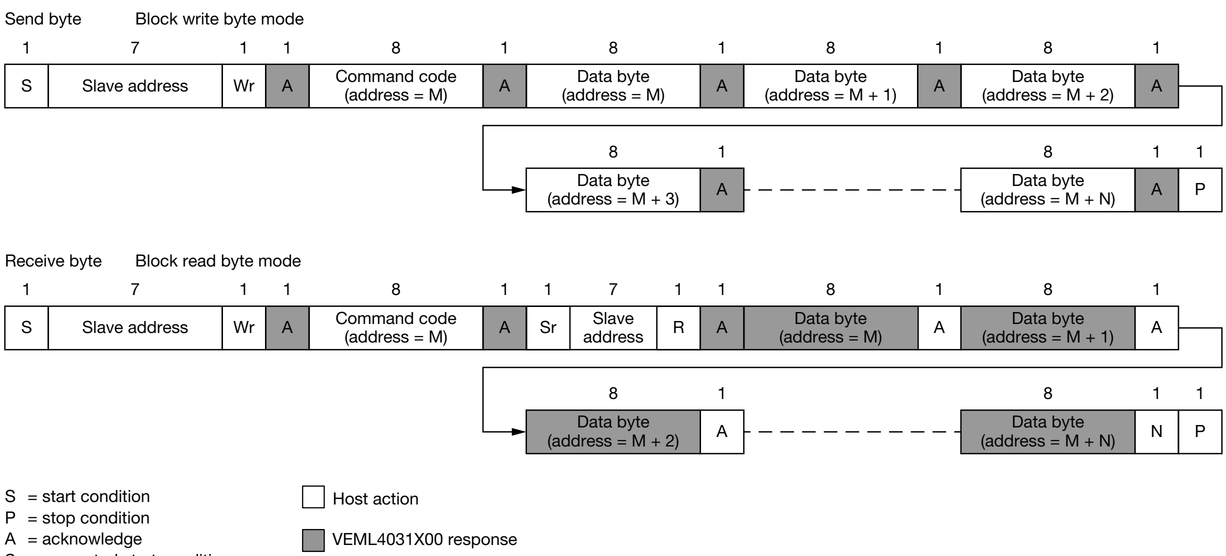
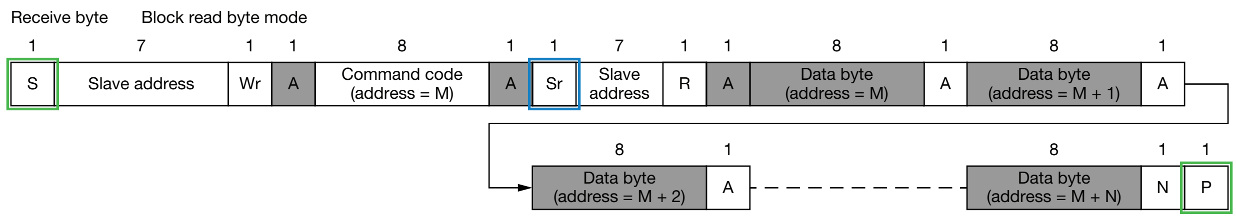


Fig. 7 - Send Byte / Receive Byte Protocol

It is imperative that only the restart condition for the I²C read is implemented instead of the stop and restart condition. For example, Fig. 8 shows an oscilloscope screenshot of the SCL and SDA line when reading the register VEML4031X00_ID for the VEML4031X00 with a slave address of 0x29. Here, the restart condition, indicated by the blue box, has been implemented and the data of 0x01 for the low byte and 0x00 matches the default values of the VEML4031X00_ID register stated in the datasheet.

