How to Select an Ambient Light Sensor for Your System

Introduction

When designing an application with an ambient light sensor, there are four main concerns or problems that must be addressed. The most important features of an ambient light sensor are spectral response, power, size, and range of lux measurement.

Selection

In many applications, ambient light sensors are used to set the display brightness based on the surrounding light conditions or variables. These use cases need light measurement at specific wavelengths, like spectroscopy and ultra-violet (UV) measurement. The ambient light sensor is used to measure optical energy at a specific wavelength or specific bands of wavelengths on the light spectrum.

The goal of these applications is to improve the visual experience and make the lighting comfortable for the end user. It is important to regulate lighting based on the surrounding variables to improve user experience in mobile displays, thermostats, and more. It is also important to ensure safety in specific applications like automotive center stacks and head-up displays (HUD), because overly bright lights in these application can distract the user, while dim lights can be difficult to see.

In some applications, the spectral response of the sensor must tightly match the photopic response of the human eye, and also include significant infrared rejection. Applications that require human eye responses include IP cameras, tablets, thermostats, and wearables.

Some applications do not require human eye responses, and instead can use a wide spectral bandwidth. For example, applications like video doorbells (Figure 1) or indoor lighting can sometimes use a wide spectral bandwidth.

The OPT3002 has a wide spectral bandwidth, ranging from 300 nm to 1000 nm. The OPT3001, OPT3004, OPT3007, and OPT3001-Q1 have human eye responses.
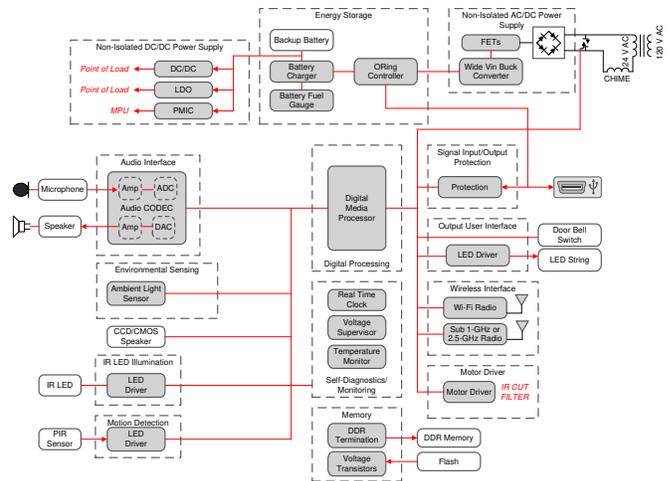

Figure 1. Video Doorbell Block Diagram Example

Another design challenge for engineers is how to extend the battery life of certain applications. Displays consume approximately 30% to 40% of the power budget in most equipment, which is critical in wearables, mobile units, tablets, and other devices, because these applications run on batteries 90% of the time.

Controlling the display intensity based on ambient conditions can help conserve power. The lifetime of the display can also increase by running at lower power. One feature of the OPT3002 is the ultra-low power at approximately 2 µA. The low power consumption of the device allows the OPT3002 to be used as a low-power, battery-operated wake-up sensor when an enclosed system is opened.

Engineers must also consider the size of their system when they choose an ambient light sensor for their applications. For the personal electronics industry (smart phones, notebook PCs, tablets, and so forth), a small form factor is extremely important because these applications are generally in a small enclosure.

The OPT3007 has a nominal body size of 0.856 mm ✕ 0.946 mm ✕ 0.226 mm, and the device comes in a picostar package. The four active pins in the 6-pin package enable the PCB designer to create a bigger opening to the active sensor area.

The OPT3004 offers similar features to the OPT3001, but the OPT3004 has an improved angular IR rejection that is beneficial in video surveillance applications.

The final design consideration for ambient light sensors is the range of lux measurement. The OPT3002 has a wide spectral bandwidth that ranges from 300 nm to 1000 nm. The built-in, full-scale setting feature of the OPT3002 can measure lux from 1.2 nW/cm2 up to 10 mW/cm2 without prompting the user to manually select the full-scale range. This capability allows light measurement over a 23-bit effective dynamic range.

The results are compensated for dark-current effects, as well as for other temperature variations. For the OPT3004, OPT3007, and OPT3001-Q1, the built-in, full-scale setting feature can measure 0.01 lux up to 83-k lux without the need to manually select the full-scale ranges. This capability also allows light measurement over a 23-bit effective dynamic range.

With certain applications like IP cameras that require IR light for night vision, angular IR rejection is an important feature that can prevent false reads. The OPT3004 has an increased angular IR rejection for these types of applications.

For automotive applications, or end equipments that are influenced by high temperatures, Texas Instruments offers the automotive-grade OPT3001-Q1 ambient light sensor. The OPT3001-Q1 offers both AEC-Q100 grade 2 (–40°C to 105°C) and grade 3 (–40°C to 85°C) qualifications.

With these added qualifications, the OPT3001-Q1 can be placed in many applications, like automotive infotainment and clusters.

Conclusion

In summary, the main design considerations for an ambient light sensor in an application are the spectral response, power, size, and measurement range. The OPT300x devices are sensors that measure the intensity of visible light, and are suitable for display applications.

The spectral responses of the OPT300x sensors tightly match the response of the human eye, include significant infrared rejection, have ultra-low power, and offer small size options. The only exception is the OPT3002, which has an optical range of 300 nm to 1000 nm and has no human eye response.

The OPT3001, OPT3004, OPT3007, and OPT3001-Q1 are single-chip lux meters that can measure the intensity of light visible to the human eye. The precision of the spectral responses, along with the strong IR rejections, allow these devices to accurately measure the intensity of light as seen by the human eye, regardless of the light source.

The strong IR rejection also helps maintain high accuracy when industrial designs must mount light sensors under dark glass for aesthetics. These parts are designed for systems that create light-based experiences for humans, and these parts can be a preferred replacement for photodiodes, photoresistors, or other ambient light sensors with less human eye matching and weaker IR rejection.

For a summary of the OPT300x parts, see Table 1.

Table 1. Device Comparison Table

	OPT3001	OPT3002	OPT3004	OPT3007	OPT3001-Q1
Optical Range/ Filter	Human Eye	300 nm to 1000 nm	Human Eye	Human Eye	Human Eye
ADC	23-Bit Effective Dynamic Range	23-Bit Effective Dynamic Range	23-Bit Effective Dynamic Range	23-Bit Effective Dynamic Range	23-Bit Effective Dynamic Range
Current Consumption	1.8 µA	1.8 µA	1.8 µA	1.8 µA	1.8 µA
Supply Range	1.6 V to 3.6 V	1.6 V to 3.6 V	1.6 V to 3.6 V	1.6 V to 3.6 V	1.6 V to 3.6 V
Temp Range	-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C (Grade 3) -40 to 105°C (Grade 2)
Package	USON6 (2 mm × 2 mm)	USON6 (2 mm × 2 mm)	USON6 (2 mm × 2 mm)	PICOSTAR (0.9 x 0.8 x 0.226mm)	USON6 (2 mm × 2 mm)
Notes	Better Sensitivity	Low Cost ALS	Better Angular IR Rejection	Thinnest ALS 4 pin operation	Automotive Grade

Table 2. Related Documentation

DEVICE	DESCRIPTION
OPT3001 Evaluation Module (EVM)	*OPT3001EVM User's Guide*
OPT3002 Evaluation Module (EVM)	*OPT3002EVM User's Guide*
OPT3004 Evaluation Module (EVM)	*OPT3004EVM User's Guide*

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