Using Digital Output Ambient Light Sensors for Automotive Displays

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When you think of displays, what do you think of? Traditionally interpreted as a part of televisions and computers, display technology is now everywhere from thermostats, handheld terminals, automotive infotainment systems, automotive clusters, to electronic point of sale machines (EPOS), and more. People like the display to be lit comfortably so it is easy to see and does not strain the eyes. In many of these applications, ambient light sensors (ALS) are used to set the display brightness based on the surrounding light conditions. Depending on the environment a product is designed to be used in, the problems in designing an ambient light sensor into these products are trying to match human eye response, reaching the correct IR rejection due to conditions under dark glass, and maintaining long battery life. Photodiodes (PDs) and Phototransistors (PTRs) have typically been used as ALS in automotive due to the lack of availability of automotive grade digital ALS, but they have pitfalls which are discussed in this application note.

Problems and Solutions

Even though ambient light sensors are becoming more and more common in automotive, they are not only used in display applications (clusters, heads-up displays, and so forth), but also in rear-view mirrors, interior lighting, side-view mirror, headlights, rain sensor, and optical control knobs. In automotive applications, there is a need for an automotive temperature grade device. Texas Instruments has designed the OPT3001-Q1 to cater to this need by having both grade 3 and grade 2-qualified devices. There is also a need for an accurate reading behind dark glass. Light sensors are typically placed behind dark glass for aesthetics. Dark glass attenuates visible light and enhances infrared (IR) light.

Since photo-diodes and photo-transistors do not reject IR light, their error is significantly increased when used behind dark glass. To give more detail, the dark glass acts as a filter so your signal needs to be gained up in order to view the visible light. The Normalized Transmission Spectral Response of the Chosen Dark Window figure in the Ambient Light Sensor Application Guide shows this attenuation compensation in more detail. Since the OPT3001-Q1 has IR rejection capabilities, you are left with more visible signal and not much IR, whereas with a PD, you are left with more IR than visible light which gives an error in measurement. A small circular cutout made in the glass is needed to address this problem for photodiodes and transistors, which can be cumbersome and costly. The OPT3001-Q1 performs very well under dark glass and does not need any cutout. This problem occurs with PDs, PTRs, and if the ambient light sensor does not have good IR rejection. The strong IR rejection aids in maintaining high accuracy when the design calls for mounting the sensor under dark glass for aesthetic purposes. The OPT3001-Q1 is designed for automotive systems that create light-based experiences for humans, and is an ideal replacement for photodiodes, photo-resistors, or other ambient light sensors with less human eye matching and IR rejection.

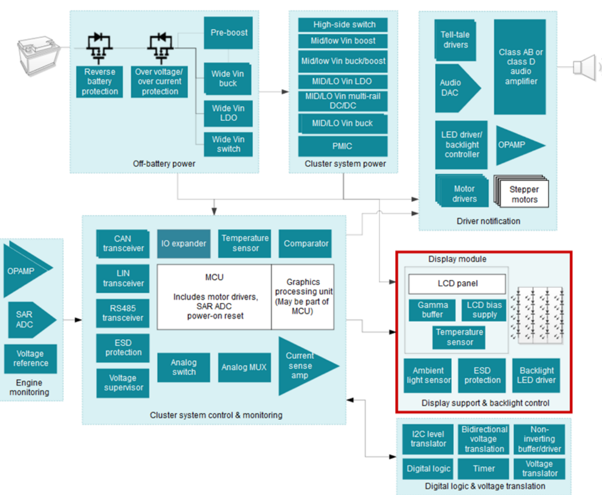

Figure 1. Cluster Block Diagram (See Other Automotive Block Diagrams on ti.com)

The end goal behind using an ALS in any display application is to be able to measure what the human eye sees, so the display can be adjusted accordingly. Each light source technology has a unique spectral profile, which means that different light sources such as florescent or incandescent lights that appear to have the same brightness are actually quite different. Display brightness needs to adapt from one light source to another to account for this. If these different light sources are not accounted for, it could result in user discomfort as well as a non-optimum display power.

