WHITEPAPER

Advanced LED Drivers Display Digital Signage Credentials

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As digital signage projects become ever more ambitious, equipment designers must rely on LED-driver ICs capable of satisfying the unique demands of this application space

Introduction: Signage-Class Drivers

High-brightness LEDs have quickly become the technology of choice for signage applications such as large-format outdoor video screens. The emitters themselves are rugged and energy efficient, while electronic control encourages innovations such as dynamic content, display networking and interactivity. Suitable LED driver ICs distinguish themselves as signage-class devices with features such as a large number of output channels offering high current-driving capability, tight current control and matching between the output channels, and special features to manage power surges and noise. On-chip diagnostics assist maintenance of large signs by pinpointing failed units. Toshiba's family of signage drivers also provides a novel means of preventing flicker when displaying moving images.

More Power and Control

As LED signage has captured the imagination of marketers, demand has grown for ever larger, brighter displays that achieve maximum visual impact. Signage-class driver ICs are typically multi-channel devices capable of supplying a high maximum output current, while also maintaining close control over driving current as the output voltage to the LED varies. Toshiba has a number of drivers for signage applications, currently providing up to 16 channels. 24-channel devices are expected to become popular in the future. By providing a large number of channels these drivers can significantly reduce the number of devices needed to control every LED in the array; this can total many thousands or millions of units in the largest displays. Even so, several thousand drivers may be needed to control the entire LED array in a large signage solution such as a stadium video screen or street-level billboard.

Toshiba's family of drivers includes the TC62D723, which has 16 output channels and allows adjustment of the LED driving current from 1.5mA up to 90mA with an excellent accuracy. This gives designers freedom to choose LEDs with the highest current-handling capability and to set the current level to achieve the best possible display brightness and viewing range. Moreover, the TC62D723 output current remains flat over a wide output voltage range (figure 1). This is effective in ensuring that the LED brightness and emitted wavelength remain constant despite fluctuations in environmental factors such as temperature, which can cause the LED forward voltage to change.

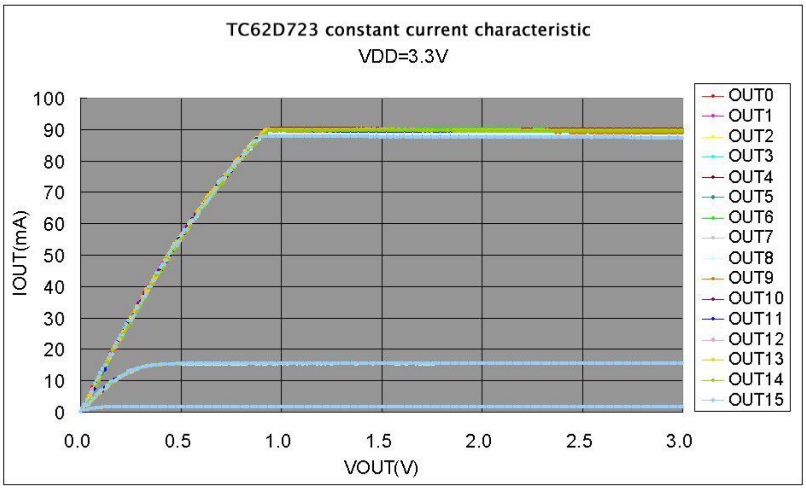

Figure 1. TC62D723 constant-current characteristic.

Channel-to-channel current matching to within ±3-6% has traditionally been adequate to maintain uniform brightness and colour across the entire face of basic LED signs. However, as signage dimensions grow, driver ICs must deliver greater precision. The TC62D723 not only has channel-to-channel matching to within ±1.5%, but also ensures that the channels from IC to IC are matched to within ±1.5%. This provides a high level of assurance that large displays with high pixel density, comprising large numbers of driver ICs, will deliver the high-quality visual impact expected. Moreover this close matching between channels, and from one driver IC to the next, allows designers to achieve acceptable optical performance with lower-cost LEDs, which can have a relatively broad spread of parameters from device to device.

