DT0030
Design tip

VL6180X ambient light sensing

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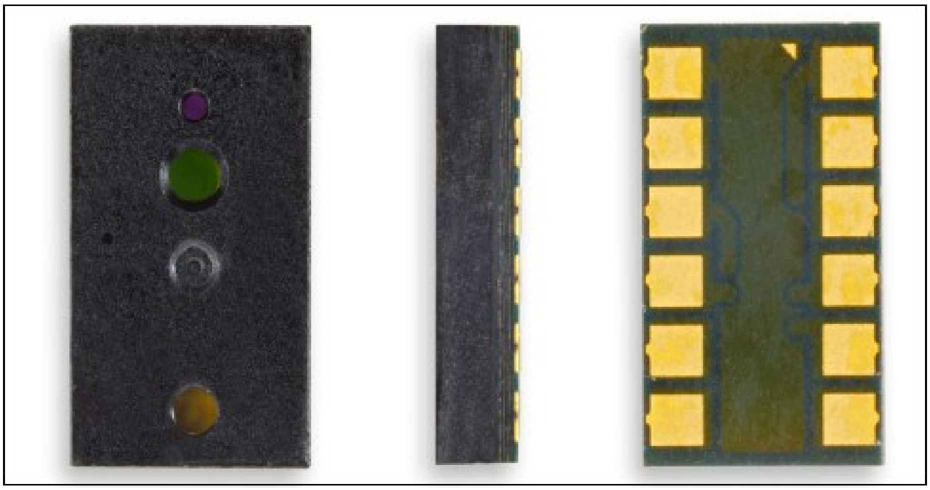
Main components	
VL6180X	Proximity and ambient light sensing (ALS) module

Purpose and Benefits

This design tip explains how to use and implement the ambient light sensing features of the VL6180X.

It is assumed that the user can communicate with the VL6180X through I^2C, is familiar with writing to the device registers and the device start up procedure.

Figure 1. VL6180X



Ambient Light Sensing (ALS) Overview

The VL6180X can measure the incoming ambient light over a wide dynamic range. The ALS sensor uses a photopic filter in order to approximate the spectral response of the human eye. The raw data output from the ALS is a 16-bit (0 – 65,535) value that is proportional to the amount of light within the field of view during the integration time. The device has a ±42 degree field of view (FOV). The ALS count is converted to lux by the host processor when necessary. Lux is the standard unit of light intensity or measurement of the amount of perceived light in an area. Table 1 shows some typical examples of lux values for different conditions.

Table 1. Typical lighting conditions

Illuminance (lux)	Scene Description
0.0001	Moonless overcast night
0.002	Moonless clear night
0.27- 1.0	Full Moon on clear night
1	Twilight
50	Typical family room lighting
80	Typical Office / Hallway lighting
100	Dark overcast day
400	Sunrise or sunset on clear day
1000	Overcast day, typical TV studio lighting
10,000 – 25,000	Clear Day indirect sunlight
32,000 – 100,000	Direct Sunlight

Analog Gain

Analog gain is selected to match the ALS dynamic range to the expected light range of the application and to compensate for the use of cover glass. The analog gain is set by writing the index value in the SYSALS_ANALOGUE_GAIN (0x003F) register as defined in Table 2.

Table 2. ALS dynamic range (1)

Index Value Reg (0x003F)	Analog Settings	Actual gain values	Dynamic Range (no Cover Glass)		Dynamic Range (10% transmissive cover glass)	
			Min (Lux)(2)	Max (Lux)	Min (Lux)	Max (Lux)
0x06	1	1.01	3.20	20,800	32.0	>100,000
0x05	1.25	1.28	2.56	16,640	25.6	>100,000
0x04	1.67	1.72	1.93	12,530	19.2	>100,000
0x03	2.5	2.6	1.28	8,320	12.8	83,200
0x02	5	5.21	0.64	4,160	6.4	41,600
0x01	10	10.32	0.32	2,080	3.2	20,800
0x00	20	20	0.16	1,040	1.6	10,400
0x07	40	40	0.08	520	0.8	5,200

1. ALS Lux Resolution 0.32 @ 100ms integration time
2. Minimum ALS count 10

When converting the ALS count value to lux using actual gain value, as shown in Table 2, will give a more accurate result.

ALS Result Scalar

In additional to analog gain, the VL6180X has a result scalar that multiplies the ALS count prior to it being written to RESULT__ALS_VAL (0x0050). This value, in addition to the analog gain, is useful in very low light conditions to increase the dynamic range. The scalar value is a 5-bit number stored in FIRMWARE__RESULT_SCALER (0x0120) with a range of (1 -32).

Integration Time

The ambient light sensor works by counting photons over a fixed time period referred to as the integration time. The resulting output value is proportional to the amount of light sensed or photons received during the integration period. The system is set in the factory to match 0.32 lux per ALS count at an integration time of 100ms. The 100ms integration time is optimal for most applications. It is recommended to adjust the analog gain setting for different light level applications rather than adjusting integration time.

