Application Note

Document Number

AS7343 Details for Opto-Mechanical Design

Opto-Mechanical Design Guide

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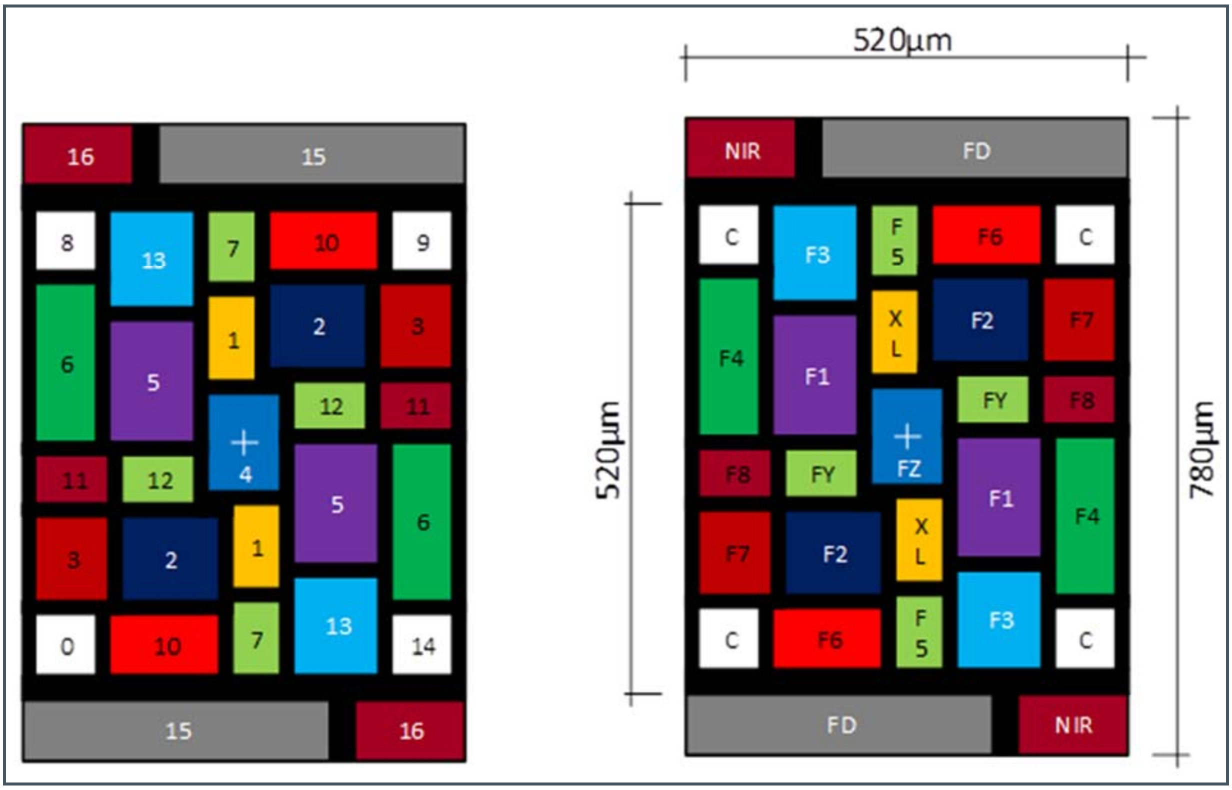
1 Introduction

This application note describes the most important optical and mechanical parameters, which need to be considered when designing the AS7343 into an application-specific sensor system.

1.1 AS7343 Sensor Chip

The AS7343 is an optical multi-channel sensor, with multiple spectral channels in the range of visible light, a NIR-channel, and an open channel, for flicker detection. The VIS channels are arranged in separated receivers.

Figure 1:
AS7343 Sensor Array



The AS7343 integrates interference filters into standard CMOS silicon via nano-optic deposited interference filter technology. These filters are stable over a lifetime without any drifts. They are designed as spectral filters with an even arrangement over VIS and one filter in NIR.

