Product Document

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Design Guide

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AS7331 Sensor

Details for the Hardware, Software and Optics

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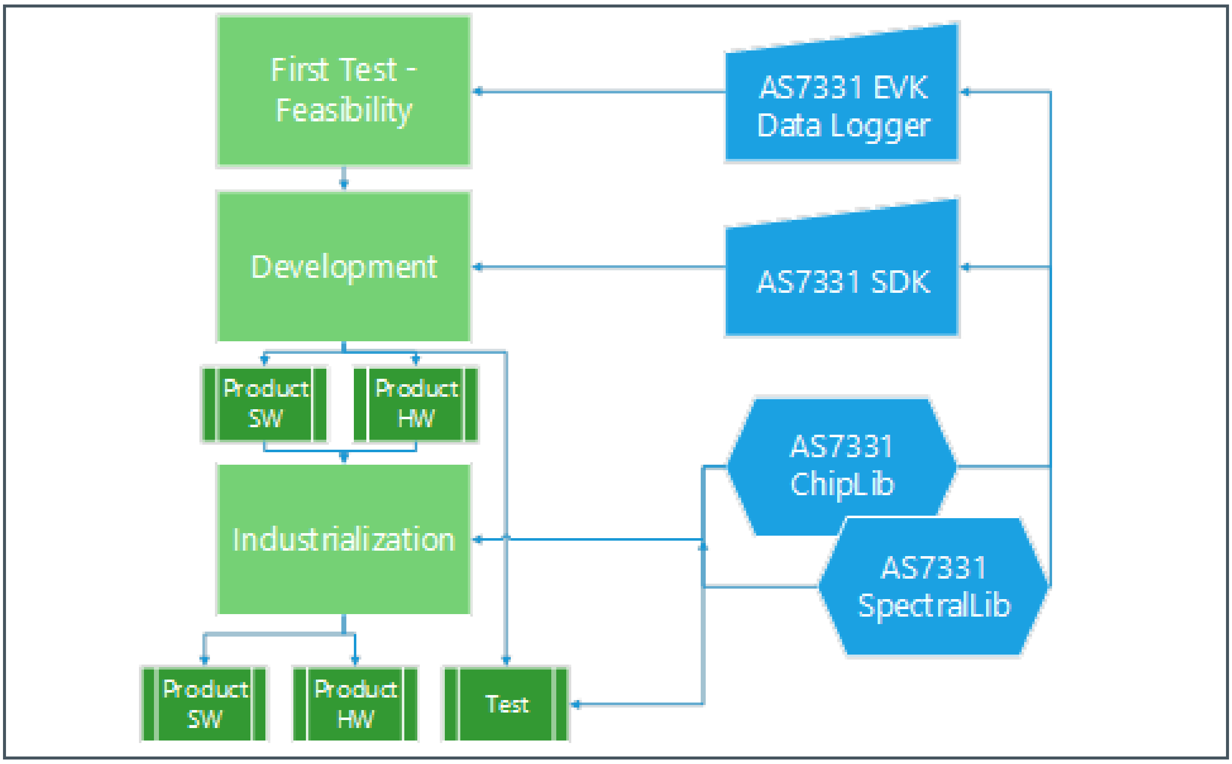
Content Guide

1 Introduction

For developments with the AS7331 UV Sensor, the following design support tools are offered in addition to the chip:

- ☑ Libraries – All sensor settings and controls can be done with the Chip Library, which is “integrate and map able” in alternative system levels and in all design steps. Using this library can be done in all steps without redesigning the sensor software.
- ☑ Evaluation Kits – These are plug-and-play test kits with pre-defined optical modules and a simple Windows GUI to realize application-specific tests under customer-defined conditions. It produces sensitive and accurate tests very quickly with a low effort.
- ☑ Source Development Kits – These easily show the work with the libraries and allow the test of customer algorithms based on sensor results without preparation of the sensor control.

Figure 1:
AS7331 Test Systems and Libraries Supporting Steps in the Development



The following chapters briefly describe the AS7331 sensor, its test and development tools in hardware and software, and gives design tips for the system design of the sensor. It is recommended to use the tools shown in Figure 1.

2 Sensor Chip

The AS7331 is an integrated UV sensor with three separated UV-sensitized channels, an integrated signal conversion, and an I²C transmission and interface. The sensor's irradiance responsivity can be adjusted by the ADC parameters – Gain, conversion time, and internal clock frequency, which affect the sensitivity, noise, full-scale range, and LSB depending on the selected clock (see Figure 5). The parameter settings apply to all channels and cannot be set separately for individual channels. The AS7331 provides the radiation it detects as ADC results and digital counts or digits. The ADC parameter settings directly affects the counts and their numbers. Counts or digits are without an application-specific unit and must be mapped to absolute units based on calibration processes. Such detailed processes and algorithms can be read in sensor calibration manuals.

Figure 2 shows the block diagram of the sensor chip. The incident light is split into three spectral channels coated by interference filters for UVA, UVB, and UVC (see Figure 3 and Figure 4). The single photocurrents are converted into digital values. A wide range of configuration options allows the measuring range, measuring time, and accuracy.

The internal resolution of the AD converter can be varied from 10-bit to 24-bit (depending on the set measuring time). The output of the measurement data is always 16-bit. A prescaler (divider or shifter) affecting each channel allows the scaling/mapping of the data from the respective internal converter. This is of particular advantage if the measuring time is selected to be greater than 2^{16} clock periods for the acquisition, such that it causes an overflow of the result registers. Thus, the prescaler allows access to the higher-order bits of the measurement results from the AD converters. They fulfill the task of a measuring range switchover. The set divider factor acts simultaneously on all three channels.

Using all the stages of the ADC parameters, gain, conversion time, and clock, defines the sensor dynamic. The AS7331 offers a range of 12 gain steps from 1 to 2048 by a factor of two for each step. The conversion time is controlled internally over a wide range of 15 steps between 125 µs and 16384 ms, by a factor of two for each step - depending on the selected clock frequency. With the input pin (SYN), the conversion time can be controlled externally to adapt the measurement of the given environment and time base. With its irradiance, responsivity factor and conversion time, the AS7331 supports an overall huge dynamic range up to 3.43E+10 (resolution multiplied by the gain range). It achieves an accuracy of up to nearly 24-bit signal resolution (mapped internally via the shifter to 16-bit I²C), with an irradiance responsivity per count down to 2.7 nW/cm² at 64 ms integration time.

Programming all the parameters and other settings is done via the integrated 16-bit/400 kHz I²C interface.

The AS7331 can operate in different modes to measure continuous, one-step, or synchronized modes - where the edges at the external pin (SYN) Start or Start and Stop the measurement. Such modes for measurements must be configured in the configuration mode.

