Driving the Backlighting for Patient Monitors: Which Technology is Best?

CCFLs powered by DC-AC inverters have been dominant in medical patient monitors, but LED BLUs are on the horizon and gaining ground in terms of usage. The benefits of each differ across many areas, including functionality, reliability, and cost. This article showcases each technology and provides the applications in which they are each best suited.

By Tom Novitsky and Bill Abbott

Medical diagnostic devices have become powerful state-of-the-art instruments for instantaneous display of vital patient information. Key to their effectiveness are monitors to display the critical information they provide. Devices such as defibrillators, cardiac monitors, vital signs monitors, and full-clinical-parameter bedside and portable monitors demand that the information displayed be clear, crisp, and easily readable.

Most medical diagnostic devices utilize LCDs in the size range of 6.4″ to 12.1″. These displays are typically backlit and have traditionally used cold cathode fluorescent lamps (CCFL) for this function. The CCFL backlight units (BLUs) are powered by DC to AC inverters, which turn direct voltage and current into alternating voltage and current.

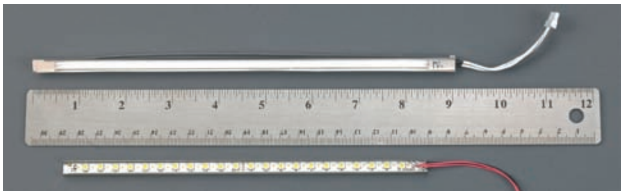


Figure 1: CCFLs have been the dominant backlighting technology for medical displays, but challenges from LED backlights (such as the LED rail shown here) are on the horizon.

Medical devices present a special set of requirements for the LCD BLU and the backlight inverter. The LCD needs to provide high contrast, high resolution images, and data, as well as a resistance to glare. Portable medical devices must provide a bright, long lasting image when powered by batteries. Displays incorporated into devices used in emergency vehicles must withstand extreme temperatures and conditions, including shock, vibration, and even harsh environments, such as being sprayed with a fire hose.

Understanding the Display Backlight

A typical medical device display uses one or two CCFLs in the BLU. These small lamps are able to provide an extremely bright white light source to properly backlight the LCD. CCFL temperatures do not rise far above the ambient temperature, making them thermally good for LCD panels since the light source may be close to other components that could be affected by excessive heat.

Depending on the application, the DC to AC inverter that powers the CCFL backlight can have an input voltage ranging from 5 to 48 VDC. The inverter provides the high AC voltages required to light the CCFL and maintains the constant AC current required to control the CCFL brightness.

Controlling Image Quality

The quality of the displayed image depends heavily on the inverter. The LCD manufacturer or distributor supplies the LCD panel to the medical device manufacturer with a CCFL BLU that meets the application requirements. The medical device manufacturer must choose an inverter that will provide acceptable brightness, lamp life, dimming features, and dependable performance. The device manufacturer may contact the LCD manufacturer for an inverter recommendation or may talk to a field application engineer (FAE) at the LCD distributor. Another, and perhaps better option is to contact an engineer at the inverter manufacturer. Inverter manufacturers are familiar with all of the panels from the major LCD manufacturers and can offer expertise in recommending the optimum inverter.

LED—The New Monitor Backlighting Technology

While CCFLs continue to be the dominant technology used to backlight medical device displays, BLUs utilizing LED (light emitting diode) light sources are being considered as an alternative and, in some cases, the design of preference.

LEDs are already used to backlight a wide range of smaller displays (e.g., cell phones and MP3 players). Because of their higher power consumption and, in some cases, their mercury content, CCFL BLUs are beginning to be replaced by LED BLUs for mid-size and even larger displays.

An LED BLU is generally driven by a constant current and does not require an alternating current at high voltage, therefore an inverter is not required. This does not mean that LED BLUs do not require appropriately designed drivers to maintain constant brightness and to provide dimming. An LED's efficiency depends on the amount of current flowing through it and, therefore, for quality performance in a BLU application, a constant current driver is required to maintain constant brightness. To compensate for changes in the voltage of an LED string, which may occur with changing temperature, or may vary with tolerances across a large number of LED backlights, drivers must be designed with the ability to adapt to changes in LED voltage.

