Common design challenges for LED backlit LCD panels

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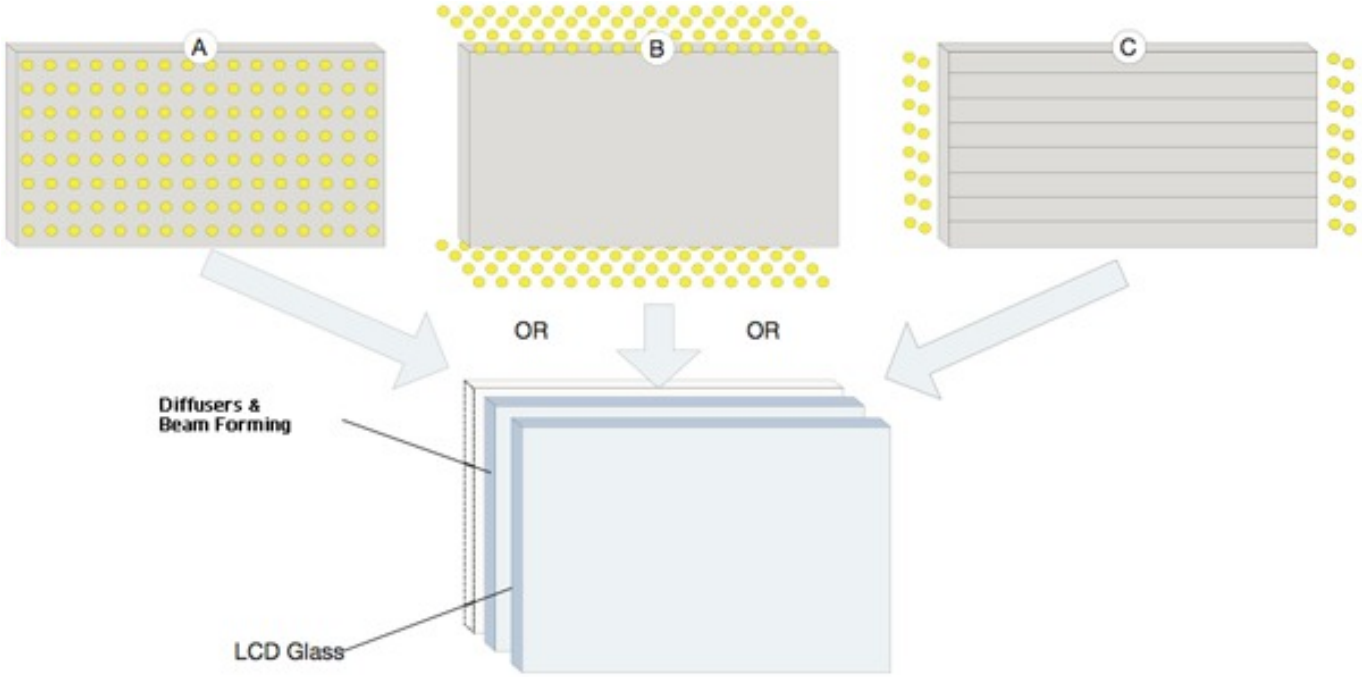
Over two-thirds of all TVs and desktop monitors shipped in 2012 will be LED backlit models (source: DisplaySearch, July 2012). The explosion of LEDs as the dominant technology for backlighting LCD panels has been enabled by the improvements in LED device performance that have provided increased efficiency and light output. LED backlighting was first deployed in mobile phones and laptops but it was during 2010 that we saw its widespread adoption in TVs and desk top monitors, with dramatic growth in market penetration from just 10% at the start of that year to nearly 50% by the first quarter of 2011 (source: DisplaySearch Quarterly Global TV Shipment and Forecast Report).