When necessary, the integration time can be changed. For example, when the sample rate is required to be faster than the 100ms integration time allowed, decreasing the integration time will allow for faster sampling rates. Lowering the integration time will, however, increase the effect of the light flicker on the result. It is recommended to keep integration time in steps of 50ms to reduce the impact of light flicker. The integration time is stored in the SYSALS__INTEGRATION_PERIOD (0x0040) in milliseconds. The range is 1 to 499ms so the value in the register is one less than the desired value in milliseconds:

SYSALS__INTEGRATION_PERIOD = integration period – 1.

In applications where the low light dynamic range is more important than measuring high brightness scenes, increasing the integration time will increase the dynamic range while lowering the brightness at which the sensor saturates.

ALS Lux Resolution

As previously stated, the default ALS lux resolution is 0.32 lux per count and it is recommended not to be changed since the system was tuned to this count with 100ms integration time. The ALS Lux resolution is not a stored value in a register nor does it affect the operation of the unit, but is a value used when converting the ALS count to lux. In applications that would benefit from a more specific value, the lux resolution can be calibrated by using an external light meter to measure the amount of light and then record the ALS count value.

ALS Lux Resolution = Lux Reading / ALS Count Value

It is best to set the analog gain to 1, set the integration time to the value used in the application, and the light level set to the most critical level for the application. For example, if either a low or high ALS threshold interrupt is used, then the threshold would be the best light level to set. Care has to be taken when making this calibration, since differences in the field of view between the VL6180X and a standard lux meter can produce differing results. Adding a cone to the lux meter or using a diffuser can mitigate this effect.

Cover Glass Calibration

The use of cover glass in an application will block a percentage of light measured at the sensor. This reflected or absorbed light by the glass needs to be accounted for when converting the ALS count to lux. The calibration of the cover glass is only needed when the cover glass is modified. Like ALS lux resolution, the calibration is only used in the conversion from ALS counts to lux and is not written to the VL6180X. To calibrate for cover glass, the device should be placed under a stable light source similar in color temperature and intensity as the application. Multiple ALS measurements are taken both with and without the cover glass. The calibration factor is the ratio of the averaged results:

Cover Glass Cal Factor = Avg without glass / Avg with glass

Converting ALS Count to Lux

To convert the ALS count to lux, the factors discussed above need to be taken into account. The ALS count read from the RESULT_ALS_VAL (0x0050) is proportional to the level of ambient light and can be converted to lux by the following equation:

Lux = RESULT__ALS_VAL / Analog Gain Value * ALS Lux Res * 100 / (SYSALS__INTEGRATION_PERIOD +1) / FIRMWARE__RESULT_SCALER * Cover Glass Cal Factor

Example: ALS Count =2040; Analog Gain = 1.67; no cover glass; scalar = 1

Lux = 2040 / 1.67 * 0.32 * 100 / (99 +1) / 1 * 1 = 390.90

Use of Interrupts and Thresholds

The VL6180X can be set up to trigger an interrupt on ALS values as well as range data. The ALS interrupt can be configured to trigger when either below a Low Threshold, above a High Threshold, outside a window, or whenever a new reading is ready. An interrupt can either be polled or set to trigger a GPIO signal. For example, this can be useful in applications where the ranging feature is not needed when there are no lights on in a room. The host processor can configure the VL6180X to trigger the GPIO1 on a high light level, then go to sleep until the lights come back on. The configuration of the GPIO is set in bits 3-5 of SYSTEM__INTERRUPT_CONFIG_GPIO (0x0014). The threshold levels are set in either SYSALS__THRESH_HIGH (0x003A) or SYSALS__THRESH_LOW (0x003C). The threshold levels are written in ALS counts rather than in lux.

In the example of a low power application where the ranging functions is needed only when the lights in a room are on and the typical lighting in the room is 100lux, the VL6180X GPIO1 can be configured trigger HIGH when the light increases to 75Lux by setting the following registers after running the standard start up scripts:

SYSTEM__INTERRUPT_CONFIG_GPIO = 0x10	ALS Interrupt to High Threshold
SYSTEM__MODE_GPIO1 = 0x30	Enable GPIO1 interrupt
SYSALS__THRESH_HIGH = 0x0960	Sets high threshold to 75 lux

0x960 = 2,400 ALS count = 75lux / Analog Gain / 0.01 (cover glass cal) / 0.32 (res)

SYSALS__INTERMEASUREMENT_PERIOD = 0x32	Sets sample period to 500ms
SYSALS__START = 0x03	Starts ALS Continuous

Next, the processor can go into a low power sleep state waiting for the VL6180X to trigger the host processor to wake up as the lights turn on and the lux level increases above 75Lux. The host processor can then change the VL6180X configuration to ranging or interleaved mode.

Support Material

Related design support material
MOB-EK2-180-03 - VL6180X Premium Evaluation Kit
Documentation
Datasheet: VL6180X - Proximity and ambient light sensing (ALS) module

Revision History

Date	Version	Changes
12-June-2014	1	Initial release