Designing the VEML6030 into an Application

By Reinhard Schaar

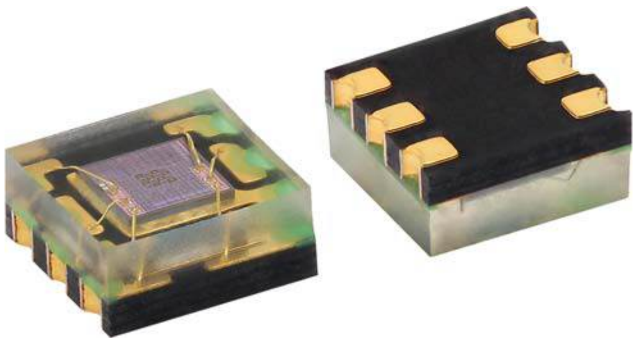
HIGH-ACCURACY AMBIENT LIGHT SENSOR: VEML6030

The VEML6030 is a very high-sensitivity, high-accuracy ambient light sensor in a miniature transparent 2 mm by 2 mm package. It includes a highly sensitive photodiode, low-noise amplifier, 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 for ambient light detection is 0 lx to ~ 167 klx, with resolution down to 0.005 lx/counts.

Beside100 Hz and 120 Hz flicker noise rejection and a low temperature coefficient, the device consumes just 0.5 μA in shut down mode. In addition, another four power-saving modes are available that allow operating current to be reduced down to just 2 μA. The device operates within a temperature range of -25 °C to +85 °C.

The VEML6030's very high sensitivity of just 0.005 lx 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 very high illumination - such as direct sunlight - will not saturate the device and read-outs up to 167 klx are possible.



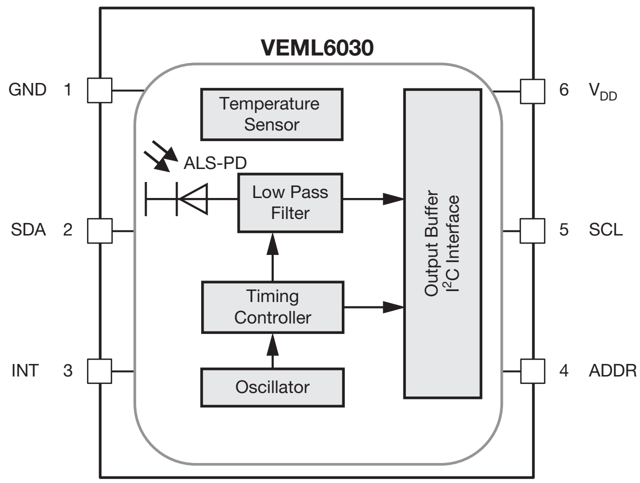


Fig. 1 - VEML6030 Block Diagram

Designing the VEML6030 into an Application

APPLICATION CIRCUITRY FOR THE VEML6030

The VEML6030 can be connected to a power supply, ranging from 2.5 V to 3.6 V. The pull-up resistors at the I²C bus lines, as well as at the interrupt line, may also be connected to a power supply between 1.7 V to 3.6 V, allowing them to be at the same level needed for the microcontroller.

Proposed values for the pull-up resistors should be > 1 kΩ, e.g.: 2.2 kΩ to 4.7 kΩ for the R1 and R2 resistors (at SDA and SCL) and 10 kΩ to 100 kΩ for the R3 resistor (at interrupt). The interrupt pin is an open drain output for currents up to 12 mA.

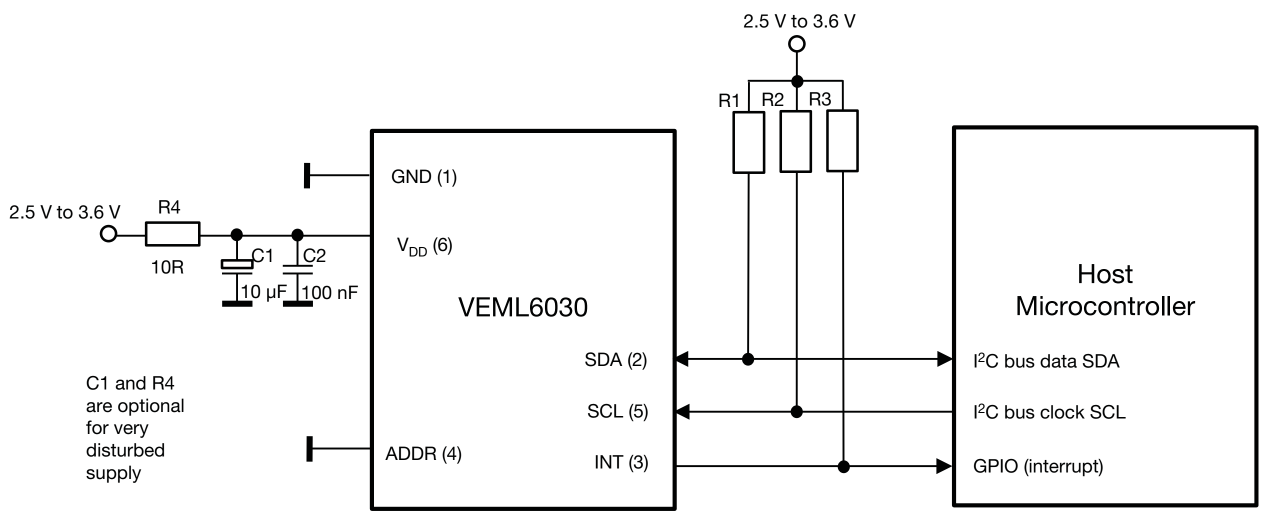


Fig. 2 - VEML6030 Application Circuit

The VEML6030 is insensitive to any kind of disturbances, so a small ceramic capacitor at its supply pin will be enough. Only if the power supply line could be very noisy and the voltage range close to the lower limit of 2.5 V should a R-C decoupler, as shown in the above circuitry, be used.

The ADDR pin allows for two device addresses: pin 4 = high (V_{DD}) = 0x48, pin 4 = low (GND) = 0x10.

Designing the VEML6030 into an Application

REGISTERS OF THE VEML6030

The VEML6030 has six user-accessible 16-bit command codes. The addresses are 00h to 06h (03h not defined / reserved).

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
00	reserved	15 : 13	Set 000b	W
	ALS_SM	12 : 11	Sensitivity mode selection 00 = ALS sensitivity x 1 01 = ALS sensitivity x 2 10 = ALS sensitivity x (1/8) 11 = ALS sensitivity x (1/4)	W
	reserved	10	Set 0b	W
	ALS_IT	9 : 6	ALS integration time setting 1100 = 25 ms 1000 = 50 ms 0000 = 100 ms 0001 = 200 ms 0010 = 400 ms 0011 = 800 ms	W
	ALS_PERS	5 : 4	ALS persistence protect number setting 00 = 1 01 = 2 10 = 4 11 = 8	W
	reserved	3 : 2	Set 00b	W
	ALS_INT_EN	1	ALS interrupt enable setting 0 = ALS INT disable 1 = ALS INT enable	W
	ALS_SD	0	ALS shutdown setting 0 = ALS power on 1 = ALS shutdown	W
01	ALS_WH	15 : 8	ALS high threshold window setting (MSB)	W
		7 : 0	ALS high threshold window setting (LSB)	W
02	ALS_WL	15 : 8	ALS low threshold window setting (MSB)	W
		7 : 0	ALS low threshold window setting (LSB)	W
03	reserved	15 : 3	Set 0000 0000 0000 0b	
	PSM	2 : 1	Power-saving mode; see table “Refresh time” 00 = mode 1 01 = mode 2 10 = mode 3 11 = mode 4	W
	PSM_EN	0	Power-saving mode enable setting 0 = disable 1 = enable	W
04	ALS	15 : 8	MSB 8 bits data of whole ALS 16 bits	R
		7 : 0	LSB 8 bits data of whole ALS 16 bits	R
05	WHITE	15 : 8	MSB 8 bits data of whole white 16 bits	R
		7 : 0	LSB 8 bits data of whole white 16 bits	R
06	ALS_IF_L	15	ALS crossing low threshold INT trigger event	R
	ALS_IF_H	14	ALS crossing high threshold INT trigger event	R
	reserved	13 : 0		

Designing the VEML6030 into an Application

WAKE-UP OF THE VEML6030

For random measurements, e.g. once per second, the sensor may be switched to shutdown mode, where power consumption is lowest.

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Supply voltage		V_{DD}	2.5	3.3	3.6	V
Shutdown current (rem_2)	V_{DD} is 3.3 V	I_{sd}	-	0.5	-	μA
Operation mode current (rem_2)	V_{DD} is 3.3 V, PSM = 11, refresh time 4100 ms	I_{DD}	-	2	-	μA
	V_{DD} is 3.3 V, PSM = 00, refresh time 600 ms	I_{DD}	-	8	-	μA
	V_{DD} is 3.3 V, PSM_EN = 0, refresh time 100 ms	I_{DD}	-	45	-	μA

Note

- rem_1: light source: white LED
  rem_2: light conditions: dark

This shutdown mode is set with a "1" within bit 0 of the command register:

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
00	ALS_SD	0	ALS shutdown setting 0 = ALS power on 1 = ALS shut down	W

When activating the sensor, setting bit 0 of the command register to "0"; a wait time of 4 ms should be waited before the first measurement is picked up, to allow for a correct start of the signal processor and oscillator.

Please also refer to the chapter "Power-Saving Modes."

RESOLUTION AND GAIN SETTINGS OF THE VEML6030

The VEML6030 is specified with a resolution of 0.005 lx/counts. This high resolution is only available for a smaller light range of approximately 0 lx to 4000 lx. For this range a high gain factor (high sensitivity) can be selected. For light levels up to about 167 000 lx, a reduced gain factor of 16 (sensitivity = 1/8) would then lead to a possible resolution of 0.042 lx.

Command Code ALS_SM

Command code: 00, bits 12 and 11

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
00	reserved	15 : 13	Set 000b	W
	ALS_SM	12 : 11	Sensitivity mode selection 00 = ALS sensitivity x 1 01 = ALS sensitivity x 2 10 = ALS sensitivity x (1/8) 11 = ALS sensitivity x (1/4)	W

Remark: to avoid possible saturation / overflow effects, application software should always start with the lowest gain: ALS sensitivity x 1/8, where ALS sensitivity x 2 shows the highest resolution.

Designing the VEML6030 into an Application

Command Code ALS_IT

Command code: 00, bits 9 to 6

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
	ALS_IT	9 : 6	ALS integration time setting 1100 = 25 ms 1000 = 50 ms 0000 = 100 ms 0001 = 200 ms 0010 = 400 ms 0011 = 800 ms	W

Remark: the standard integration time is 100 ms. If a very high resolution is needed, one may increase this integration time up to 800 ms. If faster measurement results are needed, it can be decreased down to 25 ms.

READ-OUT OF ALS MEASUREMENT RESULTS

The VEML6030 stores the measurement results within the command code 04. The most significant bits are stored to bits 15 : 8 and the least significant bits to bits 7 : 0.

The VEML6030 can memorize the last ambient data before shutdown and keep this data before waking up. When the device is in shutdown mode, the host can freely read this data directly via a read command. When the VEML6030 wakes up, the data will be refreshed by new detection.

