What Ambient Light Sensing Can Do for HDTVs

How ALS can save energy and improve image quality

TAOS, Inc. ▸ January 2010

TAOS
TEXAS ADVANCED OPTOELECTRONIC SOLUTIONS®

What Ambient Light Sensing Can Do for HDTVs

How ALS can save energy and improve image quality

The television world is turning flat... and green. With retail prices dropping 20% a year over recent years, manufacturers are working hard to find the right combination of features and costs that will attract consumers and make their products winners.

The biggest challenge, however, is how quickly the market moves. A feature such as 120 Hz refresh rate for LCD TVs was a competitive advantage a year ago, but now is viewed as almost a standard feature for all but the least expensive models.

One of the key consumer concerns has been that of energy consumption. An energy efficient flat panel television has a competitive advantage for the moment because it will cost less to operate over its lifetime.

This may not seem like much, but people tend to keep their televisions for 10 years or longer. Saving $30 a year in energy costs could add up to half the purchase price of a 42-inch LCD HDTV.

And soon that competitive advantage will turn into a feature that consumers will expect as a standard. The Energy Star program — http://www.energystar.gov/ — sets optional standards that flat panel TVs must meet in order to qualify for the logo. According to the Energy Star program, televisions account for 4 percent of the residential electricity consumption in the United States, or about 50 TWh a year.[1] More stringent version 4.0 qualifications are set to go into effect in May 2010, with even tighter requirements for version 5.0 starting in May 2012. And California has set mandatory limits that television sets will have to meet in order to be sold in that state.

Manufacturers of both plasma and LCD models have made enormous strides to make their products more energy efficient. For example, Vizio recently released some LCD models that exceed the existing Energy Star requirements by 65%.[2]

The question is how to design flat panel televisions so that they are as energy efficient as possible. And the trick is to not detract from the image quality in the process.

Designing HDTVs to Save Energy

Fortunately, there are plenty of tools available to help designers reduce the amount of electricity required by large flat panel displays. One of the most effective approaches is to control the light output of

the display using an ambient light sensing (ALS) system.

The energy consumption of a plasma display is affected by the content of the image that is shown on the screen, but the bottom line is that a brighter image requires more energy. For most LCD displays, the power use is independent of the image, as the backlight stays on at a steady level.

Whether the flat panel is plasma or LCD, a darker room will permit the use of lower backlight output. This also can improve black levels which in turn can improve image contrast. As a result, a lower brightness setting can save energy and produce a better quality image for the consumer at the same time.

ALS Component Considerations

In designing an ALS system for a television, a number of factors need to be considered in order to best match the component capabilities to the application requirements.

Digital ALS devices — pioneered by TAOS, Inc. — have a number of advantages over analog alternatives. They have digital interconnects, which increase reliability and lower manufacturing costs. Multiple devices can share a common data bus. They are much more versatile, providing flexibility with features such as wide dynamic lux range, covering dark to bright sunlight, low power consumption, programmability, 50/60-Hz flicker rejection, and reduced output noise susceptibility compared with analog alternatives.

Interrupt Architecture: An early TAOS customer for a digital ALS system was one of the leading computer manufacturers, which was developing a new notebook computer. In order to save energy and extend battery life, the company's engineers wanted to dim the LCD backlight in response to lower ambient light levels. If they used an analog part, however, they would have to poll it continuously at preset intervals.

TAOS designed its digital part to include an interrupt feature so that it was able to signal the controller when light levels dropped below predetermined levels. This interrupt feature has both an upper and lower limit that allows notification if the light level either increases above the upper limit or decreases below the lower limit. This greatly lowers the processing power required. This can have the benefit of either allowing the processing power to be available for other applications or to allow the processor to go into a low power mode thereby conserving power and extending battery life.

Persistence: In a related manner, the intelligence in a digital ALS device can be used to avoid rapid changing of the display light levels. It can be programmed so that an interrupt is only triggered after the ambient light readings have been below or above a pre-defined threshold level for a defined amount of time. With sampling intervals of 100 ms to 500 ms, this makes it possible to eliminate the false signal caused by someone walking in front of the sensor, or some other temporary event.

IR Blocking: One of the problems with the silicon photodiodes is that they are sensitive to light energy across a broad range of the spectrum. While this includes the visible light portion of the spectrum, a major portion of the response curve is in the invisible infrared (IR) range, which the human eye does not see.

As a result, an ALS system using a silicon photodiode would need to filter out this unwanted light energy. Without taking into

account the IR energy, the silicon-based reading would show the ambient light is much higher than the person would actually perceive it to be. The end result would be that the display would not be adjusted properly.

