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Introduction

White LEDs continue to make significant inroads as backlights for color active-matrix liquid crystal displays in portable equipment. They offer size, reliability and cost advantages over competing solutions such as cold cathode fluorescent lamps (CCFLs). However, they require a higher voltage than can be provided by a sagging lithium-ion battery. Charge pumps provide an economical and compact means of attaining a modest increase in voltage.

Although charge pump solutions are simple, they can have drawbacks. They are typically noisy and have only mediocre efficiency. The noise is generated from the large current changes due to the pumping action and couples galvanically to circuits powered from the same supply. The efficiency loss is due to the extra input current required to charge the flying capacitor prior to delivering output power. The LTC3202 addresses both of these problems. It is a fractional conversion charge pump that can produce a regulated voltage (up to $1.5 \times V_{IN}$) or current of up to 125mA from a 2.7V to 4.5V input.

Figure 1 shows the LTC3202 configured to drive white LEDs from a lithium-ion battery. Rather than doubling the battery voltage, it uses a split-capacitor technique to multiply it by only 1.5. With this reduced multiplication factor, the input current is reduced from more than twice the load current to just over 1.5 times the load current. This technique results in approximately 25% less input current than would be required for a voltage doubling charge pump to drive the same load.

Tackling the noise problem, the LTC3202 uses a linear regulation technique to ensure that the charging and discharging currents for the flying capacitors are just enough to supply the load current and that they

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remain nearly constant over each clock phase. Figure 2 shows the input current waveform of the LTC3202. The charge pump operates on two phases, where a break-before-make circuit creates the missing notches. The notches are all that the low impedance ceramic input capacitor is required to filter. The result is a very small amount of voltage ripple at the clock frequency and some higher harmonics due to the edges. The higher frequency noise is easily filtered by a second small input capacitor and a tiny parasitic inductor fabricated on the printed circuit board. The resulting battery waveform is shown in Figure 3.

Rather than a fixed output voltage, the LTC3202 has an external feedback pin for maximum flexibility. This feature is ideal for powering white LEDs, since they prefer a current excitation to voltage. By incorporating the first LED in the feedback loop, its current is precisely programmed. The remaining LEDs are controlled by virtue of similarity and the ballast voltage across the resistors. Using the 2-bit onboard digital-to-analog converter, the LED brightness can be set to one of three different levels under software control.

Conclusion

In the 8-pin MSOP package, the LTC3202 fractional charge pump provides a simple and efficient solution for powering white LEDs. Because of its small size, tiny external capacitors, higher efficiency and low noise, constant frequency operation, the LTC3202 is ideally suited for communications and other portable products.

Desktop/Portable VID DC/DC converter

Figure 1 shows an LTC1699 controlling the core voltage of a microprocessor powered by an LTC1778. Because all functions of the LTC1699 are integrated, no additional passive components are required to provide full SMBus control of the LTC1778.

Conclusion

The LTC1699 is an easy, fully integrated solution for applications where control of CPU power via the SMBus is desired. It provides SMBus control of standard voltage regulator ICs wherever output voltages from the VID tables are needed.

Unfortunately critical components such as the CPU are unforgiving and cannot tolerate errors in setup and operation. To solve this problem, Linear Technology has developed a special protocol that uses standard SMBus 1.0 commands that do not involve error checking.

Safeguards

The LTC1699 eliminates errors in many ways. First, the part allows the host to write and read the pre-programmed voltage values as often as needed to verify the value. Second, the ability to activate the programmed value requires simply comparing two duplicate SMBus “ON” or “OFF” commands sent on the bus one right after the other to see if every bit is identical. If any bit is out of place, the command is rejected. Next, the LTC1699 has special lockout procedures such as ignoring “ON” commands if the registers have not been set up. When two valid “ON” command sequences are received, the VID registers are locked out to prevent changes while the power supplies are operating. Finally, the LTC1699 implements the new SMBus V1.1 logic levels for improved signaling integrity. Together, these protection mechanisms offer robust and safe control of the CPU without chance of error while using the popular SMBus.

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Figure 3. Input waveform of circuit in Figure 1 (V_in = 3.6V, I_load = 90mA)