Figure 2:
Block Diagram

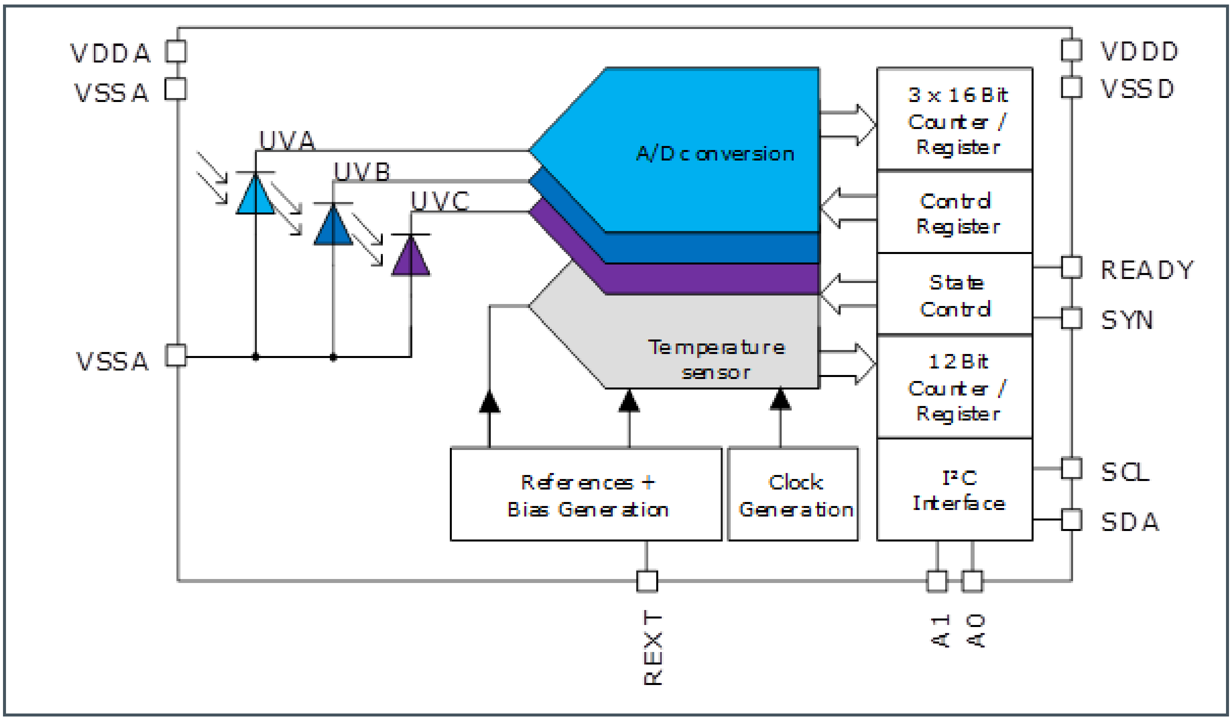


Figure 3:
Normalized Spectral Responsivity of the AS7331

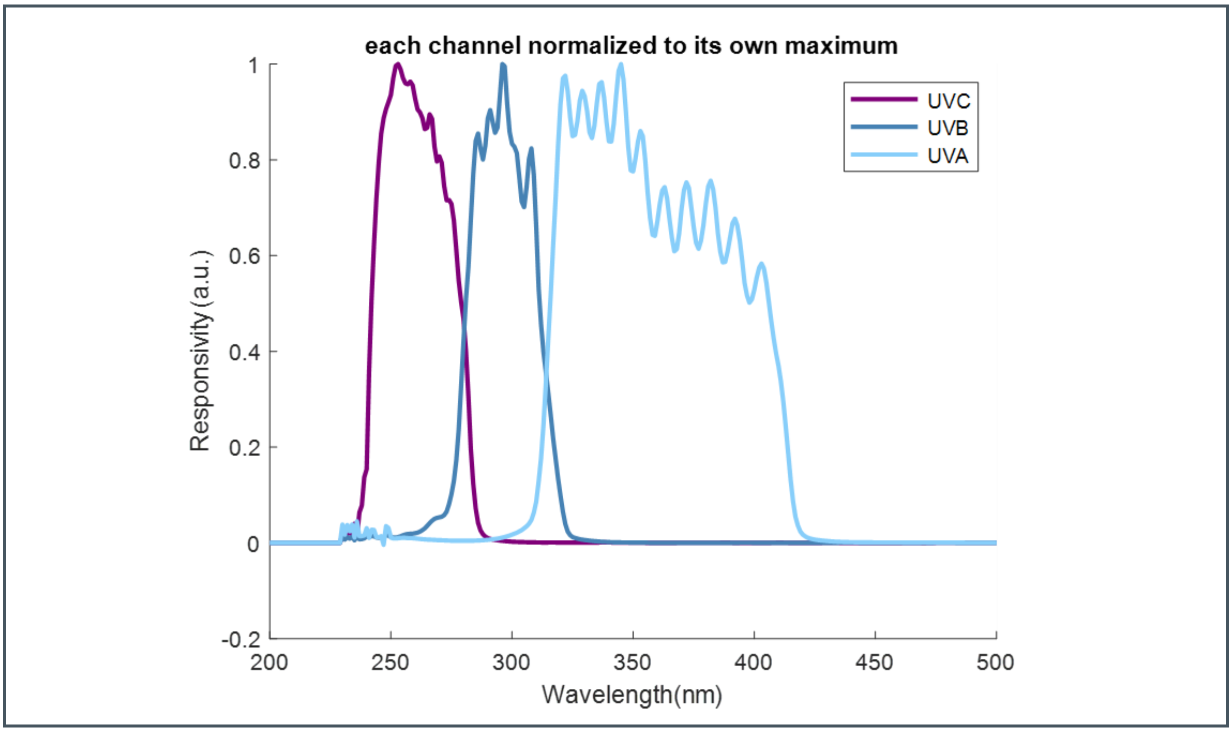


Figure 4:
Spectral Responsivity of the AS7331

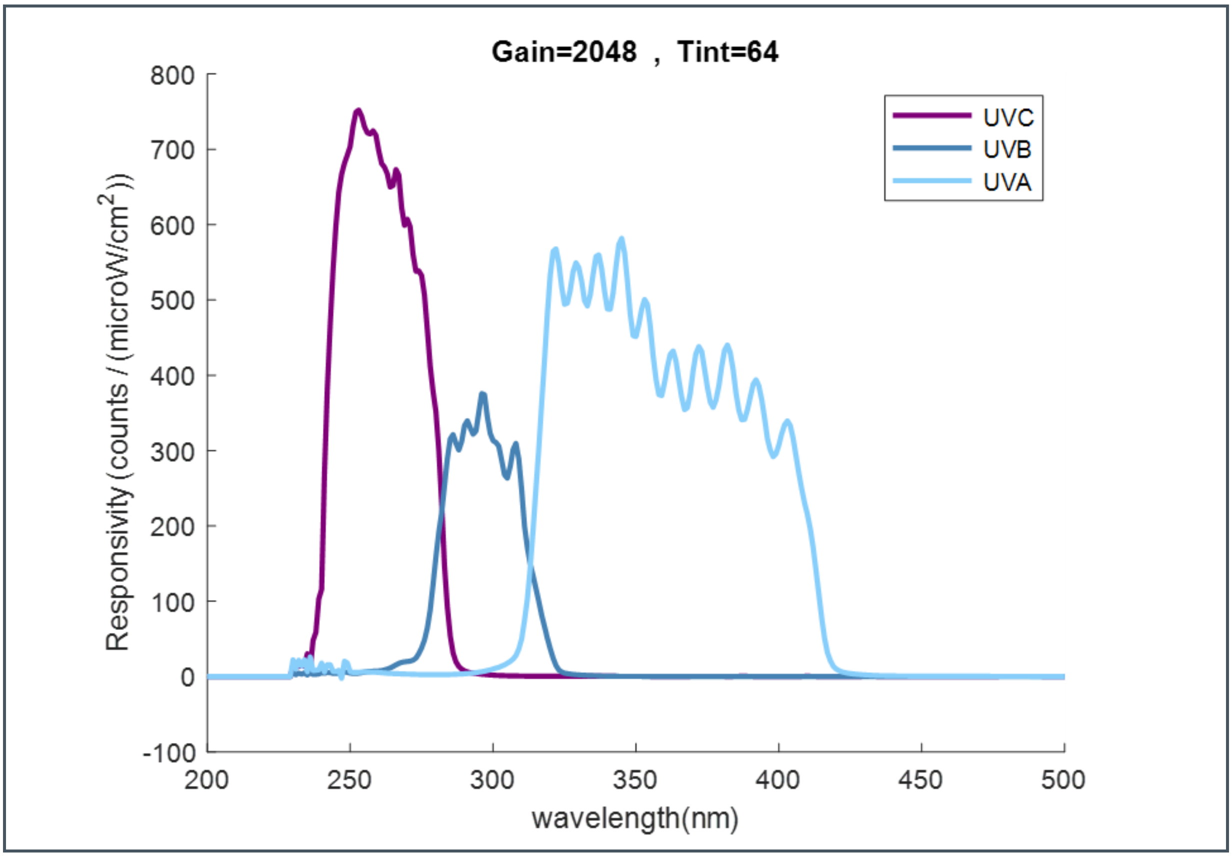
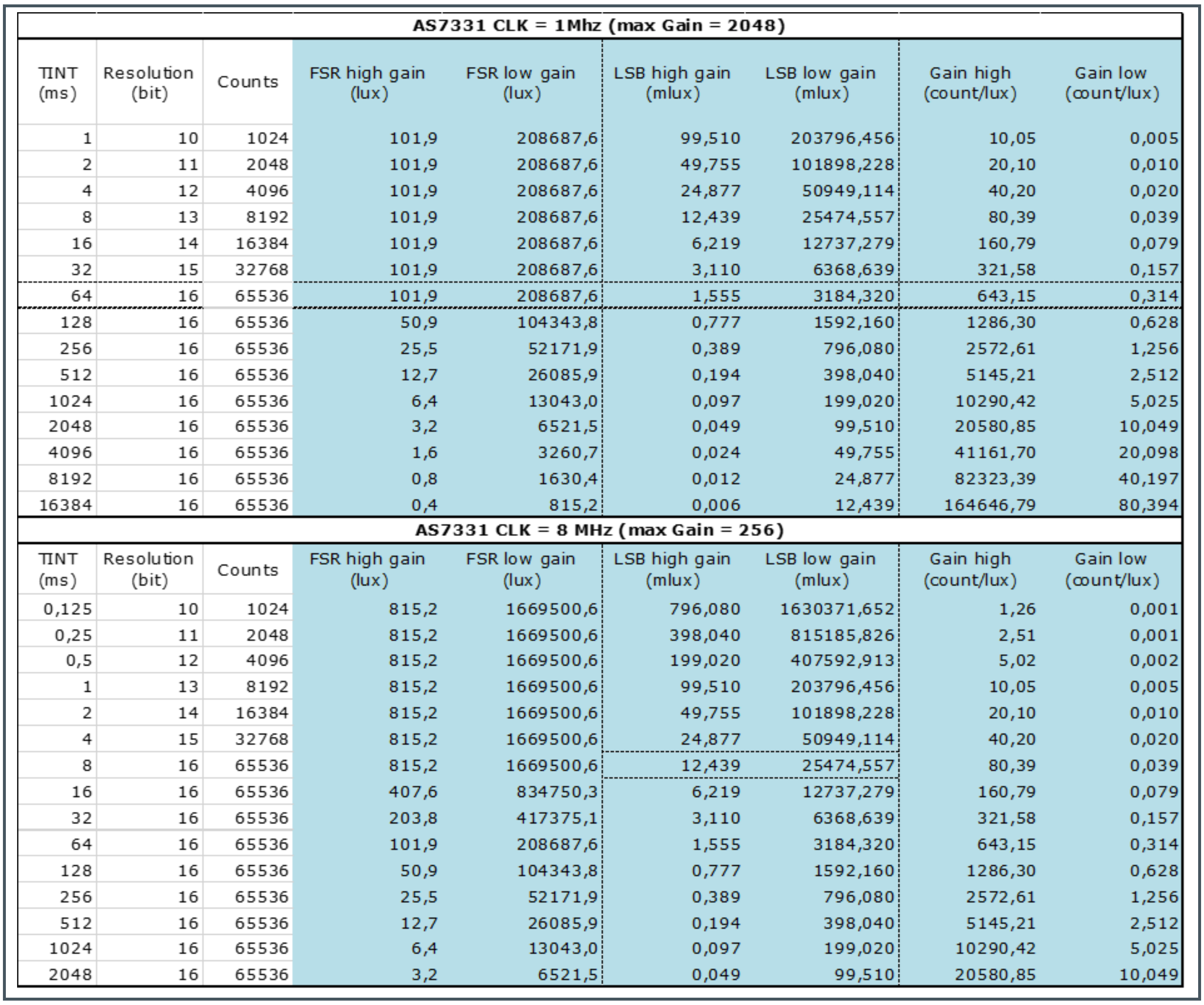