Command Code ALS

Command code: 04, bits 15 : 8 (MSB), bits 7 : 0 (LSB)

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
04	ALS	15 : 8	MSB 8 bits data of whole ALS 16 bits	R
		7 : 0	LSB 8 bits data of whole ALS 16 bits	R

TRANSFERRING ALS MEASUREMENT RESULTS INTO A DECIMAL VALUE

Command code 04 contains the results of the ALS measurement. This 16-bit code needs to be converted to a decimal value to determine the corresponding lux value. The calculation of the corresponding lux level is dependent on the programmed sensitivity / gain setting and the chosen integration time.

Designing the VEML6030 into an Application

CALCULATING THE LUX LEVEL

With the standard integration time of 100 ms, one has to just calculate the corresponding light level according to the programmed gain / sensitivity.

The corresponding formula is:

Light level [lx] is: **OUTPUT DATA [dec.] / ALS sensitivity) x (10 / IT [ms])**

Or:

- for sensitivity = 1 and 100 ms integration time: **LUX = ALS x 0.1**;
- for sensitivity = 2 and 100 ms integration time: **LUX = ALS/2 x 0.1**; and
- for sensitivity = 1/4 and 100 ms integration time: **LUX = ALS/(1/4) x 0.1 = ALS x 4 x 0.1**.

Example:

If the 16-bit word of the ALS data shows: 0000 0101 1100 1000 = 1480 (dec.), the programmed ALS sensitivity is 1/4, and the integration time is 100 ms, the corresponding lux level is:

light level [lx] = (1480 / 1/4) x (10 / 100) = 592 lx.

However, in reality the values for gain and integration time are not exact, but somewhat rounded. The exact integration time is 90 ms, so the factor should not be 0.1 but 0.110779, making the exact lux value **LUX = ALS x 0.110779**.

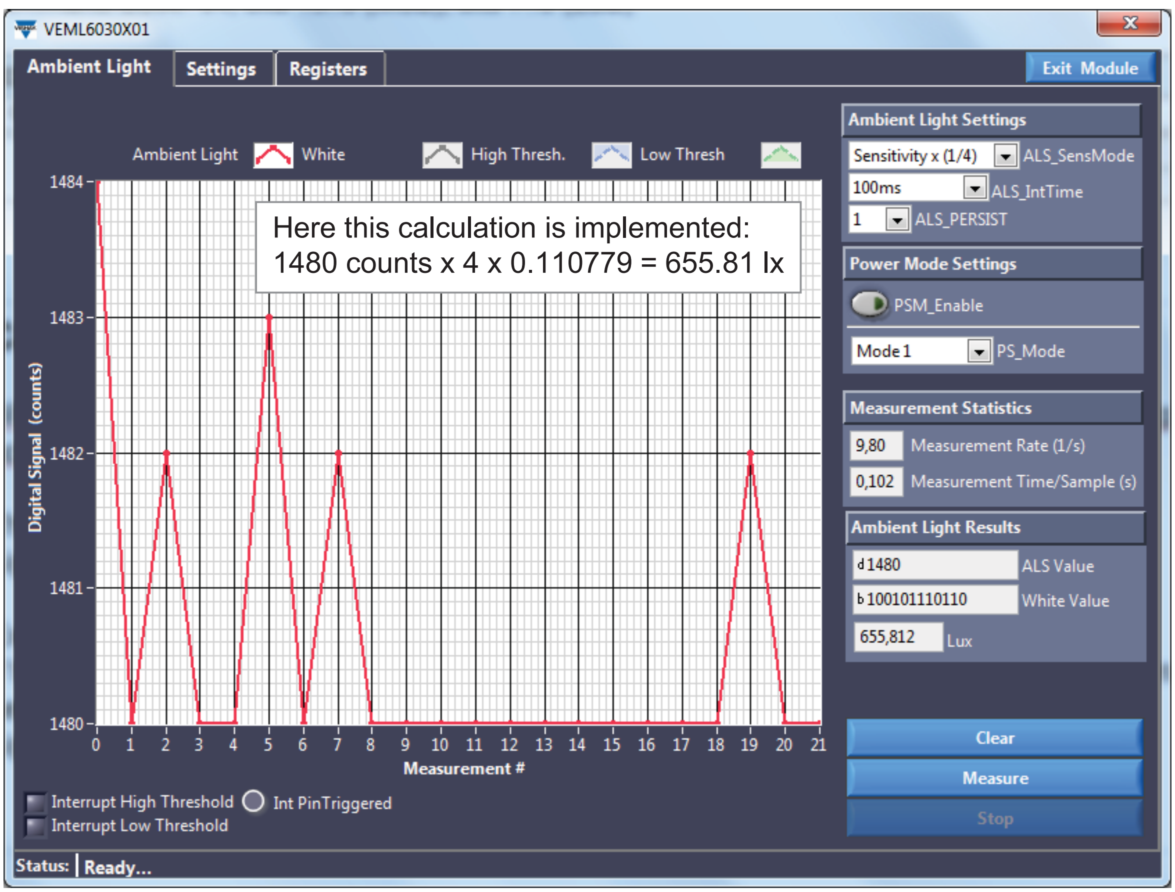


Fig. 3 - Screen Shot of the VEML6030 Demo Tool

Designing the VEML6030 into an Application

The maximum possible light level for the ALS sensitivity mode:

- "sensitivity x 2" (0, 1 bits 12 : 11 within ALS_SM command code 0) will be 3276 lx:
  LUX = ALS/2 x 0.1 = 65 535/2 x 0.1 = 3276;
- "sensitivity x 1" (0, 0 bits 12 : 11 within ALS_SM command code 0) will be 6553 lx:
  LUX = ALS/1 x 0.1 = 65 535/1 x 0.1 = 6553;
- "sensitivity x 1/4" (1, 1 bits 12 : 11 within ALS_SM command code 0) will be 26 214 lx:
  LUX = ALS/1/4 x 0.1 = 65 535 x 4 x 0.1 = 26 214; and
- "sensitivity x 1/8" (1, 0 bits 12 : 11 within ALS_SM command code 0) will be 52 428 lx:
  LUX = ALS/1/8 x 0.1 = 65 535 x 8 x 0.1 = 52 428.

To also allow for higher values without saturation, the integration time needs to be shortened. For just 50 ms it is doubled and with 25 ms it is again doubled, theoretically ending up at 209 712 lx.

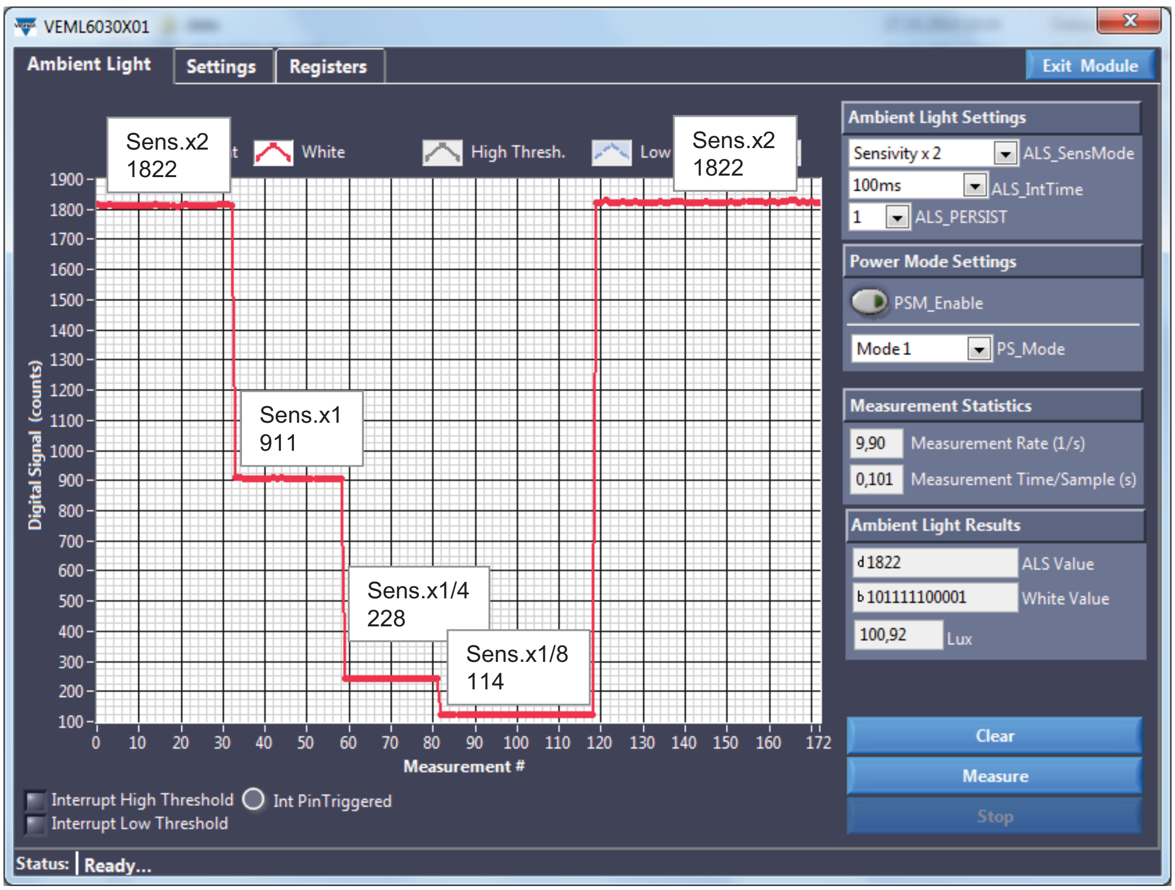


Fig. 4 - VEML6030 Counts vs. Gain

Designing the VEML6030 into an Application

If the light level is very low, or if just a small percent of outside light is reaching the sensor, a higher integration time will need to be chosen.

For just 10 lx, a sufficient 180 counts are shown with the ALS sensitivity mode: “sensitivity x 2,” but for 1 lx just 18 counts will remain. With an integration time of 200 ms, this will be doubled to 36 counts, and with 800 ms 144 counts are shown.

This also means that with this high integration time, together with the highest gain, even 0.01 lx will deliver 2 digital counts, resulting in a high resolution of 0.005 counts/lx.

