DESIGN NOTES

An Efficient and Low Cost Alternative to LEDs for Backlighting Handheld Computer Displays – Design Note 1004

David Canny

Introduction

The backlight for a handheld computer's liquid crystal display should be efficient, compact and inexpensive. The two primary competing backlight solutions, white LEDs and Cold Cathode Floresent Lamps (CCFLs), satisfy some of these requirements but neither excel in all. Of these two, white LEDs have recently gained popularity because of their smaller size and easier-to-design controller circuits—important during the technology boom when time-to-market often took precedence over cost and product performance. CCFL solutions, however, continue to have advantages, including better efficiency (resulting in longer battery run times) and lower overall production costs. Furthermore, recent advancements in CCFL drivers and changes in the market have given CCFLs the advantage in many applications. One of the most significant changes is the rise in the importance of cost cutting where inexpensive CCFL solutions have always held the upper hand over comparable LED circuits. This, plus easier-to-design and more compact CCFL solutions, have made CCFL solutions more desirable.

A Compact CCFL Circuit

The circuit shown in Figure 1 is specifically designed to control a single 1W CCFL. T1, Q1, Q2 and associated components form a current fed resonant Royer converter that produces a high voltage at transformer T1's secondary winding. The CCFL current is the feedback signal to the LTC®1697. The LTC1697 delivers switch mode power to the L1-internal synchronous diode node closing a control loop around the Royer converter. R3 sets the lamp current operating point. The loop stabilizes the lamp current against variations in time, supply, temperature and lamp characteristics.

The Royer topology is well suited for driving CCFLs. The lamp drive should ideally contain no DC component, which would degrade the life of the lamp. The converter should deliver the lamp drive in the form of a sine wave. A sinusoidal CCFL drive maximizes current-to-light conversion and minimizes EMI and RF emissions which can interfere with other devices and further degrade overall operating efficiency.

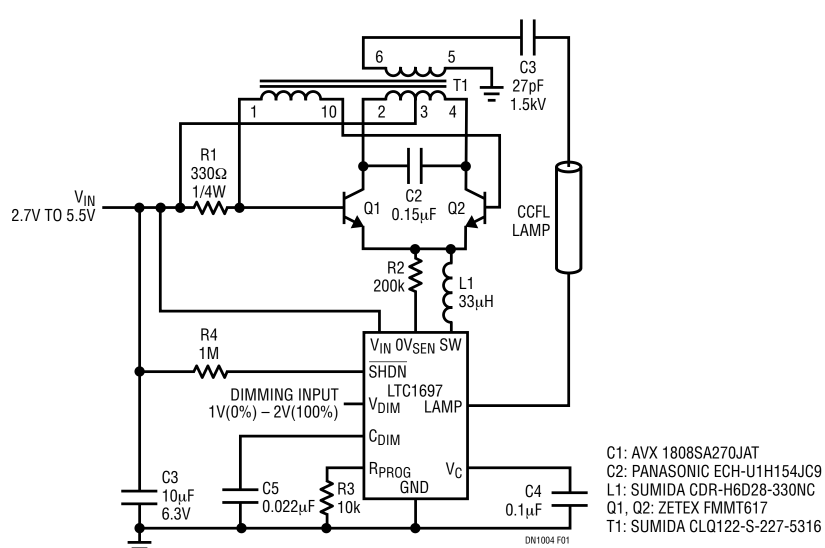

Figure 1. 1W CCFL Controller for Backlighting a Handheld Device's LCD

The LTC1697 includes a synchronous current mode PWM controller with two internal 1A MOSFET switches. It contains a 300kHz oscillator, 0.8V reference and internal current sensing. It operates from a 2.7V to 5.5V input voltage and has a thermal limit and a shutdown mode which reduces its supply current to 1μA. An on-chip PWM dimming circuit enables and disables the current mode regulator for each dimming cycle. The frequency of the oscillator for the dimming PWM is determined by the external capacitor C5. The dimming PWM duty cycle is set by the voltage on the V_{DIM} pin where DC = 0% at V_{DIM} = 1V and DC = 100% at V_{DIM} = 2V. This permits lamp intensity control from zero to full brightness with no hysteresis or "pop-on."

LTC1697 Includes Important Safety Features

Figure 2 shows the overvoltage protection feature reacting to the loss of lamp current feedback. When the lamp is removed (the trigger point, T, in Figure 2), the lamp feedback current drops to zero (see the top trace of Figure 2). The LTC1697 responds to this open-loop condition by driving the Royer converter toward full output power, but as the transformer primary voltage increases so too does the current through R2 (Figure 1). The LTC1697 monitors and limits this current by limiting the duty cycle, thus protecting the transformer from excessive output voltages.

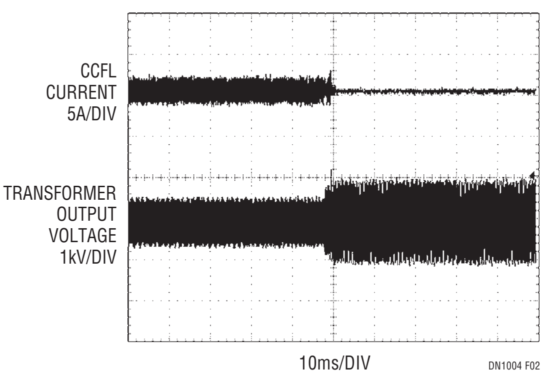

Figure 2. The Transformer Output Voltage is Limited to a Safe Value When the Lamp is Removed. Note That These Traces are ~100kHz Waveforms—the 10ms/DIV Horizontal Scale is Wide Enough to Capture the Voltage Change, but too Wide to Resolve the Sine Wave

The circuit in Figure 1 limits the output voltage to approximately $700V_{RMS}$ with R2 = 200k. This can be seen in the bottom trace of Figure 2. The typical operating voltage across the transformer output winding is ~$425V_{RMS}$ (bottom trace, left of the trigger point T). When the lamp is removed and the CCFL current drops to zero, the output voltage is limited to $700V_{RMS}$ (bottom trace, right of the trigger point T).

The LTC1697 also has a current limit feature. A current limit amplifier shuts the internal MOSFET switch off once the current exceeds the current limit threshold. These combined safety features provide a safe, simple and reliable CCFL driver for handheld devices.

Conclusion

The rush to white LEDs for the backlighting of handheld device displays may have been overdone. CCFLs have always offered attractive features such as longer battery run-times and lower costs, but these were often ignored in the rush to bring products to market with easy-to-design LED solutions. The new LTC1697 overcomes some of the traditional disadvantages of CCFL solutions by simplifying circuit design and shrinking the solution size. Now, it is practically as easy to design a CCFL solution as it is an LED solution and the total CCFL solution can fit easily into PDAs.

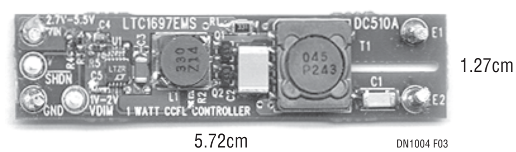

Figure 3. Actual Size of the Circuit Shown in Figure 1. A Production Circuit Would Actually be Smaller Since the Turrets Added Here for Testing Purposes are not Necessary in a Production Board

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