Designing the VEML4031X00 Into an Application



S | 010 1001 | 0 | 0 | 0001 1000 | 0 | Sr | 010 1001 | 1 | 0 | 0000 0001 | 0 | 0000 0000 | 1 | P
S | 0x29 | 0 | 0 | 0x18 | 0 | Sr | 0x29 | 1 | 0 | 0x01 | 0 | 0x00 | 1 | P

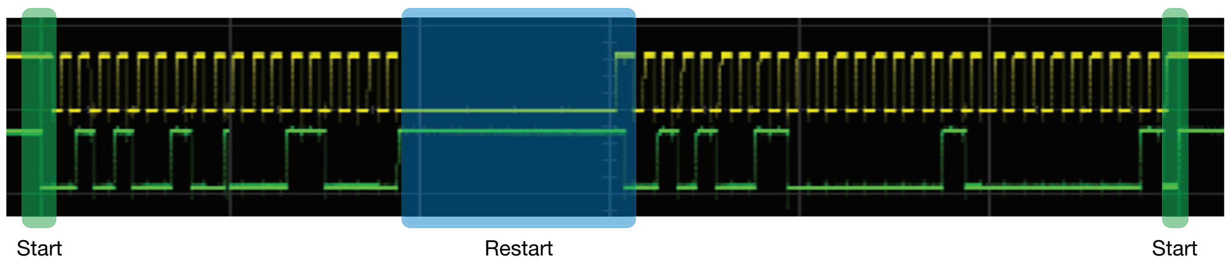
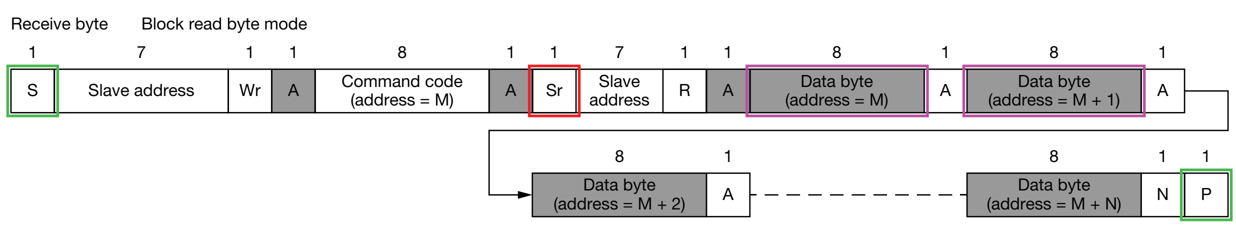


Fig. 8 - I²C Read With Necessary Repeated Start Condition

On the other hand, Fig. 9 shows the logic analyzer screenshot, but with an incorrect read I²C protocol when reading the register VEML4031X00_ID. Here, the stop and restart conditions have been applied, causing an error in the data field. As a result, the sensor writes a constant 0x00 in the VEML4031X00_ID register.



S | 010 1001 | 0 | 0 | 0001 1000 | 0 | P | Sr | 010 1001 | 1 | 0 | 0000 0000 | 0 | 0000 0000 | 1 | P
S | 0x29 | 0 | 0 | 0x18 | 0 | P | Sr | 0x29 | 1 | 0 | 0x00 | 0 | 0x00 | 1 | P

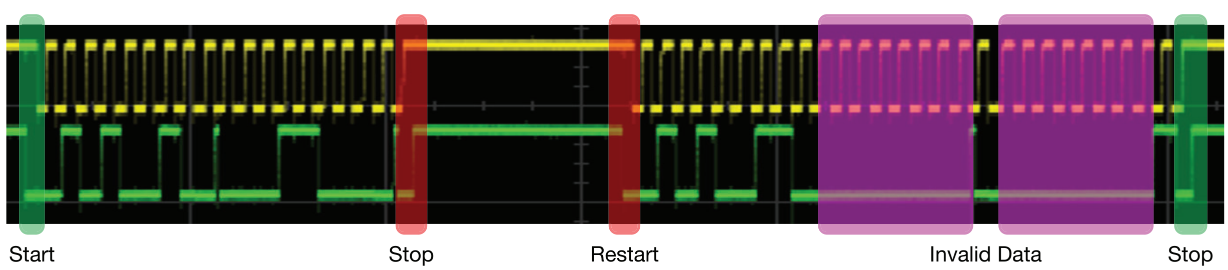


Fig. 9 - I²C Read With Invalid Stop and Read Condition

Therefore, the designer should use the correct I²C library, especially the I²C read, from the microcontroller manufacturer that implements only the restart condition, without the stop condition before the restart condition. This is a typical mistake when communicating with the VEML4031X00_ID, as shown in Fig. 9.

