White Paper

Color Sensing Improves Look and Feel of Smart Products

The development of the market for tablets and smartphones has shown the power of novel, attractive industrial design to build strong market positions for OEMs. As the attention widens out to wearable products such as smart watches, the need for fashionable, distinctive product design will only become more intense.

An obstacle to creating novel designs lies in the amount of real estate that needs to be devoted to the user's primary focus: the user interface itself. Because the combination of color-rich liquid crystal or organic LED displays and capacitive touch screens is so powerful, it's only natural that this should dominate the design. But this doesn't mean that all products need to use a clear glass and silver design. Tinted glass offers many possible ways to differentiate on look and feel.
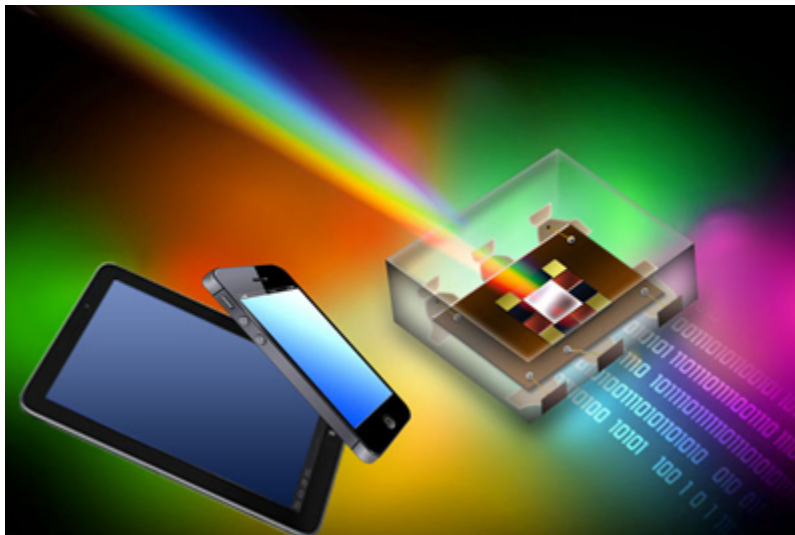

Figure 1. RGB sensors can differentiate product design

Although the tint of the glass will alter the look of the user interface, it's possible to compensate for this through the display panel itself—altering the color balance of the pixels so that, when activated, the glass over the display appears to clear. Not only that, the display can be designed such that it not only compensates for colored glass, but for changes in ambient light conditions, from the blue light of a sunny day to the yellow or red tinge of some indoor lighting.

The key requirement for this capability is an accurate red, green, blue (RGB) ambient light sensor in place of the simple white ambient light sensor used today on smartphones to help determine the level of brightness needed by the display. By taking account of color as well as ambient brightness, the display can be made easier to see and more pleasurable to use.

A second benefit of ambient RGB detection in handsets and tablets is when it's used with the built-in camera sensor. By providing feedback on the ambient lighting, the sensor provides vital information to algorithms

that perform automatic white balancing to ensure accurate skin tones and color consistency in photographs that the user takes. Through the use of accurate color feedback, the algorithms can even determine the likely light source, such as fluorescent lighting or a cloudy sky, to help calculate exposure settings for better results. In addition, flash output and flash drive current can also be optimized knowing the light source and light intensity. This contributes to improved battery life.

The technology can also benefit instrument panels in automotive applications to improve their readability and attractiveness under the fast changing lighting conditions of night-time roads, where yellow sodium lights mix with other sources that pass by quickly.

There are other applications for a high-quality RGB sensor. Integrated into a TV, the sensor can be used to inform the display electronics of any changes caused by device aging. For example, in OLED displays, the blue pixels tend to shift color more quickly than the red and green elements as they age. By sensing this color, the RGB sensor helps ensure a more consistent output over the lifetime of the TV.
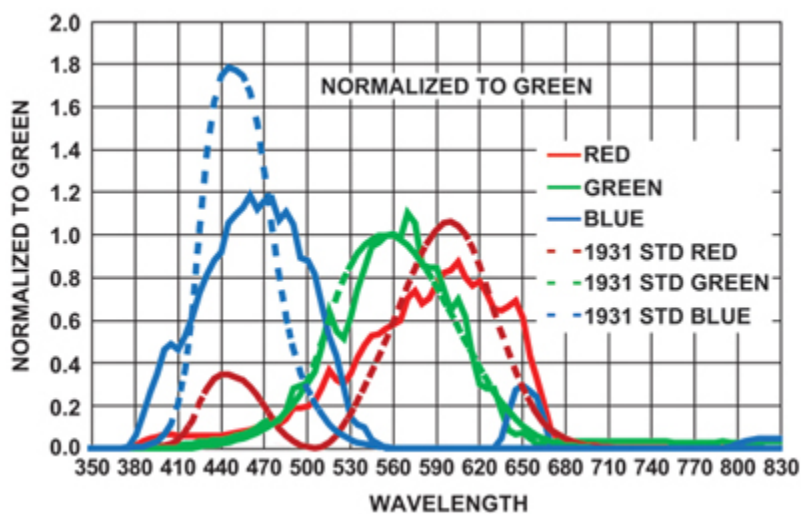