The optical filter characteristics like irradiance responsivity, center wavelength, and FWHM, are listed in the AS7343 datasheet. Please note the minimum and maximum values, which are specified based on series deviations.

The data for the responsivities of the spectral channels were defined under specific conditions. Therefore, measured values may deviate from these values under changed conditions. The same applies to the electronic amplifier/converter results (exclude the AutoZero function on the chip) and to temperature dependencies. We recommend that such variations should be investigated and corrected in the overall system. For more details, check the datasheet.

Figure 2:
Normalized Spectral Responsivity of the AS7343 (VIS Scale)

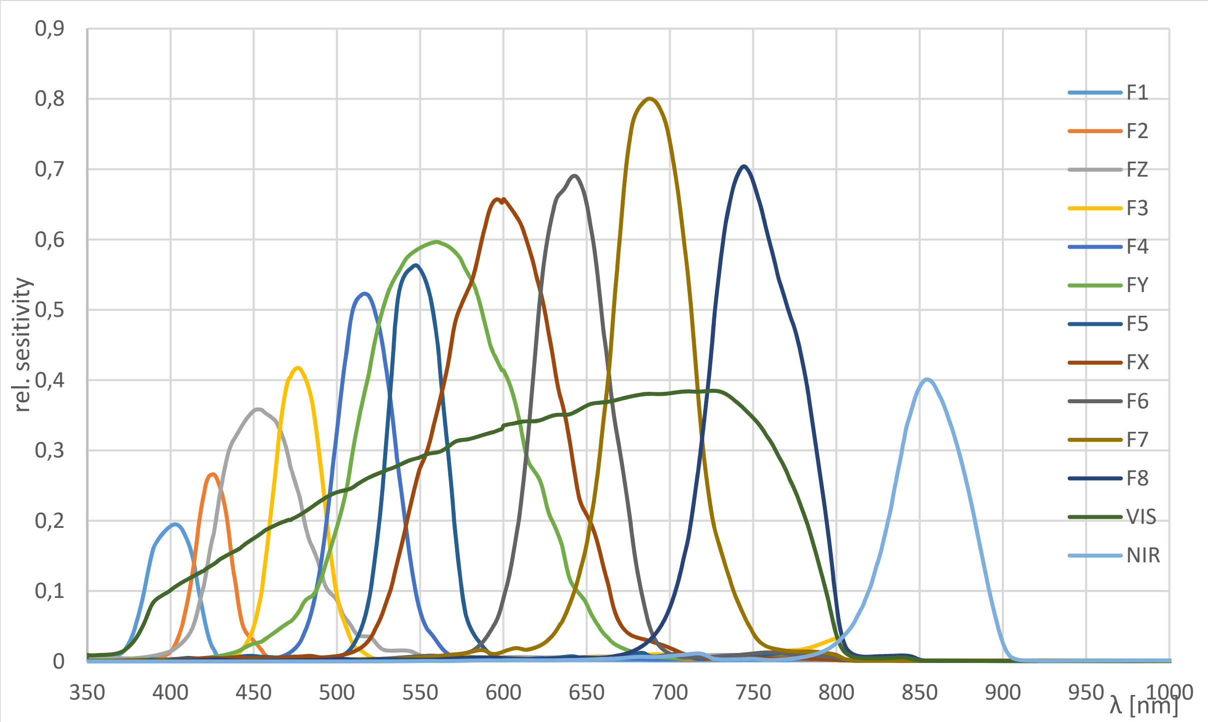
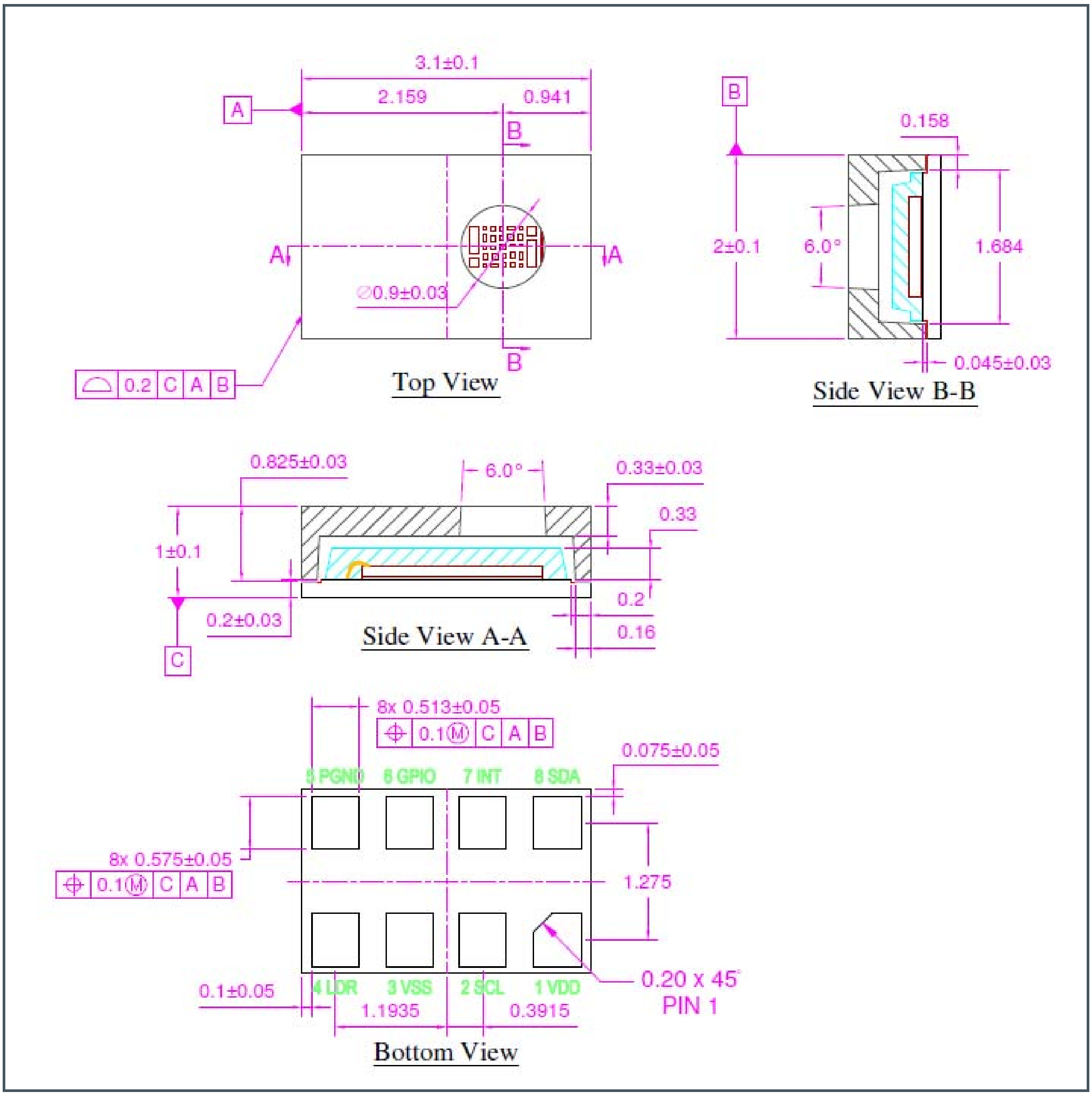