Designing the VEML4031X00 Into an Application

6. AMBIENT LIGHT MEASUREMENT

As shown in Fig. 10, the spectral characteristics of the ambient light channel matches well with the so-called "Human Eye" v(λ) curve. Accordingly, reading the 16-bit ALS channel and multiplying the data with the given resolution, based on the selected sensitivity, will lead to an accurate ALS result in lux.

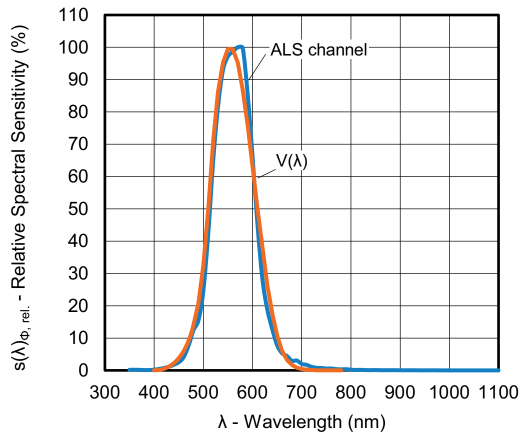


Fig. 10 - Spectral Response vs. Wavelength

6.1 CALCULATING THE LUX LEVEL

The command codes 0x10 and 0x11 contain the results of the ALS channel measurement. As the ALS channel matches the human-eye response, this 16-bit code can be converted into an illuminance (lux) level. Therefore, the measured count level needs to be multiplied with the given resolution at the applied settings. The resolution changes linearly over the corresponding settings. For example, every time the integration time is halved, the resolution is doubled. The adjustment of the resolutions due to the setting change leads to a wide dynamic range of the sensor from the sub lux range up to 172 klx. Table 17 and table 18 contain all the available resolutions and maximum possible illumination levels with regard to the applied setting combinations.

TABLE 17 - RESOLUTION AND MAXIMUM DETECTION RANGE AT ALS_PDDIV (4/4 PD used)

	TYPICAL RESOLUTION (lx/cnt)					MAXIMUM POSSIBLE ILLUMINATION (lx)			
	ALS_GAIN					ALS_GAIN			
IT (ms)	x 2	x 1	x 0.66	x 0.5		x 2	x 1	x 0.66	x 0.5
400	0.0026	0.0051	0.0078	0.0103		168	337	510	673
200	0.0051	0.0103	0.0156	0.0205		337	673	1020	1346
100	0.0103	0.0205	0.0311	0.0411		673	1346	2040	2693
50	0.0205	0.0411	0.0623	0.0822		1346	2693	4080	5385
25	0.0411	0.0822	0.1245	0.1644		2693	5385	8160	10 771
12.5	0.0822	0.1644	0.2490	0.3287		5385	10 771	16 319	21 542
6.25	0.1644	0.3287	0.4980	0.6574		10 771	21 542	32 639	43 083
3.125	0.3287	0.6574	0.9961	1.3148		(-) (1)	(-) (1)	(-) (1)	(-) (1)

Designing the VEML4031X00 Into an Application

TABLE 18 - RESOLUTION AND MAXIMUM DETECTION RANGE AT ALS_PDDIV (1/4 PD used)									
	TYPICAL RESOLUTION (lx/cnt)					MAXIMUM POSSIBLE ILLUMINATION (lx)			
	ALS_GAIN					ALS_GAIN			
IT (ms)	x 2	x 1	x 0.66	x 0.5		x 2	x 1	x 0.66	x 0.5
400	0.0103	0.0205	0.0311	0.0411		673	1346	2040	2693
200	0.0205	0.0411	0.0623	0.0822		1346	2693	4080	5385
100	0.0411	0.0822	0.1245	0.1644		2693	5385	8160	10 771
50	0.0822	0.1644	0.2490	0.3287		5385	10 771	16 319	21 542
25	0.1644	0.3287	0.4980	0.6574		10 771	21 542	32 639	43 083
12.5	0.3287	0.6574	0.9961	1.3148		21 542	43 083	65 278	86 166
6.25	0.6574	1.3148	1.9921	2.6296		43 083	86 166	130 555	172 333
3.125	1.3148	2.6296	3.9843	5.2593		(-) [1]	(-) [1]	(-) [1]	(-) [1]