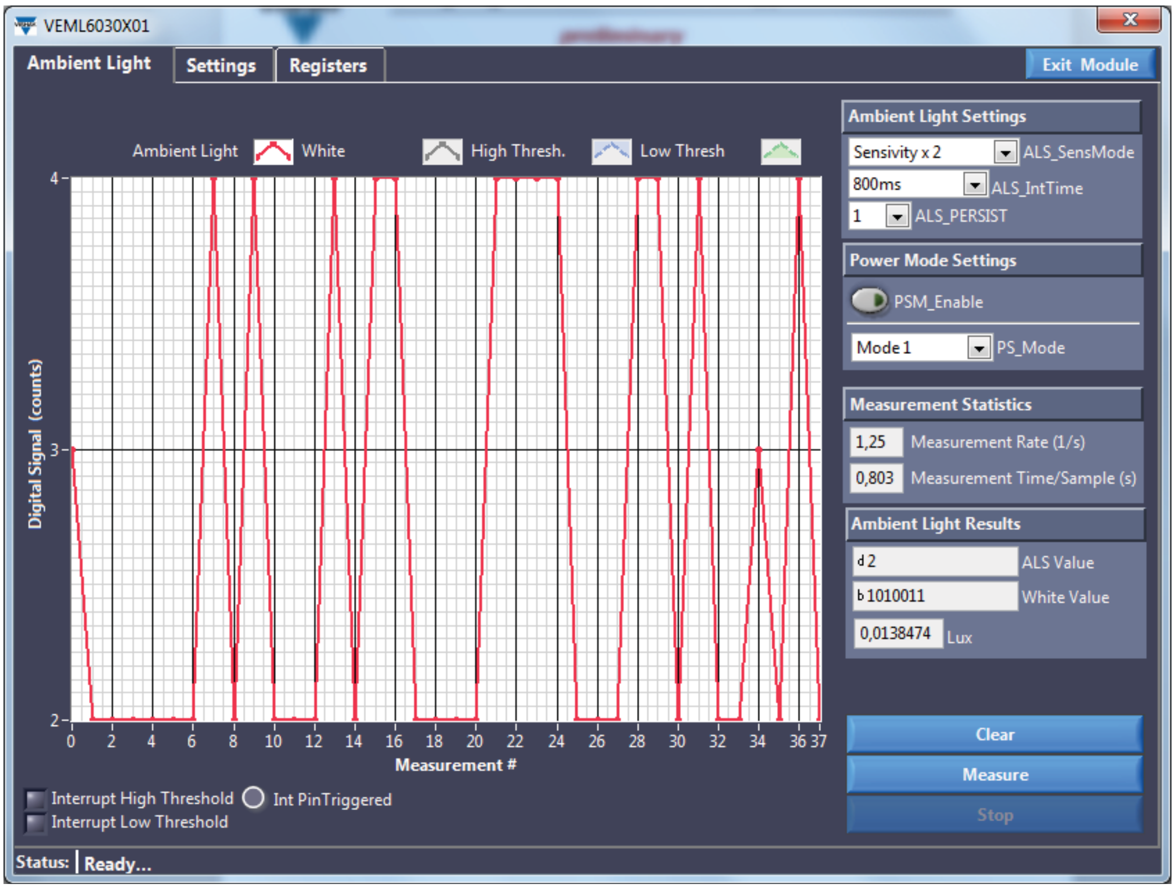


Fig. 5 - VEML6030 Highest Sensitivity

The lowest possible detectable illuminance is 0.01 lx, because with needed gain / sensitivity of “2” only 2 counts are shown as the lowest result above “0.” Every next step (2, 3, 4, ...) is possible, so, the resolution of 0.005 counts/lx is valid.

Designing the VEML6030 into an Application

LUX LEVEL MATCHING FOR DIFFERENT LIGHT SOURCES

The VEML6030 shows very good matching for all kinds of light sources. LED light, fluorescent light, and normal daylight show about the same results in a close tolerance range of just ± 10 %. Only a halogen lamp with strong infrared content may show higher values.

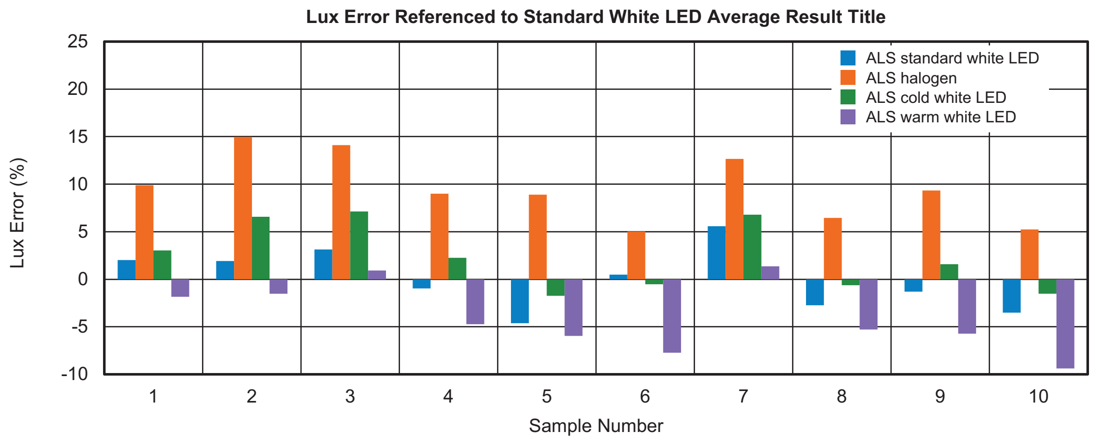


Fig. 6 - Tolerances for Different Light Sources

LINEARITY OF THE ALS RESULTS

For light levels up to ≥ 1000 lx, the output data is strictly linear for all possible gain settings. “Gain 1” and “Gain 2” will show non-linearity for very high illuminations, until saturation effects result from lux levels that are too high.

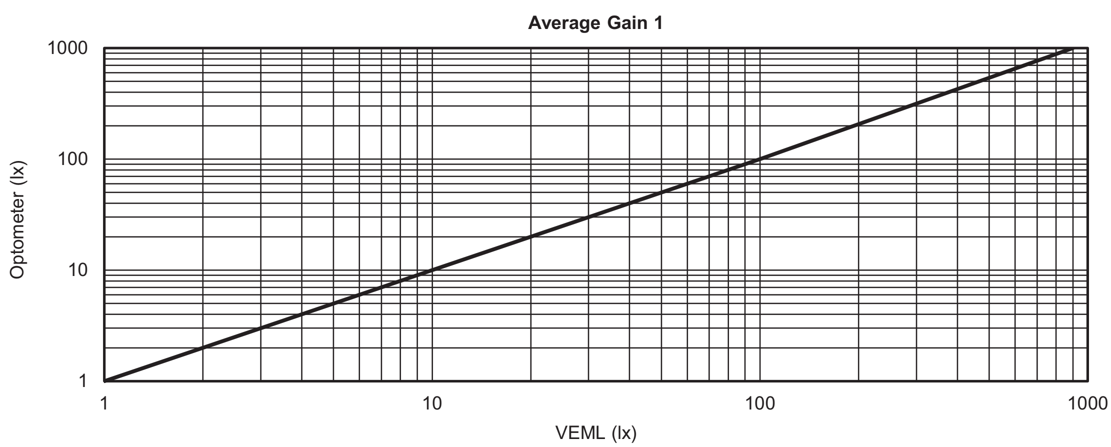


Fig. 7 - Linearity for Gain 1: Lux_Optometer vs. Lux_VEML6030

Comparison measurements with a calibrated optometer show the same results as the read-out from the VEML6030.

Designing the VEML6030 into an Application

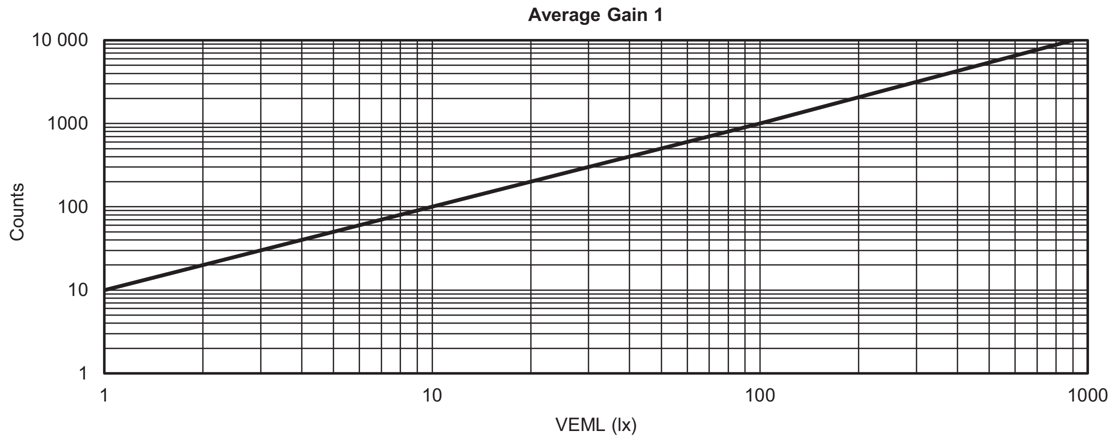


Fig. 8 - Linearity for Gain 1: Digital Counts vs. Lux_VEML

With a standard integration time of 100 ms, the actual ambient lux level exactly follows the digital counts divided by 10, or to be more exact, divided by 9.

APPLICATION DEPENDENT LUX CALCULATION

If the application uses a darkened / tinted cover glass, just 10 % - or even just 1 % - of the ambient light will reach the sensor. For a tinted cover glass where there is 1 lx up to 100 klx of light outside, just 0.01 lx to 1 klx is reaching the sensor, and the application software may always stay at “Gain 2” (“sensitivity x 2”). It should be noted also that the gain factor between the gain modes “1” and “1/4” is not exactly a factor 4 but 3.687.

Between the lower gain modes: gain 1/8 and gain 1/4 as well as between gain 1 and gain 2, there is exact factor 2.

So the calculation should use: gain 1/8 = 0.125, gain 1/4 = 0.25, gain 1 = 0.92175, gain 2 = 1.8435.

If the application uses a clear cover glass, nearly all ambient light will reach the sensor. This means even 100 klx may be possible. For this clear cover where < 1 lx to ≥ 100 klx is possible, the application software will need to adapt the gain steps according to light conditions.

As explained before, with “Gain 2,” a maximum 3276 lx will be possible before saturation occurs, and with “Gain 1” 6553 lx is maximum.

For unknown brightness conditions, the application should always start with the lowest gain: sensitivity x 1/8 or sensitivity x 1/4. This avoids possible overload / saturation if, for example, strong sunlight suddenly reaches the sensor. To show this high value, an even lower integration time than 100 ms may be needed.

Only for lower illumination levels with too low digital counts should the sensitivity = gain be increased. One possible decision level could be 100 counts (= 80 lx with “sensitivity x 1/8”).

Designing the VEML6030 into an Application

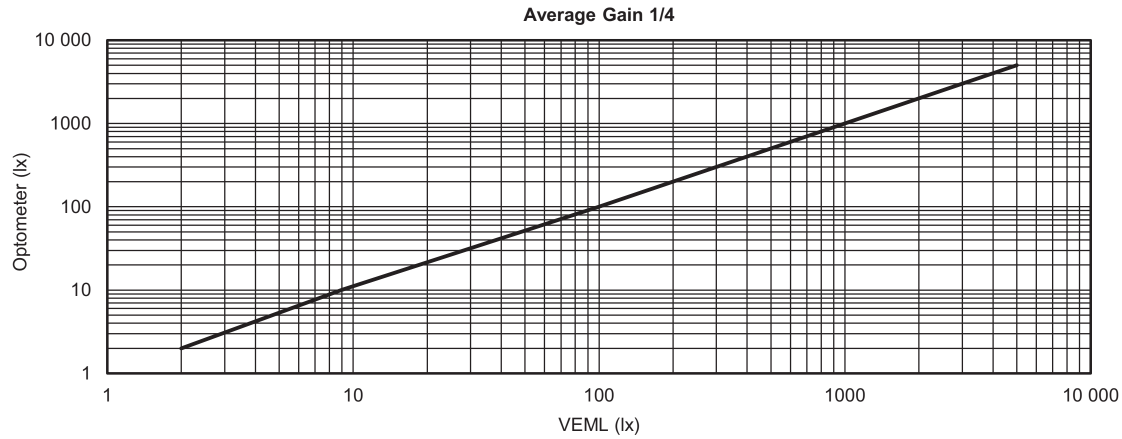


Fig. 9 - Linearity for Gain 1/4: Lux_Optometer vs. Lux_VEML6030

The VEML6030 shows good linear behavior for lux levels from 0.005 lx to about 10 klx.

A software flow may look like the flow chart diagram at the end of this note:

Starting with the lowest gain (sensitivity x 1/8), check the ALS counts. If ≤ 100 counts, increase the gain to sensitivity x 1/4.

Check the ALS counts again. If they are still ≤ 100 counts, increase the gain to sensitivity x 1.

Check the ALS counts again. If they are if still ≤ 100 counts, increase the gain to sensitivity x 2.