Figure 3:
Dimensions of the AS7343 Sensor (in millimeters)



1.2 Optical diffuser requirements

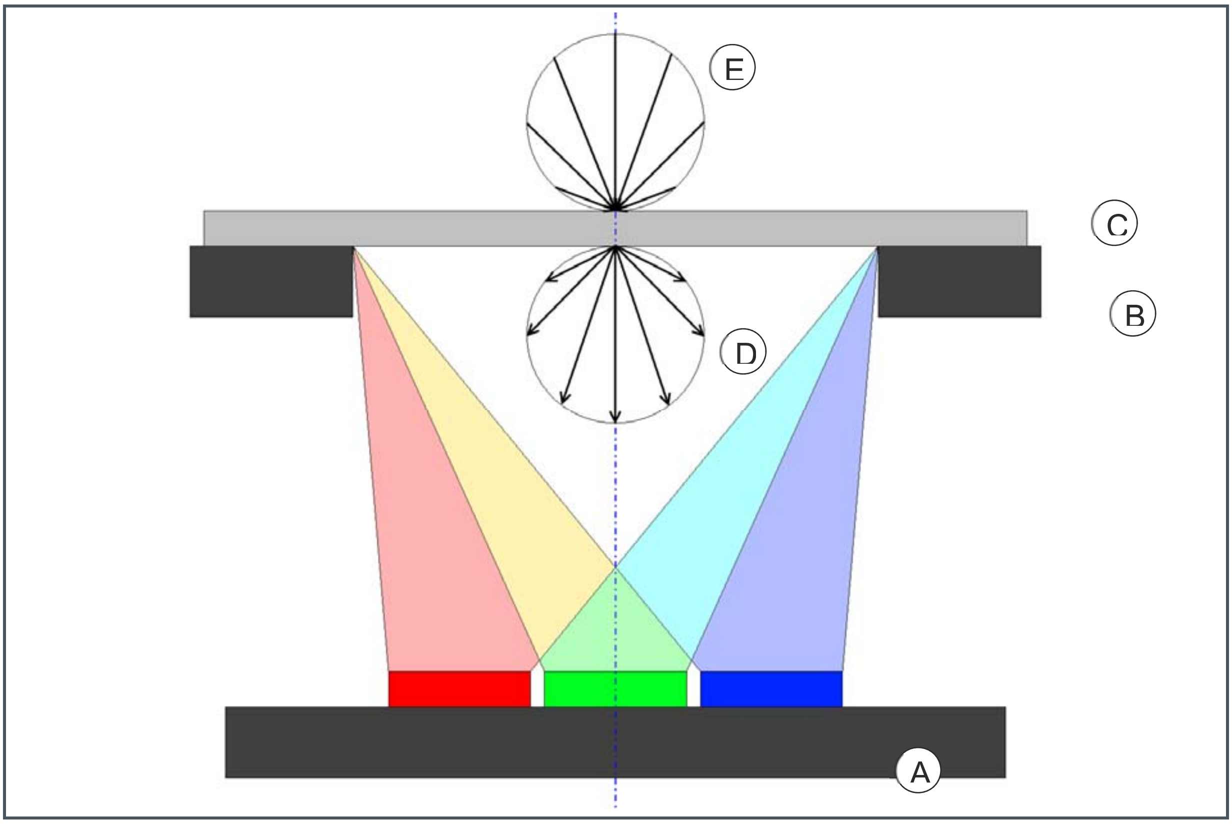
The photodiodes inside AS7343 have a near cosine response to incoming light. The color filters used for channel separation are specifically designed interference filter stacks on top of the photodiodes. Because of physical effects in the filter stacks, the interference filters are designed for only a limited range of angle of incidence (AOI) and expect a Lambertian power distribution.

The maximum angle of incidence to the photodiodes is limited to the design requirements of the filter stack by the aperture/pinhole of the package. The rays with the most obtuse angle should hit only the edge of the photodiodes; sharper angles hit the full diode areas (Figure 4).

To meet the requirements of power distribution, it is necessary to use an achromatic diffuser that emits light, with a Lambertian characteristic to the sensor, independent of the angle of incidence. The minimum scatter characteristic is shown in Figure 5. If the diffuser is placed very close to, or directly on the AS7343 package, its structure has to be very fine to get the same distribution to each photodiode of the detector array.

Note that the technical parameters listed in the datasheet apply to a diffuser in front of the sensor. Different diffusers, and the use without a diffuser, lead to different sensor parameters.