Figure 2. Example of color normalization to green

For sensing ambient light and the effects of color filtering through tinted glass, the sensor will typically be mounted underneath the glass panel. This provides an accurate color reference of the lighting conditions that affect the display that can be used by a display driver to alter the RGB balance of the active pixels to compensate for the filtering effect as well as ambient light conditions, such as excess red or other colored light.

To overcome the effects of flicker, the use of integrated ADCs in the sensor design can filter out the effects of 50Hz or 60Hz on artificial light sources or the effect of a camera flashgun. Sample data can be transferred to the display driver controller using a serial interface such as I2C.

A sensor mounted so that it can receive light from the display itself provides the ability to react to changes in overall pixel output. For example, a comparison of received light for a given output image versus the factory calibration readings can be used by the firmware to boost or reduce R, G or B elements to maintain a consistent color output over the lifetime of the product—assuming that a panel of OLEDs, for example, will experience consistent aging effects across the surface.

Color printers also require an accurate sensor to ensure that during calibration and printing the correct amount of ink is being deposited onto the paper—an essential requirement when the target output is for color photographs.

Because physical design is so important to many of these applications, to be effective, an RGB ambient light sensor needs to be compact as well as accurate. If a device is less than 2mm on a side, it can easily be packaged close to an image sensor or unobtrusively sit within the frame of a glass panel without reducing display real estate.

The sensor also needs the flexibility to be mounted in many different situations, such as behind the specialized dark glass used for the infrared (IR) remote control port in TVs or for proximity sensors in mobile devices that rely on the reflection of IR signals from the user's skin to function. Unlike standard glass, this material allows IR transmission far more effectively than most other forms of glass. IR filtering or compensation are needed to prevent strong IR signals affecting visible light measurement.

One option is to place an IR filter over the RGB sensor itself, but this increases costs and construction complexity. An alternative is to integrate on the device, not just visible-light photodiodes, but IR sensors as well, to allow processing electronics to perform the compensation digitally. This approach has one key advantage over IR filtering in that it allows greater intelligence to be applied to light detection. Different types of visible light source produce widely variable amounts of IR. For example, incandescent sources generate a large amount of IR whereas fluorescent produces very little, and less than is generally encountered in natural daylight. By interpreting this data, it is possible for image-compensation software to account for different lighting conditions.

Because IR glass filters out a high proportion of visible light, high sensitivity is needed in the RGB photodiode array to ensure accurate color response when a sensor is used in those conditions. The sensor needs to be able to gauge color with light levels as low as 0.005 lux to handle dark environments, such as operation under IR glass, but still cope with intensities of up to 10,000 lux in applications where the glass transmittance is much higher. For ease of use, the sensor should work directly with the device's core processor to continuously adjust the lux range and ensure that the display maintains consistent perceived color and the ideal brightness level based on the current lighting environment.
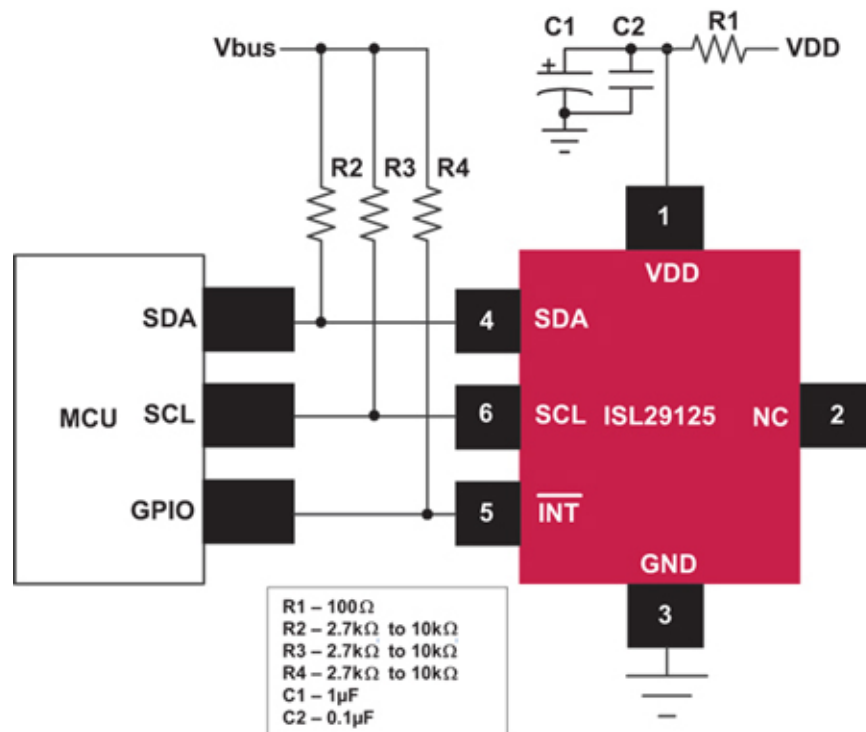

