Upgrading to an LED-Backlit Module from a CCFT-Backlit Module

Sharp Microelectronics of the Americas

INTRODUCTION

Many manufacturers of LCD modules are moving to LED-backlit units, and Sharp is a leader, responding to increasing Customer demand for LED-backlit modules. LED backlights offer several advantages over CCFTs, with the primary reason being power savings, followed by the absence of mercury and superior low-temperature operation.

Moving a product from a CCFT-backlit module to an LED-backlit module raises a number of concerns for the designer:

- Overall compatibility
- Mechanical compatibility
- Optical compatibility
- Color compatibility
- Revision control
- Long-term availability.

Why Change At All

The advantages of LED backlighting are many: better cold, shock and vibration tolerance, better color, less power consumption, more environmentally-friendly, and complete lack of RF output created by an inverter.

However, as our world goes “greener,” more and more CCFT backlight subassembly suppliers are closing shop or restricting product output due to environmental concerns. This means a fundamental shift for designers and customers who are currently purchasing or considering CCFT-backlit LCD modules.

Longevity of the backlight luminaire is often considered when contemplating the transition to LED, and the extreme ends of the temperature specification had been an area of concern. The rule-of-thumb used to be, “Hot - CCFT, Cold - LED,” but no longer.

CCFTs have long been the choice when a module is being operated at its maximum operating temperature, yet their lifetime is severely shortened when operating them near their minimum operating temperature. In some cases of continued operation in extreme cold, CCFTs may not reach even the greater half of their rated lifetime. LEDs tend to perform best in the opposite manner: long-lived when being operated at the module's minimum operating temperature, and shorter-lived when operating near the module's maximum operating temperature.

Meanwhile, by testing modules to the maximum limit of their Specifications, Sharp guarantees their modules will perform to Specifications at those published extremes. So even though the target application may involve higher ambient temperatures, as long as the design maintains the module within its published *Absolute Maximum Values*, you can have confidence that a Sharp module will perform to its lifetime specifications. Often the LED-backlit upgrade module will have the same *Absolute Maximum Values* specified.

When it comes to driver circuits for the two different backlight types, LED drivers again are at an advantage. CCFT drivers must generate a high ‘start-up’ (or striking) voltage and then maintain a certain high level of run voltage at a given current level. These high voltages require proper management and precautions in the final design; sealing against high dust and humidity levels, for instance.

In the past, the LED’s shortened lifetime at higher temperatures was a reason to reject an LED-backlit module for a high-temperature application. However, LED technology continues to evolve, allowing them to become better-suited for higher temperature applications.

Modern LED backlights feature higher-efficacy emitters, meaning in a watts-per-lumen sense they are not being operated nearly as close to the upper end of their performance envelope as in times past. They also feature adequate heatsinking so that all generated heat is dissipated properly. In Figure 1, the LED string and circuit board is bonded to the back chassis of the LCD module. This gives the LED string more than adequate heatsinking.

Figure 1. Closeup of LED Backlight Assembly

LED drivers are much less complex in nature, with no high voltages to generate and manage in the design. The LED string(s) do however require a constant-current supply with current limiting to prevent thermal runaway. Some suppliers are now making a' driver-in-a-chip' solution so driving an LED backlight is becoming even simpler.

MAKING THE TRANSITION

Fortunately, companies like Sharp are working hard to ease the transition, by introducing upgrade LCD modules that are as close to a "drop-in replacement" for their CCFT-counterparts as possible.

Whenever Sharp is forced to discontinue a CCFT-backlit module and replace it with an LED-backlit one, extensive research is performed to properly map form, fit, and function issues between the discontinued module and its upgrade.

Often, the upgraded module will be slightly thinner and slightly lighter due to the LED strip requiring less space and less mechanical reinforcement. While most customers do not find this a drawback, designers should always be aware of these differences and how it may affect their particular design.

In all cases where there are differences in the upgraded module, these differences will be called out in Sharp's Product Change Notice document.

These items are also reviewed for compatibility:

- Electrical - the connectors will typically be the same and have similar functionality, unless otherwise stated.
- Hardware-based display functions - such as Display Invert and Display Reverse are typically supported, using the same combinations of pin voltages.
- Driver availability - many third-party driver manufacturers have built replacement backlight drivers for LED-based modules to be 'drop-in' replacements for existing CCFT inverter units; these units are made to utilize the same power supplies with minimal modifications to the existing design.
- Built-in LED Drivers - Sharp is building many modules (many as upgrades) with built-in LED backlight drivers, so Designers need not consider the expense of replacing a CCFT inverter with a standalone backlight driver.
  Sharp's upgrade modules come with a built-in advantage in backlight drivers that are designed to be compatible with common CCFT driver supply voltages, Backlight ON/OFF signals, and PWM dimming signals.