Note

[1] For an integration time of 3.125 ms, the maximum count level is no longer 16 bit, so, half the integration time no longer leads to double the max. lux level

Example

The example shows the conversion of the 16-bit raw values measured by the sensor into an illuminance value. At the programmed setting are ALS_IT = 100 ms, ALS_GAIN = x1, and ALS_PDDIV (4/4 used), and an assumed measurement result of 1480 (dec) counts from the sensor.

$$\text{Illuminance} = \text{resolution} \times \text{raw value green channel} \quad (1)$$

$$\text{Illuminance} = 0.0103 \text{ lx/cts} \times 1480 \text{ cts}$$

With Formula (1), this leads to an illuminance of 15.24 lx at the given settings.

IT, GAIN, and PD Size Settings

The output value of the sensor is linear across the integration (ALS_IT), gain (ALS_GAIN), and photodiode size (ALS_PDDIV) settings, respectively.

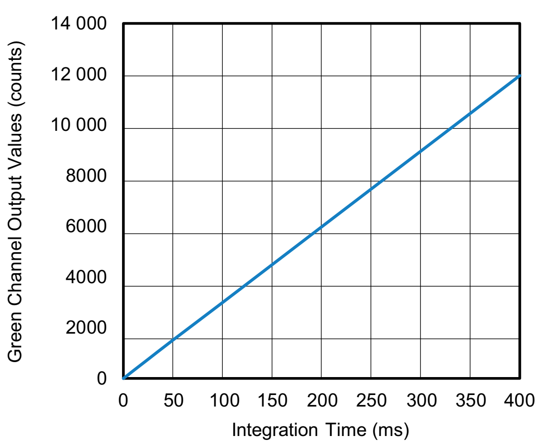


Fig. 11 - Linearity of the Integration Time

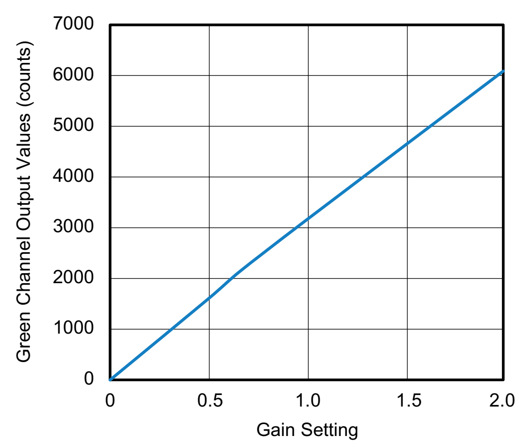


Fig. 12 - Linearity of the Gain

The integration time has a linear relationship to the output value in counts. A doubling in the integration time leads to a doubling in counts.

Designing the VEML4031X00 Into an Application

6.2 AMBIENT LIGHT MEASUREMENT OVER DIFFERENT LIGHT SOURCES

The VEML4031X00 shows very good matching for all kinds of light sources. The results are based on the green channel results of the VEML4031X00.

