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Components

Displays and Opto

Reducing laptop battery drain with LED backlights

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Andrew Smith from Power Integrations looks at the benefits and techniques for switching from CCFL to LED backlighting on displays

The established technology for backlighting LCDs has been CCFL (cold cathode fluorescent light), however, LED technology now results in better displays than CCFL can provide.

The colour spectrum for CCFL lamps only spans about 80 per cent of the permissible range due to the mercury arc spectrum and the type of phosphors used.

CCFL lamps are based on mercury vapour arcs in glass tubes which are not as robust as solid-state devices, which is why laptop users can get a black screen if they drop their computer, even though the rest of the electronics still function. Even without the computer being dropped, the operational lifetime of LED technologies is much longer than that of CCFL.

The mercury vapour is considered a toxic material in many areas of the world, leading to government regulations requiring appropriate disposal processes for fluorescent lamps. The RoHS Directive in Europe and other national standards specifically identify mercury compounds as hazardous. Although the CCFL tubes in portable electronic systems are currently granted an exemption from RoHS, industry analysts report that many display companies are developing strategies to eliminate mercury, as well as the other banned materials, from their products.

Added to that, CCFL lamps and their power circuitry use about a third of the total power in laptop computers, making them the single largest user of power within the laptop. Any technology that can reduce this power drain will provide significant assistance to the ongoing quest for longer system run time from a single battery charge cycle.

Transition to LEDs

Given these limitations, equipment manufacturers are looking into alternatives such as LEDs to replace CCFLs in backlighting applications.

However, the design of a highly regulated, protected power supply suitable for driving LED backlights is far from trivial.

In LCD TVs, one technique to replace CCFLs is to construct strings of red, green and blue LEDs in a panel behind the LCD. A string can be 20 or more LEDs in series. There are multiple strings in a display, with the precise number of strings depending on screen size. The LED strings are interleaved in a red-green-green-blue sequence to produce zones of white light (see Figure 1 below).

