DESIGN NOTES

Versatile TFT LCD Bias Supply and White LED Driver in a 4mm × 4mm QFN – Design Note 440

Eddy Wells

Introduction

The makers of handheld medical, industrial and consumer devices use a wide variety of high resolution, small to medium sized color TFT LCD displays. The power supply designers for these displays must contend with shrinking board area, tight schedules, and variations in display types and feature requirements. The LTC®3524 simplifies the designer's job by combining a versatile, easily programmed, TFT LCD bias supply and white LED backlight driver in a low profile 4mm × 4mm QFN package.

The LTC3524's 2.5V to 6V input supply range is ideally suited for portable devices powered from Li-Ion or multiple alkaline or nickel cells. Both the LCD and LED drivers operate at 1.5MHz, allowing the use of tiny, low cost, inductors and capacitors.

The TFT bias portion of the circuit consists of a synchronous boost converter, adjustable between 3V and 6V, providing the main analog V_{OUT} for the TFT. Low current gate drive voltages (VH and VN) are generated using integrated charge-pump circuits. These low noise outputs are programmable to ±20V, allowing optimal bias for multiple display types and makers. The TFT outputs are sequenced at power-up and discharged at power-down as shown in Figure 1.

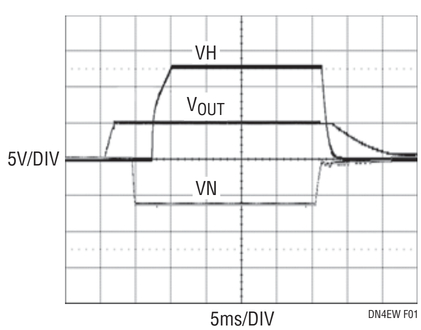

Figure 1. LTC3524 TFT LCD Supply Sequencing at Power-Up and Power-Down

A second nonsynchronous boost converter generates the voltage required to regulate one or two LED strings at up to 25mA each. LED current can be adjusted by either analog or digital means, optimizing the TFT display for varying ambient light conditions. Each string is independently enabled and can contain 1 to 5 LEDs in series. Internal circuitry maintains equal current in the strings, even when the forward voltage drops of the LEDs do not match. Open LED protection is provided to prevent the output from exceeding 24V.

3-Output TFT Supply with Digitally Dimmed LED Backlight

A LTC3524-based TFT and backlight solution for a 4 to 6 inch LCD is shown in Figure 2. High frequency operation of the power components and the QFN package shrinks the total converter footprint to approximately 120mm^2 (single sided).

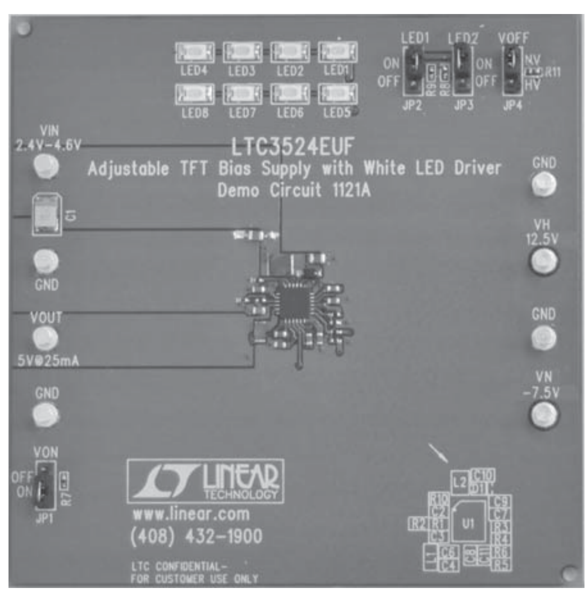

Figure 2. LTC3524-Based LCD and White LED Supply

The circuit schematic is shown in Figure 3. The TFT bias portion of the circuit provides a 5V, 25mA output for the TFT drivers as well as 12.5V and –7.5V outputs with up to 2mA for the gate bias. These voltages are programmed using the FBVO, FBH, and FBN pins respectively.

