Complete Power Solution for Digital Cameras and Other Complex Compact Portable Applications

by Brian Shaffer

Introduction

Digital cameras, portable GPS systems, MP3 players and other feature-rich mobile devices have complicated power requirements. In these complex devices, the flow of power must be carefully managed between a number of specialized sources and loads, including charging/discharging the battery, current-limited USB power and a set of multivoltage power supply rails, including negative rails for CCDs or LCDs. The supply rails must be sequenced and tracked and faults must be handled cleanly and communicated to a microcontroller.

When these requirements are added together, the task of squeezing an efficient and robust power system into a handheld device can seem near impossible. Linear Technology solves this problem with a family of devices called PMICs (Power Management Integrated Circuits) that greatly simplify the design of complex rechargeable battery power systems.

Some Linear Technology PMICs use a switching PowerPath controller topology with the unique Bat-Track feature, which allows charge currents above the USB limit (see Figure 1) for faster battery charging. The power solution for digital cameras presented here takes advantage of this and other powerful PMIC features.

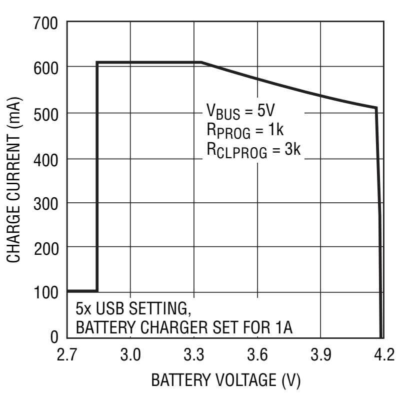

Figure 1. Battery charge current vs battery voltage

The LTC3586 implements Linear Technology's unique Bat-Track™ technology, which can use more power from a USB source than traditional linear chargers, resulting in faster charging.

Complete Digital Camera Power System

Figure 2 shows a complete digital camera power solution using the LTC3586 PMIC as the power traffic control center. Its 4mm × 6mm QFN package includes a USB PowerPath manager, a battery charger, plus a boost DC/DC converter, a buck-boost and two buck converters. The LT3587 in a 3mm × 3mm package is used to drive a CCD and an LED backlight for an LCD screen with a high voltage monolithic inverter and dual boost converter.

Switching PowerPath Controller Maximizes Available Power

The LTC3586 implements Linear Technology's unique Bat-Track™ technology, which maximizes the use of available power from a USB source for either providing current to the load or charging the battery at rates greater than achievable from linear chargers.

The switching PowerPath controller maintains accurate control of the average input current for USB applications. The average level of input current is controlled by the state of two digital inputs and can be set to 100mA, 500mA, 1A or suspend (500µA). The switching PowerPath controller is highly efficient, which results in battery charge currents of well over 600mA from a 500mA USB source (Figure 1).

The battery charging efficiency is between 85% and 90% for the entire battery voltage range. In contrast, the efficiency of a traditional linear charger falls as low as 57%, generating the losses as heat. See Figure 3 for a graph of the battery charger efficiency as a function of battery voltage.

Instant-On Operation

The LTC3586 also features instant-on operation, which allows the camera to function immediately when external power is applied even if the battery voltage is below the system cutoff voltage. This is achieved by generating a separate voltage rail, V_{OUT}, which is decoupled from the battery voltage when the battery is below 3.3V. When external power is applied, the PowerPath controller prioritizes load current over battery charge current and regulates V_{OUT} to 3.6V, enabling the system to operate immediately upon the application of external power. The instant-on feature is important in camera applications because important moments do not wait for batteries to charge.

Fault Handling

The $\overline{\text{FAULT}}$ signals on both of these devices are designed to work together for seamless fault handling. By making the fault signals both an input and an output, the two chips can communicate fault events to each other. If either of the devices has a fault then all the outputs turn off, protecting the system and battery from damage. The enable lines and the fault signal