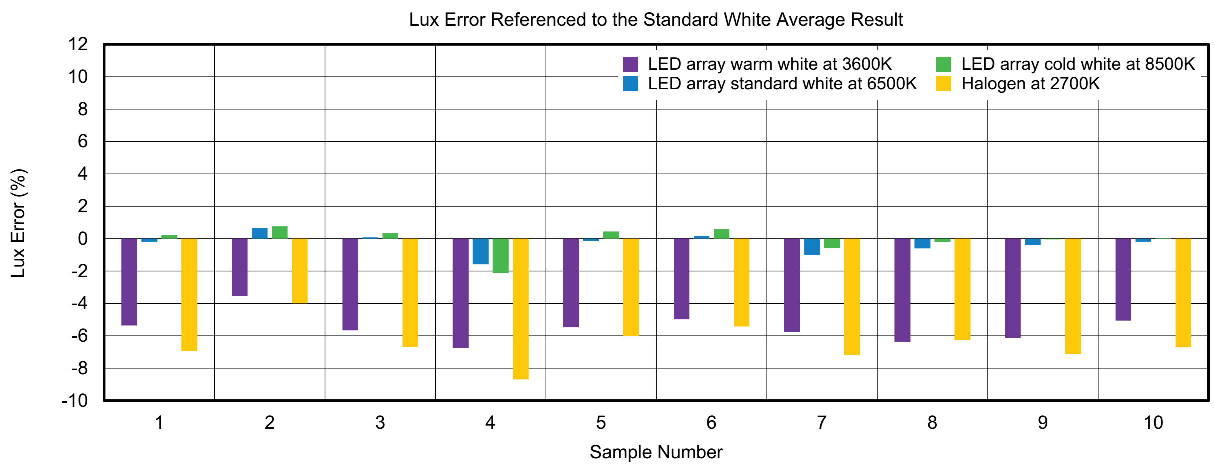


Fig. 13 - Tolerances for Different Light Sources

6.3 GATHERING ADDITIONAL INFORMATION WITH THE IR CHANNEL

In addition to the ALS channel, the sensor also has an IR channel available, which is capable of measuring in the range of 800 nm to 1100 nm.

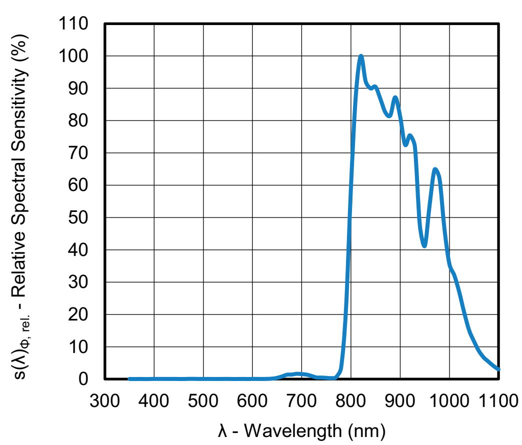


Fig. 14 - IR Channel Response

Due to the fact that the sensor can be exposed to light sources with different spectral responses, it can be helpful for an application to be able to differentiate between those light sources and react accordingly. The additional IR channel offers the possibility of doing a light source differentiation based on the IR content measured with the IR channel. A ratio between the IR and ALS channel can be calculated to determine the amount of IR light within the light source's spectrum. This easily allows, for example, for the differentiation between a halogen bulb and an LED light.

Designing the VEML4031X00 Into an Application

7. MECHANICAL AND OPTICAL DESIGN CONSIDERATIONS

Within most applications, a housing is an essential part of the product design. To ensure a properly functioning ALS sensor within this environment, the window design for the sensor is a key parameter during the design-in phase. For a cover, generally every type of material can be used as a window material, as long as it is transmissive to the light that should be detected by the sensor. The window should be transmissive at a sensitivity range from around 400 nm to 700 nm (for ALS) and from 400 nm to 1100 nm (for ALS + IR). Accordingly, the amount of transmissivity determines the attenuation of the light, meaning, for example, an 80 % transmissive material within this region leads to attenuation of 20 % of the signal compared to an open-air measurement, which accordingly diminishes the dynamic range of the sensor. This trade-off must be considered when choosing the cover material for the application.

Besides the transmissivity, the dimensions of the cover window need to be calculated correctly to ensure the optimal performance of the sensor. While in most designs the window should be kept as small as possible, the window size should still be large enough to ensure that enough light reaches the sensor and the active area of the sensor is illuminated properly. When calculating the window size, the main dimension that has to be considered is the distance from the top of the surface to the outside surface of the window, and the required viewing angle of the sensor.