As shown in Figure 1, these outputs are sequenced with V_{OUT}, VN, then VH powered, as required by most displays. The outputs are actively discharged when ELCD is brought low, removing voltage from the display.

The white LED backlight for the Figure 3 circuit consists of two strings with four series LEDs. The LEDs are driven from the high side with the LTC3524, allowing the strings to terminate at ground, reducing the number of wires required to power the display. With R_{PROG} = 100k, each LED is regulated to 20mA. Maximum power for the backlight is approximately 600mW, assuming a forward voltage around 3.6V per element.

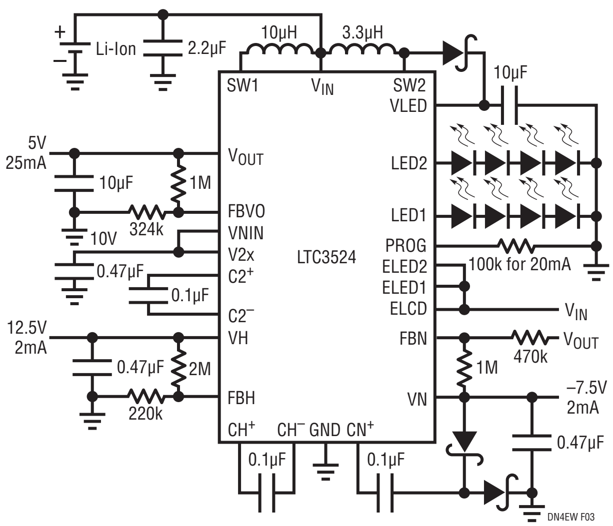

Figure 3. Complete TFT and LED Solution

Dimming is achieved by changing the duty cycle of a 200Hz power signal applied to the LED strings. The frequency is high enough to prevent visually detectable flickering, but low enough to allow a better than 100:1 dimming range. Dimming is implemented by simply connecting a microprocessor controlled port to ELED1 and ELED2. Scope waveforms at 50% duty cycle are shown in Figure 4.

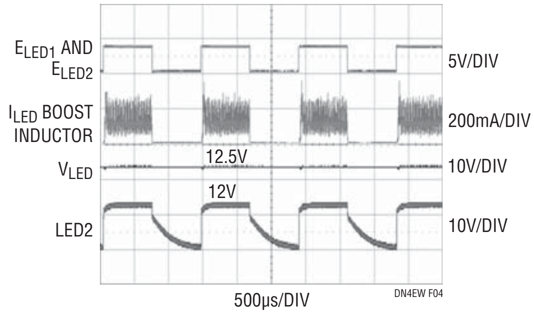

Figure 4. Burst Dimming Waveforms

Efficiency results for this design are given in Figure 5 with a 3.6V input. The LCD efficiency curve shows the performance of the synchronous boost converter with V_{OUT} at 5V and varying load current. This curve includes the no load quiescent current of the charge-pumps, which are powered from V_{OUT}.

Analog dimming of the LEDs can be implemented by adjusting the current through the PROG pin. Efficiency for analog dimming is shown in Figure 5. Efficiency with PWM dimming would remain close to 78% over a wide dimming range.

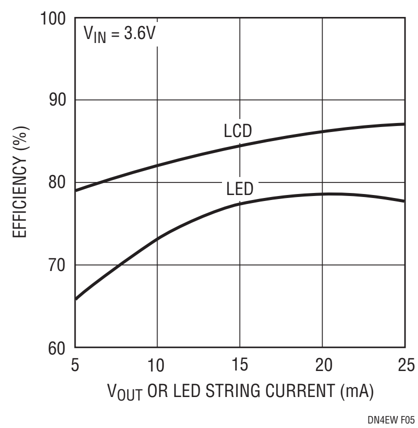

Figure 5. LCD Bias and LED Efficiency

Conclusion

The LTC3524 shrinks and simplifies the design of small to medium sized TFT LCDs by combining the LCD supply and LED driver in a single compact package. LCD bias voltages and LED currents are programmable, making it possible to simplify parts stock by using the LTC3524 for a wide variety of displays.

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Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
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