Special Demands

In a large display it is normal to connect the drivers controlling blocks of up to 64 LEDs to one power supply. Switching on a large proportion of these LEDs simultaneously imposes high peak demand. The worst case would be if all the LEDs in a multi-million LED display were switched on simultaneously; this would call for a relatively large and expensive power architecture capable of supplying a very high peak demand.

In the past, drivers have typically implemented edge-rate control for each channel to prevent excessive peak demands from causing sudden fluctuations in current. One drawback is that this approach limits the change in current as the outputs are enabled or disabled, leading to slow and relatively unresponsive signage. Toshiba has used an alternative technique that automatically inserts a short time delay to stagger the turn on of each channel. This reduces the peak power demand per driver, reducing power surges and allowing the use of smaller, lower cost power supplies.

Another challenge that signage-class drivers must address is to combat noise and ringing on the driver output channels resulting from switching large numbers of LEDs. Such noise can interfere with the driver's own circuitry, and that of adjacent drivers. It also presents EMC compliance challenges, which may require expensive extra shielding to gain necessary product certifications, such as CE marking.

Addressing these issues in a large display panel has typically involved the use of large numbers of external components such as capacitors to flatten spikes and damp oscillations. Newer generations of multi-channel drivers for high-output signage applications, however, integrate circuitry to combat switching noise. This greatly reduces the need for external components, which can have a significant impact on aspects such as cost and reliability in signage products comprising many thousands of LEDs and their associated drivers. Figure 2 shows how the internal circuitry of Toshiba's signage-class drivers effectively reduces noise in the LED switching waveforms while minimising external components.

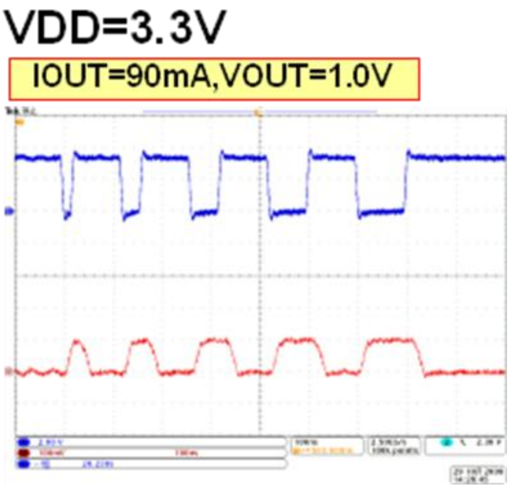

Figure 2. Internal circuitry improves the noise characteristics of LED switching waveforms

Improving the Moving Image

In dimmable signage where animations or frequently changing images are displayed, controlling pixels by PWM dimming can produce a noticeable flickering if the PWM output cycle is not sufficiently fast relative to the image update rate. Consider a dimmable driver with 16-bit dimming resolution. If a PWM clock frequency of 30MHz is applied, the PWM output rate would be 458Hz. If moving images are to be displayed, this frequency is close enough to the image update rate to produce a noticeable flickering. Increasing the clock frequency to raise the PWM output rate would increase noise, power and thermal issues, as well as cost.

Toshiba's Division PWM technique effectively increases the PWM rate without a corresponding increase in clock frequency. Given the same 30MHz frequency and 16-bit dimming resolution, Division PWM divides the 2.18ms PWM output cycle (1/458Hz) into 128 sections each corresponding to 512 clock cycles. The PWM duty cycle needed to achieve the selected dimming level is then replicated within each division period. This effectively increases the PWM output rate from 458Hz to 59kHz, eliminating the tendency for the sign to flicker when displaying moving images.

The TC62D723 supports normal PWM as well as Division PWM modes, and provides an internal register for the user to select the desired operation. The PWM resolution is programmable, with 16-bit, 14-bit, 12-bit or 10-bit settings permitting grey-scale control up to 65536 steps per channel. Selection of one-shot output PWM mode or automatic repeated PWM output mode is supported. Figure 3 illustrates Division PWM compared to normal PWM operation in the TC62D723.