Check the ALS counts again. If they are still ≤ 100 counts, increase the integration time from 100 ms to 200 ms, and continue the procedure up to the longest integration time of 800 ms.

If the illumination value is > 100 counts (started with sensitivity x 1/8) a correction formula may be applied to get rid of small non-linearity for very high light levels.

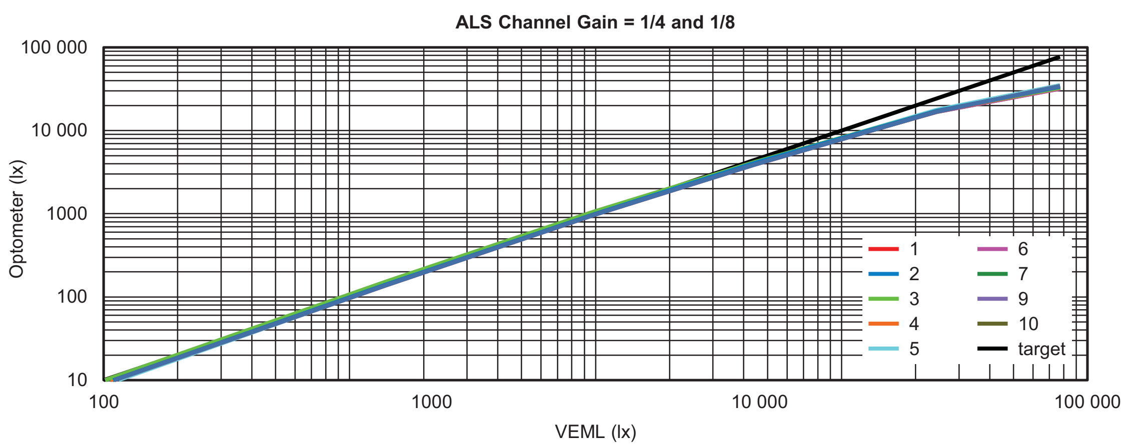


Fig. 10 - Non-Linearity for Gain 1/4 and Gain 1/8 for Higher Light Levels

The VEML6030 shows good linear behavior for lux levels from 0.01 lx to about 10 klx.

Designing the VEML6030 into an Application

Illumination values higher than 10 000 counts may show non-linearity. This non-linearity is the same for all sensors, so a compensation formula can be applied if this light level is exceeded.

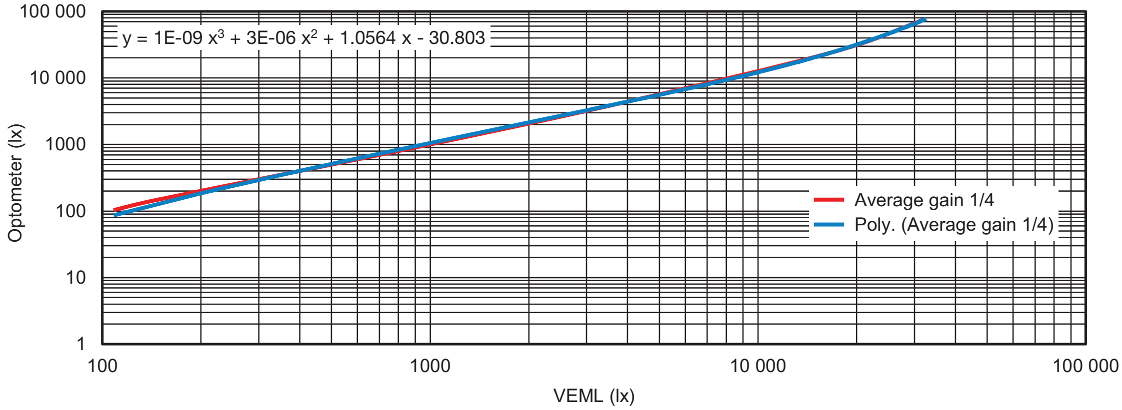


Fig. 11 - Correction Formula for Gain 1/4 and Gain 1/8 for Higher Light Levels than 100 lx

If this correction formula has already been applied for ≥ 100 lx, this third-order polynom will not be that accurate for low values. Either a polynom of a higher order should be used (fifth) or the correction formula should just start from ≥ 1000 lx.

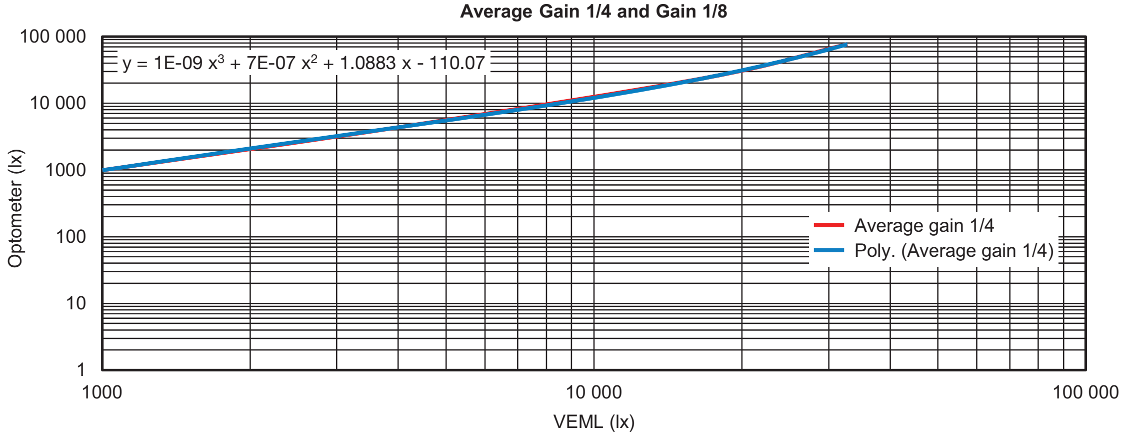


Fig. 12 - Correction Formula for Gain 1/4 and Gain 1/8 for Higher Light Levels Higher than 1000 lx

Designing the VEML6030 into an Application

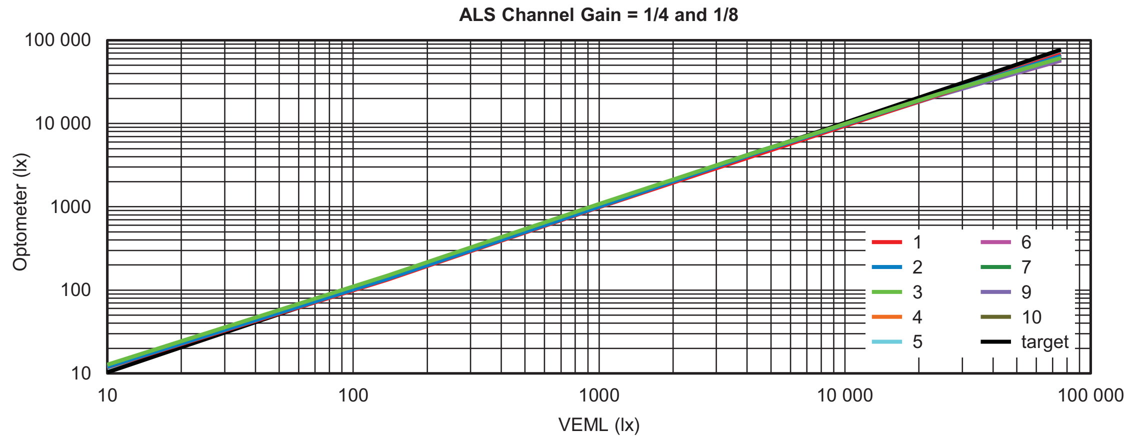


Fig. 13 - Linearity for Gain 1/4 and Gain 1/8 with Applied Correction Formula

With the correction formula mentioned before, and taking into account the 90 ms integration time, the output is linear from 0 lx to > 100 klx.

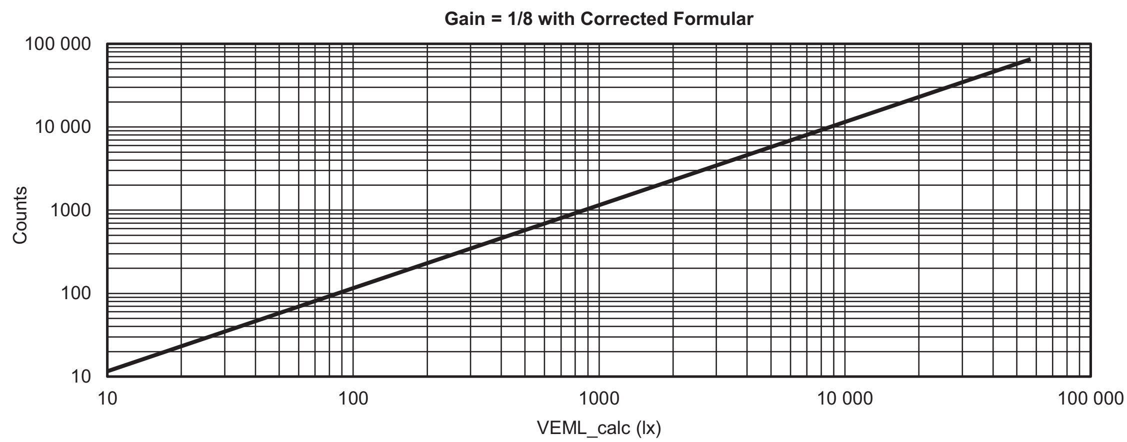


Fig. 14 - Linearity (counts vs. lux) for Gain 1/8 with Applied Correction Formula

Designing the VEML6030 into an Application

For most single photodetectors / ambient light sensor devices, there is a certain discrepancy in the output value for the different light sources. They either do not follow the exact v(λ) curve due to wider sensitivity within the blue area - being not that exact within the red region - or they do not stay at zero for near infrared wavelengths.

The VEML6030 follows a very exact v(λ) curve in all areas. This is the reason that it reproduces the exact same output values under any kind of lighting condition, including fluorescent light, sunlight, halogen light, or LED light.

The maximum deviation to nominal value (as measured with an accurate optometer) is within ± 10 %.

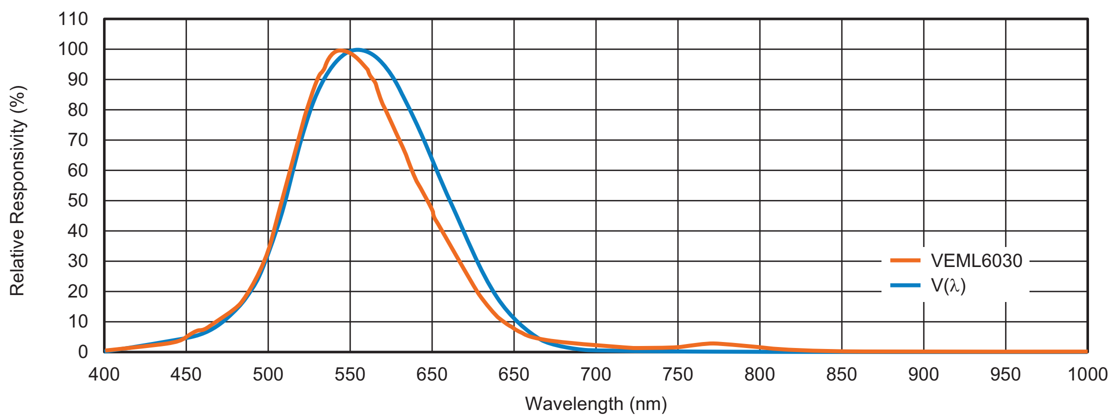


Fig. 15 - Spectral Response ALS Channel

WHITE CHANNEL

In addition to the ALS channel that follows the so-called human eye curve very well, there is also a second channel available called the white channel, which offers a much higher responsivity for a much wider wavelength spectrum.