Figure 4:
Vertical cross section of structured color sensor with perfect diffuser

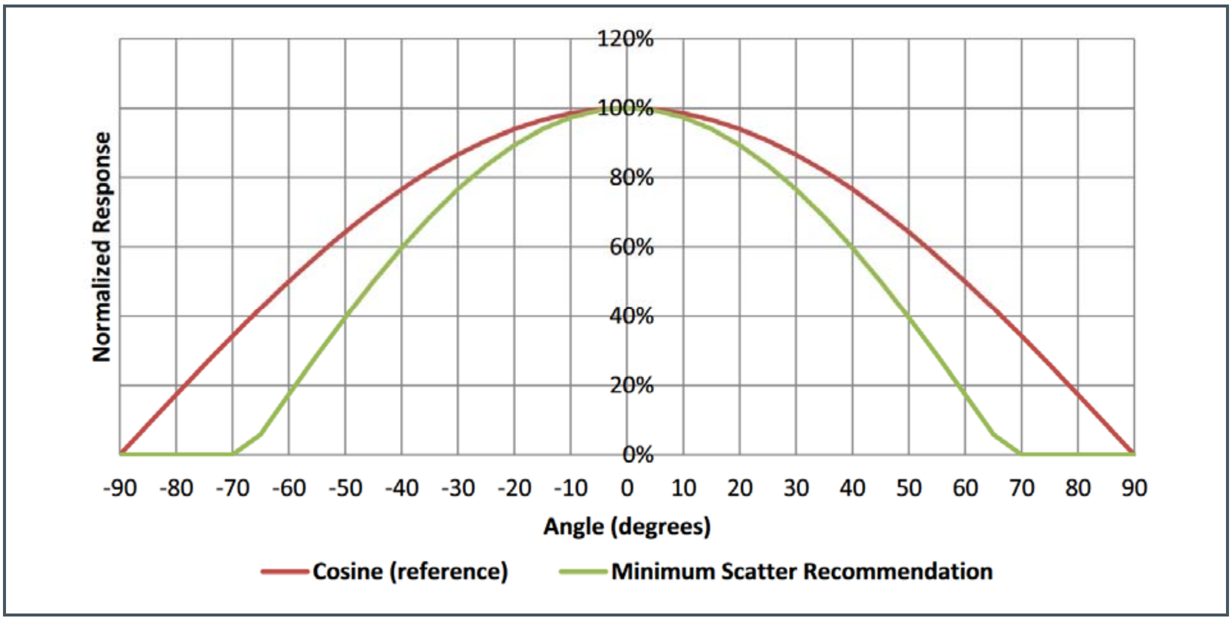


Key

- **A** - Photodiode array (structured detector).
- **B** - Aperture/pinhole in the package.
- **C** - Diffuser with perfect cosine power distribution.
- **D** - Cosine power distribution on the sensor side – usable range of angles depends on the maximum angle of incidence of the filters and defines efficiency of the sensor system.

- **E** - Angular response of the sensor system including a diffuser which is independent from sensor AOI;
  Vector length is equivalent to a response: the highest response for normal input and decreasing response for increasing angles.

Figure 5:
Diffuser characteristics: Cosine and minimum scatter recommendation



A recommended diffuser is pre-mounted in the AS7343 Evaluation kit directly above the sensor; by using two simple plastic shells as the diffuser holder and adapter, which are fixed on the evaluation kits by two bolts and nuts. In case of a new installation of the diffuser holder, make sure that the diffuser is correctly placed between the upper and lower plastic holder. Fix the bolts and the nuts by hand and check if all are fixed. Prevent touching the optical diffuser with your finger.

Figure 6:
Installation of Diffusor Holder on AS7343 EVK

- Note that the diffuser specification depends on the customer application and the planned position in front of the sensor. Therefore, check the technical parameters of the standard diffuser (see Figure 7 for technical details) before you start any tests. Select a diffuser with sufficient diffusing power so that the sensor has a smooth angular response (no spikes in the angular response curves) exceeding ±45° (FWHM). You can test the limit of the diffuser by using the AS7343 EVKs.

- The diffuser in the EVK can be changed very fast and easily. Be careful not to touch the diffusers with your fingers in case of any mounting activities. The surface of the diffusers is very sensitive and any touches or other mechanical stress or dirty can change the optical behavior dramatically. Changing the diffuser and re-assembling it with the same type changes the calibration parameters and requires recalibration for optimal results.