Figure 5:
Relationship Between TINT, Gain, Clock and LSB, FSR Based on Typical Values



AS7331 CLK = 1Mhz (max Gain = 2048)

TINT (ms)	Resolution (bit)	Counts	FSR high gain (lux)	FSR low gain (lux)	LSB high gain (mlux)	LSB low gain (mlux)	Gain high (count/lux)	Gain low (count/lux)
1	10	1024	101,9	208687,6	99,510	203796,456	10,05	0,005
2	11	2048	101,9	208687,6	49,755	101898,228	20,10	0,010
4	12	4096	101,9	208687,6	24,877	50949,114	40,20	0,020
8	13	8192	101,9	208687,6	12,439	25474,557	80,39	0,039
16	14	16384	101,9	208687,6	6,219	12737,279	160,79	0,079
32	15	32768	101,9	208687,6	3,110	6368,639	321,58	0,157
64	16	65536	101,9	208687,6	1,555	3184,320	643,15	0,314
128	16	65536	50,9	104343,8	0,777	1592,160	1286,30	0,628
256	16	65536	25,5	52171,9	0,389	796,080	2572,61	1,256
512	16	65536	12,7	26085,9	0,194	398,040	5145,21	2,512
1024	16	65536	6,4	13043,0	0,097	199,020	10290,42	5,025
2048	16	65536	3,2	6521,5	0,049	99,510	20580,85	10,049
4096	16	65536	1,6	3260,7	0,024	49,755	41161,70	20,098
8192	16	65536	0,8	1630,4	0,012	24,877	82323,39	40,197
16384	16	65536	0,4	815,2	0,006	12,439	164646,79	80,394

AS7331 CLK = 8 MHz (max Gain = 256)

TINT (ms)	Resolution (bit)	Counts	FSR high gain (lux)	FSR low gain (lux)	LSB high gain (mlux)	LSB low gain (mlux)	Gain high (count/lux)	Gain low (count/lux)
0,125	10	1024	815,2	1669500,6	796,080	1630371,652	1,26	0,001
0,25	11	2048	815,2	1669500,6	398,040	815185,826	2,51	0,001
0,5	12	4096	815,2	1669500,6	199,020	407592,913	5,02	0,002
1	13	8192	815,2	1669500,6	99,510	203796,456	10,05	0,005
2	14	16384	815,2	1669500,6	49,755	101898,228	20,10	0,010
4	15	32768	815,2	1669500,6	24,877	50949,114	40,20	0,020
8	16	65536	815,2	1669500,6	12,439	25474,557	80,39	0,039
16	16	65536	407,6	834750,3	6,219	12737,279	160,79	0,079
32	16	65536	203,8	417375,1	3,110	6368,639	321,58	0,157
64	16	65536	101,9	208687,6	1,555	3184,320	643,15	0,314
128	16	65536	50,9	104343,8	0,777	1592,160	1286,30	0,628
256	16	65536	25,5	52171,9	0,389	796,080	2572,61	1,256
512	16	65536	12,7	26085,9	0,194	398,040	5145,21	2,512
1024	16	65536	6,4	13043,0	0,097	199,020	10290,42	5,025
2048	16	65536	3,2	6521,5	0,049	99,510	20580,85	10,049

Regarding power consumption, the AS7331 supports different power-saving modes. The standby mode can be used, for example, when single measurements are performed at longer time intervals. In this case, the AS7331 automatically goes into sleep mode with reduced power consumption after the measurement. Then, it can be woken up for the next measurement via an external command. However, the power down mode, allows the sensor chip to be switched off under software control. This reduces the power consumption again compared to the standby mode. However, a longer settling time is required here when switching it back on. At a typical operating voltage of 3.3 V, the sensor has a current consumption of 1.6 mA during measurement.

For the temperature measurement, an integrated temperature sensor with a maximum resolution of 12-bit, with a typical slope of 20 counts/K, is integrated. It measures the temperature of the silicon. However, direct measurement of the ambient temperature in the application is only possible, to a limited extent, since this largely depends on the thermal behavior and the design of the application. The internal temperature sensor can support this.

The AS7331 is completed with an internal generation of all reference voltages and bias currents, as well as an internal clock generation. For an accurate and safe sensor operation, the external circuits and their parameters must be observed.

Attention

Please note that all external circuits, parameters, processes, and components in connection with the sensor determine its accuracy and stability during measurement.

More details about the external components and their suggested parameters are listed in the datasheet of the sensor.

3 Hardware

The reference design is from the AS7331 EVK Data Logger. In addition to the sensor chip, the Data Logger can contain LEDs and their drivers as possible illumination in the case of reflection measurements. Further components include the power supply, a temperature sensor for monitoring and as a base for temperature correction of the LED, as well as test points on the board for important signals and extensive interfaces, for example, for operation on the FTDI for the standard AS7331 EVK.

The parameters of the external components must be observed in particular to ensure the safe and accurate operation of the sensor (e.g. maximum tolerances and temperature stability requirement of the external resistor, REXT, to generate reference currents on the sensor chip).

Figure 6 and Figure 7 show the block diagram and schematic of the sensor board.

Information

On the USB stick of the “AS7331 EVK Data Logger”, the complete hardware project with the schematic, layout, and BOM is stored and can be used as a basis for customer-specific designs (see on USB Stick: “…\Documents\Hardware\a001pc1_CSS Evalboard AS7331”).

Figure 6:
Schematic Block Diagram of the Sensor Board

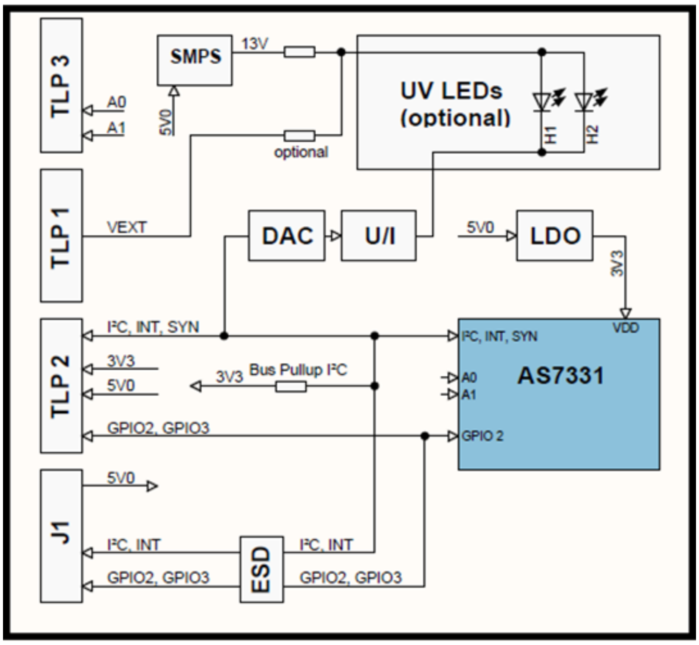
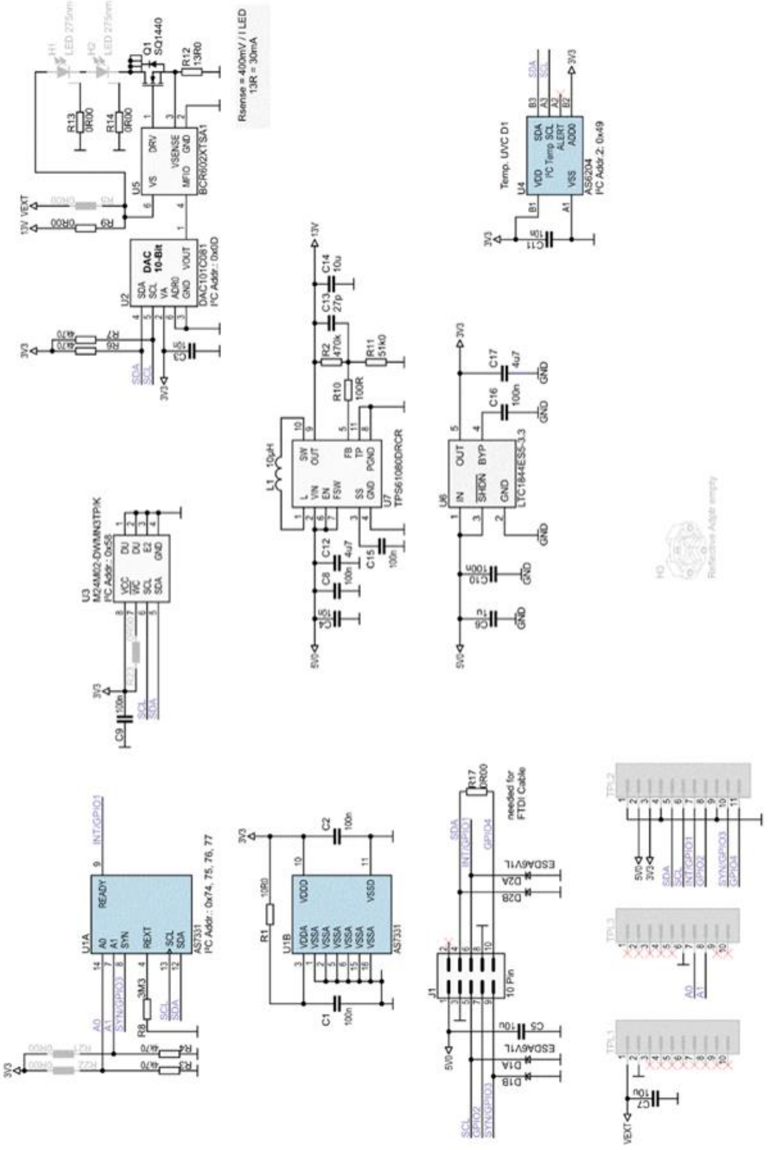