This white channel could be used to eliminate the last few tolerance percentages that light sources with strong infrared content are showing at a bit higher values due to this small bump around 750 nm to 800 nm.

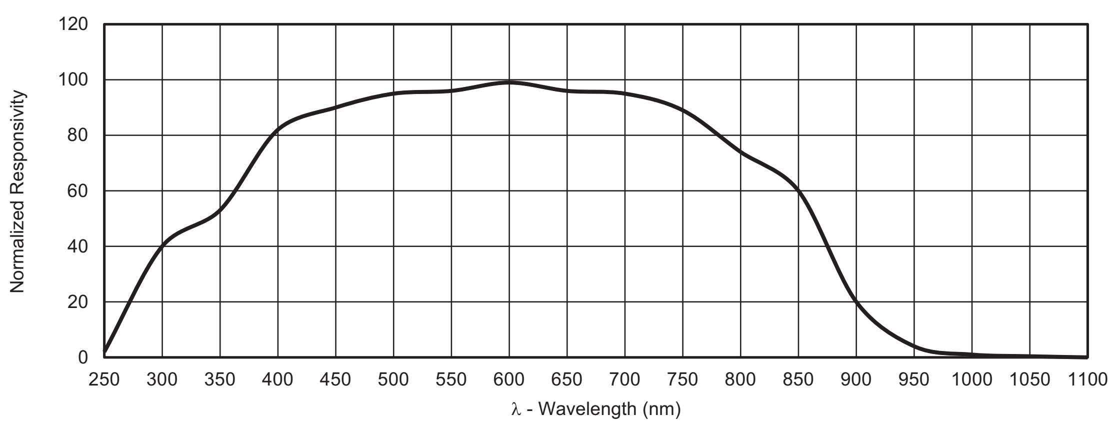


Fig. 16 - Spectral Response White Channel

Designing the VEML6030 into an Application

COMMAND REGISTER FORMAT				
COMMAND CODE	REGISTER NAME	BIT	FUNCTION / DESCRIPTION	R / W
05	WHITE	15 : 8	MSB 8 bits data of whole white 16 bits	R
		7 : 0	LSB 8 bits data of whole white 16 bits	R

The data for this channel is available within the command code 05. Several measurements with many different light sources show that the output data of this channel will lead to higher data, up to 2 x that read from the ALS channel.

All kind of LEDs, as well as fluorescent lights, will deliver output data within a small tolerance window of just ± 10 %.

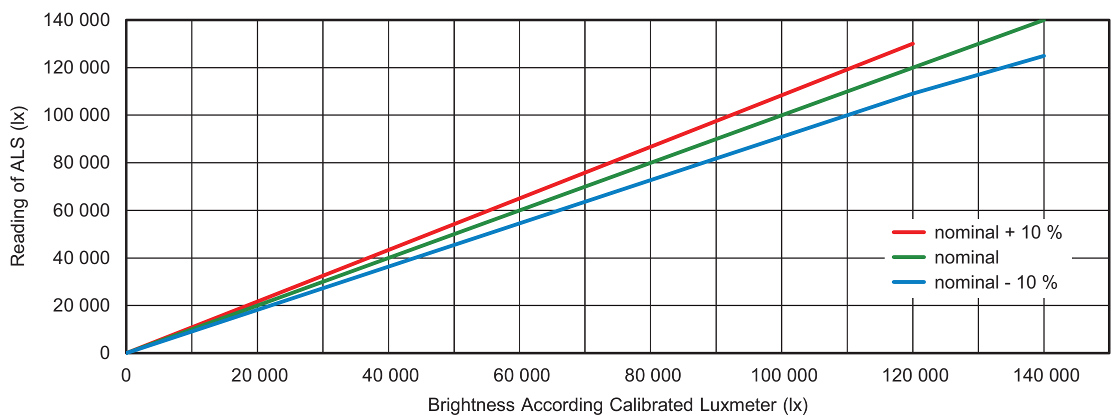


Fig. 17 - ALS Measurement Deviation Between Different Light Sources: ≤ 10 %

Only strong light from incandescent or halogen lamps and strong sunlight may show higher tolerances within the ALS channel (see also Fig. 6 above).

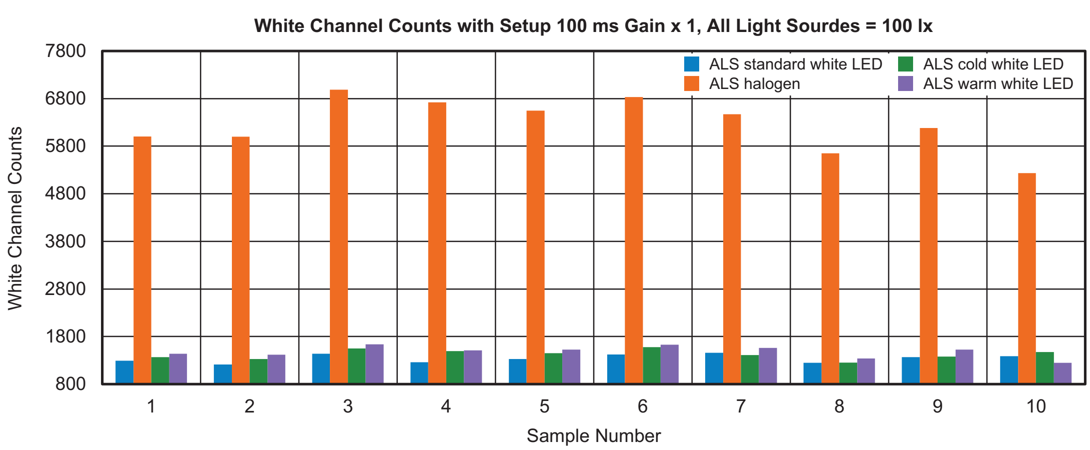


Fig. 18 - White Channel Counts for Different Light Sources

Designing the VEML6030 into an Application

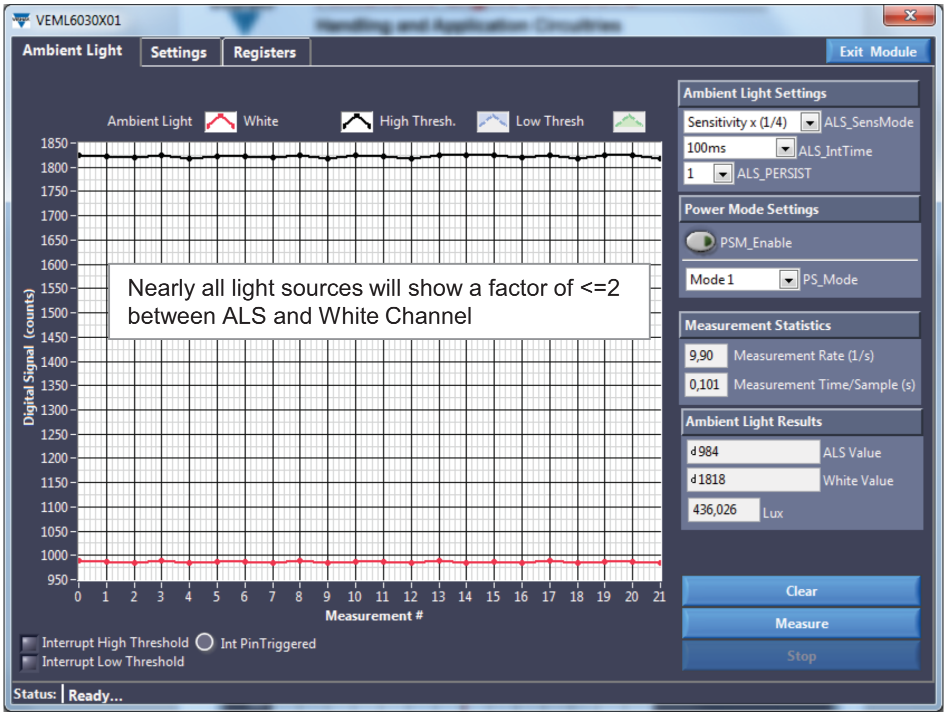


Fig. 19 - White Channel and ALS Channel for Fluorescent and Daylight Spectra

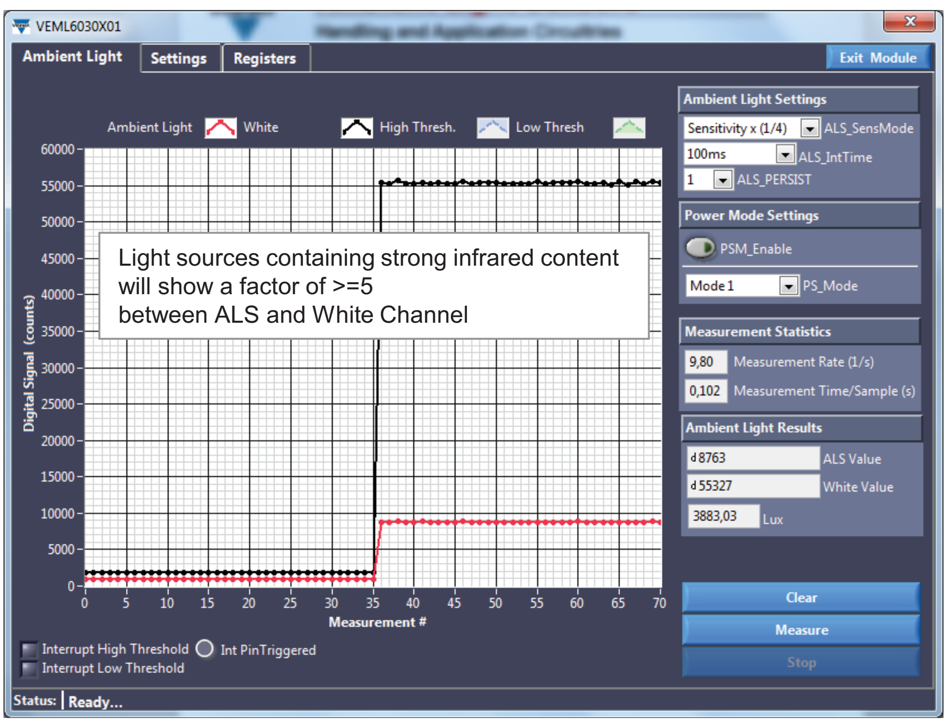


Fig. 20 - White Channel and ALS Channel for Incandescent Lamp Spectra

Designing the VEML6030 into an Application

Knowing that light sources with strong infrared content deliver about ≥ 5 x higher output data at the white channel than all other light sources, which show a maximum factor of about 2, one may use it to optimize the lux conversion now.