Figure 7 lists the recommended diffuser parameters and/or the parameters of the used Kimoto diffuser in the AS7343 Evaluation Kit.

Figure 7:
Diffuser Parameters

Parameter	Value
Diffuser Material	Kimoto 100 PBU
Diffuser Thickness	125 microns
Transmission	66%
Haze	89.5%
Half-Angle	35.5°

1.3 Diffuser types and recommendations for selection

For an application in front of the AS7343, a translucent diffuser is required, which uses scattering centers to spread incoming directed light in pseudorandom directions. These scattering centers can be very small surface structures on top (e.g. grounded glass) or small white particles inside (e.g. opal glass) the diffuser. This property can be used to divide diffusers into two main groups of “surface diffusers” and “volume diffusers”.

1.3.1 Surface Diffusers

Surface diffusers usually consist of a clear base material that is structured on one or both plane surfaces. The structures are microscopically small and random to refract incoming light, depending on the orientation of every single ray towards the surface segment where it hits the diffuser. According to Snell’s law, the level of refraction also depends on wavelength, which could cause chromatic aberrations in the border regions. Scattering is often enhanced by structuring the input and output surface of the diffuser, which leads to multiple refractions and partly to internal reflections. Since refraction is the main effect, the transmission efficiency can be very high for diffusers with a narrow radiation pattern and is superior to volume diffusers with a wider radiation pattern. Regarding the angular limits of the surface structures and the lower count of interactions, surface diffusers do not reach perfect cosine characteristics.

The parameters of the diffusers are typically determined with far-field measurements and in the case of surface diffusers, these parameters are usually scaled with the resolution/size of the structures. This makes it necessary to prove the chosen diffuser individually for the use case.
ams uses the “Kimoto 100 PBU” with a thickness of 125 micrometers, which is a double-sided surface diffuser with a wide radiation pattern.

1.3.2 Volume Diffusers

In volume diffusers, incoming light is scattered when it hits a scattering center within it. The scattering centers are typically microscopically small white particles. Depending on the design, each particle can generate a Lambertian reflection on its surface, which leads to multiple internal reflections and creates random light paths through a labyrinth of particles. The result is a near-perfect cosine and a wavelength-independent/achromatic characteristic in the near field, but because of the multiple Lambertian reflections, a high percentage of the light is reflected on the input side of the diffusers. Due to this reflection, the transmission efficiency of cosine volume diffusers is smaller than 50%.
ams uses the “Lexan 8B28 – opaque white” with a thickness of 250 micrometers - which is a volume diffuser with nearly Lambertian characteristics.

The selection of a diffuser always depends on the use case, the irradiance on the diffuser or sensor, and the needed flexibility of the setup:

- For low light applications, a surface diffuser with high transmission, and the widest radiation pattern possible, should be used. Narrowing the radiation pattern for a higher transmission efficiency is only possible for detecting large and homogenous light sources (see chapter 1.4) or if the conditions for calibration are equal to the measurement geometry and stable. Under stable conditions, chromatic effects, etc. could be compensated for with calibration.
- In applications under changing conditions regarding size, direction, and/or orientation of the light source, a volume diffuser with nearly Lambertian and achromatic characteristics is the best choice to create a sensor system that is not affected by the direction of incoming light.