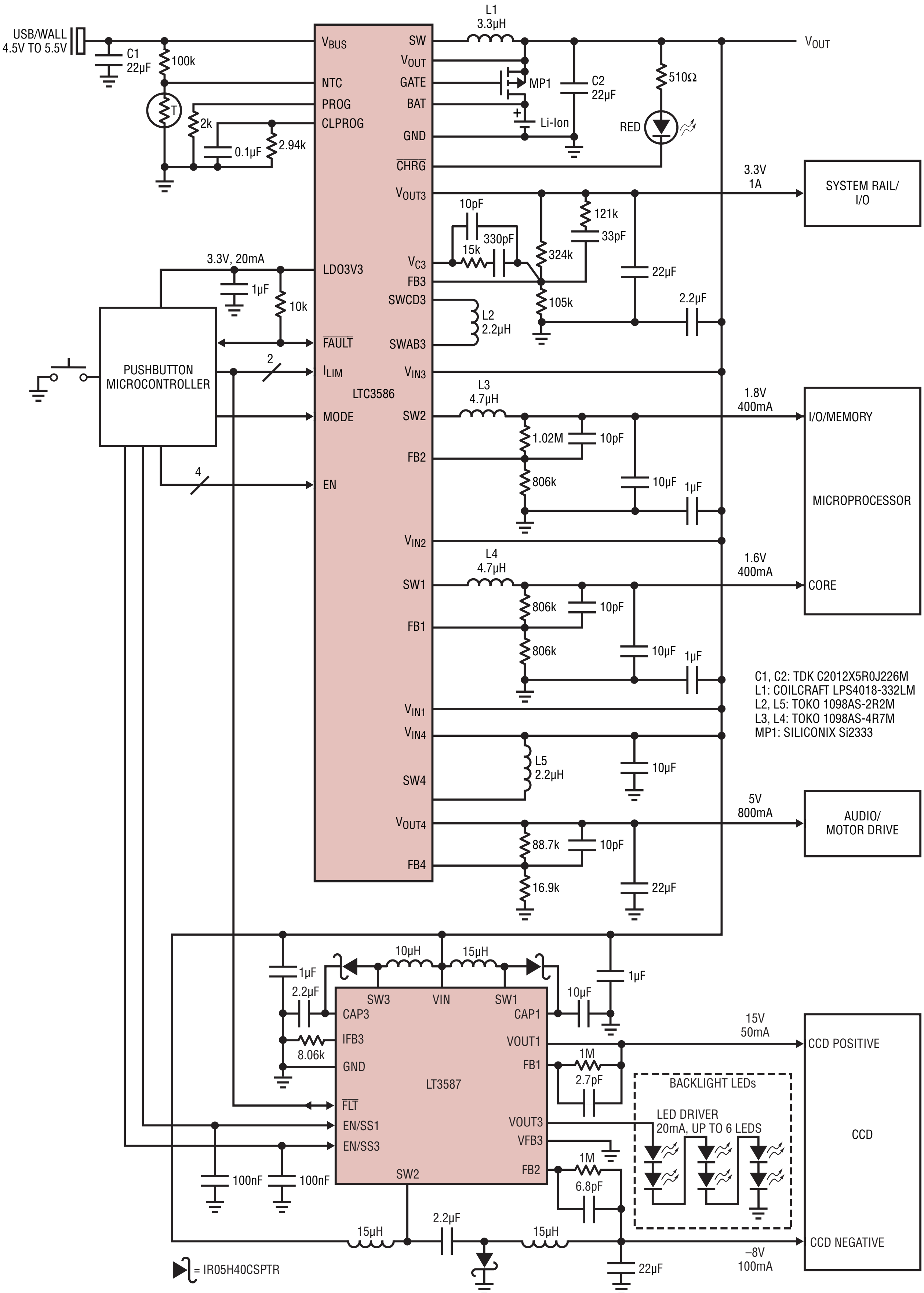

Figure 2. Complete power solution for portable cameras

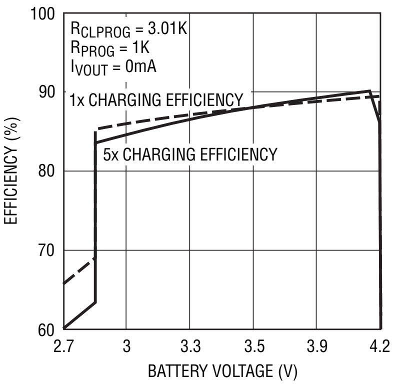

Figure 3. Battery charging efficiency vs battery voltage with no external load (P_{BAT}/P_{BUS})