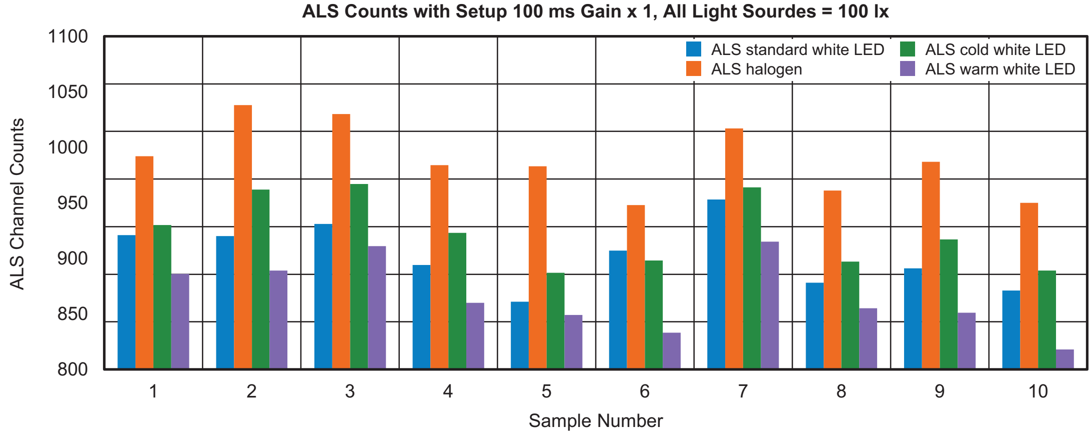


Fig. 21 - ALS Channel Counts for Different Light Sources

The nominal lux value for the above measurements should be: 100 lx x 1 x 9 = 900 counts.

The tolerance should be within ± 10 %, so 810 lx to 990 lx.

The halogen light source shows values about 50 counts to 140 counts higher, so around +5 % to +15 % more. The values shown are between 950 counts to 1040 counts.

But with an additional reading of the white channel and seeing a 5 x higher value (≥ 4750 counts in this example), one could now subtract 10 % in this case, which will lead to a very exact value for this light source: 950 counts to 1040 counts → 855 counts to 936 counts.

POWER-SAVING MODES

The device stays in shutdown mode as long as no measurements need to be done. Once activated with ALS_SD = 0, measurements are executed.

COMMAND REGISTER FORMAT				
COMMAND CODE	REGISTER NAME	BIT	FUNCTION / DESCRIPTION	R / W
00	ALS_SD	0	ALS shutdown setting 0 = ALS power on 1 = ALS shutdown	W

Without using the power-saving feature (PSM_EN = 0), the controller has to wait before reading out measurement results, at least for the programmed integration time. For example, for ALS_IT = 100 ms a wait time of ≥ 100 ms is needed.

A more simple way of continuous measurements can be realized by activating the PSM feature, setting PSM_EN = 1.

Designing the VEML6030 into an Application

COMMAND REGISTER FORMAT				
COMMAND CODE	REGISTER NAME	BIT	FUNCTION / DESCRIPTION	R / W
00	PSM	2 : 1	Power-saving mode; see table "Refresh Time" 00 = mode 1 01 = mode 2 10 = mode 3 11 = mode 4	W
00	PSM_EN	0	Power-saving mode enable setting 0 = disable 1 = enable	W

The default this comes up with is mode 1 = 00 for the bits 2 and 1 within the command code. Depending on the chosen integration time (ALS_IT), this leads to a certain measurement speed / repetition rate.

For ALS_IT = 100 ms (0000 for bits 9 : 6 within command register) this is about 600 ms. For 200 ms (0001) it will be 700 ms, for 400 ms (0010) 900 ms, and for 800 ms (0011) about 1300 ms.

PSM	ALS_IT	REFRESH TIME (ms)
00	0000	600
00	0001	700
00	0010	900
00	0011	1300

Other PSM modes will lead to even lower repetition rates. This will also lead to a lower power consumption (see the table on the next page).

The higher the PSM value and the longer the integration time, the lower the current consumption will be. The possible sensitivity also depends on integration time, where the longest (800 ms) will lead to 0.005 lx/counts, together with the highest sensitivity: ALS_SM = 01 (ALS sensitivity 2).

All refresh times, corresponding current consumptions, and possible sensitivities are shown in the table on the next page.

REFRESH TIME, I_{DD}, AND SENSITIVITY RELATION					
ALS_SM	PSM	ALS_IT	REFRESH TIME (ms)	I_{DD} (µA)	SENSITIVITY (lx/counts)
01	00	0000	600	8	0.042
01	01	0000	1100	5	0.042
01	10	0000	2100	3	0.042
01	11	0000	4100	2	0.042
01	00	0001	700	13	0.021
01	01	0001	1200	8	0.021
01	10	0001	2200	5	0.021
01	11	0001	4200	3	0.021
01	00	0010	900	20	0.010
01	01	0010	1400	13	0.010
01	10	0010	2400	8	0.010
01	11	0010	4400	5	0.010
01	00	0011	1300	28	0.005
01	01	0011	1800	20	0.005
01	10	0011	2800	13	0.005
01	11	0011	4800	8	0.005

Designing the VEML6030 into an Application

INTERRUPT HANDLING

To avoid too many interactions with the microcontroller, the interrupt feature may be used. This is activated with ALS_INT_EN = 1.

Only when the programmed threshold is crossed (above / below) consecutively by the programmed number of measurements (ALS_PERS) will the corresponding interrupt bit (ALS_IF_L or ALS_IF_H) be set and the interrupt pin pulled down.

COMMAND REGISTER FORMAT				
COMMAND CODE	**REGISTER NAME**	**BIT**	**FUNCTION / DESCRIPTION**	**R / W**
00	ALS_INT_EN	1	ALS interrupt enable setting 0 = ALS INT disable 1 = ALS INT enable	W
00	ALS_PERS	5 : 4	ALS persistence protect number setting 00 = 1 01 = 2 10 = 4 11 = 8	W
01	ALS_WH	15 : 8	ALS high threshold window setting (MSB)	W
		7 : 0	ALS high threshold window setting (LSB)	W
02	ALS_WL	15 : 8	ALS low threshold window setting (MSB)	W
		7 : 0	ALS low threshold window setting (LSB)	W
06	ALS_IF_L	15	ALS crossing low threshold INT trigger event	R
	ALS_IF_H	14	ALS crossing high threshold INT trigger event	R
	reserved	13 : 0		

MECHANICAL CONSIDERATIONS AND WINDOW CALCULATION FOR THE VEML6030

The ambient light sensor will be placed behind a window or cover. The window material should be completely transmissive to visible light (400 nm to 700 nm). For optimal performance the window size should be large enough to maximize the light irradiating the sensor. In calculating the window size, the only dimensions that the design engineer needs to consider are the distance from the top surface of the sensor to the outside surface of the window and the size of the window. These dimensions will determine the size of the detection zone.

First, the center of the sensor and center of the window should be aligned. The VEML6030 has an angle of half sensitivity of about ± 55°, as shown in the figure below.

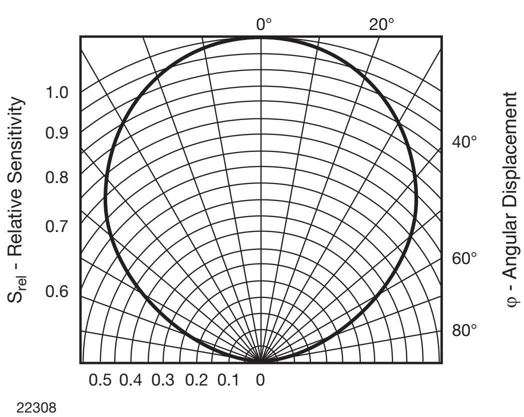


Fig. 22 - Relative Radiant Sensitivity vs. Angular Displacement

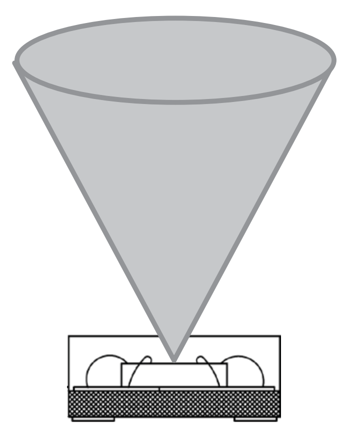


Fig. 23 - Angle of Half Sensitivity: Cone

Remark:

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

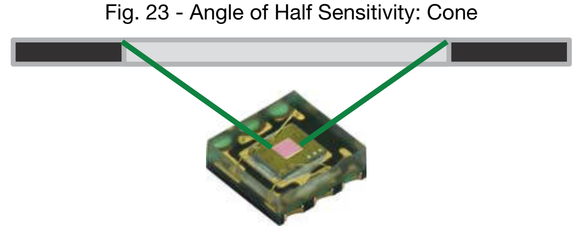
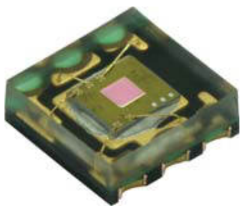


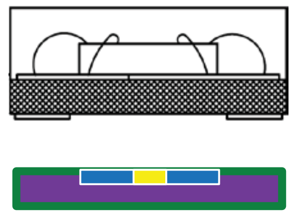
Fig. 24 - Windows Above Sensitive Area

Designing the VEML6030 into an Application

The size of the window is simply calculated according to triangular rules. The dimensions of the device are shown within the datasheet, and with the known distance below the window's upper surface and the specified angle below the given window diameter (w), the best results are achieved.

VEML6030





Dimensions (L x W x H in mm): 2 x 2 x 0.85

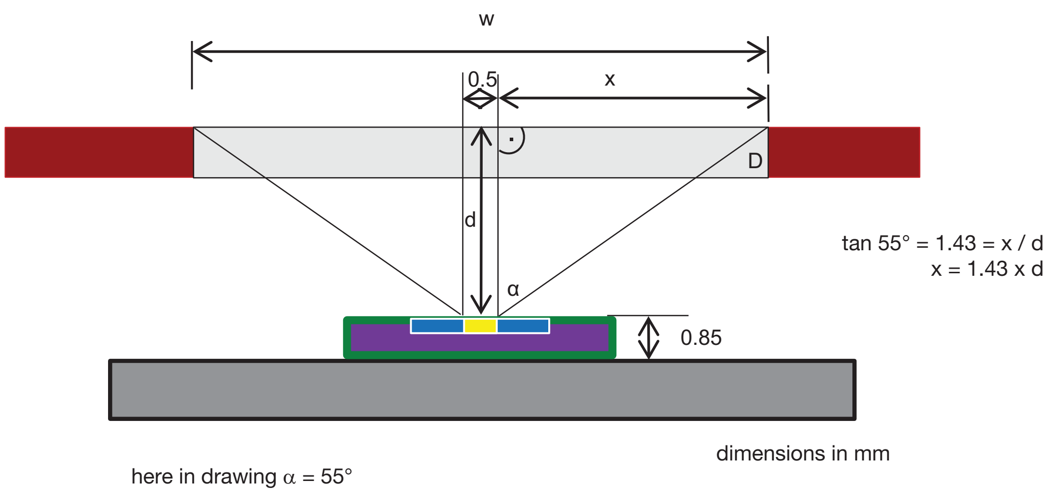


Fig. 25 - Window Area for an Opening Angle of ± 55°

The calculation is then: tan α = x / d $\rightarrow$ with α = 55° and tan 55° 1.43 = x / d $\rightarrow$ x = 1.43 x d

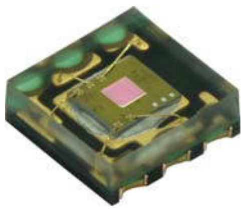
Then the total width is w = 0.5 mm + 2 x x.