The arguments that favor LEDs over cold-cathode fluorescent tubes for LCD backlighting are not just about power saving or cost parity. It is also the ability for LEDs to deliver superior picture quality with greater contrast and reduced motion blur that is increasingly important, especially as larger panel sizes and 3D TVs become more and more popular. This article will look at the demands these new features place on different LED backlighting schemes and the solutions provided by the sophisticated timing and control circuits designed into the latest LED driver chips.

Evolution of LCD backlighting
LCD TVs first appeared in the early 1990s but were initially very expensive. Consequently, despite the appeal of being much thinner, lighter and lower power, sales didn’t overtake CRT-based televisions until the end of 2007. The primary use of LCDs in computers through the 1990s was in laptops; standalone LCD computer monitors were only introduced in the late-90s and didn’t become prevalent until the following decade. Through this period, cold cathode fluorescent lamp (CCFL) technology has been used almost exclusively for backlighting these LCD panels. Typically two CCFL tubes are placed on opposite edges of the display with diffusers and polarizers used to spread the light evenly.

Although RGB (red, green, blue) LED arrays were first used to backlight a TV LCD panel in 2004, it was the advent of high-brightness white LEDs that made it possible to replace CCFL tubes with LED light bars in edge-lit displays on a wider scale. White LEDs can also be used in arrays for direct backlighting but for cost reasons these are only found in high-end TV models; edge-lit panels still account for greater than 90% of the LED backlit LCD panel market. And, with high brightness LEDs reducing the number of LEDs required per light bar, this share is only forecast to fall slowly.

LED backlight architectures
Figure 1 shows the placement of LEDs for various different backlighting schemes.



With the direct backlight array approach (A) there is a clear correspondence between each LED and the area of the LCD screen that it illuminates. So, for the group of pixels in that part of the displayed image, the LED's brightness can be varied in real time to achieve greater contrast than is possible with a constant level of backlight illumination. The same result can be achieved with edge-lit displays (B & C) through the deployment of light guides that associate LEDs at the edge of the screen with a particular area of the display.

Whether linked to a direct backlight LED or to an edge LED via a light pipe, these areas of the display are known as illumination zones while the groups of LEDs that illuminate rows or columns of the display are known as an LED strings. It is then the ability to precisely control the LED strings in concert with the pixel activity in each illumination zone that ultimately delivers superior display performance.

The challenges for LED driver circuits

A recognized disadvantage of LCDs compared to other screen technology (CRTs or plasma displays) is the slow response time of the liquid crystal material. Despite many improvements over the years, fast moving images can still suffer from motion blur. LED backlighting offers a solution here since LEDs have fast on/off switching times. This allows the possibility of turning off the LEDs during the pixel-writing period i.e. while that part of the image is changing. This blinking or interrupting of the backlight is commonly referred to as black frame insertion and requires accurate timing.

3D display applications are even more demanding. In order to present different left- and right-eye images, 3D TVs must use some form or polarization or active shutter scheme. Unfortunately, unless compensated for, both these techniques impact on screen brightness, potentially reducing output by 60% and 80%, respectively. This is partly why 3D displays are more likely to use direct LED backlighting or edge lighting with a higher number of LEDs.

Another issue with 3D TVs is the potential for ‘ghost images’ created by incorrect shutter timing, partially allowing the left image to be seen by the right eye or the right image by the left eye. This crosstalk typically occurs during the open-to-close switching period of the liquid crystal shutter but, being similar to the previously discussed problem of motion blur, this can also be solved by black frame insertion. However the timing requirements are even more stringent. Since the backlighting is blanked between every left and right image, the average display brightness is further reduced, requiring the LEDs have to be driven even harder during their ‘on’ period to compensate.

Conclusion

Clearly the performance requirements for an LED driver are not trivial. Not only must the device be capable of sourcing the peak currents needed for maximum LED brightness, it must also be able to switch the LED strings on and off at precisely the right moment, to reduce motion blur and 3D ghosting. And not just on and off, but with the ability to vary LED brightness, typically using pulse-width modulation, for dynamically improved display contrast. Fortunately, LED driver ICs providing all these features and more are now available from leading manufacturers.