LED Backlights Require Integrated, Full-Function Drivers

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After the LCD itself, backlighting is the most important technology affecting display image quality. The typical LCD backlight has traditionally been cold cathode fluorescent lamps (CCFLs). Increasingly, however, LEDs are becoming more common as the backlighting technology of choice in many LCDs. The backlight driver is important to the quality and consistency of the displayed image. This article addresses selection criteria for drivers for LED-based LCD backlights, or backlighting units (BLUs).

LEDs are already commonly used to backlight a wide range of smaller displays, such as the LCDs used in portables, hand-helds and notebook PCs. Today, use of LEDs in LCD backlights is rapidly growing from the smaller LCD panels to applications across the entire spectrum of LCD sizes, such as industrial LCDs in the 6.5 inch to 20.1 inch diagonal size range. LEDs are being increasingly used in place of CCFLs because of CCFLs' higher power consumption, and in some cases, mercury content.

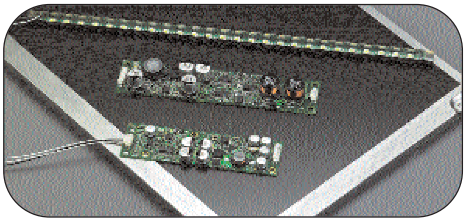

Figure 1. Drivers for LED-backlit industrial LCDs should be full-function, integrated driver boards (or cards) rather than just an IC chip.

The new generation of high-bright LEDs (HBLEDs) provides a quantum leap in brightness, as well as higher reliability, higher efficiency (lumens/watt), better dimming, longer life and operation over a wider temperature range than CCFLs. However, let it be noted that CCFLs are still the backlight of choice for a wide range of applications that do not require the advantages of LEDs or whose users do not need or want to make the capital investment of switching to LED BLUs. This can also be true of applications demanding absolutely high reliability, where vacuum-encapsulated inverters can be used to ensure reliable CCFL ignition, even in harsh environments where shock, vibration, humidity and extreme cold or heat are present. Predictions that use of CCFLs may decline as rapidly as CRTs are probably somewhat overstated.

That being said, LCD backlighting is none the less becoming a hot area of business opportunity for LED and LED BLU manufacturers and will gradually continue to gain ground over CCFLs as LEDs' price/performance ratio improves. LEDs also create new challenges for the backlight driver; challenges that cannot be met by the many single chip IC solutions available on the market, despite claims to the contrary. Getting optimum performance from LED BLUs requires an integrated full-function LED driver.

The LED Backlight

LEDs for LCD backlighting may be arranged along the edges of the LCD or as a matrix over the back of the LCD assembly. The LEDs may be electrically connected in series or parallel; either configuration will provide uniform LCD lighting. LED strings arranged in parallel using a series resistor in each string provide string-to-string current balancing as well as lighting redundancy.

Unlike a CCFL, LED backlights don't require high AC voltages; therefore, they don't require an inverter. The basic LED driver is powered by 5 to 48 V DC and employs DC-DC boost to provide voltage to a constant-current driver that drives the LED string.

LEDs emit light when biased in the forward direction. For quality performance, a constant current driver is required to compensate for LED voltage drops and changes with temperature. This ensures stable light output.

Selecting a Driver Board

LEDs are semiconductors with light-emitting junctions that are designed to use low-voltage, constant current DC power to produce light. LEDs have polarity and therefore, current only flows in one direction. Unlike fluorescent or discharge lamps, LEDs do not require an ignition voltage to start. However, too little current will result in little or no light and too much current can damage the light-emitting junction of the LED diode.

For a given temperature, a small change in forward voltage produces a disproportionately large change in forward current. In addition, the forward voltage required to achieve a desired light output can vary with LED die size, LED die material, LED die lot variations and temperature.

An IC chip driver may look good for powering your LED backlight at first, but consider the voltage the device needs across it to accurately regulate current. Is there enough voltage across the device remaining to light the LED rail and provide proper current regulation?

Consider the temperature at which the LED voltage is specified. Say it is 25ºC, or approximately 77ºF (LED die wavelength characteristics are commonly reported at 25°C junction temperatures). If you were to take the LED string below 25ºC (unlit) and then power the string, the LEDs may not light at all because the LED string voltage is greater.

It is important to select an LED driver board that is designed to account for this voltage change and can light across the entire normal operating range of temperatures, with no time or expense devoted to designing a boost circuit. As with DC-AC inverters used for CCFL or EL backlights, or any other power supply for that matter, properly selecting a LED driver board during the design phase of the display will help to avoid common pitfalls, such as brightness instability.

Application Considerations

Operating temperature is the ambient temperature in which the LCD operates is a key consideration in the selection of the backlight driver. Although the performance of LED backlights is less sensitive to low temperatures, high application temperatures, above all other variables, have the most significant impact on LED function and reliability. Recent advances in LED technology, packaging and materials have provided dramatic increases in LED brightness, which in turn, leads to increased LED temperature. As LEDs heat up, the forward voltage drops and the current passing through the LED increases. The increased current generates additional heating of the junction. If nothing limits the current, the junction will fail due to the heat, a phenomenon referred to as thermal runaway.

