Where Do the LEDs Belong?

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At CES 2009 in Las Vegas this year, it appeared that every major LCD TV manufacturer had at least one model with an LED backlight. It quickly became apparent that there are some clear advantages to using LEDs as the light source, but a closer look at the way this solid state lighting is implemented raises some interesting questions.

First, let’s cover the plus side. LEDs can draw less power than an equivalent cold cathode fluorescent lamp (CCFL) backlight. Some manufacturers claim that the energy savings can be as much as 40%. In today’s energy-conscious markets, this is a significant factor. Another positive point is that LED backlights that use separate red, green, and blue LEDs tend to provide a larger color gamut than CCFL backlights, which is especially noticeable in performance with red shades of the spectrum.
And in general, LEDs take up less space than CCFLs, even when you get through with adding the diffusers and other layers required to create a light source with adequate uniformity. As a result, you can make thinner sets, which can have some marketing appeal for consumers.

But as with just about any other technology decision, designers of LED TVs are faced with a choice that involves trade-offs and compromises. Just where do these LEDs go? This may seem like a trivial question; they go behind the LCD panel, of course. But it’s not so simple. The LEDs for an LCD backlight can be mounted either behind the LCD panel, or mounted along its edge. And neither approach is perfect.

The most common approach is to put the LEDs behind the panel in a matrix. The problem is that these light sources are highly localized. It is a challenge to get the light to disperse evenly from the LEDs, and then mix smoothly with the light from the adjacent LEDs so that you get uniform lighting. One way to help with the mixing is to use air. With space between the LEDs and the panel, you have more room for the light to spread out.
Unfortunately, designers have other goals to meet in addition to uniform brightness. The marketing department wants the set to be as thin as possible, which means getting the LEDs as close to the panel as you can. This in turn requires very clever diffusion layers to get the light to spread out evenly.

But wait, there’s more. You don’t want the light to spread out too much. Astronomical contrast ratios apparently help sell TV sets, as consumers must figure that a bigger specification number means that it’s better. One way to achieve this is to use dynamic backlight control. This technology examines each frame of the image, and locates areas of high brightness and of shadow. It then turns down the light output of the LED backlight in those regions that are generally dark. This makes the blacks even blacker, and as an added bonus, provides plasma-like energy savings because the power requirement of the backlight varies with the content of the image.
This approach has led to an arms race in LED backlights. While some of last year’s LCD TVs had backlights that could control their light output across 128 separate zones, some of the models shown this year at CES have 240 zones. More zones means more LEDs, and an increased part count for the backlight, which in turn means more cost for materials and assembly, as well as more points of failure.

There also remain the questions of how well the local dimming feature actually works, and whether it can increase contrast without introducing artifacts into the

image. It clearly requires some hefty image processing to keep all the detail in the highlights and shadows.

So what's the alternative? You can put the LEDs along the edge of the panel, and use light guides to bring the light to the back of the panel and distribute it evenly. This has a number of advantages. First, it moves all the LEDs out from behind the panel where it's easier to manage the heat that they produce. In addition, you need far fewer LEDs which lowers the parts and assembly costs, and increases reliability because it has far fewer interconnects. And putting the LEDs on the side makes it possible to make the flat panel even thinner still.

On the downside, however, you cannot use localized dimming for increased contrast. You can turn the bands on and off as needed, and the strobe effect can help reduce motion blur. This makes the image processing easier but you probably won't be able to claim the highest dynamic contrast levels. Also, the light guides required to distribute the light evenly require sophisticated technology, as they are more complex than your typical diffusion film. And since you're using fewer LEDs for the same size screen, you'll need to use more expensive high-brightness LEDs. According to some sources, however, this will still cost as much as 40 percent less than a matrix of lower brightness modules.

One question that remains unanswered is whether or not consumers will pay more to get a thinner flat panel TV, since they can't see how thick it is when they're watching it. Fortunately, that's a problem for marketing, not engineering. So we can just focus on the trade-offs between placing LEDs behind or beside the LCD panel.

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