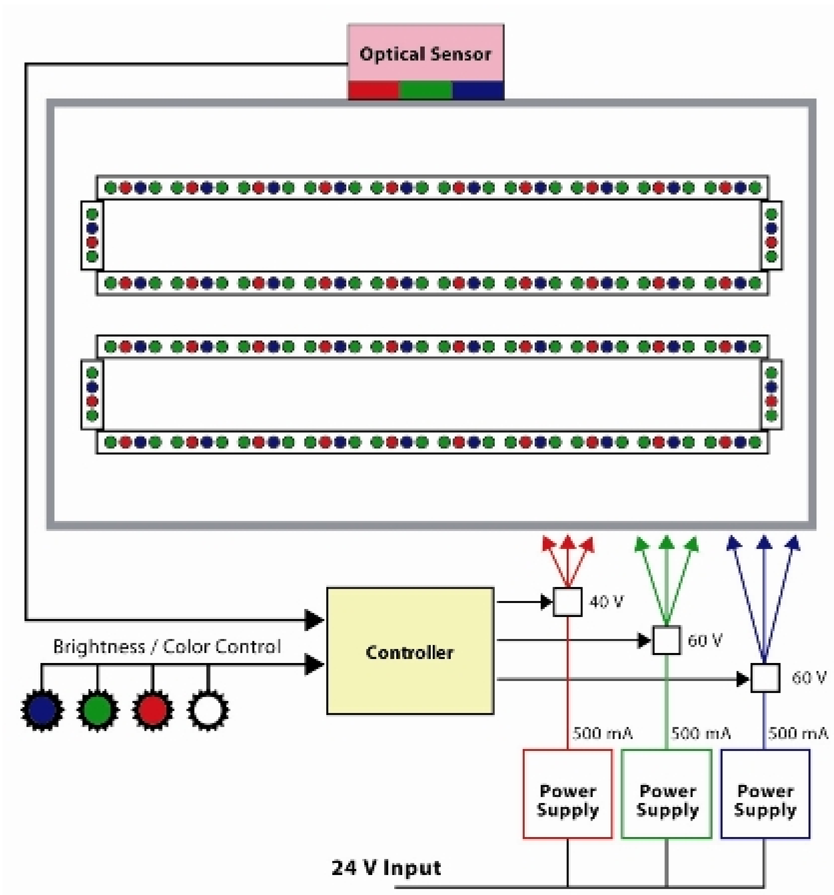

Figure 1: RGB backlight power and control system

This combination of LED strings produces a spectrum that covers 98 per cent of the NTSC colour space. The LED-backlit panel produces more uniform illumination than a set of CCFL tubes and can be adjusted for colour balance over a greater range of intensities. This form of illumination is referred to as an RGB backlight.

To drive the LED string in the 60V – or 40V for red LED – range, a constant current source is required.

A typical constant current/constant voltage-transitioning characteristic for an actual LED string power supply is shown in Figure 2. Around the operating voltage point, current is held constant. The normal protection features can be applied to the control scheme.

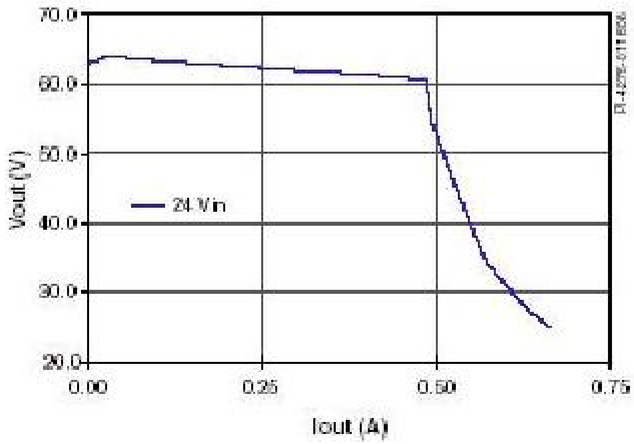

Figure 2: Constant current characteristic for a 500W, 60V RGB LED power supply

The power supply for a string with 20 red LEDs would require a 40V output, since a single red LED has a Vf of about 2V at an If of 30mA max. The supply for each of the blue and green LED strings would require a 60V output since the Vf is about 3.2V at an If of 30mA. A panel would use multiple parallel strings with correspondingly increasing power requirements.

A moderately sized LCD TV system would require perhaps 15 parallel strings of LEDs with a 450-500mA current requirement. The overall supply efficiency needs to be at least 90 per cent to minimise heating issues and to achieve EnergyStar ratings for operational efficiency. The LED supply would have over-temperature and over-current protection to prevent thermal runaway and circuit damage from short circuits.

LED brightness is adjusted by pulse width modulation of the power supply unit output current in the downstream control circuitry. The overall current distribution scheme needs independent current adjustments for each string for colour balance and to set the strings for uniform illumination.

Matching requirements and load balancing may not be too critical, as the LEDs should be fairly closely matched as a set for Vf, in colour and intensity. The control circuitry for colour and brightness would also be the stages that compensate for low or high Vf LED strings and overall illumination balance across the screen.

RGB backlight power supply

The requirements for a 20 or 30W DC-DC constant current power supply are straightforward.

First, the basic function of boosting the lower voltages in the system to the higher ones needed by the LED string requires an architecture that simultaneously meets the stringent requirements of high efficiency, tight regulation, protection and low cost. Then the designer has to develop the driver and control circuitry for the specific supplies to satisfy the voltage and current requirements.

The DPA switching regulator family has been designed to simplify the task of designing power supplies for applications such as LED backlighting. By combining the drive and control circuitry and power Mosfet together in a single monolithic device, the complexity of the switching and control functions to implement the DC-DC converter has been removed.

The IC includes circuitry to accurately monitor temperature, voltage and current. In addition, reference designs with full bills of materials and PCB layouts for the specific applications are available

The DPA-Switch family performs the conversion with minimal external components.

By choosing a 400kHz switching frequency, the size of the boost inductor and the filter capacitors are minimised. A monolithically combined control circuit and power Mosfet simplifies the task of the designer and minimises board space.