COMPARING LED AND CCFT BACKLIGHTS

Light Output

CCFTs (Cold Cathode Fluorescent Tubes) make light by striking and maintaining an arc through a noble gas and exciting a phosphor layer on the inside of the tube. The CRI (Color Rendering Index) of these tubes is high, but the light output tends to be 'peaky' in that it has lots of output in some narrow bands and next to none in other bands of the visible spectrum. Manufacturers can manipulate this characteristic to some extent, but Figure 2 is representative of a typical CCFT. Note how the manufacturer has peaked the output in the green/yellow portion of the spectrum to produce more apparent brightness; this works well since the eye is more sensitive in this portion of the visual spectrum.

LEDs make light by using a blue die to excite a phosphor, and the resulting light has a much smoother spectral curve (see Figure 3). Today's LED phosphors benefit from continued development in light output, efficacy, and consistency of color. The CRI of the LEDs is equal that of the CCFT, but because the light output is higher over a broader range of the spectrum, LCD modules with LED backlights can have a 'richer' look to their color palette since their intermediate colors are somewhat more saturated.However good overall colorimetry depends on where the manufacturer's backlight LEDs are sourced; some have good performance in the red-orange region of the spectrum, and others do not.

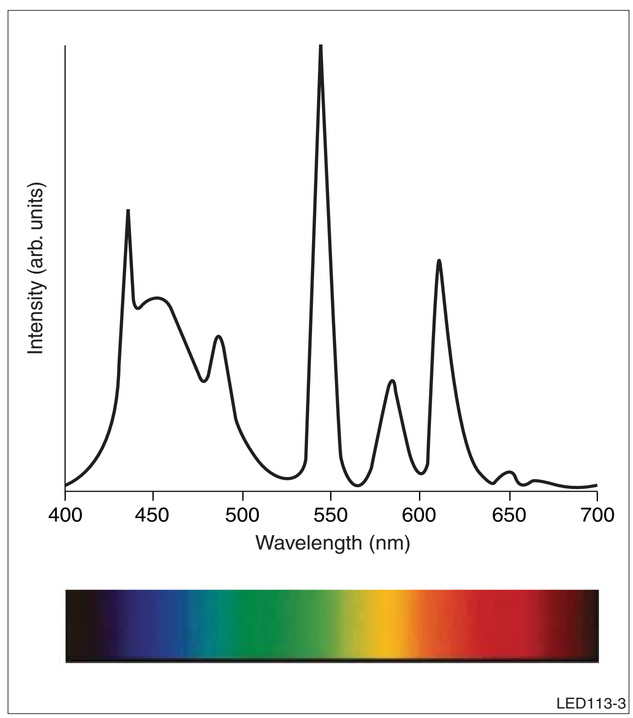

Figure 2. Spectral Output of a Typical CCFT Backlight

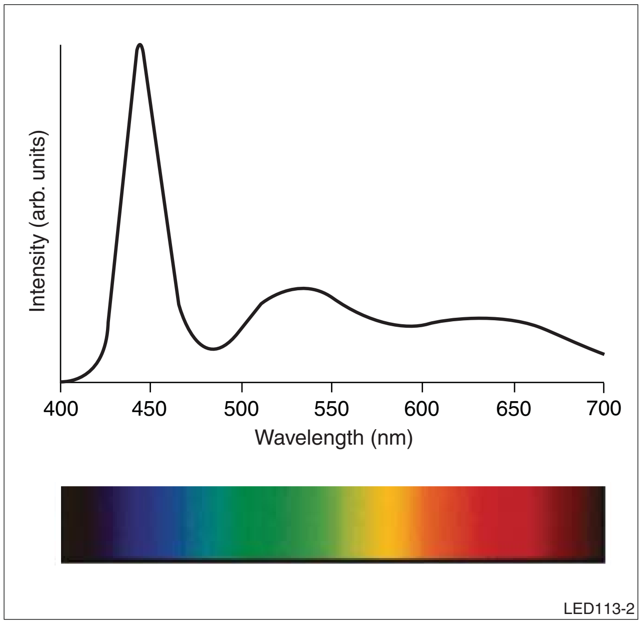

Figure 3. Spectral Output of a Typical LED Backlight

COMPARING SPECTRAL CURVES

When glancing back and forth between these two spectral curves, the differences become apparent. But it's when the two sets of spectral curves are superimposed that the differences of the LED backlight's output become apparent. See Figure 4.

With this overlay, it also becomes even more apparent how the green/yellow portion of the output has been peaked by the manufacturer of the CCFT backlight to gain more apparent brightness; as the eye is most sensitive to the 550 nm (green/yellow) band of light.