Figure 7:
Schematic and Interface of the AS7331 Sensor Board

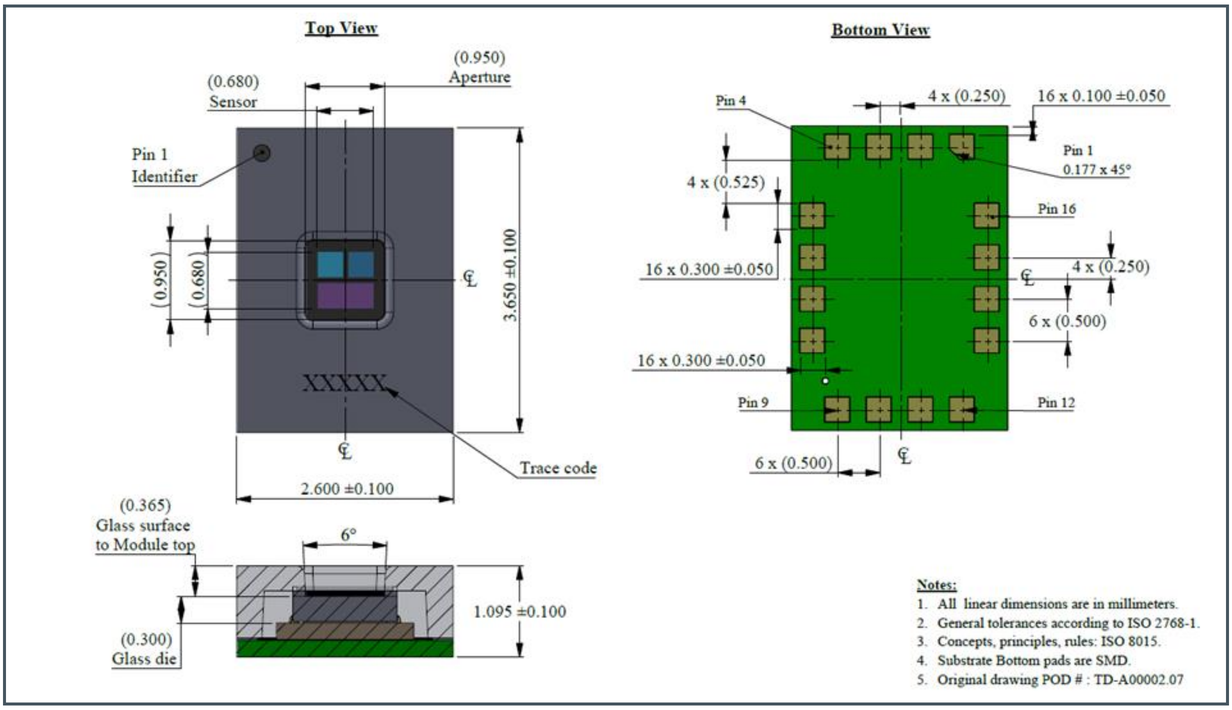


4 Optics

4.1 Limitation of the Angle of Incidence

The AS7331 sensor does not contain optical components for adaptation to the geometry and filter of the sensor. These must be adapted in the system design according to the application. Figure 8 shows the housing dimensions and the size of the optical window and the diodes in the sensor.

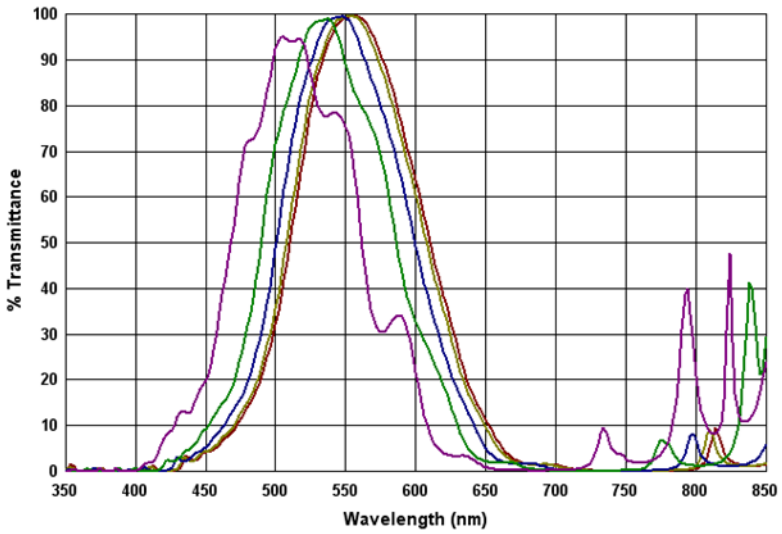
Figure 8:
Housing Dimensions of the AS7331



Notes:
1. All linear dimensions are in millimeters.
2. General tolerances according to ISO 2768-1.
3. Concepts, principles, rules: ISO 8015.
4. Substrate Bottom pads are SMD.
5. Original drawing POD # : TD-A00002.07

The filters on the diodes are interference filters. These were calculated for a vertical light entry into the filters. This indicates that a 90° light entry deviation in real life means a filtered shift into the short wavelength and a filter deformation to the filters specified in the datasheet [1]. This can lead to a complete filter deformation in the case of larger deviations. Therefore, it is recommended to limit the angle of incidence (AOI) to ±10° deviations from the perpendicular light incidence of 90°. Figure 9 shows simulated filter shifts depending on various AOI's as a typical example.

Figure 9:
Simulated Variations of AOI (from left to right: 0°, 10°, 20°, 30°, and 45°)



Such an angle of incidence can be realized easily by an optical hole in front of the sensor - where the AOI is limited by the height and diameter of the hole. The diameter or radius of the hole must be defined based on the maximum size of the diodes on the chip. The height of the hole can be calculated using the ARCTAN function, which gives the height above the sensor to the light entrance.

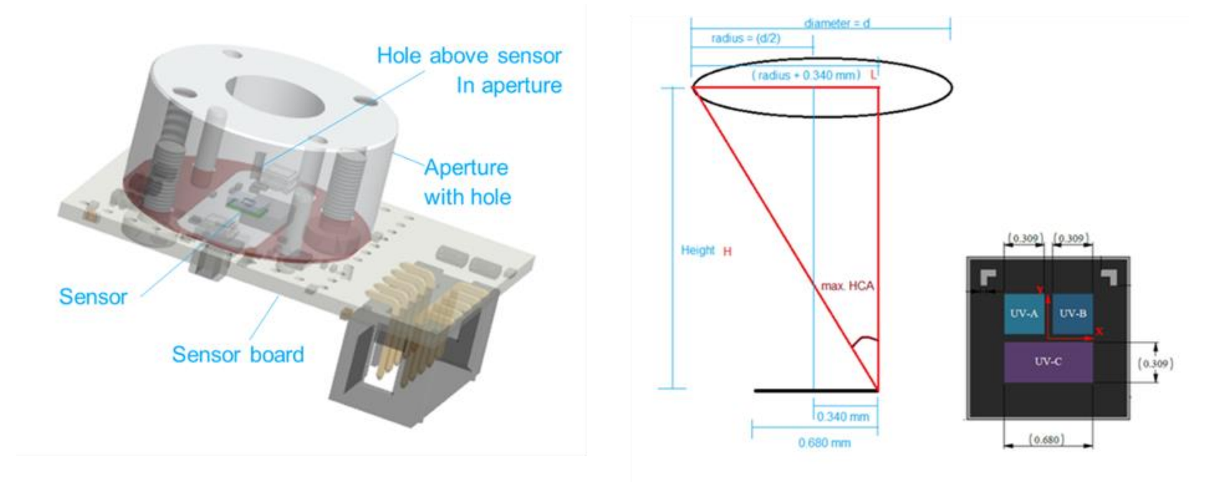
Attention

Due to its design, the AS7331 package has an opening of 0.345 mm above the filter to the outer package edge (see Figure 8), which must be considered when calculating the AOI.

Figure 10:
Calculated Heights Based on Different Diameters of the Aperture

Height of Aperture From Sensor H (mm)	Diameter of Aperture (mm)	Radius of Aperture (mm)	(Radius of Aperture + 0.340) L (mm)	Max. HCA = [arcTan(L/H)*(180/pi)] (degree)
7.9	1.4 (the original)	0.7	1.040	7.49 (8°)
9.5	3.3 (modified)	1.65	1.990	11.8 (12°)
11.5	8.0 (modified)	4.0	4.340	20.67 (21°)
11.5	12.0 (modified)	6.0	6.340	28.86 (29°)

Figure 11:
Sensor Board with the Aperture and Hole Above the Sensor to Limit the AOI



Information

On the USB stick of the AS7331 EVK Data Logger, the project files with the 3D models and sizes are stored and can be used as a basis for customer-specific designs
(see on USB Stick: “*..\ AS7331_EvalSW_v1-3-0\Additional accessories\Adapter*”).