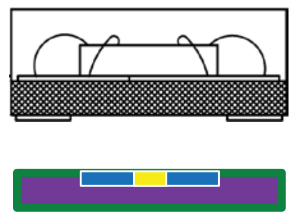
d = 0.5 mm	→	x = 0.72 mm	→	w = 0.5 mm + 1.44 mm	=	1.94 mm
d = 1.0 mm	→	x = 1.43 mm	→	w = 0.5 mm + 2.86 mm	=	3.36 mm
d = 1.5 mm	→	x = 2.15 mm	→	w = 0.5 mm + 4.30 mm	=	4.80 mm
d = 2.0 mm	→	x = 2.86 mm	→	w = 0.5 mm + 5.72 mm	=	6.22 mm
d = 2.5 mm	→	x = 3.58 mm	→	w = 0.5 mm + 7.16 mm	=	7.66 mm
d = 3.0 mm	→	x = 4.29 mm	→	w = 0.5 mm + 8.58 mm	=	9.08 mm

Designing the VEML6030 into an Application

A smaller window is also sufficient if reference measurements can be done and / or if the output result does not need to be as exact as an optometer.

VEML6030





Dimensions (L x W x H in mm): 2 x 2 x 0.85

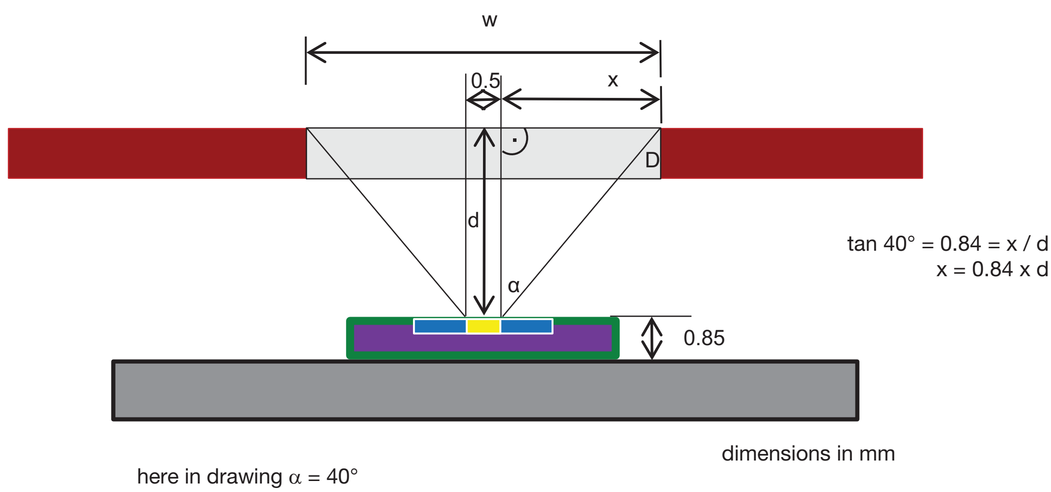


Fig. 26 - Window Area for an Opening Angle of ± 40°

The calculation is then: tan α = x / d $\rightarrow$ with α = 40° and tan 40° 0.84 = x / d $\rightarrow$ x = 0.84 x d

Then the total width is w = 0.5 mm + 2 x x.

d = 0.5 mm	→	x = 0.42 mm	→	w = 0.5 mm + 0.84 mm	=	1.34 mm
d = 1.0 mm	→	x = 0.84 mm	→	w = 0.5 mm + 1.68 mm	=	2.18 mm
d = 1.5 mm	→	x = 1.28 mm	→	w = 0.5 mm + 2.56 mm	=	3.06 mm
d = 2.0 mm	→	x = 1.68 mm	→	w = 0.5 mm + 3.36 mm	=	3.86 mm
d = 2.5 mm	→	x = 2.10 mm	→	w = 0.5 mm + 4.20 mm	=	4.70 mm
d = 3.0 mm	→	x = 2.52 mm	→	w = 0.5 mm + 5.04 mm	=	5.54 mm

Designing the VEML6030 into an Application

TYPICAL SOFTWARE FLOW CHART

For a wide light detection range of more than seven decades (from 0.01 lx to 167 klx), it is necessary to adjust the sensor. This is done with the help of four gain / sensitivity steps and seven steps for the integration time. To deal with these steps, they are numbered as needed for the application software.

The ALS sensitivity (or gain) modes are called G1 to G4 and the integration times are called IT:

Sensitivity Mode Selection	G
00 = ALS sensitivity x 1	→ 3
01 = ALS sensitivity x 2	→ 4
10 = ALS sensitivity x (1/8)	→ 1
11 = ALS sensitivity x (1/4)	→ 2

ALS Integration Time Setting	IT
1100 = 25 ms	→ -2
1000 = 50 ms	→ -1
0000 = 100 ms	→ 0
0001 = 200 ms	→ 1
0010 = 400 ms	→ 2
0011 = 800 ms	→ 3

Whereas the programmed gain begins with the lowest possible value, in order to avoid any saturation effect the integration time starts with 100 ms: IT = 0.

With this just about 52 klx is possible. If this is not enough due to a wide and clear cover, and the sensor being exposed to direct bright sunlight, one may also begin with the shortest integration time.

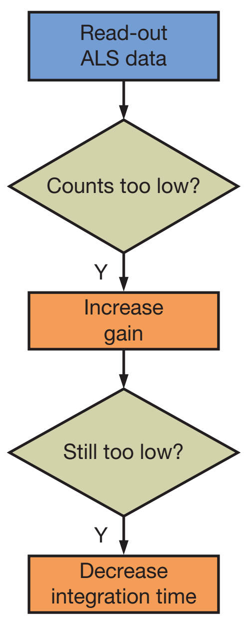


Fig. 27 - Simple Flow Chart View

Designing the VEML6030 into an Application

TYPICAL SOFTWARE FLOW CHART WITH CORRECTION FORMULA (1)

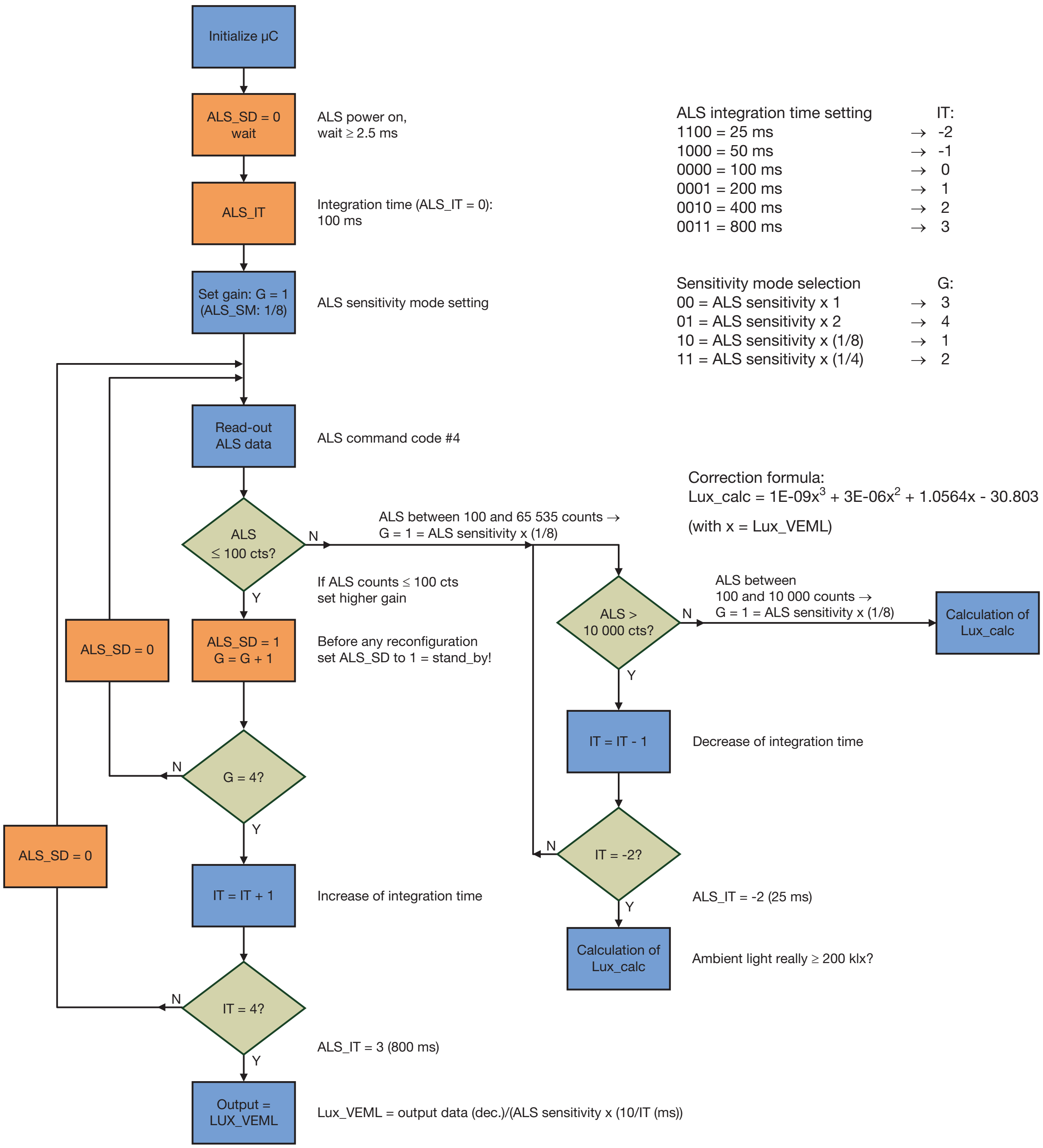


Fig. 28 - Flow Chart with Correction Formula from ≥ 100 lx

Designing the VEML6030 into an Application

TYPICAL SOFTWARE FLOW CHART WITH CORRECTION FORMULA (2)