When dimming CCFTs, many inverter boards offer extended capability, allowing CCFTs to be dimmed reliably to about 5%. Some care must be exercised in cold environments, as attempting to dim a CCFT in such environments can greatly shorten its life. LEDs have no such restrictions, as they are dimmable all the way to zero, without restriction of temperature, within the limits of the Specifications.

Internal Drive Circuitry

CCFT-backlit Modules smaller than the 12- to 15-inch sizes seldom incorporate onboard CCFT drivers, due to the power-handling needs and isolation problems caused by a CCFT driver sharing a power supply with, and in close proximity to, the panel drive circuits.

Onboard LED drivers are far easier to incorporate as a part of the overall panel circuitry, and are often included in all but 'economy-grade' modules.

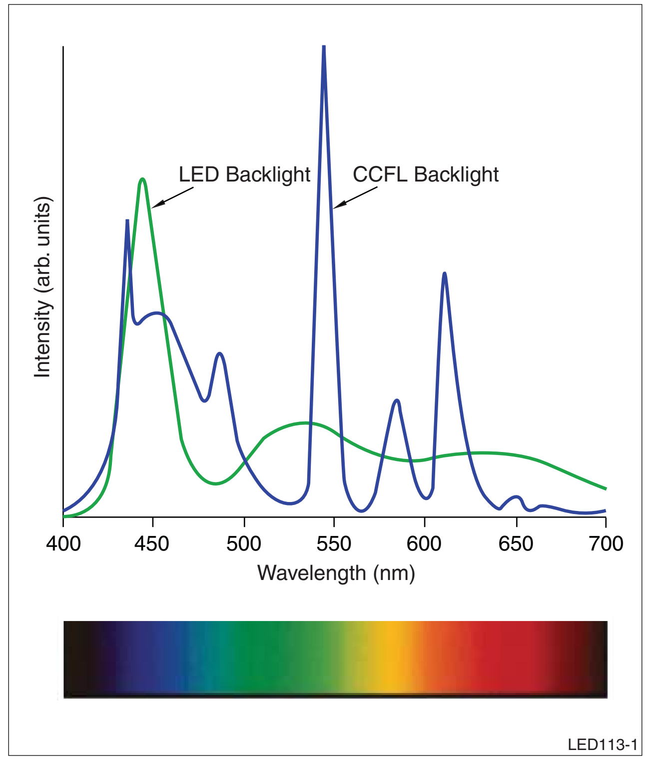

Figure 4. Comparison of CCFT and LED Backlights

External Drive Circuitry

When comparing a CCFT inverter to an LED driver, there are a number of positives for the LED driver - no need for the precautions required by high voltage, less power used, and similar form-factors are available from most suppliers for inverter boards and LED driver boards.

In cases where all other things are equal (except the backlight), changing the LCD module type can be as simple as removing the CCFT-backlit unit, removing the inverter, replacing the inverter board with an LED driver board from the same manufacturer, hooking up the new LED-backlit unit, and replacing it. Sharp has a video online that shows how simple this process can be. Go to http://www.sharpledlcd.com/resources.html to watch Todd Stonewall demonstrate how easily the change can be made.

For a drop-in driver solution, Endicott Research Group (ERG) has the Smart Force™ Drop-in Replacement Series of LED drivers that have the same footprint and input voltages as their CCFT-driver counterparts.

When using a PWM for dimming, many available LED driver boards offer plug-and-play replacements, with PWM inputs as well as analog inputs for dimming. Generally, LED backlights are made to be compatible with existing PWM and DC dimming schemes. A number of manufacturers offer outboard LED drivers that utilize common dimming input methods for their driver boards.

When contemplating an overall redesign from scratch, mSilica (now owned by Atmel) markets a line of controller chips that only require a few external components to form a complete LED backlight driver.

EDGE-LIGHTING VS. DIRECT LIGHTING

The discussion of backlights presents us with an opportunity to discuss one or two of the differences between edge-lit modules and direct-lit modules.

Edge-lit modules offer economy and simplicity, along with an overall thinner module. Direct-lit modules offer a number of different advantages. Because they use individual LED emitters, these modules can allow for dynamic backlight changes to enhance contrast.The module shown in Figure 5 has a much higher color gamut than an equivalent edge-lit module, due to its use of individual red, green, and blue emitters. The backlight can also be locally dimmed or brightened as needed for greater contrast. The penalty is higher power usage and a thicker module due to the necessary heatsink. This heatsink maintains its backlight well within lifetime specifications; the backlight in this module is specified for a 50,000 hour lifetime, even at +70°C.

Figure 5. Direct-lit LED-backlit Industrial Module

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