The topology for the DC-DC converter is a non-isolated inductive boost configuration (see Figure 3).

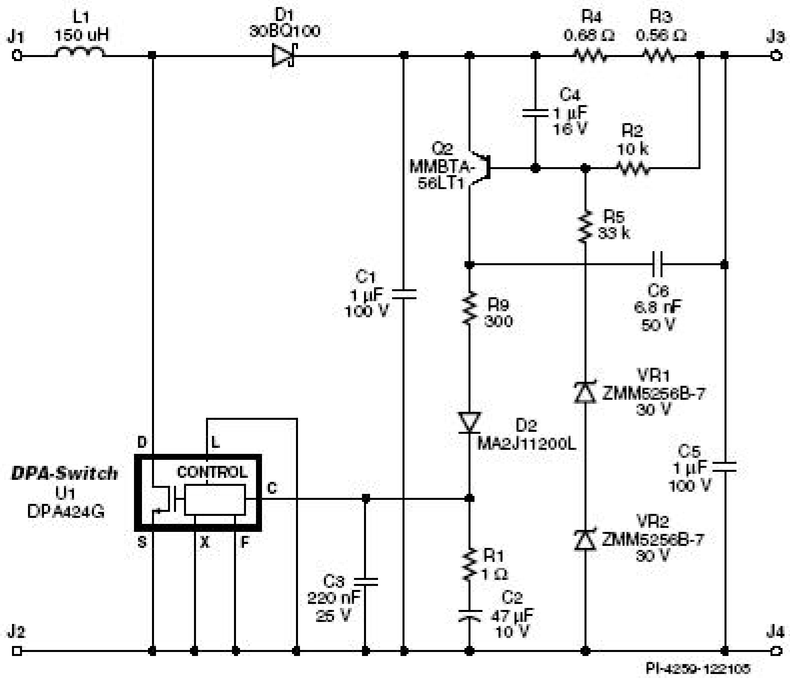

Figure 3: A 60V supply for LED backlighting

Circuit operation

L1, D1 and U1 are configured to provide a standard boost converter topology. Boost voltage is regulated by U1 via Q2, which provides a feedback current signal to Pin C of U1. C3, R1, C2 and C6 provide loop stabilisation.

At turn on, input voltage rises (to 40Vdc), and the base of Q2 is driven by zener diodes VR1 and VR2 controlling the Q2 collector feedback current signal. The load current causes a voltage drop across R3 and R4. This voltage is filtered by R2 and C4 and drives the base of Q2 taking over the control loop when the output voltage drops below 40V (and VR1 and VR2 stop conducting). As such, the output can be controlled for both constant output voltage (VR1, VR2) and constant current (R3, R4).

The 40V supply converts a 24V input to a 40V, 500mA constant current / constant voltage supply at an efficiency of greater than 90 per cent (see Figure 4 left).

The 30W 60V green and blue power supply is also shown. The DPA-Switch family of IC's includes all the necessary circuitry to perform soft start, hysteric thermal protection, under-voltage, over-voltage and current limit functions.

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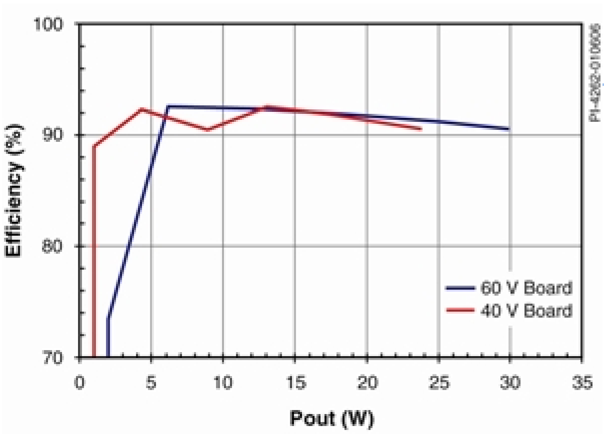

Figure 4: Efficiency versus power output