Attention

When making adapters or using accessories in the optical path, note the transmission curve of the materials used, whether it is UV stable, UV transmissive, or non-transmissive - depending on the planned function of the component.

4.2 Using the Diffuser

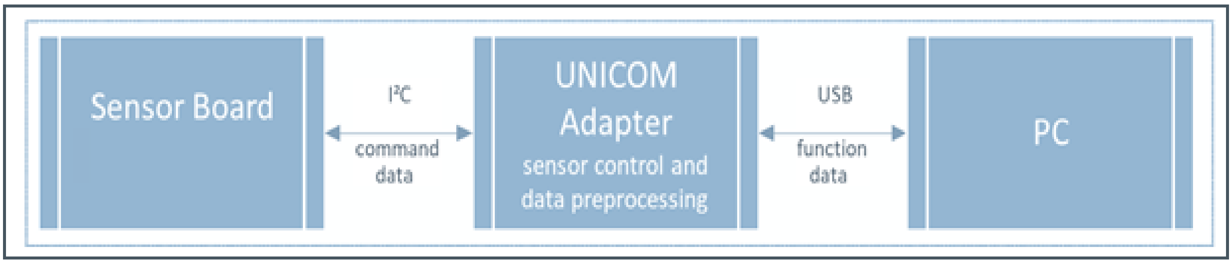
In certain applications, using a diffuser can be helpful to increase the angle of view of the sensor. The diffuser should be placed in front of the optics, which realizes the angle of incidence of the sensor. The diffuser is selected with a thickness, transmission, haze, and half-angle parameter according to the application. Such a diffuser could be fixed on the adapter shown in Figure 11 to increase the Field of View of the sensor by considering the angle of incidence at ±10°.

5 Evaluation Kit Data Logger

The AS7331 Evaluation Kit Data Logger should be used for the first tests and feasibilities to verify if the sensor is suitable for the planned application. With plug-and-play hardware and comfortable software on a PC, the working parameters can be tested in a brief time - to find out achievable accuracies under typical conditions that customers can define.

The EVK Software supports all typical chip parameter settings, simulates all working modes of the sensor in real-time (but under Windows), shows the sensor results in different user interfaces, and allows a post-calculation of the sensor results in other CAD programs such as Excel or MATLAB. The software also supports application-specific corrections and calibrations based on initialization files (for example, mapping the sensor counts into mw/cm² and the UV index).

Figure 12:
AS7331 EVK Hardware



The AS7331 EVK hardware consists of a sensor board with a plugged optical adapter above the sensor and LEDs (if LEDs are mounted) and an attached interface board. The interface board is connected to the PC via USB, which supplies all the connected hardware with a power supply. The adapter realizes the optical requirements for the used interference filters on the chip and the optical path when using LEDs on the board.

Information

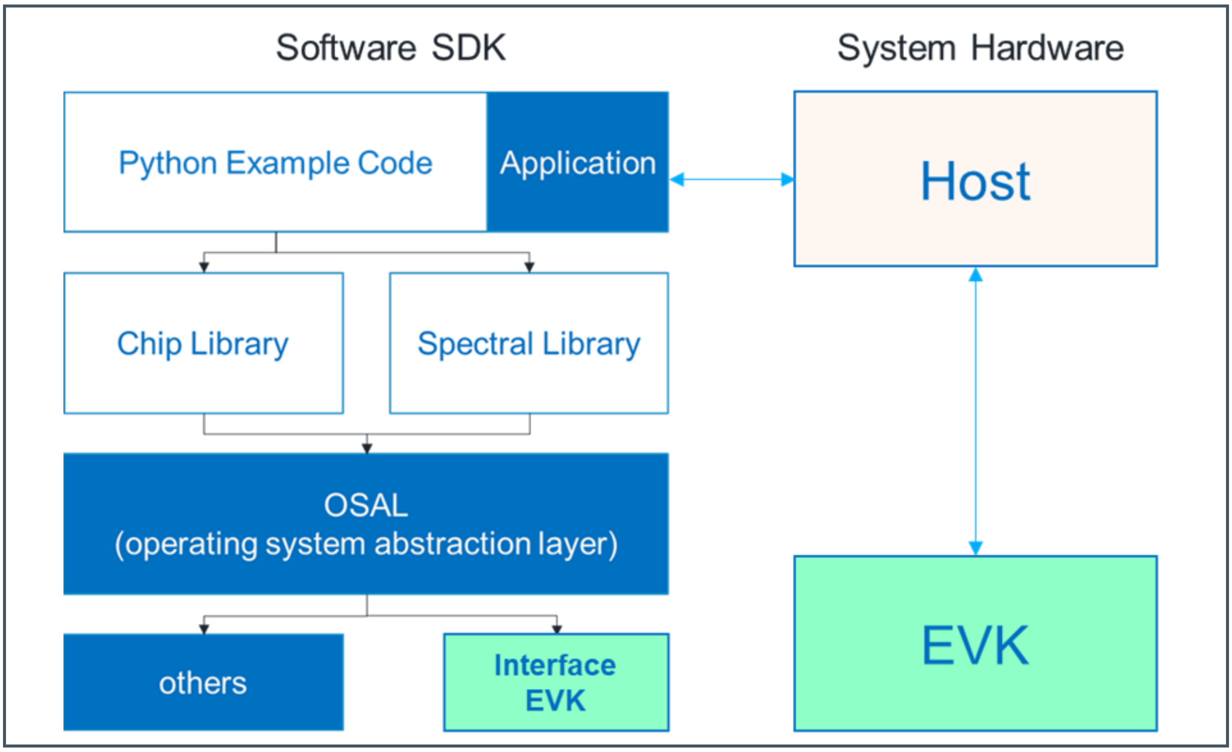
On the USB stick of the AS7331 EVK Data Logger, all projects for the hardware and software are stored and can be used as a basis for customer-specific designs (see the following folders on the USB Stick: “additional accessories”, “hardware”, and “library”).

6 Source Development Kit

The programming and control of the AS7331 are done via I²C and register settings depending on the customer target system in the microcontroller, directly via interface card on a PC or something similar. The registers with their contents, timing, the states of the sensor, and possible state machines are included in the datasheet [1].

To simplify the sensor programming, a Source Development Kit (SDK) is offered (the same AS7331 EVK Data Logger hardware can be used), which contains a library for sensor programming and a source code in Python - which shows the work with the library practically and all the steps; from the LIB implementation to the exemplary output of the RAW counts.

Figure 13:
Structure of the AS7331 Source Development Kit



It is recommended to use such an EVK to get fast and easy results in the feasibility and to use the Chip Library in this step and without register programming. After successful feasibility, the Python script and Libraries can be mapped quickly and easily to the customer target system without a complete redesign on another system level. The SDK and Libraries, as well as the process of mapping to other hardware systems, are described in special manuals for the libraries [4] and SDK [3].

7 Sensor Corrections

7.1 Basics

Sensor corrections are intended to eliminate production-related deviations between exemplary or external disturbances in the measurement process, which affects the sensor results temporarily or permanently, so that all measurements of all sensors of a series are always identical and have highly accurate results independent of disturbances.

In principle, deviations and disturbances can come directly from the sensor, the sensor system, or the environment. Sensor-related influences are based on filter properties in the electronics on the chip or from the package. Thus, each stage must be considered separately for possible corrections, i.e. do deviations occur, do they disturb the result, if so by how much, and can the disturbances be corrected, with what effort and result? Therefore, “as good as necessary” and “not as possible” should be corrected. Figure 14 shows examples of possible deviations and disturbances for AS7331 applications and examples of possible corrections.

Figure 14:
Examples of Deviations/Disruptions and Typical Correction Methods

Effect	Reason	Impact	Correction Method
Differences in diode sizes.	Manufacturing-related (diodes on the chip, shading in the housing and the optical path).	Deviations of the sensor response.	Target balancing
Filter deviations	An individual tolerance in manufacturing <1% * λ	Deviations of the sensor response.	Target balancing
Filter rest transmission	An individual tolerance in manufacturing <<1%	Falsification of sensor results.	Depends on the application.
Sensor dark current	An individual tolerance in manufacturing few digits.	Falsification of sensor results.	Offset correction
Sensor gain error	An individual tolerance in manufacturing <<1% from on stage to another.	Gain effects in the result.	Lookup table for balancing.
Temperature effects	In the sensor or other system components e.g. light source.	Temperature effect in the results.	Curve fitting
Ambient light	A system-related issue.	Falsification of the sensor results.	E.g. backside compensation as a temporary offset

7.2 Basic_Counts

The sensor results of the AS7331 are the digits or counts of the individual channels. Their amount depends on the ADC setup for TINT (Integration Time), gain, and divider. In principle, corrections should be made after normalization of the sensor results, which is independent of the ADC setup. Equation 1 shows the normalization of the sensor results to Gain = 1 and TINT = 1 ms, considering the divider.