The response of photodiodes (PDs) in most light sensors is quite different from that of the human eye due to the wide spectrum of wavelengths the PD measures. The human eye naturally has high IR rejection and the OPT3001-Q1 matches the response of the human eye and includes significant infrared rejection. For example, during times of very bright sunlight, the display needs to adjust the brightness higher so that it is viewable to the user. Conversely, during nighttime, the display needs to be adjusted down so it is not too bright which may harm the driver's eyes. The OPT3001-Q1 interprets the light source and provide optimal display brightness. Figure 2 shows the typical behavior.

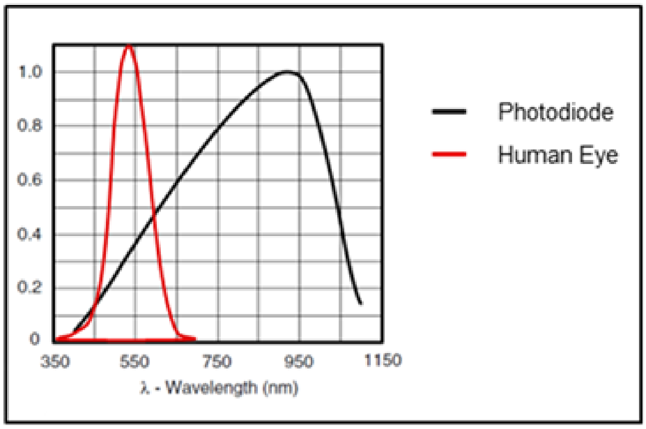

Figure 2. Typical Photodiode Response

The OPT3001-Q1 response matches the human eye response. It detects the ambient light precisely and enables optimum control of backlight, which leads to extended battery and display life as well as an improved user experience. Daylight is around 100 k lux, outdoor shadow is around 10 k, and night is around 50 lux (200x less than shadow). To get the same performance in each scenario, the backlight LED current can be reduced significantly. Figure 3 shows the OPT3001-Q1 response data.

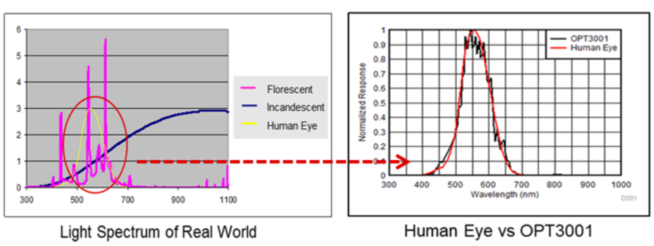

Figure 3. OPT3001-Q1 Response (Wavelength on Y-Axis)

To achieve a comparable dynamic range to that of the human eye without added complexity for the user, the OPT3001-Q1 has an auto-gain setting feature that adjusts the full scale range setting automatically based on input light level. No additional adjustments are needed, unlike those required when using a discrete solution. The device always stays in optimal range with good resolution and tight accuracy between ranges (see Figure 7 and 8 in the datasheet for more information). This feature is achieved by the OPT3001-Q1 automatically selecting the appropriate gain setting, unlike other ambient light sensors that may require manual changes to the gain setting. This allows for less MCU cycles as well since this feedback loop is integrated in the device as opposed to a discrete solution. The OPT3001-Q1 allows for optimal display brightness under all light levels by providing a very accurate feedback to the controller.

Conclusion

As displays get more and more common in the automotive market, Texas Instruments has specifically designed the OPT3001-Q1 to solve the typical problems faced in a system that uses PDs and PTRs. The availability of grade 2 and grade 3 OPT3001-Q1 devices from TI enables the spectral response of the sensor to tightly match the response of the human eye and include significant infrared rejection. The OPT3001-Q1 maintains performance regardless of light source or application.

References

- OPT3001-Q1 Product Folder
- OPT3001EVM
- Texas Instruments, OPT3001-Q1 Datasheet (SBOS853)
- Texas Instruments, Ambient Light Sensor Application Guide (SBEA002)