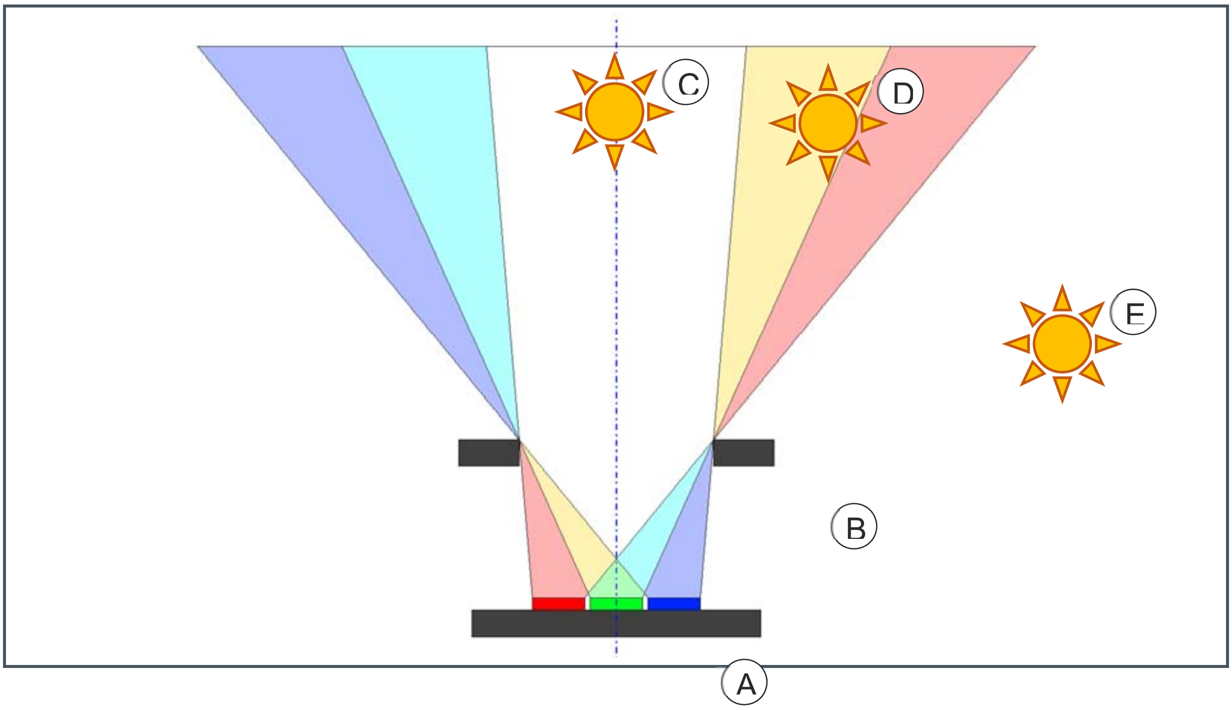
1.4 Average angular response and light homogeneity

The average angular response of the AS7343 is related to the angle of incidence and is limited to ±40° over all channels. As a result of the structured detector (4x4 array), the field of view is individual for each photodiode: almost symmetrical for the centered photodiodes and more asymmetrical for those at a distance to the center (see Figure 8). To avoid blurred imaging of a light source or its position on the sensor's array, the diffuser is also used.

Regarding its characteristics, the diffuser also modifies the average angular response of the sensor system (AS7343 + diffuser). When using a diffuser that is not a perfect Lambertian and meets the minimum scatter recommendation (see Figure 5), the angular response of the system will have the same characteristics, only in the case of a normal incidence. In the case of a tilted light incidence, the response may shift to an asymmetrical shape. This causes different color measurements in relation to the positioning light source and sensor, which decreases accuracy.

To avoid such inaccuracies during calibration, it is necessary to illuminate the diffuser with homogeneous light over the hemisphere.