Equation 1:

$$Basic_{Counts} = \frac{Raw_{Counts}}{Gain \ \times TINT \times \ Divider(1)}$$

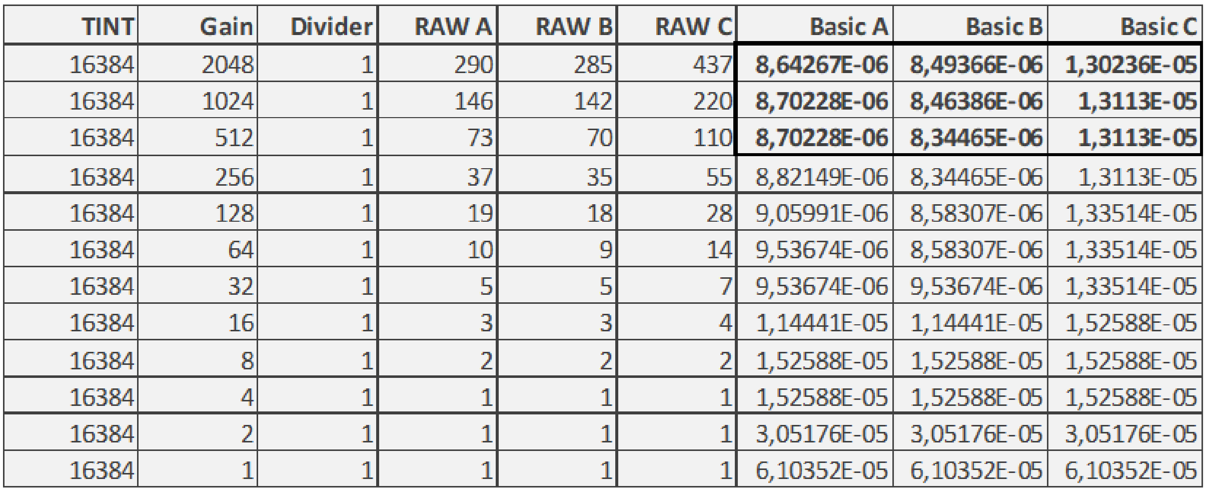
(1) If Divider is disabled then division through one. If enabled, then division through value $2^{1+DIV[dec]}$ (register CREG2, section 8.2.4 in the datasheet).

7.3 Dark Current

One effect from Figure 14 is dark or ambient light, which can be corrected as an offset. Here, offset refers to all the disturbances constantly shifting the sensor's measuring range. It is also recommended to measure the disturbance (dark or ambient light) with the sensor, and to subtract the corrected counts later as an offset per channel from the measurements.

Figure 15 shows the results from dark measurements with different gains without gain correction. From this, it means that these offset measurements should be corrected before use (e.g. gain and temperature) and that the choice of parameters is also essential here to prevent bit errors or measuring noise. The numbers marked in bold (their average) can be used as an offset to compensate for dark currents.

Figure 15:
Results From Dark Measurements with Different Gains (without Gain and temperature correction)

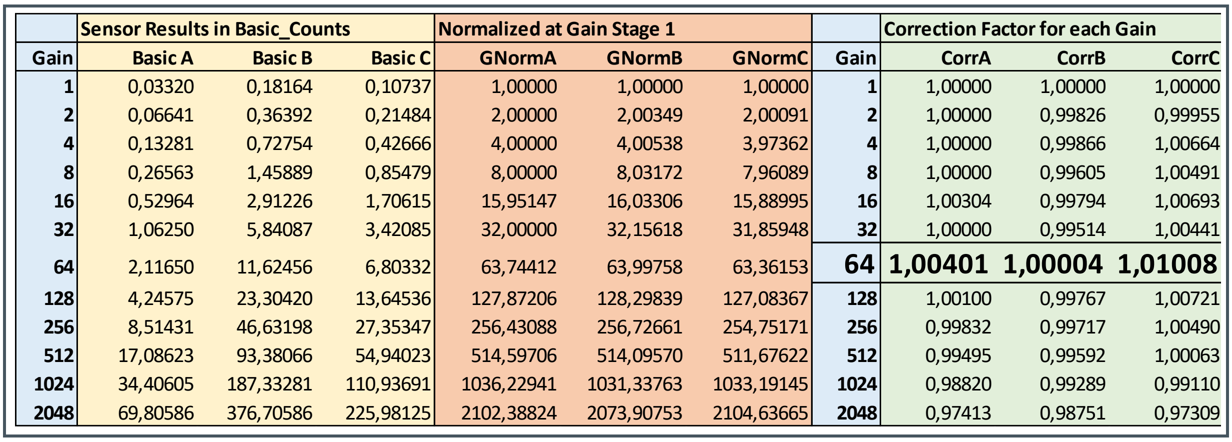


TINT	Gain	Divider	RAW A	RAW B	RAW C	Basic A	Basic B	Basic C
16384	2048	1	290	285	437	**8,64267E-06**	**8,49366E-06**	**1,30236E-05**
16384	1024	1	146	142	220	**8,70228E-06**	**8,46386E-06**	**1,3113E-05**
16384	512	1	73	70	110	**8,70228E-06**	**8,34465E-06**	**1,3113E-05**
16384	256	1	37	35	55	8,82149E-06	8,34465E-06	1,3113E-05
16384	128	1	19	18	28	9,05991E-06	8,58307E-06	1,33514E-05
16384	64	1	10	9	14	9,53674E-06	8,58307E-06	1,33514E-05
16384	32	1	5	5	7	9,53674E-06	9,53674E-06	1,33514E-05
16384	16	1	3	3	4	1,14441E-05	1,14441E-05	1,52588E-05
16384	8	1	2	2	2	1,52588E-05	1,52588E-05	1,52588E-05
16384	4	1	1	1	1	1,52588E-05	1,52588E-05	1,52588E-05
16384	2	1	1	1	1	3,05176E-05	3,05176E-05	3,05176E-05
16384	1	1	1	1	1	6,10352E-05	6,10352E-05	6,10352E-05

7.4 Gain Correction

If disturbances or deviations are directly measurable as typical values in the application, they can be determined in advance and implied as a rule or reference in the correction. This means that the disturbance source is measured under application conditions with the sensor(s) in a way that the ACTUAL values can be compared to the expected TARGET values, and the correction for the sensor(s) can be derived. Examples are gain, dark current, temperature effects, or the deviations of the sensor receivers to each other. Here, the behavior at the targets can be measured and compared to the target values. Then, the results can be implemented into the software for signal correction using lookup tables (LOT) or formulas according to Curve Fitting into linear or polynomial functions. The decision of which form the correction takes place, i.e. using LOT or formula, individual, batch, or product-specific, must be specified and tested in the application.

Figure 16:
Gain Correction Results



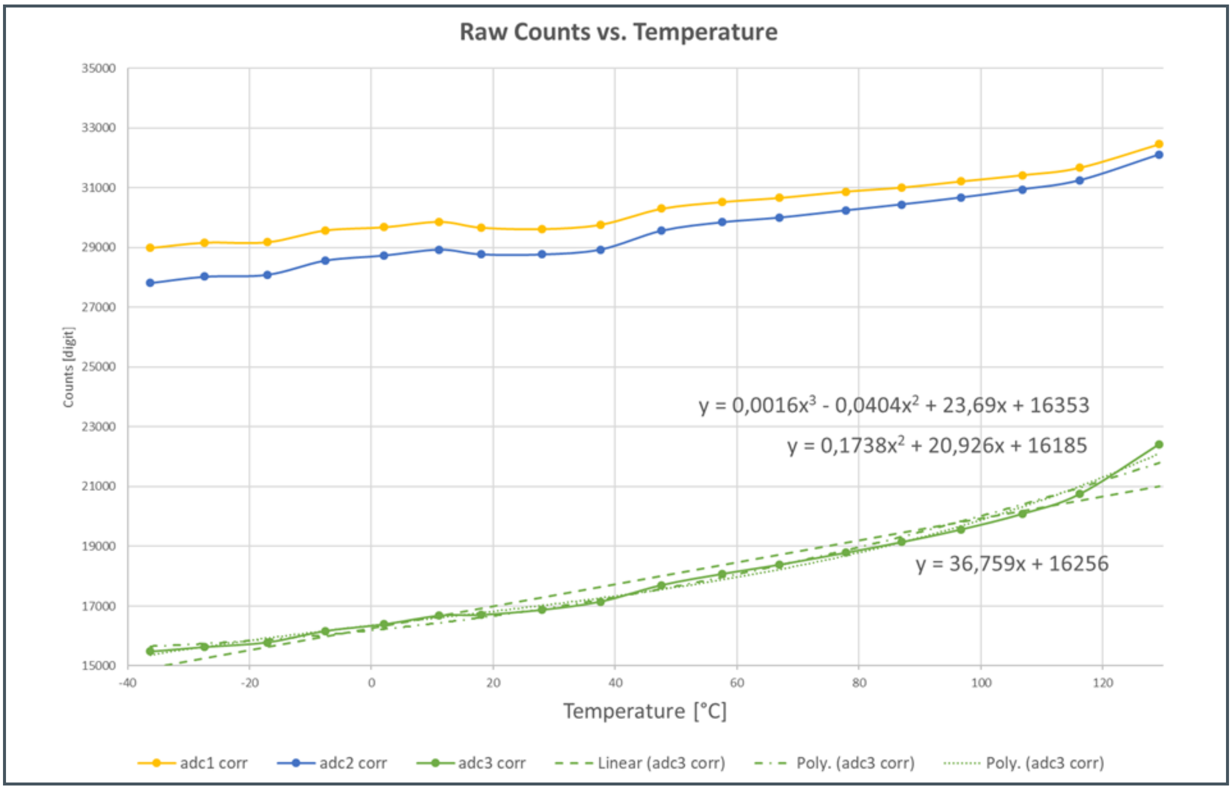
	Sensor Results in Basic_Counts			Normalized at Gain Stage 1				Correction Factor for each Gain		
Gain	**Basic A**	**Basic B**	**Basic C**	**GNormA**	**GNormB**	**GNormC**	**Gain**	**CorrA**	**CorrB**	**CorrC**
1	0,03320	0,18164	0,10737	1,00000	1,00000	1,00000	**1**	1,00000	1,00000	1,00000
2	0,06641	0,36392	0,21484	2,00000	2,00349	2,00091	**2**	1,00000	0,99826	0,99955
4	0,13281	0,72754	0,42666	4,00000	4,00538	3,97362	**4**	1,00000	0,99866	1,00664
8	0,26563	1,45889	0,85479	8,00000	8,03172	7,96089	**8**	1,00000	0,99605	1,00491
16	0,52964	2,91226	1,70615	15,95147	16,03306	15,88995	**16**	1,00304	0,99794	1,00693
32	1,06250	5,84087	3,42085	32,00000	32,15618	31,85948	**32**	1,00000	0,99514	1,00441
64	2,11650	11,62456	6,80332	63,74412	63,99758	63,36153	**64**	**1,00401**	**1,00004**	**1,01008**
128	4,24575	23,30420	13,64536	127,87206	128,29839	127,08367	**128**	1,00100	0,99767	1,00721
256	8,51431	46,63198	27,35347	256,43088	256,72661	254,75171	**256**	0,99832	0,99717	1,00490
512	17,08623	93,38066	54,94023	514,59706	514,09570	511,67622	**512**	0,99495	0,99592	1,00063
1024	34,40605	187,33281	110,93691	1036,22941	1031,33763	1033,19145	**1024**	0,98820	0,99289	0,99110
2048	69,80586	376,70586	225,98125	2102,38824	2073,90753	2104,63665	**2048**	0,97413	0,98751	0,97309

