Technical Article

How intelligent sensors expand our detection of light

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Our eyes constantly interpret the world around us, perceiving a spectrum of colors and adapting to various situations. In the same way that our eyes provide signals to our brain, ambient light sensors precisely measure lighting conditions in an environment and provides lux reading to a system. Light sensing technology continues to improve the way we see things – as well as what we can't see.

Imagine a security camera constantly surveilling cars in a parking lot at night, or a car's headlights intuitively dimming and brightening when the light intensity changes drastically, such as when entering or exiting a tunnel. Innovations in ambient light and color sensors are helping determine how to handle light beyond what the human eye can see, increasing safety and efficiency in automotive and industrial applications.

Applications of ambient light sensors

Ambient light and color sensors enable intelligent light control in many applications, improving energy in homes and factories and enhancing vehicle safety in adaptive headlights. One popular use for ambient light sensors is day and night detection, which enables automatic adjustments of outdoor lighting and camera systems such as the security camera shown in Figure 1. For camera applications, it's important that ambient light sensors (ALS) have high infrared rejection, in order to filter out the infrared light from LEDs used for camera night vision.

Figure 1. An Internet Protocol network camera using ambient light sensors and infrared LEDs

Challenges and design requirements

Designing an ALS and color-sensing device includes challenges such as how to achieve the best accuracy, sensitivity and resolution, while accommodating package constraints and the need for system-level integration.

TI's ambient light and color sensors address these challenges with features that improve functionality. Common design requirements for ambient light sensors include high accuracy and resolution, since many applications require precise light measurements for display brightness adjustment, automotive lighting control or video surveillance (see Figure 2).

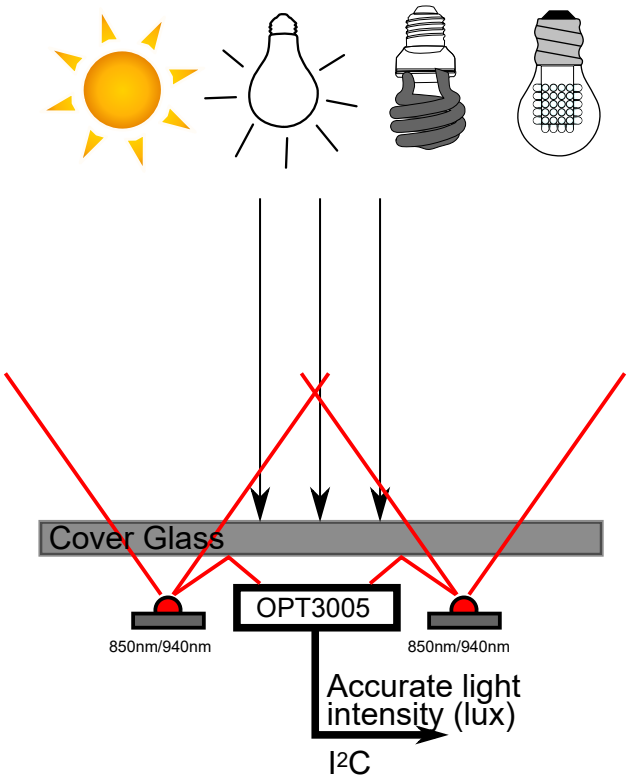

Figure 2. The TI OPT3005 ALS in a video surveillance application

ALS such as TI's OPT4003-Q1 digital light sensor provide system flexibility based on application needs, enabling reaction times to environmental changes with customized conversion times ranging from 600µs to 800ms per channel in 12 steps. These conversion times work well in automotive applications, where rapid adjustments are necessary for safety when driving into and out of tunnels. The OPT4003-Q1 can identify light sources including incandescent, halogen, sunlight, LED and fluorescence, helping improve system operating conditions such as detecting whether light is coming from a well-lit indoor environment or from outside, which impacts the type of headlight needed.

It's also possible to use ALS for tamper detection and brightness adjustment in end equipment such as electric vehicles (EVs) and EV charging stations, as shown in Figure 3. With adaptive brightness control, the screen on an EV charging station remains visible in various lighting conditions without excessive power consumption.

Light sensors also enhance energy efficiency and improve the user experience for display and LED brightness adjustment in personal electronics applications, making devices such as smartphones, laptops, smartwatches and tablets more efficient and seamless to use.

Figure 3. An EV charging station featuring ALS for tamper detection and brightness adjustment

In imaging and color-sensitive applications, color sensors provide excellent automatic white balance, exposure control and low-light performance, and enable precise color calibration for displays, as shown in Figure 4.

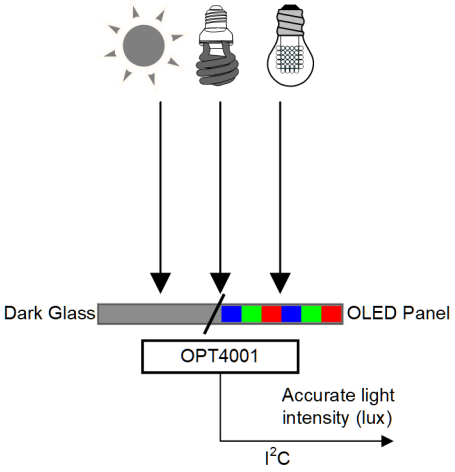

Figure 4. The OPT4001 ALS in displays

The OPT4041 dual-channel ALS measures light with a spectral response very closely matched to the human eye, and effectively filters out infrared interference. Matching the sensor spectral response to the human eye response is vital, as ALS measurements help create better human lighting experiences. Strong rejection of infrared light, which humans do not see, is a crucial component of this matching, which makes the OPT4041 especially effective in products located underneath windows that are visibly dark, but infrared-transmissive for applications such as video surveillance. The OPT4041 can also recognize different light sources and has a wide-bandwidth sensing channel that can indicate the illumination of infrared LEDs in camera applications.

Another challenge for designers is packaging and integration. As electronics decrease in size, the need for compact, flexible solutions to fit in space-constrained designs is growing. TI optical sensors are available in multiple package options, including the PicoStar™ package with a bottom-facing sensor or industry-standard

small-outline transistor (SOT) packages (see Figure 5). Additionally, TI's ALS and color-sensing solutions help extend device lifespans and enable significant energy and cost savings through low power consumption.

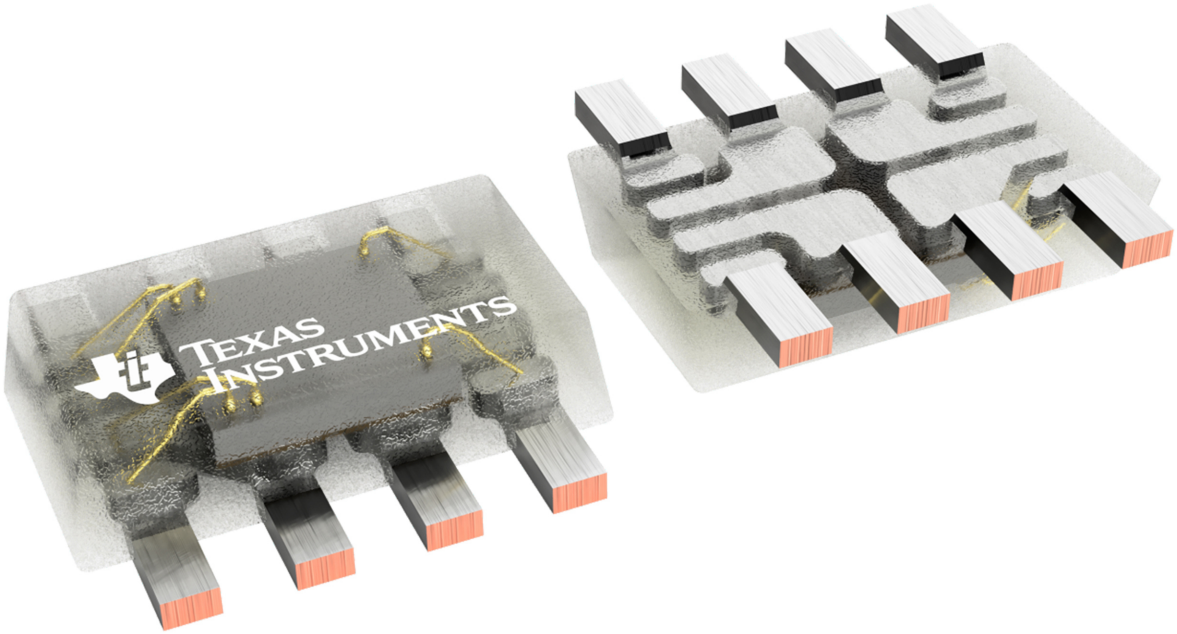

Figure 5. The OPT4041 SOT package is 2.1mm by 1.9mm by 0.6mm

To help contract manufacturers and object design manufacturers achieve the best possible performance, TI also provides in-line calibration support. A dedicated light source for end-of-line testing and calibration of ambient light and color sensors ensures consistent and accurate performance across different production batches available on TI.com. High accuracy, fast response times, flexible packaging and calibration support enable seamless integration of our optical sensors into applications ranging from automotive lighting to advanced consumer electronics.

Conclusion

Ambient light and color sensors are becoming vital in more applications: in automotive, these devices enhance the user experience when driving at night and through tunnels, and improve security in camera systems with higher infrared rejection.

As technology trends continue, you can expect advancements in light and color sensing such as a focus on a higher infrared rejection, integrated sensors behind organic LED displays in personal electronics and automobiles to enable ultra-thin bezels, and even smaller packages for size-constrained applications. Ambient light and color sensors will continue improving the ability to understand and interact with our surroundings in ways we cannot yet see.

Additional resources

- Read the application note, How to Select a Light Sensor for Your Application.
- Order the LightSourceEVM.
- Learn more about calibration for ALS with Stable Light Source for Calibration of TI Ambient Light Sensors.
- Select a TI sensor from our optical sensing portfolio.
- Get started today using the Field of View Simulator.

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