LED Advantages

LEDs can provide higher brightness than CCFLs. Lower efficiency (lumens/watt) LEDs may provide 20% more brightness than CCFLs. A typical increase in brightness might be 420 cd/m^2 or "nits" for an LED BLU compared to 350 cd/m^2 for the CCFL BLU version of the same LCD utilizing the same amount of power. High brightness, higher efficiency LEDs may provide 200% more brightness than conventional CCFL BLUs.

Also, LED backlights are typically more reliable and more durable over the lifetime of the display. LEDs are less fragile than CCFLs, and won't degrade if operated for long periods of time at cold temperatures (down to -30°C).

Other advantages include higher light output per electrical power input efficiencies and the ability to optimize color gamut. Also, since LEDs contain no mercury, they provide a "green" backlight. Finally, the wide range dimming capability of LEDs can be a valuable advantage up to 20,000:1. At present, the biggest obstacle to more widespread adoption of LED backlights is that LED backlights cost more than CCFL backlights.

LED Rails

Efficient thermal management (i.e., keeping the LEDs cool) is one of the major design challenges for LED BLUs. The LED BLU rail shown in Figure 1 and Figure 4 incorporates the LEDs on a long, narrow PC board that is thermally bonded to a metal channel or "rail" that is similar to the channel used to house the CCFLs. The thermal management technology utilized in the rail assembly addresses the challenge of efficient thermal management by keeping the LEDs cool. The design provides a technologically more efficient way to conduct heat away from the LEDs to maintain a low LED junction temperature, which is critical to long-life operation of the LED BLU.

Driving the LED Rails

A wide variety of LED driver ICs are becoming available for use in LED driver circuits. Most of these driver ICs employ

Intelligent Inverter

A new series of "intelligent" DC to AC inverters named "Smart Force" has been designed for display applications like medical monitors that require high efficiency, wide range dimming, and lamp current stability over a wide range of input voltages and operating temperatures, and with either non-RoHS or full RoHS compliance. The Smart Force inverter series offers a low profile (‹6.0 mm high), wide input voltage range, and wide range PWM (pulse width modulation) dimming. Available in single and dual-lamp versions, they feature a ruggedized transformer that has helped them test successfully at extremely wide temperature ranges.

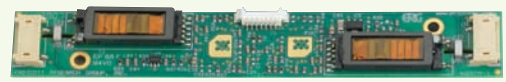


Figure 2: Smart Force inverters have been designed for display applications like portable defibrillators (Figure 3) that require high efficiency, wide range dimming, and lamp current stability over a wide input voltage range.

A dual-lamp Smart Force inverter (Figure 2) has recently been selected by the manufacturer of a widely used portable defibrillator (similar to the device shown in Figure 3). The application required an inverter with a minimum five year life, a wide input voltage operating range, closed loop lamp current regulation, and a wide operating temperature range. The selected Smart Force closed-loop CCFL inverter provides constant voltage and current output over a range of input voltages so that constant brightness is maintained on the LCD screen. The brightness does not change as the input voltage changes—a key performance feature for this battery-powered application. This inverter also provides higher efficiency and, consequently, less heat, than alternative inverter designs.

Figure 3: Portable defibrillator with CCFL backlight

switching and/or linear circuits to control the LED current. Depending on the configuration and number of strings, there is generally an optimum topology choice for a given display backlight. Many times, the voltage available is not usable to drive the wide array of string voltages that are required from display to display; therefore, it is not possible to use the standard +5 or +12 V available with a driver IC chip to drive the backlight. Many LED drivers employ boost or buck circuits to either increase or decrease the supply voltage, and they also employ a secondary circuit that will directly drive the LEDs to a constant current. High power backlights are often driven by a different topology than a lower power backlight, as one topology may be more optimized than another for a given power level. Along with making the correct topology choice, those developing a backlight driver need to be well versed in power supply layout for switching and linear circuits. The designer will also face EMI and thermal issues if the proper components are not chosen and the layout is not optimized.