TAOS has developed a patented dual-diode solution that addresses this problem. By adding a second diode that is responsive primarily to IR light, its light energy can be subtracted from that of the primary diode (which is responsive to both visible and IR light energy). This dual-diode approach also provides the flexibility of having a simple subtraction as opposed to a more complex series of equations.

Sensitivity Requirements: It's not enough to read room lighting conditions accurately, however. Flat panel television designers typically want to create a bezel that is as uniform and aesthetically pleasing to the end customer as possible; drilling a hole in the bezel for a light sensor is not an acceptable solution in most cases.

However, it is possible to hide the sensor behind a translucent plastic or glass bezel, even if it appears to be solid black. This is because some light will be transmitted through the bezel, and even though it's a small fraction of the ambient light in the room, its levels remain proportional with the room light levels.

One complication is that the certain bezel materials can be transparent to IR wavelengths while visible light can be attenuated by 100 times or more, so the ability to compensate for the IR component is essential.

As a result, this requires a digital ALS that is far more sensitive at very low-light levels than might be needed for other applications. The TAOS digital ALS product family supports analog gain setting options up to 120X that are ideal for challenging low-light level applications such as when the light sensor is operating behind darkened glass. Additionally, TAOS digital ALS devices can be further fine-tuned to match the specific transmissivity of the bezel glass or plastic in order to achieve the optimum system performance. Programmable gain, when combined with programmable integration times, supports up to a 1,000,000:1 dynamic range which enables them to operate effectively in very low-light conditions (tenths of lux) as well as in high light conditions.

50/60-Hz Lighting Flicker: Alternating current (AC) powered light sources such as incandescent or fluorescent lighting have variations in light output. This variation — or flicker — can cause an ALS to trigger when it's not supposed to, resulting in unwanted variations in light measurements. The integrated analog to digital converter (ADC) in TAOS digital ALS devices serve to filter out optical noise, such as 50/60-Hz lighting flicker, through high-resolution sampling.

Color Temperature: A digital ALS system can also include color sensors with color filters that will read the red, green, and blue components of the visible light spectrum. A system with this ability can be used to measure the color temperature of the light source — fluorescent or incandescent — to further optimize the picture display quality. This feature can help improve image quality by maintaining a correct white color balance under changing lighting conditions, automatically and without any intervention from the user.

For HDTVs using RGB LEDs for backlighting, LED aging can cause the white point for the entire backlight to shift over time. Color sensors provide an automatic feedback mechanism that can maintain the white point at the original factory settings for the life of the set.

To accelerate time-to-market and simplify design-in effort, support for device drivers and/or C-reference code is available from TAOS.

Proximity Detection

Another device that can be incorporated into flat panel HDTV designs — and work in concert with an ALS system — is a proximity detector.

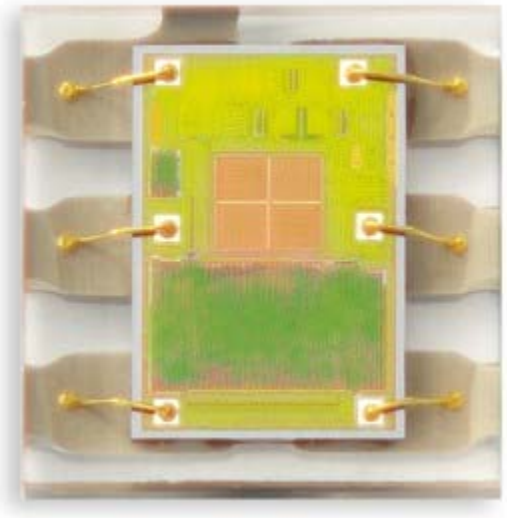
Proximity detectors rely on an IR light source and an IR optical sensor. Since the TAOS digital ALS system already provides the IR sensor, all that is needed is the IR source.

One of the most unique features of the TAOS implementation is the use of a state machine to control the ALS, proximity, and wait timing. This allows the device to provide both ALS and proximity sensing at the same time without having to change the operational mode of the device. In addition, the ability to insert wait states allows for very low power operation.

Proximity detection in the TAOS system is designed to be highly flexible. The high gain allows the device to operate from sensing very short distances to several feet by changing the programmed values with no resistor or component changes.

To simplify the interface to an external IR LED, a constant current source driver is implemented to eliminate the need for an external current limiting resistor. In addition, the current can be programmed from 12mA to 100mA. If higher power is needed, an external transistor can be implemented to increase the sensing distance.

