TI TechNotes

Automatic control of Display backlight using an Ambient Light Sensor with Human-eye response

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 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 present 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. Texas Instruments provides not only the OPT3001 to solve these problems, but also the OPT3001-Q1 that is an automotive qualified device to be used in infotainment systems.

A problem with display backlights in portable electronics is the need to provide a clear picture in all ambient light conditions while simultaneously optimizing the power consumption to preserve battery life. The same problem occurs with display backlights in stationary applications, such as thermostats, but the environmental conditions are varied. Stationary applications must provide a clear picture in a variety of light conditions, like florescent light, incandescent light, or no light at all. Ambient light sensors from TI are being designed into products such as these to provide information to the display about the ambient light level surrounding the display. This light level can then be used to automatically adjust the display brightness via the backlight, providing just the right brightness level for clear viewing, preserving power and avoiding end user frustration that the display is too bright or too dim.

Figure 1 shows a typical block diagram for a display application.

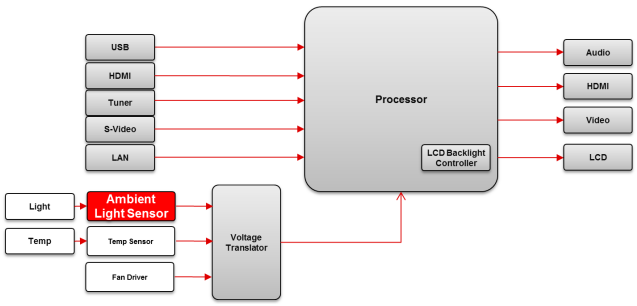

Figure 1. Display Block Diagram

The end goal behind using ALS in any display application is to be able to measure what a human sees, so the display can be adjusted accordingly. Just as the human eye adjusts under different light sources, display brightness needs to change from one light source to another. If these different light sources are not accounted for it could result in user discomfort as well as a non-optimum display power.

The photodiodes (PDs) in most light sensors are not as responsive as the human eye due to the wide spectrum of wavelengths the PD measures. The human eye naturally has high IR rejection and the OPT3001 matches the response of the human eye and includes significant infrared rejection. The IR light that is captured during a sunset for example is interpreted as “high ambient” by a regular photodiode, which leads to increased display brightness. The OPT3001 will interpret the light source and provide optimal display brightness. See Figure 2 for the typical behavior.

Copyright © 2017, Texas Instruments Incorporated

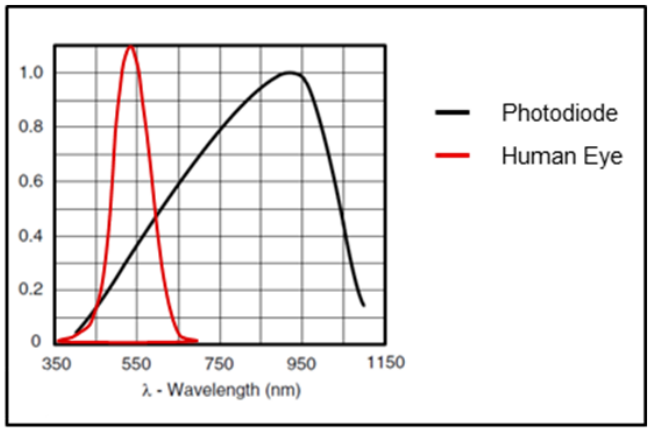

Figure 2. Typical Photodiode Response

The OPT3001 response matches 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 100k lux, outdoor shadow is around 10k, 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 by 200x during night. See Figure 3 for OPT3001 Response data.

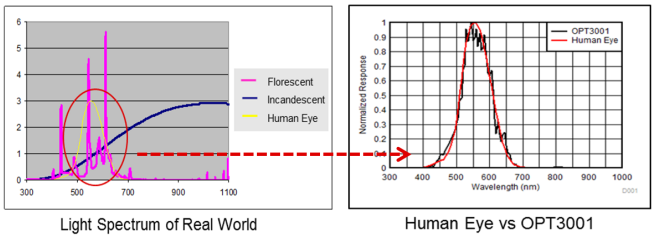

Figure 3. OPT3001 Response

To help achieve the reaction of the human eye the OPT3001 also has an auto-gain setting feature that adjusts 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. The relative accuracy between gain ranges is 0.2%. This allows for optimum display under all light levels.

Another problem that can occur with backlight display is that light measurement changes under different light inputs. Dark glass, for example, transmits IR. Sources like incandescent light have high IR that reaches the sensor due to glass transmissivity. If a photodiode were to be used, there is a higher risk for inaccuracy due to the wideband of the photodiode. The OPT3001 has a very high IR rejection and discards most of the IR light reaching the actual sensor, measuring only what is in the visible region. See Figure 4 for graphical data. The Input Spectrum is the same graph seen in Figure 3 of the different light sources. Green Curve: Human Eye, Pink Curve: Florescent, Blue Curve: Incandescent, Black Curve glass response.

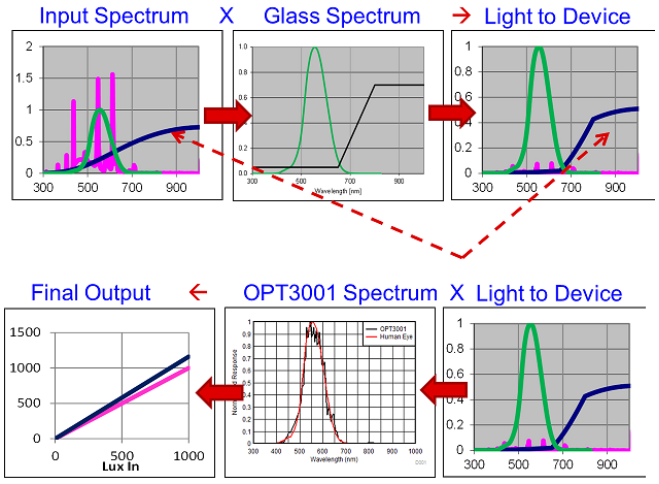

Figure 4. IR Rejection

The strong IR rejection also aids in maintaining high accuracy when the design calls for mounting the sensor under dark glass for aesthetic purposes. The OPT3001 is designed for systems that create light-based experiences for humans, and is an ideal replacement for photodiodes, photoresistors, or other ambient light sensors with less human eye matching and IR rejection.

The OPT3001 and OPT3001-Q1 devices are sensors that measure the intensity of visible light and are suitable for display applications. The spectral response of the sensor tightly matches the response of the human eye, includes significant infrared rejection. The OPT3001 maintains performance regardless of light source or application.

1 Related Documentation/Learn More

- OPT3001 Product Folder: http://www.ti.com/product/OPT3001
- OPT3001-Q1 Product Folder: http://www.ti.com/product/OPT3001-Q1
- OPT3001EVM: http://www.ti.com/tool/opt3001evm

1.1 Trademarks

All trademarks are the property of their respective owners.

Copyright © 2017, Texas Instruments Incorporated

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated