

AMBIENT-LIGHT SENSORS PACK IN FEATURES TO HELP APPLICATIONS GET **smarter,**

greener

AMBIENT-LIGHT SENSORS HELP SMARTPHONES CONSERVE DISPLAY POWER AND IMPROVE BATTERY RUNTIME. NEWER VERSIONS COMBINE IMPROVED FEATURES, SUCH AS SPECTRAL RESPONSE AND DYNAMIC RANGE, INTEGRATED PROXIMITY, AND DIGITAL COMMUNICATIONS. THESE FEATURES ARE READYING THE SENSORS FOR USE IN LARGE-SCREEN AND AUTOMOTIVE DISPLAYS AND SOLID-STATE LIGHTING.

ALSs (ambient-light sensors) have been around for years, but they are now seeing increased use due to the success of smartphones, such as Apple's iPhone. The iPhone uses an ALS to reduce power demands and eke out battery life by adjusting the display lighting for ambient-light conditions. The iPhone also uses a proximity detector, a close cousin of the ALS, to reconfigure itself in response to user actions. Today, smartphones, with their trademark large LCDs, are the main users of ALSs, but future applications can realize energy savings and increased ease of use. For example, a large-screen LCD TV must

adjust its LED backlighting to the ambient light. Similarly, a room with SSL (solid-state-lighting) illumination can change its lighting based on natural lighting or to suit its occupant's mood. Automobile lighting can accommodate day or night driving or reflect the brightness of streetlights, saving power and providing a better user experience.

At its most basic, an ALS consists of a photodiode or a phototransistor. However, a simple light-sensitive semicon-

ductor is insufficient because the ALS must be "photopic," meaning sensitive to the same frequency spectrum as the human eye (Figure 1). Incandescent and HID (high-intensity-discharge) lights emit 50 to 60% of their radiation in the nonvisible IR (infrared) range as heat. According to Oleg Steciw, product-marketing manager for ALS products at Intersil, you should use the HID with the best spectral response you can find. Otherwise, he says, "You'll be in a

room, and, suddenly, the backlight will go haywire because there's some external light source that you can't even see, wreaking havoc."

Werner Mashig, application engineer on Arrow Electronics' lighting team, explains, "[Some] manufacturers put IR-filter [compounds] into the epoxy to filter out the IR light so that the sensor will respond like the human eye."

Another approach is to use multiple photodiodes in the ALS. "One photodi-



The proximity sensor in a 3G (third-generation) iPhone is within the red circle, and the ambient-light sensor is the green part to its left. The iPhone's speaker is the gray, mesh-covered oblong (courtesy iFixit). Light and proximity sensors are often next to a handheld device's speaker because both the sensors and the speaker require access to the outside world. A speaker is a better choice than a microphone because of the humidity that's likely next to a microphone.

ode is a broadband one that sees everything from 300 to 1100 nm,” says Carlo Strippoli, vice president of marketing and sales for TAOS (Texas Advanced Optoelectronic Solutions). “The second diode is a dedicated IR photodiode and serves to monitor the IR reaching the sensor and then subtracting it from the light received at the broadband photodiode.”

Fluorescent-light sources, which are more efficient than incandescent or HID lights, emit almost none of their radiation in the IR range, but they may exhibit a 60-Hz flicker that can cause an ALS to trigger when it’s not supposed to. The newer digital ALSs integrate ADCs that convert the photocurrent to a digital signal to interface to a digital-communication bus. The ADC can serve double duty by filtering out optical noise, such as 60-Hz flicker, through high-resolution sampling. Rohm’s BH17xx series integrates a 16-bit ADC that produces 1-lux resolution over a range of 0 to 65,000 lux. Two measurement-resolution levels allow selection between sampling time and performance. In the high-resolution sampling mode, the ADC filters out optical noise. The lower-resolution mode with its shorter sampling time suits applications such as GPSs (global-positioning systems), in which the light-level changes are dynamic: A GPS system will probably operate in an automobile’s interior or in natural light. The ideal ALS exhibits uniform light sensitivity regardless of the light source.

“Digital is the direction ambient-light

AT A GLANCE

Although smartphones are the major users of ALSs (ambient-light sensors), look for their ability to bring intelligence and power savings to such applications as laptops, TV screens, and automotive and room lighting.

The most important feature for an ALS is its ability to see light as the human eye does. This task requires filtering out the IR (infrared) spectrum.

Vendors are integrating more features, including digital interfaces and proximity sensors, into ALSs.

More complex devices perform RGB (red/green/blue) sensing.

sensing is going,” says TAOS’ Strippoli. “It allows you to put multiple sensors on a single two-wire bus,” such as the I²C (inter-integrated circuit). This feature is especially important for flip phones. A digital bus minimizes the number of wires at the hinged interface where the cell phone flips up.

An analog interface requires at least two wires for every sensor. Analog ALSs are still good fits for some designs, such as those in which the voltage or current output of the ALS directly drives the lighting subsystem, those lacking a microcontroller or an available ADC input, and those low-end designs in which price is the dominating feature (Figure 2).

In the past, ALSs could vary from

part to part in the amount of current a given amount of light produces. Such variability makes it difficult to design for a tight sensitivity range. “The manufacturers are [now] doing a great job of binning the components to give more consistency across the design so there’s not as much variation of the photocurrent,” says Arrow’s Mashig. He suggests looking at the specification for photocurrent versus brightness to check the tightness of manufacturers’ binning.

A low-power lighting system is especially important for battery-powered devices, and this requirement includes the ALS itself. In general, both analog and digital versions of ALSs have a shutdown or sleep mode, during which the sensor operates at approximately 1 μ A. Because of the relative simplicity of analog ALSs, they require less power than their digital counterparts. For example, a representative digital ALS draws 190 μ A in active mode and 1 μ A in power-down mode due to the integration of the ADC; an analog equivalent of the part draws 97 and 0.4 μ A, respectively. However, the total power consumption is comparable to or a little less than that of an analog ALS with a separate ADC.

In addition to an ALS, smartphones often use proximity detectors. Apple’s integration of a proximity detector in the iPhone prompted a move toward making handheld consumer devices more intelligent when interacting with their users (see sidebar “iPhone puts proximity detection on the map and in your face”).

IPHONE PUTS PROXIMITY DETECTION ON THE MAP AND IN YOUR FACE

The Apple iPhone packs several sensors into its slim profile: an ALS (ambient-light sensor), an accelerometer, and a proximity sensor. In addition, the display itself is a giant touch sensor, and that fact could pose a problem when the phone is in use next to a user’s face. Apple solved the problem of inadvertent activation of the screen by including a proximity sensor that detects proximity and turns off the touchscreen when the phone is 3 to 5 cm from a user’s face (Reference A).

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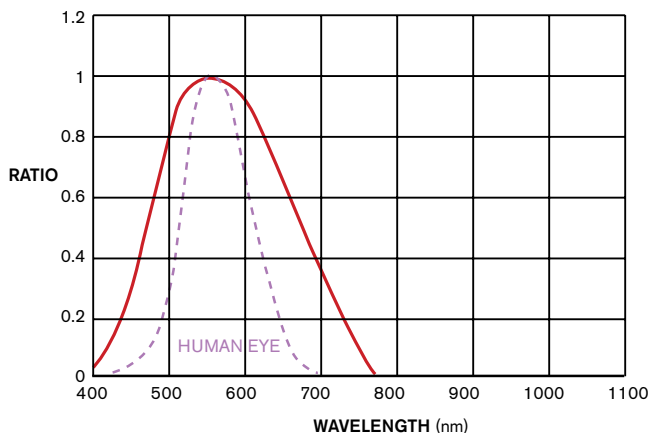


Figure 1 The human eye is sensitive to wavelengths of approximately 380 to 780 nm, peaking at approximately 555 nm. The wider red curve shows the sensitivity of a representative ambient-light sensor.

Because of the close links in both technology and usage between ALSs and proximity detectors, ALS vendors are starting to add proximity detection to the list of integrated features in ALSs. “The ISL29011 drives an external IR LED so that it synchronizes the transmittivity of the LED and then captures the reflection off the object in front of it,” says Intersil’s Steciw. “You want the sensing range to be within about 3 to 5 cm.”

The placement of the IR LED outside the sensor package gives designers more flexibility in where they place the device or what they’ll place it behind, says TAOS’ Strippoli. “The iPhone puts [the proximity detector] behind a glass that blocks about 95% of visible light,” he adds. “So if you use a device that gives you just a [fixed] single output, you get a very low signal.”

For discrete proximity sensors, it’s still common to keep the IR-radiating

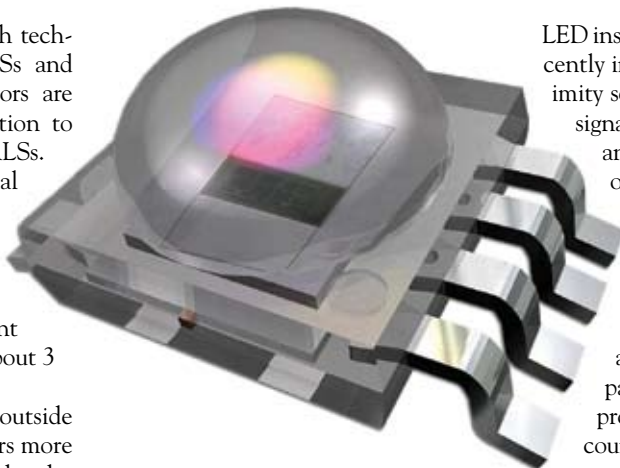


Figure 2 Although digital ALSs are now available, analog sensors are still popular for many applications. Microsemi’s Best Eye processing provides a nearly perfect photopic light-wavelength-response curve. The sensor output feeds into a wide-dynamic-range compression amplifier that provides accurate resolution over five decades of ambient light.

LED inside the sensor package. Avago recently introduced the APDS-9120 proximity sensor, which combines a built-in signal-conditioning IC, an emitter, and a detector into a package that offers both analog- and digital-output options. Like Steciw, Strippoli views the power-saving requirements of portable devices driving the trend in packaging proximity detectors along with the ALS but sees it as part of the move toward greener products. He believes that Asian countries in particular are likely to mandate the ability to tell when a viewer is using a large screen or monitor by monitoring proximity.

ALSs in smartphones detect light intensity but provide no information about the color spectrum. A recent development in ALSs is the ability to perform RGB (red/green/blue) sensing, a necessary feature for large-screen LCDs. For the best viewing experience, these

TAKING ADVANTAGE OF LIGHT SENSORS WITH MICROCONTROLLERS RUNNING DALI

By Bobby Wong, NEC Electronics America Inc

In our energy-conscious world, one simple way to reduce energy consumption is by adjusting office lights to take advantage of the available natural light. Light sensors can operate in multiple locations to detect the amount of naturally occurring ambient light. With the appropriate lighting system, users could accordingly adjust office lights to produce the desired amount of total lighting necessary for each area. Sensors have proved that they can dramatically enhance lighting systems—from improving energy efficiency by sensing ambient light to improving color by detecting light output. Although sensors provide the data, the lighting system still needs an intelligent microcontroller to receive and process the data and adjust the lights accordingly.

However, saving energy should not reduce productivity. A smart microcontroller-based lighting system would allow users to override the automatic light-level sensors when necessary and “remember” programmed user settings to enhance the users’ experience.

Although multiarea lighting control, sensor input/processing, and scene setting may sound complicated, the DALI (digital-addressable-lighting-interface) protocol for white-light control in offices and factories already implements many of these features. Companies space these sensors and lights throughout their facilities, and the devices therefore require a network. The DALI network

can control as many as 64 lights with 64 generic controls, such as slider dimmers and sensors. Each area light can store as many as 16 scenes, and each scene stores a digital-dimming level of 0 to 255. When a sensor provides ambient-light input to the microcontroller, the microcontroller can send a DALI command through the network to any of the 64 lights and control them to dim to a specific scene setting. The DALI protocol is also extensible, allowing a supplier to include vendor-specific features for added value. Some microcontrollers have specialized hardware for driving lights from fluorescent tubes to LEDs, and they simplify the support for a DALI network. Unlike discrete light drivers, these microcontrollers can process sensor inputs and intelligently control lights in a wide area using the DALI protocol to produce the optimized amount of light and save energy along the way (Reference A).

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AUTHOR’S BIOGRAPHY

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displays must match their backlighting to the color temperature of the ambient lighting (**Reference 1**). The LCD controller uses the RGB ALS output to tune the RGB HB (high-brightness) LEDs to match the ambient lighting: Backlighting for a fluorescent-lit room has a different color temperature from that of a natural- or incandescent-lit room. In addition, as RGB LEDs age, their color changes slightly, calling for an additional RGB ALS in the backlight itself to sense and give feedback to drive the compensation for the LEDs' color change. Intersil, TAOS, and Rohm all offer RGB sensors.

SSL is an emerging application for RGB ALSs. In this application, color sensors provide feedback to a room's lighting-control system to adjust the light intensity, color, and color-temperature output of the HB LED-based luminaires. Lighting-control information is more complex than the simple on/off-light-switch information that room lighting currently uses, and lighting designers must be familiar with communication

protocols. The DALI (digital-addressable-lighting-interface) protocol, which theatrical lighting has used for years, is one possible approach (see **sidebar** "Taking advantage of light sensors with microcontrollers running DALI").

Automotive lighting also needs ALSs. Night-driving applications have for years used simple photosensors to turn lights on and off, but more complex ALSs optimize cabin lighting for safe driving and for aesthetics, such as colored lighting

and light-intensity variation. Like most other automotive components, ALS specifications must include operation over the wider temperature and vibration range. **EDN**

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FOR MORE INFORMATION

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