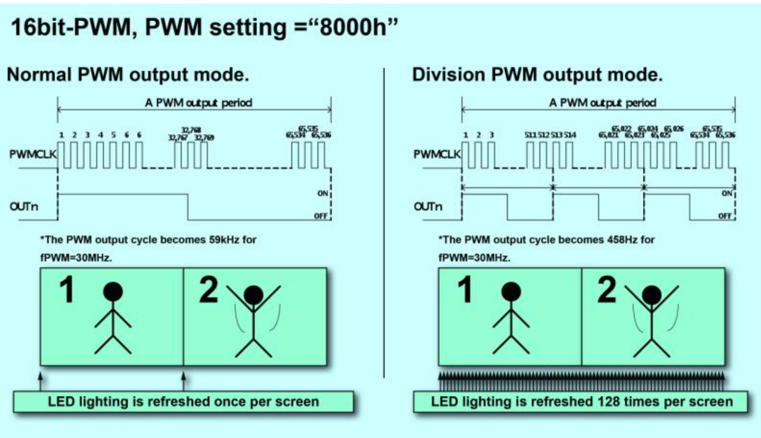

Figure 3. Division PWM dimming enables flicker-free moving images.

Reducing Operating Costs

Other design considerations are growing in importance, as the typical size of new signage designs continues to increase. The provision of power-management functions in driver ICs is a good example, since a small reduction in the power consumed per driver can deliver a valuable total saving when considered at the system level. For example, a typical multi-channel driver may draw only a few milliamps in its quiescent state. However, in a large display featuring around 1000 drivers operating at 5V, the total power drain could be in the region of 30-40W, even when no LEDs are lit.

To help realise power savings in energy-conscious applications, the TC62D723 provides a standby mode that reduces the IC's current draw to below 1µA. The mode is controlled from the application software by setting a bit in an internal register. In a comparable 1000-driver system, the simple provision of this feature could enable the quiescent power consumption to be reduced from 30-40W to a standby figure of 5mW. This not only reduces energy usage but can unlock further savings by permitting smaller, lower-cost power architectures.

Directing Efficient Maintenance

Maintenance and repair of large signage installations is potentially expensive, for example if teams need to arrange safe access to modules mounted high over a street or stadium. Although LEDs are known to have long lifetimes, open- or short-circuit failures of individual units can occur. Although a large display can continue functioning despite the failure of a small number of LEDs in isolated locations, a single open-circuit failure can result in an entire string of series-connected LEDs going dark. This can produce a noticeable visual effect.

Failsafe shunt devices may be fitted to individual LEDs, to bypass the device in the event of an open-circuit failure. This enables other LEDs in the string to continue operating, thereby minimising the visual effect of the failure. Signage-class drivers such as the TC62D723 implement internal circuitry capable of detecting open-circuit or short-circuit LED failures at each output, which can help reduce the total component count and can allow the type of fault and its location to be communicated to the controlling application. In the TC62D723 two comparators are integrated at each output, and assert open-circuit or short-circuit error bits in an internal shift register if the voltage at the output pin rises above 2.0V or falls below 0.1V. This allows the driver to communicate the exact nature of an LED fault via its serial data output pin. Thermal shutdown protection and a power-on reset function are also provided.

Conclusion
With the tremendous take-up of LED-based digital signage, improved drivers offering higher drive levels and greater current-matching accuracy, large numbers of output channels, features to control power and noise, and built-in diagnostic and protection circuitry can improve the performance, reliability and cost of ownership of new signage equipment. As digital signage markets mature, innovations such as these will be essential for sign designers to respond to increasing price sensitivity in mainstream applications and also to tackle ever larger and more ambitious premium projects.

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For more information visit Toshiba Electronics Europe's web site at www.toshiba-components.com

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