Figure 16 shows the results (yellow table) of tests for gain correction, where all the gains (blue) were used in combination with a stable light source - to measure the sensor output depending on alternative gains. The expected behavior with a constant input signal and doubling of the gain would also double the sensor counts. The yellow table shows minor deviations from the expected value from gain to gain. If the sensor results are normalized to a gain (red table), the correction values can be calculated in a LOT, based on this for each channel and gain (green table). It means that using gain = 64 requires a correction for the results of channel A up to channel C, with the factors listed in Figure 16 (green table), gain = 64 {for A 1.00401; for B 1.00004; for C 1.01008}.

7.5 Temperature Compensation

A similar correction to gain is Temperature Compensation. Here, the same test setup can be used by varying the temperature to measure alternative sensor counts depending on the increasing temperature around the sensor system. Figure 17 shows the results of counts vs. temperature for three channels. These could be taken as a LOT for correction, which would then require interpolation in the correction, if necessary. Therefore, the correction values can also be used as a basis for curve fitting. In the green curve are three exemplary results listed as a correction function with the corresponding formula, from linear function to polynomial of the second and third degree (X = the temperature in real-time measured by the temperature sensor, Y = the correction factor for this function). The best result shows a third degree polynomial function with the measurement curve.

Figure 17:
Results for the Temperature Test and Curve Fitting



Equation 2:

$$\begin{aligned} &Corrected\_Counts \\ &\quad = Corr\_Gain(Gain) \times Corr\_Temp(Temperature) \times \ldots \times Basic\_Counts \pm Offset1 \pm \cdots \end{aligned}$$

If more than one issue must be corrected by correction factors, it can be done systematically by multiplying the correction factors with the Basic_Counts (see Equation 2).

7.6 Spectral Response

Other deviations can directly affect the sensor response as a spectral sum over the wavelengths. These are, for example, the filter deviations of the series (peak, filter shape, FWHM, spectral sum), the size of the diodes on the chip, shadowing by the package, and other effects in the optical path. This leads to slightly different results for sensors in series using the same parameters and measurement setup. This is not acceptable and must be corrected.

Each channel in the sensor provides integrally, within the filter bandwidth, a sum of counts corresponding to the amount of light transmitted by the filter, converted into current by the diodes, and digitized by the ADC. The resulting counts correspond to the spectral sum of the overlap of all spectral sensitivities. With respect to a constant light source, deviations in the sensor (e.g. filter shift, masking, etc.) affect the different counts. However, these can be compensated or balanced by measuring standard light sources in a stable setup. This indicates that there are expected TARGET values for all channels measured by a spectrometer and actual values measured by the SENSOR. Dividing the TARGET by the SENSOR will result in the correction values (see Equation 2) for each channel. If this relationship is done separately for each sensor, then this balancing will result in the highest accuracy. Using the correction values from a Golden Device for all sensors is also possible, but affects the accuracy negatively. This balancing process is described in the spectral sensor calibration manual [5, 6], among other procedures. In these manuals, other sensors are used, but the algorithms are identical when using the AS7331.

7.7 Rest Transmission

Each filter on the sensor is characterized by transmittance and rest transmittance. The used interference filters have a tiny rest transmission of <<1% and achieve a blocking of OD3 ~1/1000 related to the wavelength. On the other hand, the rest transmission is directly included in the sensor signal as a spectral sum and disruption.

Figure 18:
Typical Sensor Variations of a Sensor LOT for UVA/B/C (y-axis in logarithmic form)

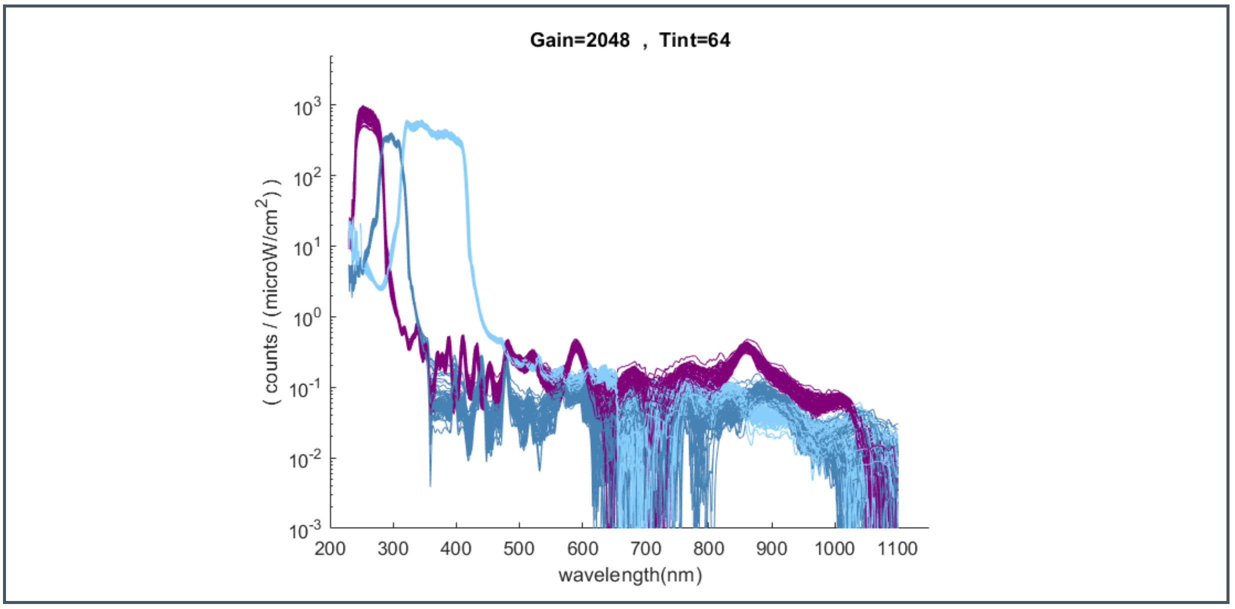
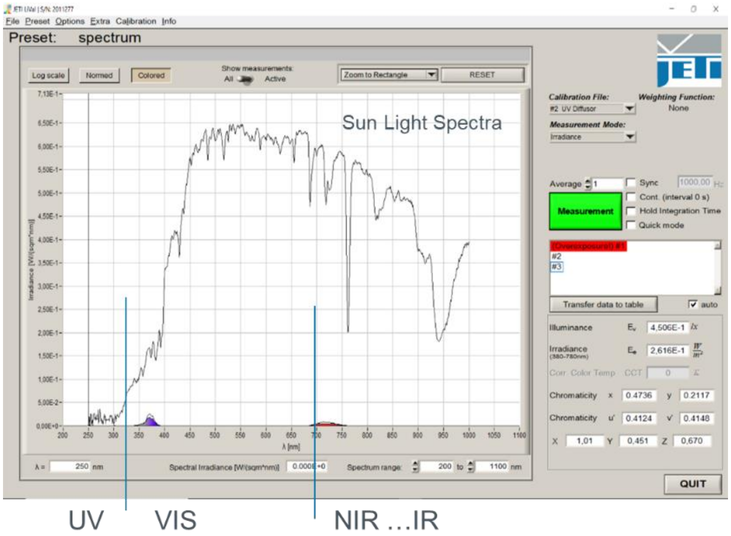


Figure 19:
For Sunlight, Spectral Sum in UV is Many Times Smaller Than in VIS/NIR



Preset: spectrum

Calibration File: #2 UV Diffusor
Weighting Function: None
Measurement Mode: Irradiance
Average 1
☐ Sync 1000,00 Hz
☐ Cont. (interval 0 s)
☐ Hold Integration Time
☐ Quick mode
☑ auto
Illuminance E_v 4,506E-1 lx
Irradiance (380-780nm) E_e 2,616E-1 $\frac{W}{m^2}$
Corr. Color Temp. CCT 0 K
Chromaticity x 0.4736 y 0.2117
Chromaticity u' 0.4124 v' 0.4148
X 1,01 Y 0,451 Z 0,670
λ = 250 nm
Spectral Irradiance [W/(sqm*nm)] 0.000E+0
Spectrum range: 200 to 1100 nm

As long as such disruptions are tiny (as a spectral sum over the filter wavelengths) or do not change spectrally in the application, they have fewer effects on the accuracy. In such cases, they are to be treated like noise. Alternatively, if the signal of the rest transmission is very large compared to the signal of the transmission (e.g. UV vs. VIS+NIR in the case of the sun), the disruption can overlay the useful sensor signal in transmission. If the disruption signal can still change spectrally in the application, special methods must be taken in the sensor system, for example, blocking the disruption signal by the optical filters.