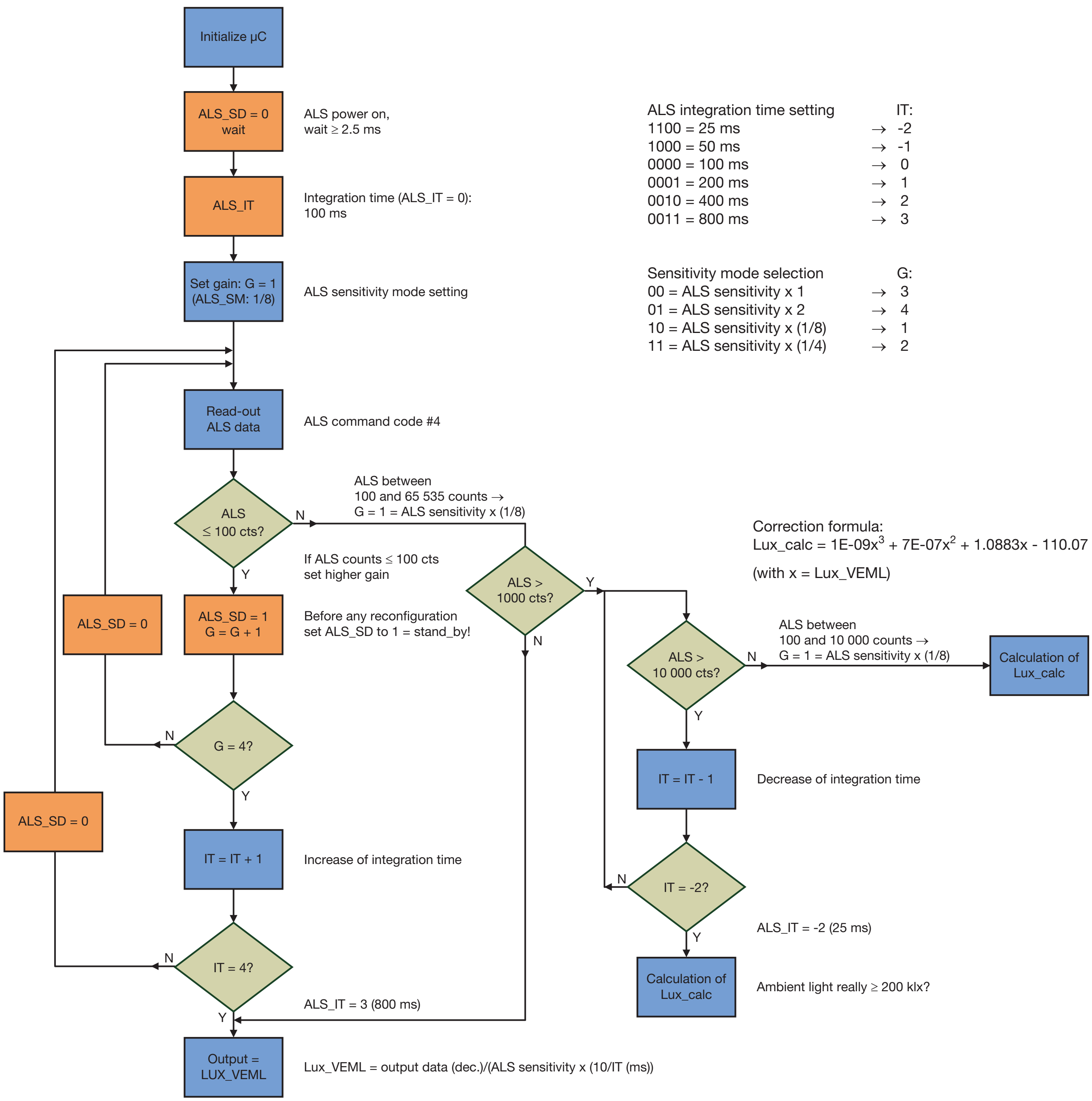


Fig. 29 - Flow Chart with Correction Formula from ≥ 1000 lx

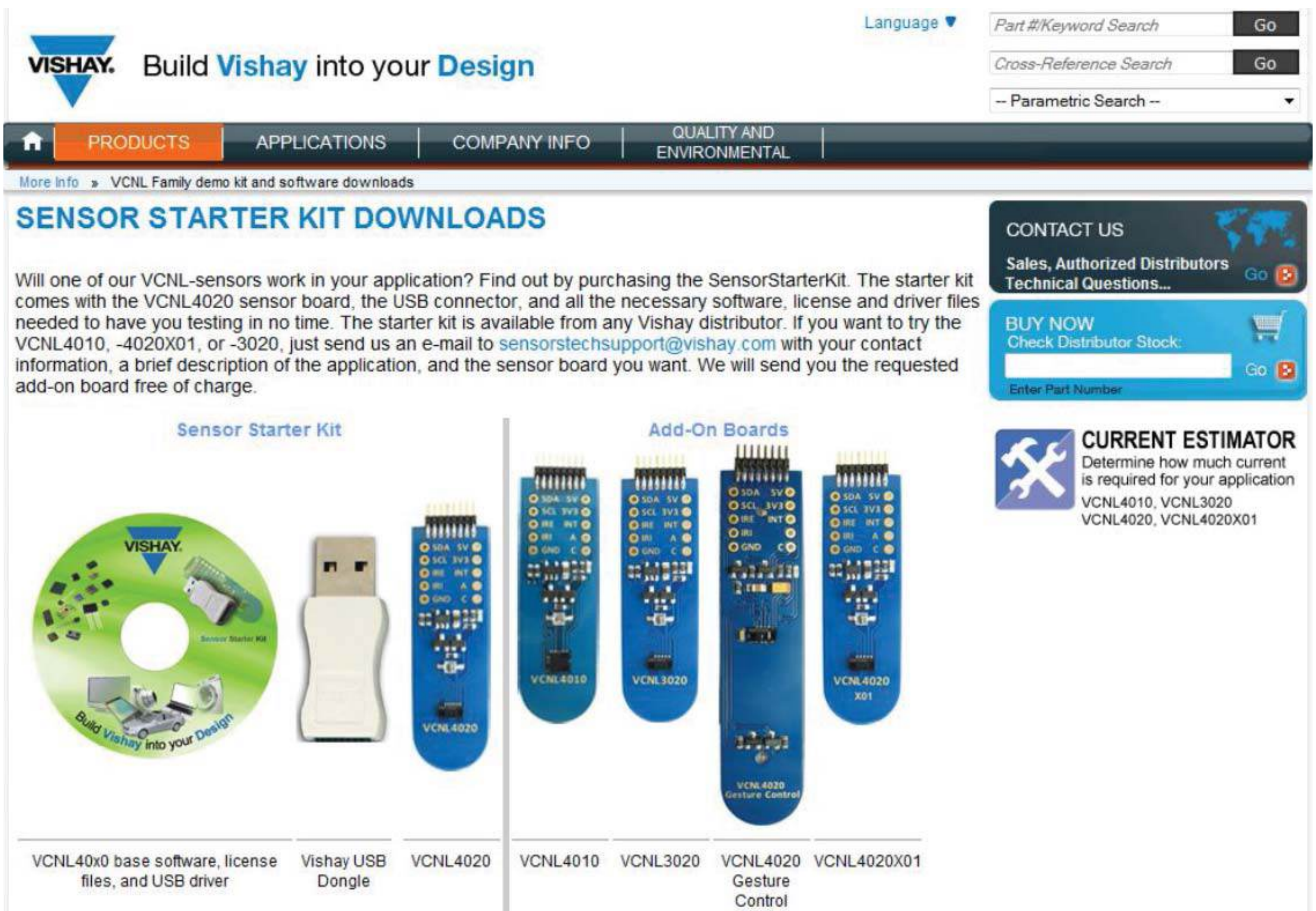
Designing the VEML6030 into an Application

TYPICAL LUMINANCE VALUES

Luminance	Example
10^{-5} lx	Light from Sirius, the brightest star in the night sky
10^{-4} lx	Total starlight, overcast sky
0.002 lx	Moonless clear night sky with airglow
0.01 lx	Quarter moon, 0.27 lx; full moon on a clear night
1 lx	Full moon overhead at tropical latitudes
3.4 lx	Dark limit of civil twilight under a clear sky
50 lx	Family living room
80 lx	Hallway / bathroom
100 lx	Very dark overcast day
320 lx to 500 lx	Office lighting
400 lx	Sunrise or sunset on a clear day
1000 lx	Overcast day; typical TV studio lighting
10 000 lx to 25 000 lx	Full daylight (not direct sun)
32 000 lx to 130 000 lx	Direct sunlight

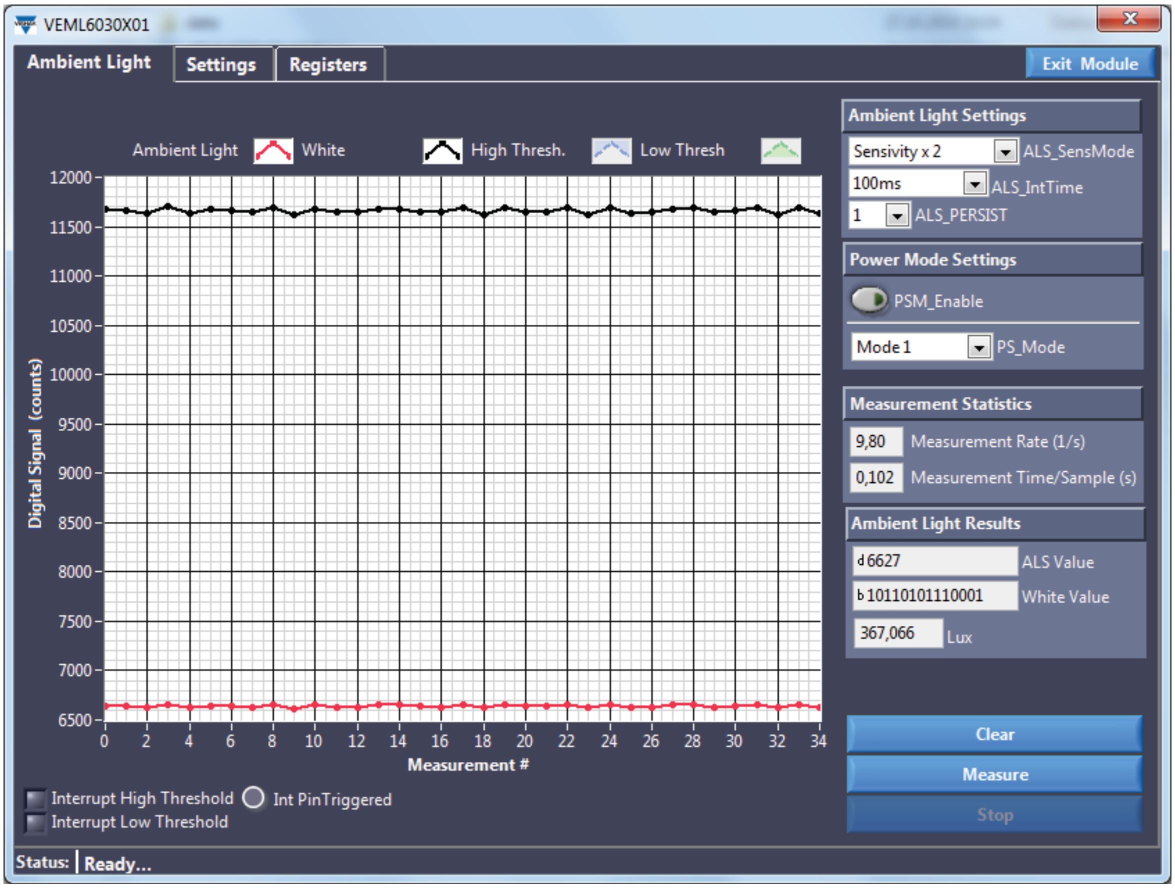
VEML6030 SENSOR BOARD AND DEMO SOFTWARE

The small blue VEML6030 sensor board is compatible with the SensorStarterKit.
Please also see www.vishay.com/moreinfo/vcnldemokit/



Designing the VEML6030 into an Application

After plugging in the VEML6030 sensor board to the USB dongle (both up or down are possible) and activating with the "VEML6030.exe" file, the "Ambient Light" menu appears.



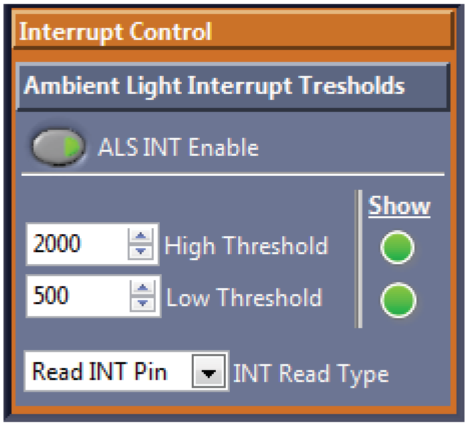
The ALS sensitivity mode is preprogrammed to "sensitivity x 2" and integration time to "100 ms." Self-timed measurements are started by clicking the measure button.

Both, the ALS and the white channel are shown. A channel can be deactivated by clicking within the small white box on top of the graph and clicked again to make visible. In addition, decimal, binary, or hex formats can be selected in the small white boxes on the right side, where the small letters "d" and "b" are shown.

The lux level is calculated according to the rules mentioned above, and the chosen gain and integration time are displayed in the lowest white box "Lux."

Designing the VEML6030 into an Application

The screen shots below appear when programming the upper and lower thresholds within the "Settings" menu.



Selecting "ALS INT Enable" and "Show" within the measurement menu will then show the high and low thresholds as blue and green lines, respectively. If the light source changes to that higher or lower value, the below appears.