Similar to the ALS interrupt functionality, the proximity sensor also has both a programmable level detection and a persistence function. This again reduces the amount of interrupt overhead.



TAOS makes a single-chip package that includes an ALS device and a proximity detector.

The TAOS single-chip ALS and proximity solution is available in a small 2 mm by 2 mm package. This approach simplifies system design, reduces part count, increases system reliability, and lowers assembly costs.

Application Examples

A digital ALS system can be an important component in a consumer electronics product design, including flat panel HDTVs. In some cases, integration of a proximity detection feature can yield additional

benefits. Here are some examples that such features can help various products.

Notebook computers: In creating a notebook computer, designers are constantly struggling with the trade-off between weight and battery life. Make the battery smaller and the total unit weighs less, but the battery won't last as long. The only way to reduce weight without cutting battery life is to cut power consumption.

If a notebook can use an ALS system to automatically dim the backlight by 50% when ambient lighting is lower, this can result in a significant power savings. As a bonus, the screen image will be easier on the eyes for the user under dimmer lighting conditions.

Mobile phones: The main display on a mobile phone consumes the major portion of the device's energy budget.

Today's smart phones require a proximity detection system to turn off the display panel and the touch screen features when the user brings the phone close to his or her ear. This eliminates the inadvertent pressing of controls during a conversation, and saves power by shutting down the display.

Flat panel HDTVs: The LCD TV Association recognizes that the backlight of an LCD HDTV is responsible for the largest part of the device's energy consumption. As a result, the group established ALS-controlled dimming of the backlight in response to ambient lighting conditions as the sole requirement for its "Green TV" logo program.

According to the LCD TV Association (www.lcdtvAssociation.org), automatic brightness control can cut the backlight power consumption by as much as 30% over normal usage patterns.[3]

In addition, of all the flat panel televisions that meet the stringent qualifications of the Energy Star Version 3.0 requirements, 40% of the LCD models and 40% of the plasma models have some form of automatic brightness control.[4]

The Vizio 19" and 23" Razor LED LCD HDTV models use proximity sensing to activate the front panel touch controls.

Adding proximity detection to an HDTV design makes additional features and benefits possible such as touchless human interface sensing.

For example, Vizio's VM190XVT and VM230XVT LCD HDTVs have a novel front panel with touch controls. The lighted icons for these controls only turn on as the user's hand approaches the bezel. This design makes it possible to have a clean, unblemished bezel design, while supporting a user interface that is intuitive and interactive.

The Sony Bravia WE5 uses a proximity sensor that can tell when the viewer leaves the room, at which point the set will turn the picture off but leave the sound playing. When the person returns to the room, the set will turn the screen back on. This can save a significant portion of the energy consumed by the set.

The Digital ALS Advantage

A digital ALS system can deliver a number of important benefits to both the manufacturer and end user of flat panel HDTVs.

They can simplify system design while adding more sophisticated functions and automatic controls. Fewer components and interconnects make for easier assembly, lower costs, and greater reliability. And they can save power multiple ways.

Consumers will appreciate the "green" qualities of lower power consumption, but they'll also value the improved image quality that comes with automatic brightness control. And when proximity detection is added to the design, new features are possible that can enhance the user interface and provide additional power savings.

[1] Energy Star Web site; http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TV

[2] Vizio Web site: http://www.vizio.com/flat-panel-hdtvs/vm230xvt.html

[3] LCD-TV Association White Paper #2: TV Power Consumption: Is There a Problem? (and Can LCD TVs Help?), 2008; http://www.lcdtvassociation.org/images/TV_Power_Consumption_White_Paper_LCD_TV_Association.pdf

[4] Energy Star Television Product List, List Current as of October 2, 2009; http://downloads.energystar.gov/bi/qplist/tv_prod_list.pdf

About TAOS, Inc. (Texas Advanced Optoelectronic Solutions)

With more than a decade of analog mixed-signal technology innovation and market leadership, Texas Advanced Optoelectronic Solutions (TAOS), Inc. designs and manufacturers digital and analog light-sensing solutions that deliver increased system integration, design flexibility and functionality to a wide range of products in the consumer, computer, industrial, medical and automotive markets. Integrated ambient light sensing and proximity detection solutions enable "Green" displays by reducing system power consumption. An expanding portfolio of programmable analog and digital RGB color sensors provides accurate color discrimination, determination and measurement.

1001 Klein Road • Suite 300 • Plano TX 75074-3762 • P 972.673.0759 • F 972.943.0610 • www.taosinc.com