8 Sensor Calibrations

The results of all corrections should be an approximate uniform response from sensors of the same type/LOT (or individual corrected) under the same conditions and free from the effects of external and internal known disturbances – as corrected sensor values. Then, these values can be used to transform and map them into the application and its units.

A simple method to map the sensor results is a curve fitting based on a relationship between the sensor results and reference values. These reference values can be generated by a spectrometer or alternatives but should represent the true references with high accuracy and stability.

In Figure 20 are the target spectra of a UV LED measured with a spectrometer at ten alternative levels - to be used for curve fitting.

Figure 20:
Target Spectra of a UV LED – Measured with a Spectrometer in ten Alternative Stages

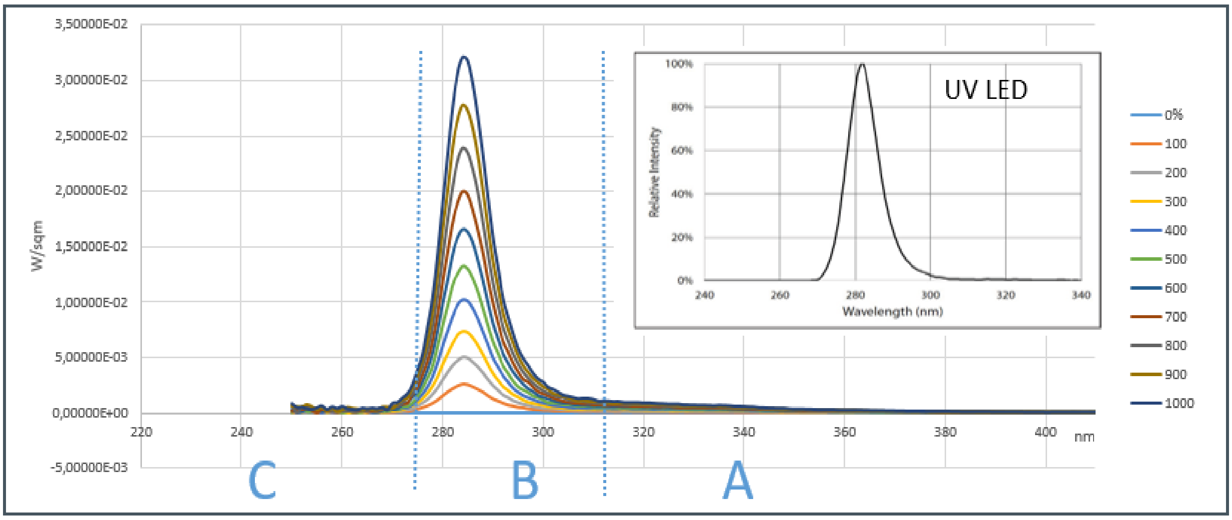


Figure 21 shows the sensor results in corrected counts and the reference values from the spectrometer in W/sqm. The curve fitting process should then generate the relationship between the sensor and reference, as a mathematical function or similar, which can later be used in the sensor software to convert the sensor results into the application-specific unit (W/sqm here).

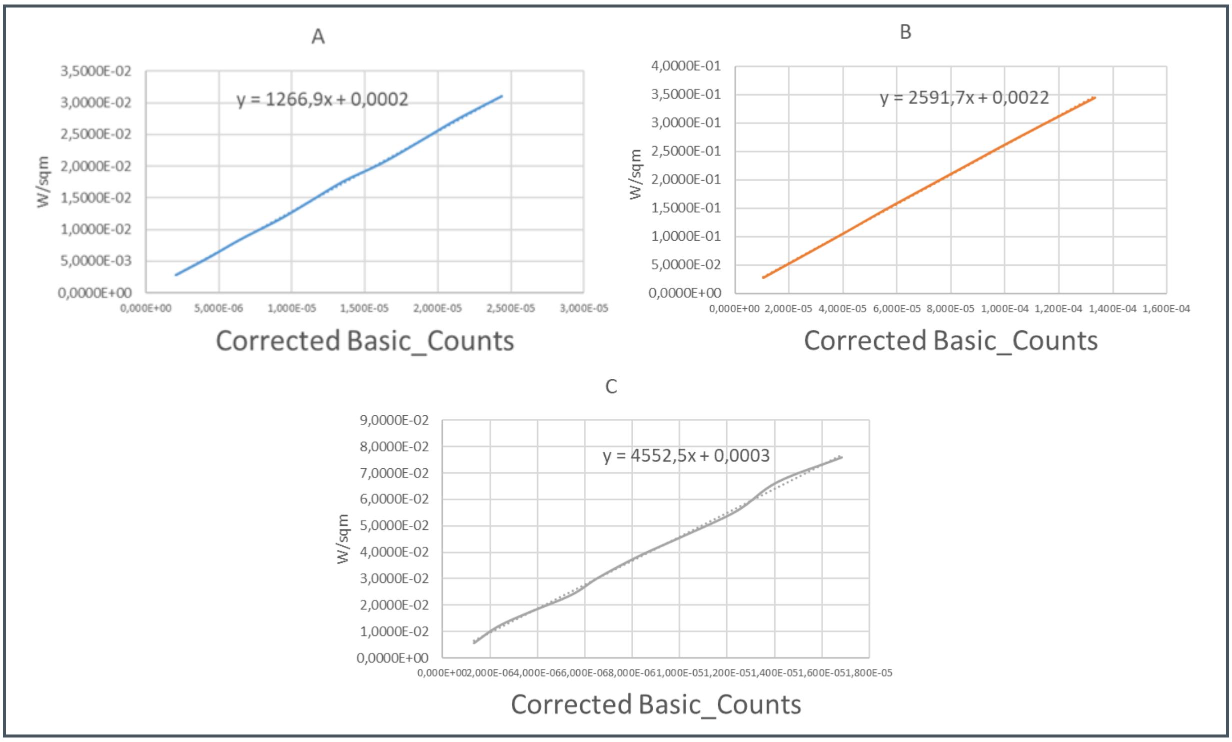
In Figure 22, are the curve fitting results for the three channels (UVA/B/C) using linear functions. In the functions in the diagrams, “y” stands for the application-specific number in W/sqm, and “x” is for the corrected sensor values of the individual channels.

In the example (see Figure 20), channels C and A are not inside the LED spectra and are not an interest for the calibration. It means that only the B channel will be used to map sensor counts into the UV radiation in W/sqm. This mapping or calibration can now be used for similar applications with active radiation in the B channel, and it is expected that the more similar the spectrum of the application is to the calibration, the more accurate the result will be. Other target LEDs must be selected for mapping the A and C channels.

Figure 21:
Measured Sensor Results and Reference Values from the Spectrometer

LED Driver in %	Sensor A	Sensor B	Sensor C	Ref A in W/sqm	Ref B in W/sqm	Ref C in W/sqm
10	2.0504E-06	1.0395E-05	1.3351E-06	2.8680E-03	2.7771E-02	5.6854E-03
20	4.3869E-06	2.0361E-05	2.3365E-06	5.7381E-03	5.3948E-02	1.1966E-02
30	6.4373E-06	3.0231E-05	3.6716E-06	8.4340E-03	7.9865E-02	1.7392E-02
40	9.1076E-06	4.1771E-05	5.4359E-06	1.1587E-02	1.1042E-01	2.3948E-02
50	1.1158E-05	5.3501E-05	6.5804E-06	1.4364E-02	1.4232E-01	3.0520E-02
60	1.3542E-05	6.7186E-05	8.2970E-06	1.7648E-02	1.7793E-01	3.8713E-02
70	1.6165E-05	8.1635E-05	1.0157E-05	2.0489E-02	2.1506E-01	4.6241E-02
80	1.9073E-05	9.7847E-05	1.2398E-05	2.4357E-02	2.5707E-01	5.5726E-02
90	2.1362E-05	1.1463E-04	1.4114E-05	2.7450E-02	2.9913E-01	6.6680E-02
100	2.4366E-05	1.3337E-04	1.6832E-05	3.1021E-02	3.4511E-01	7.6067E-02

Figure 22:
Curve Fitting Results for UVA/B/C



9 Revision Information

Changes from previous version to current revision v2-00	Page
Figure 3, Figure 6, Figure 7 & Figure 18 changed for B3 samples, Figure 4 added.	5, 9, 10, 21, & 6

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

10 Additional Documents

The following list includes a selection of available documents with more technical details for the AS7331 Sensor and AS7331 Evaluation Kit. This list is not fixed and it is constantly changing. Ask us for new details.

For further information, please refer to the following documents:

1. ams-OSRAM AG, AS7331 Spectral UVA/B/C Sensor (DS001047), Datasheet.
2. ams-OSRAM AG, AS7331 EVK Logger (UG001037), User Guide.
3. ams-OSRAM AG, AS733x SDK Quick Start Guide.
4. ams-OSRAM AG, AS733x Chip Library, API Documentation.
5. ams-OSRAM AG, AS7343 Spectral Sensor Calibration (AN001038), Application Note.
6. ams-OSRAM AG, AS7341 Eval Kit Spectral Balance and Calibration (QG000139), Quick Start Guide.

11 Legal Information

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