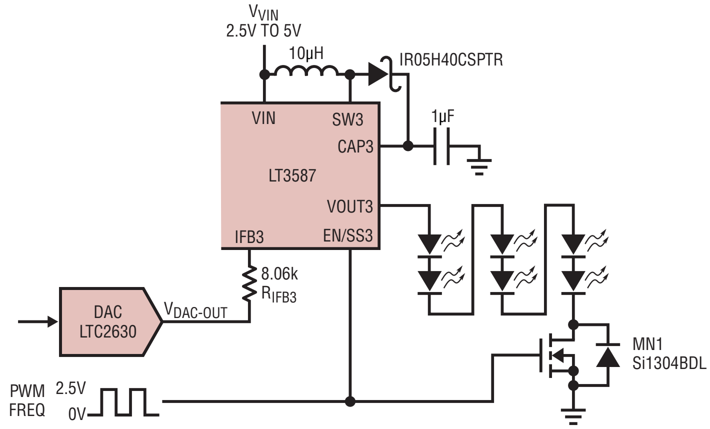

Figure 4. Six white LED driver with PWM and analog dimming

should be pulled-up to the same voltage. In Figure 2 the LDO3V3 regulator is used as the pull-up voltage for the $\overline{\text{FAULT}}$ signal and the power supply for the low power microcontroller used to process pushbutton events and sequence the power supplies. The $\overline{\text{FAULT}}$ pin also acts as an input and hence, must be high before any outputs are enabled.

Compact LED Driver

The LT3587 LED driver is designed to drive up to six LEDs with average LED currents between 20mA and 1µA. When the LT3587's V_{OUT3} is used as a current regulated LED driver, the V_{FB3} pin can be used as an overvoltage protection function. By connecting a resistor between V_{OUT} and V_{FB3} the device limits the maximum allowable output voltage on V_{OUT3}. This feature is extremely important in LED applications because without it the client device may be damaged if one of the LEDs were to open; in such a case, the output would continue to rise as the current regulation loop increases voltage in an attempt to regulate the current.

The integrated LED driver in the LT3587 is capable of accepting a direct PWM dimming signal into its enable input (EN/SS3) and/or accommodates analog dimming via an external DAC. See Figure 4 for a partial application circuit showing the LED driver with direct PWM and analog dimming.

LEDs can change color when the current through them changes, but PWM dimming maintains color consistency over the dimming range, as the ON part of the PWM cycle is always the same current. In PWM dimming, the brightness of the LEDs is a function of average current, adjusted by changing the duty cycle of the PWM signal. In analog dimming, the constant current through the LEDs is adjusted, which causes variations in color.

The LT3587 accepts PWM signals with frequencies over 60Hz to assure flicker-free operation. High PWM frequencies are achievable because of the internal disconnect FET between CAP3 and V_{OUT3}. This FET ensures that CAP3 maintains its steady-state value while the PWM signal is low, resulting in minimal startup delays. For a 100Hz PWM dimming signal and allowing for 10% deviation from linearity at the lowest duty cycle, the LT3587 allows for a dimming ratio of 30:1. If the maximum amount of adjustment range is desired, an external DAC, such as the LTC2630, can be used to feed an adjustment voltage onto the IFB3 resistor, creating an LED current range of 20,000:1.

Conclusion

Two highly integrated devices, the LTC3586 and LT3587 can be combined to create a complete USB compatible power solution for portable cameras and other feature-rich portable devices. The solution is robust, high performance and compact, with efficient battery charging, instant-on capability and LED protection.

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protects against insufficient turn-on voltage for the top MOSFET.

3.3V/15A Regulator with DCR Sensing

Figure 2 shows a 400kHz, 3.3V output regulator using DCR current sensing. The DC resistance of the inductor is used as the current sense element, eliminating the need for a discrete sense resistor and thus maximizing efficiency. Figure 3 shows a plot of the efficiency vs load for all three modes of operation with an input voltage of 12V.

1.5V/15A Regulator Synchronized at 350kHz

Figure 4 illustrates a 1.5V output regulator that is synchronized to an external clock. The loop filter components connected to the FREQ/PLLFLTR pin are optimized to achieve a jitter free oscillator frequency and reduced lock time.

Conclusion

The LTC3851 combines high performance, ease of use and a comprehensive feature set in a 3mm × 3mm 16-pin package. DCR current sensing and Burst Mode® operation keep efficiency high. With a broad 4V to 38V input range, strong MOSFET drivers, low minimum on-time and tracking, the LTC3851 is ideal for automotive electronics, server farms, datacom and telecom power supply systems and industrial equipment.