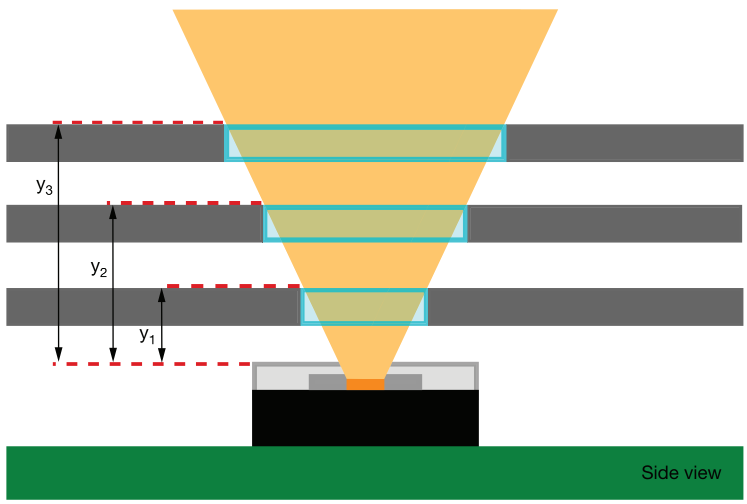


Fig. 15 - Asymmetric Window Design Where the Diameter Increases With Increasing Distance From the Sensor

In the beginning, the center of the sensor and center of the window should be aligned. Then the calculation can be done based on Formula (2). For the viewing angle of the sensor, a good approach is to use the angle of half sensitivity, which is ± 50° for the VEML4031X00, as show in Fig. 18.

The minimum window cover diameter D can be calculated as follows:

$$D = x + 2 \times (y \times \tan\theta) \quad (2)$$

Designing the VEML4031X00 Into an Application

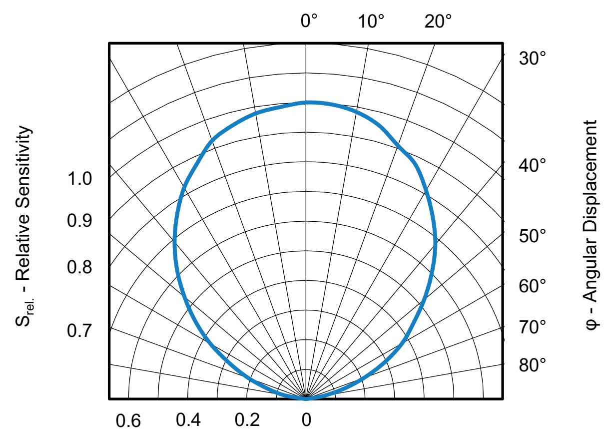
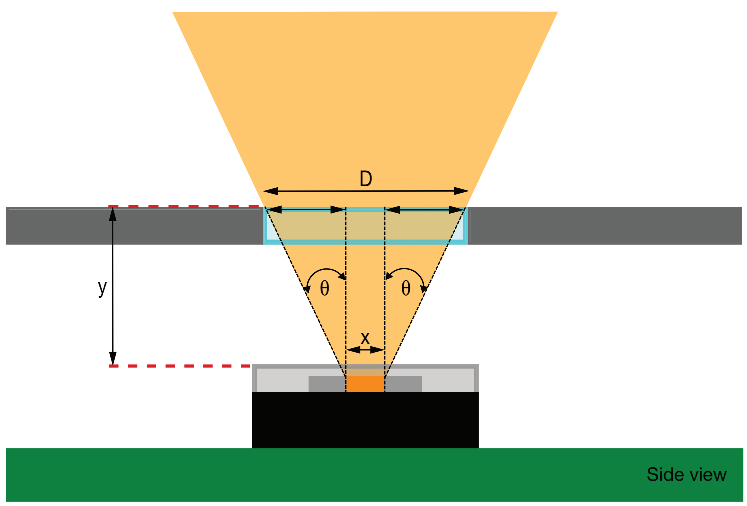


Fig. 16 - Relative Sensitivity vs. Angular Displacement

Remark:

This wide angle and the placement of the sensor as close as possible to the cover is needed to show comparable results to an optometer, which also detects light reflections from the complete surroundings.



$$D = x + 2 \times (y \times \tan\theta)$$

Fig. 17 - Window Design Calculation

Table 19 provides an overview of possible window diameters at different distances between the cover and sensor.

Designing the VEML4031X00 Into an Application

TABLE 19 - MINIMUM WINDOW COVER DIAMETER			
y (mm)	x (mm)	θ1 (°)	D (mm)
0.5	0.2	50	1.99
1.0	0.2	50	2.58
1.5	0.2	50	3.78
2.0	0.2	50	4.97
2.5	0.2	50	6.16
3.0	0.2	50	7.35
3.5	0.2	50	8.54
4.0	0.2	50	9.73