Optoelectronics

Using Fibre Optic Backlighting to Increase Brightness and Life While Reducing Power Consumption

By David Page

Fibre optic backlighting technology has recently made significant improvements in LCD performance possible by using LEDs more efficiently than ever before possible. These improvements have resulted in a 5-10x increase in brightness without a corresponding increase in power. There are of course, many options available when considering which backlighting technology to use.

Liquid crystal displays (LCDs) can be backlit by a number of different technologies. These include electroluminescent (EL) lamps, cold cathode fluorescent lamps (CCFLs), LED light pipes, LED edge lights, LED arrays, and of course, fibre optic backlights. Each method has advantages and disadvantages.

EL is the most commonly used LCD backlight. It is thin and has a relatively high initial output, but it degrades rather quickly and has typical half brightness ranging from 2,000 to 4,000 hours. It operates on high-voltage, high-frequency power and thus requires an inverter, which adds complexity to the circuit and also produces EMI/RFI.

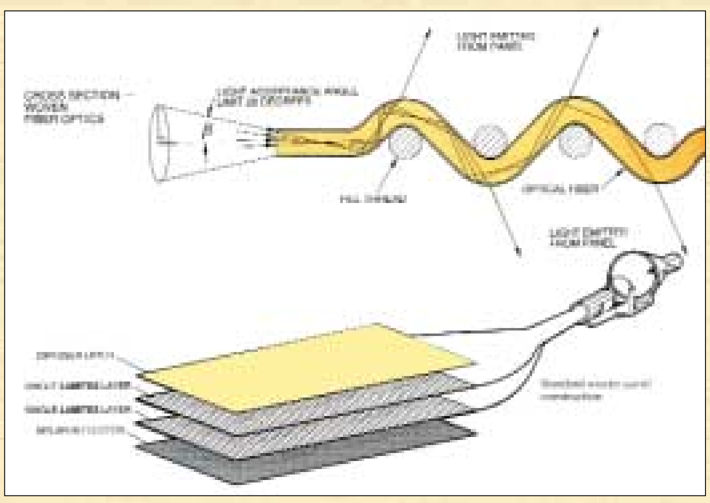

Figure A: Fibreoptic backlight - fibre and panel construction.

Light pipes, edge lights, and arrays have the long life associated with all LED-driven products. Light pipes and edge lights have relatively low power consumption and require 2 to 4 LEDs for small backlights. For larger backlights however, the light output tends to not be as uniform. The LEDs cannot uniformly spread the light out without some sophisticated engineering and tooling, which isn't practical unless the project is of very high production volume. LED arrays are effective for very small backlights, but, for larger displays, many LEDs are necessary and the power consumption and heat generation can become unmanageable.

CCFLs are usually the backlighting of choice when very high brightness is required. Color LCDs have low transmission rates (about 3-5%) and thus require the high brightness of the CCFL to function. CCFLs however, are more expensive and draw more power. So, if the high brightness is not required, the designer is better off choosing an alternative. The white output of the CCFL is desirable but can also be achieved with white LEDs. And CCFL tubes are fragile and add overall thickness to the display.

Fibre optic backlights have all of the advantages of other LED-driven backlights. Depending on the design, the fibre optic backlight will require fewer LEDs (as few as one) thus reducing power consumption, reducing backlight cost, and simplifying the drive circuitry. In addition, these backlights are thinner than most alternatives. Typical LCD backlight construction is .068 inches and alternate constructions are available as thin as .013 inches. Fibre optic backlights have very low engineering costs, thus small production volumes are more feasible than with other technologies.

FIBRE OPTIC BACKLIGHT

Fibre optic backlights use .010" diameter acrylic (PMMA) fibres woven into cloth layers and then laminated together to form a thin backlight. The fibres are then bundled into a round cable and terminated with a polished brass ferrule. This ferrule is then attached to a light emitting diode (LED) or incandescent light bulb in a reflector. The fibre optic cable is flexible and can be routed to the most convenient place to mount the LED.

The collimated light from the LED enters the fibre optic ferrule through each of the highly polished fibre ends. The cladding on the fibre causes the light to stay inside the fibre until it is disrupted. Computer controlled 'micro-bends' cause the transmitted light to be emitted from the sides of the fibre through the cladding. Precisely engineered construction causes nearly all light to be emitted uniformly along the length of the panel.