Figure 3. Typical application diagram for an RGB sensor

Accuracy and repeatability are vital to ensure a consistent user experience across individual products without incurring lengthy calibration procedures during manufacturing. A variation of less than 10% is sufficient to ensure that ambient color levels are matched effectively. As many of the applications for an RGB sensor are in mobile devices, low-power operation is vital. Not only does the analog front end need to draw comparatively low current, it's important that the sensor electronics can be put into a low-energy standby mode when not required. As lighting conditions are unlikely to change rapidly, an effective strategy for using this type of device is to take several readings over a short period of time to account for flashes from a proximity sensor's LED photodiode, for example. Once the necessary readings have been taken, the sensor can be powered down to wait until the next cycle a few seconds later. This strategy can cut energy consumption in the sensor subsystem by several orders of magnitude.
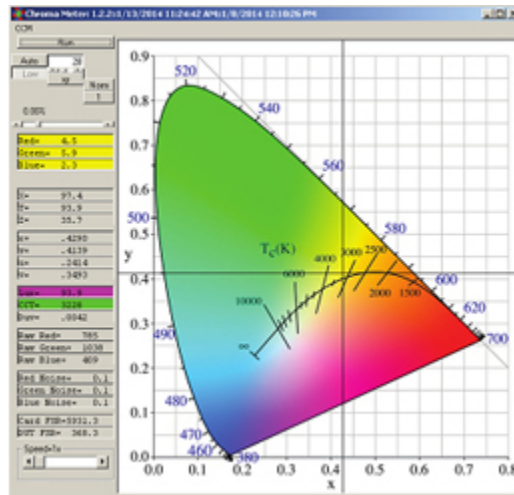
Figure 4. Chroma test GUI chart example

The availability of software tools to demonstrate the performance of the sensor is also important. By showing the developer how readings of ambient light match up with the industry standard CIE 1931 Chromaticity chart, it's much easier to evaluate how a particular piece of glass will affect the readings and alter the degree of color compensation needed in the final product. It can also show how close an IC sensor can approach the accuracy of a dedicated, handheld color meter.

An example of an RGB sensor that satisfies the requirements for this fast-growing market is the Intersil ISL29125. It offers low-power operation through power-down modes and transfers data to the host using a standard I2C interface. The ISL29125 also offers a wide dynamic range of 0.005 lux to 10,000 lux, enabling designers to use the device across a wide range of operating environments and applications. In power-down mode, the Intersil RGB sensor consumes less than 0.5µA of current and on active mode it runs at approximately 85µA.
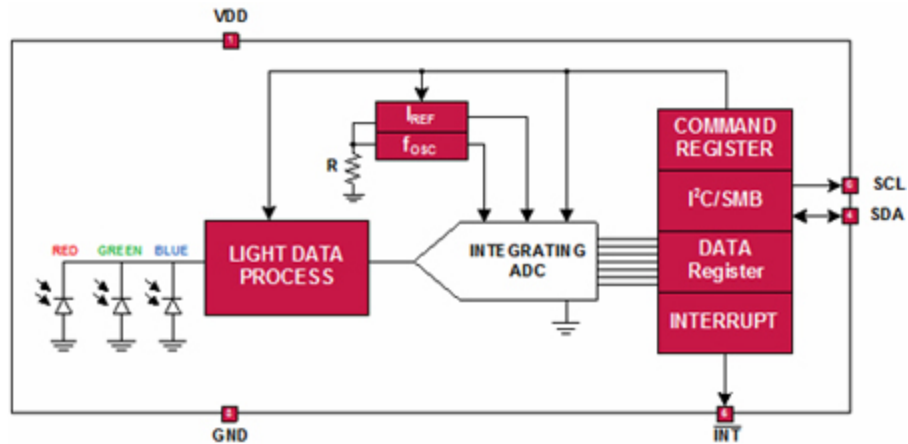
Figure 5. ISL29125 RGB sensor block diagram

Summary

Through integration and effective IC design, a new generation of RGB sensors will enable more advanced and attractive user interfaces that span consumer, automotive and industrial applications.

Next Steps

- Learn more about the ISL29125 digital RGB sensor

- Order free samples of the ISL29125

- Find out about the ISL29125EVAL1Z evaluation board

- Learn more about Renesas' ambient light sensors

- Use our parametric search to find the best ambient light sensor for your application

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