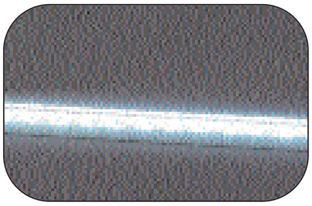

Figure 2. Recent advances in LED technology has led to HBLEDs running hotter. As the LEDs heat up, the forward voltage drops and the current passing through the LED increases, generating additional heating of the junction. If nothing limits the current, the junction will fail due to the heat, resulting in brightness instability.

By driving LED light sources with a regulated constant-current driver, the light output variation and lifetime issues resulting from voltage variation and voltage changes can be eliminated. Therefore, constant current drivers are generally recommended for powering LED light sources.

The major challenge for HBLED backlights is to get the heat out of the LED device itself and then out of the display assembly. The key design point is to keep the LED junction temperature below the specified maximum junction temperature of the LED to ensure reliability for the increasingly stringent demands of most LCD applications.

One solution for heat management is a new LED rail that offers improved thermal management. Called Smart Force LED Rails, these were developed by ERG for use with our LED driver boards, although they can also be used with the existing drivers in OEM LCD panels. These are special rails that utilize a proprietary new design to provide improved thermal management. The LEDs are put on a long, narrow PC board that fits into a metal channel or "rail" that is similar to the channel into which CCFLs are commonly fitted. The thermal management technology utilized inside the rails addresses the challenge of keeping the LEDs cool and preventing overheating. It is a technologically more efficient way to conduct heat from the LEDs that keeps the junction temperature at or below specification, which is critical to preventing overheating and ensuring cool, high-brightness, long-life operation of the LED BLU. Smart Force LED rails can be provided as a drop-in replacement for CCFL rails for a number of OEM LCDs. This provides the often simpler and less costly option of replacing the lamps and power source in an existing LCD rather than re-designing the whole system.

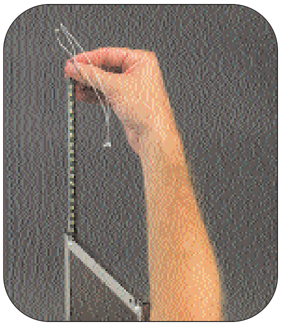

Figure 3. Special rails with proprietary thermal management that gets the heat out of the LEDs are available for use with OEM LED drivers or for use with ERG's Smart Force LED Driver Boards.

Dimming is used in LCD applications requiring a wide range of brightness are constantly increasing. The driver must be capable of providing high brightness for daylight vision and low brightness for night vision. This again points to the need for a full-function driver board, not just an IC driver chip. Brightness control across this wide requirement range must be smooth and flicker-free.

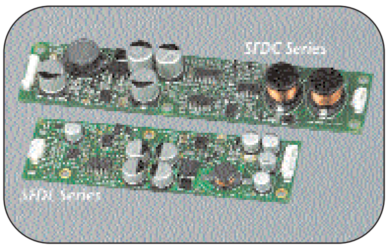

Figure 4. LED driver boards are now available as standard product that can be used with virtually all major OEM LCD panels.

Much higher dimming ratios can be achieved with LED backlights than with CCFLs because the basic switching time of an LED is measured in nanoseconds as compared to milliseconds for a CCFL. Although acceptable at one time, the limitations of analog dimming no longer meet most application requirements for LED BLUs. LED backlights can be analog dimmed, but this dimming scheme will not provide the high dimming ratios required by many of the more demanding LCD applications and also will produce varying color temperatures. LED backlights are best dimmed using PWM (pulse width modulation) dimming. PWM dimming provides better dimming control where the duty cycle of the light source, in this case the LED, is modulated. In this type of dimming, the LED is pulsed ON and OFF at a fixed frequency and the duty cycle is modulated to provide variable brightness.

The Driver Board

So, why a driver board and not an IC chip? The basic reasons have been addressed:

• The ability to handle wide input voltage ranges (typically 8 to 24 V) and wide operating temperature ranges in order to account for voltage changes and accurately regulate current to maintain brightness stability and reliability

• Separate brightness and enable controls

• The capability to provide on-board PWM dimming ratios of 1,000:1 and external PWM dimming to a ratio of 5,000:1 or, for higher-power HBLED arrays, as high as 20,000:1

• Design flexibility and ease of integration that permits use with existing OEM LED backlights or new Smart Force LED Rails

Beyond Backlighting?

The driver board operates strictly on DC current; performing a DC-to-DC conversion onboard, with no AC involved. It can take the input power of virtually any DC power source, regulated or unregulated voltage from whatever power bus is available, and regulate the output power. This opens the door to applications beyond backlighting, such as general lighting or illumination, architectural lighting, automotive and aircraft lighting or anywhere an LED string or array can be used.

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