The woven fibre optic panel is constructed of one to six layers, which are assembled using clear laminates. Multiple layers allow more efficient use of the light source, enhancing brightness and uniformity. A reflective layer is attached to one side of the panel to provide single-sided emission and higher intensity. In LCD applications, a semi-transparent diffuser layer is used to enhance uniformity.

BETTER LEDs MEAN BETTER BACKLIGHTS

Besides improvements in backlighting, recent years have seen significant advances in the output of LEDs. Display designers have been able to use LEDs of unprecedented efficiency, including the highest-efficiency blue, green and white, all at a moderate cost. The new LED colors are pleasing to the eye, offer improved contrast versus previously available LED backlights, and have optical characteristics that work very efficiently with fibre optic backlights. White LEDs have recently become available for the first time and give backlighting a very unique and high quality look.

LEDs USE LESS POWER

The fibre optic backlight is so effective in uniformly spreading out the light from a single LED that it can cover up to about 2 inches (50 mm) in width and 9 inches (200 mm) in length. A single LED is typically driven at 20-30 mA and 2.0-4.0 Vdc. The same LED can be driven around 10 mA when power consumption is of greater concern than output. Thus, depending on the design configuration, a fibre optic backlight can consume as little as 50 mW for an area as large as 16 square inches or about 3 mW per square inch.

LEDs LAST FOR 100,000 HOURS

Green, amber, and red LEDs typically last for 100,000 hours when driven at 20 mA, while blue and white LEDs last for approximately 60,000 hours. The fibre optic backlight itself has an unlimited life under its rated conditions and the light source can be replaced if necessary. An even longer life can be achieved when lower driving currents are used. Of course, the proper application of these LEDs is important in reaching the design life. LEDs are sensitive to ESD damage and must be treated accordingly. The fibre optic backlight is rated up to 85 degrees Celsius and, while the LEDs can withstand that as well, they reach their maximum life at lower ambient temperatures.

EL BRIGHTNESS WITHOUT THE DEGRADATION

EL is one of the most common LCD backlights in use. While it provides superior brightness at first, EL degrades quickly and has a typical brightness half-life of 2,000 hours or, with inverter circuits at lower initial brightness, of 4,000 hours. With recent improvements in LED technology, fibre optic backlighting has been able to achieve the same high brightness that used to be reserved for EL, but without the very short brightness half-life. For a 1.5 inch by 3 inch (2 layer) fibre optic backlight with a single ultra-bright green LED, the brightness will be about 30 Foot-Lamberts. For applications requiring very high brightness, the number of LEDs and layers can be increased. Using 5 layers and 4 LEDs on the same panel can boost brightness up to about 140 Foot-Lamberts.

The recent development of the white LED has enabled designers to modernize the look of their displays. The white LED is, however, very expensive, but the fact that very few LEDs are required to drive the fibre optic panel make the use of the LED feasible and cost effective.

SIMPLE TO INTEGRATE

The fibre optic backlight is simple, thin and inert. It is flexible and the potential design variations are unlimited. Since engineering and startup costs are minimal, the designer can experiment with this technology and implement it on a pilot scale without a large investment in time or money. The lack of an inverter and lack of heat generated makes the panel a simpler choice, as the designer does not have to worry about these issues. The driving circuit requires only a current limiting resistor chosen to maintain the LED current in its normal operating range.

Unique circumstances and tough design issues are easy to overcome with the fibre optic backlight due to its flexibility of features and design. Issues such as wide temperature ranges (-50 to 85 degrees Celsius), shock and vibration, tight space requirements, dimmable brightness, change in colors, redundancy, hazardous environment, battery backup, etc. are all easy to solve.

OTHER APPLICATIONS

In addition to LCD backlighting, this technology is also used in a number of other lighting applications. Membrane switch backlighting is easy to accomplish because the fibre layers are flexible enough to press right through them. The backlight is simply placed between the overlay and the contact domes. The uniform light is spread evenly throughout the entire switch area.

Fibre optic backlighting adds unique value to machine vision lighting applications. With 150 watt halogen light sources and multiple layers, uniform backlights up to 4000 Foot-Lamberts in a thin package. The light source can be located a convenient distance away from the panel. By lighting up an object with this diffuse and uniform light source, a high speed digital camera can photograph a manufactured object and identify defects.

Figure B: Fibreoptic panels come in a range of colors and are ideal for LCD backlighting.

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