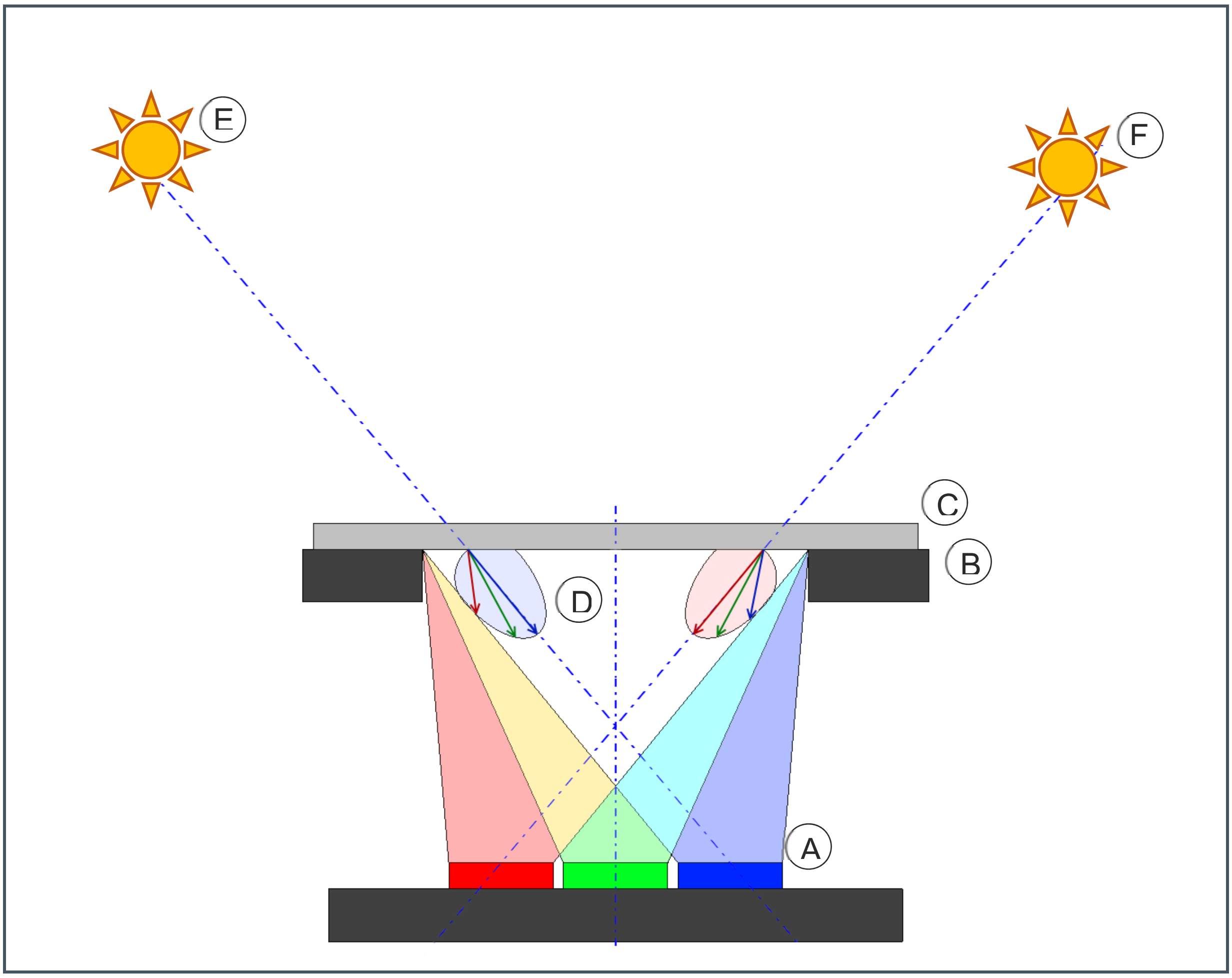
Figure 8:
Vertical cross section and field of view (FOV) of a structured color sensor without a diffuser (simplified and with exaggerated dimensions for illustration)



Key

- **A** - Photodiode array (structured detector).
- **B** - Aperture/pinhole in the package.
- **C** - Light source 1 → correctly detected by all channels.
- **D** - Light source 2 → blue channel partly shadowed; detected as yellowish light.
- **E** - Light source 3 → out of FOV; not detected directly.

Figure 9:
Vertical cross section of a structured color sensor with non-cosine diffuser (simplified and not drawn to scale)



Key

- **A** - Photodiode array (structured detector).
- **B** - Aperture/pinhole in the package.
- **C** - Diffuser with non-cosine power distribution.
- **D** - Angular depending on the power distribution: vector size is equivalent to the power hiding each channel.
- **E** - Light source at Pos. 1 → detected more blueish.
- **F** - Light source at Pos. 2 → detected more reddish.

2 Revision Information

Changes from previous version to current revision v0-01	Page
Initial version	all

- 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.

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