LED drivers are now available as standard products for a broad range of LCDs, including the 6.4″ to 12.1″ sizes commonly used in medical device displays (Figure 4.) These drivers provide full function in a compact size, with wide range dimming, wide input voltages, and full brightness and enable controls. Available in a range of sizes, input voltages, and dimming ratios, they are compatible with most OEM LED-backlit panels or can also be used with the Smart Force LED rails shown in Figure 1 and Figure 4.

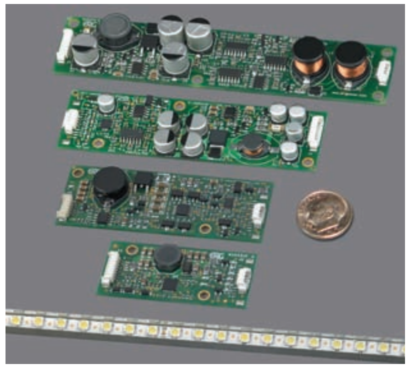
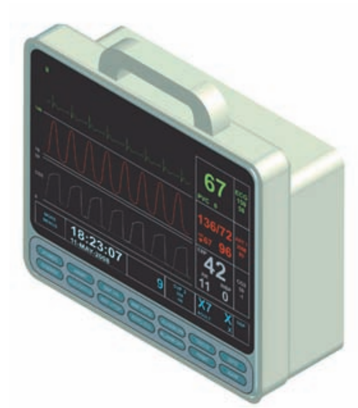


Figure 4: LED driver board families that offer customers a "plug and play" solution for LED displays from less than 1 W up to 50 W can be the ideal solution for powering LED rail BLUs.



One OEM's patient monitors utilize CCFL-backlit LCDs, but the company is considering replacement of the CCFLs with LED backlighting and driver boards rather than keeping the CCFL backlight and replacing the inverters.

Cost of LED versus CCFL

Switching from CCFL to LED will enhance performance but will also increase the cost of the backlight.

One option is to use an LED-backlit LCD from an LCD manufacturer. These LCDs provide slightly higher brightness than the CCFL equivalents or lower input power at the same brightness as the CCFL equivalents. The LED drivers previously described will provide the control needed to optimize display operation.

Another option is to retrofit the CCFL BLU to an LED BLU. This can provide a solution for LCDs already in the field. The LED BLU rail shown in Figure 1 is designed as a drop-in replacement for CCFL BLU rails. When used with compatible LED drivers, the LED rails provide the often simpler CCFL to LED retrofit option.

A major manufacturer of patient monitoring solutions was looking for drop-in replacement inverters for their high-performance transportable patient monitors, which are backlit with a CCFL BLU. When presented with the option of an LED rail/driver retrofit solution that could be installed in the field by their service personnel, they decided to consider the performance advantages of LED backlights now instead of in the future, regardless of the higher cost of the LED BLU.

LED BLUs using Smart Force LED rails with lower-efficiency LEDs can cost twice as much as comparable CCFL BLUs, while those using higher efficiency, higher-brightness LEDs (H/B LEDs) can cost five times the price of a CCFL BLU. However, there is also a proportional increase in performance. In the former case, the LED BLU will provide the same brightness with 20% less power, or 20% more brightness at the same power. In the latter case, LED BLUs using H/B LEDs can provide twice the brightness with as much as 50% less power The high efficiency of the drivers combined with rails with built-in thermal management to keep the LEDs running cool provide ~50,000 hour LED BLU lifetimes.

Costs for the LED drivers for the lower efficiency LED BLUs are comparable to costs for CCFL inverters. An LED driver for an OEM LED-backlit panel that has previously used a $15.00 DC-AC inverter would be approximately the same. Costs for LED drivers using the higher efficiency LED BLUs are higher but also provide much higher brightness.

Conclusion

CCFL BLUs powered by DC-AC inverters are the dominant backlighting technology for medical device displays. As LED costs decline and efficiencies increase, LED BLUs will become more popular. So, while CCFLs driven by DC-AC inverters remain the leading backlighting technology for the present, LEDs are likely to be the future backlight technology of choice.

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