Dealing with Power Management Requirements in Ultraportable Devices

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A new breed of extremely small electronic products promises to extend the digital lifestyle into entirely new domains. Ranging from Bluetooth® wireless headsets and handheld GPS devices to tiny MP3 players and utility watches, these new ultraportable devices allow users to take their communication links, data, music, and video farther than ever before. Optimized for on-the-go use and powered by single-cell Lithium-Ion (Li-Ion) batteries, these tiny devices set new standards for packing high levels of functionality into small packages.

While this equipment category opens up new applications for today's product development teams, it also brings a new set of challenges for power management. Core processors demand sources to supply power with high efficiencies under varied load conditions. RF and audio circuits require power management systems that deliver low noise and high isolation while maintaining high power efficiency requirements inherent in small ultraportable systems. Battery charging circuits must be capable of automatically adapting to changing conditions coming from USB ports and line-supplied power adapters or "wall warts." Displays vary in type and purpose, yet require highly flexible and efficient power conversion. This article examines how evolutionary changes in power management IC design are helping designers meet these new requirements.

Maximize efficiency for the system core

Since many of these new ultraportable devices operate from relatively small Li-Ion batteries, and battery life between charges plays such a key role in the user's perception of product quality, optimizing power efficiency in a small footprint is critical to their success. Moreover, the typical on and off usage model most ultraportables must endure requires DC/DC converters that can supply the core processor with power at high efficiency under both heavy and light load conditions. Traditionally, the efficiency curve for most DC/DC converters drops off significantly below 100mA. In light load modes under 10mA, some devices suffer from relatively poor efficiency. Thus, a prudent designer would select a DC/DC converter that offers good efficiency for both heavy and light load conditions.

To support this requirement, many power semiconductor suppliers now offer step-down converters ideally sized for these applications. For example, some manufacturers are offering 250mA step-down converters in packages as small as 2mm x 2mm. Moreover, by operating in both fixed and variable frequency modes, they can support power conversion efficiency levels that range as high as 96%.

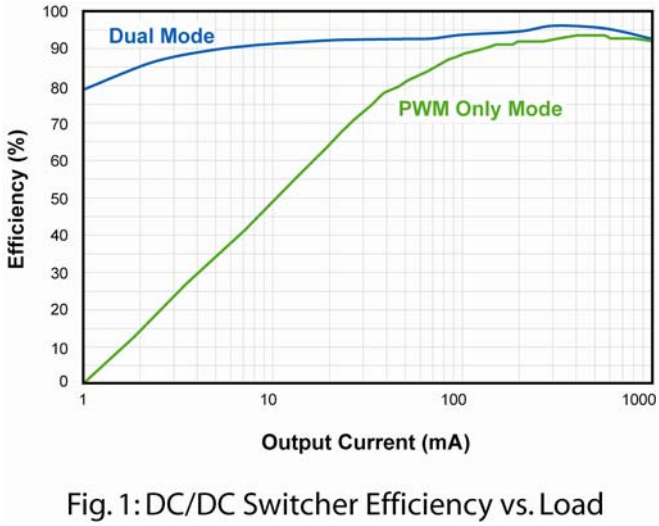

Fig. 1: DC/DC Switcher Efficiency vs. Load

Another key parameter to look for in step-down converters is whether the device uses a synchronous or non-synchronous circuit topology. A synchronous converter offers a number of advantages from a product footprint standpoint. It allows the system designer to reduce component count and size by integrating an external diode. The switching frequency of a DC/DC converter is another important parameter, as it can also help reduce system footprint by allowing the use of smaller external inductors and capacitors.

Noise-free operation for critical circuits

Noise-sensitive RF and audio circuits in ultraportables place unique requirements on their power source. Wireless transceivers, microphones, headsets, and other similar circuits demand a high degree of isolation and must be powered from a low-noise source. Noise will propagate through a typical RF circuit and adversely impact transceiver performance. On the audio side, high noise levels will have an adverse impact on sound quality.

Given these unique requirements, designers typically turn to linear regulators which provide excellent isolation from the input source to the load and do not produce the noise or ripple associated with switching regulators. In effect, linear regulators do double-duty as voltage converters and active filters. However, linear regulators typically sacrifice efficiency to achieve this low noise performance. So, theoretically, designers pay a penalty in power efficiency to achieve low noise for the RF and audio segments of their design. Fortunately, many of these circuits use relatively low power so, even though there is an efficiency penalty for using linear regulators, the impact of the inefficiency does not adversely affect the overall system power budget.

Powering the display

Displays in ultraportables range from simple multi-color LED indicators in Bluetooth headsets to full-color TFT displays in MP3 players. White LEDs are typically used to backlight these color TFT displays. Ultraportable designers face the same problems powering white LEDs that virtually any other portable electronics designer faces; voltage requirements for the white LEDs often differ widely from the power

available from the Li-Ion battery power source. Accordingly, designers must turn to a power conversion device to convert the power in an efficient manner.

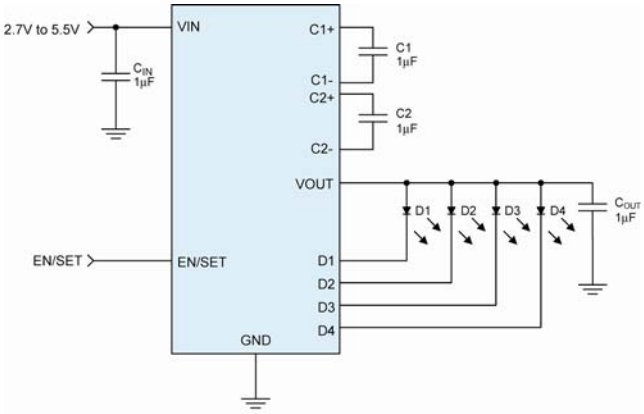

Fig. 2: Simple Charge Pump Lighting Solution

A popular solution designers turn to for this application is a charge pump IC that incorporates a switched capacitor DC/DC converter to boost the battery voltage level when it dips below the required forward voltage of a given LED or string of LEDs. However, when the single-cell battery is fully charged, the available voltage is typically higher than needed for a single LED. Accordingly, designers need a mixed-mode device capable of either intelligently stepping battery voltage down, which is typically done through linear regulation, or boosting the voltage in a switching fashion, depending on available voltage level from the battery versus that required by the display backlight LEDs.

To address this need, power semiconductor manufacturers have recently brought to market a wide range of new switched capacitor step-up converters that incorporate linear step-down functions with intelligent feedback and control. These compact devices combine fast transient response, high stability, and excellent load isolation in a tiny package.

Battery charging and control

Given their limited power requirements and virtually universal ability to interface to PCs, many ultraportable devices are prime candidates to use the USB port of a desktop PC or notebook computer as a charging source, as well as for data exchange. Wide variations in the interpretation of the USB standard make this task more challenging than expected when utilizing the USB port as a battery charging source.

Power semiconductor manufacturers are meeting this demand by offering new devices that incorporate battery charge reduction circuits. These circuits automatically monitor the USB port voltage and prohibit it from dipping below a pre-specified threshold by automatically lowering the current level used to charge a battery. If the voltage available for charge decreases due to a USB port overload, fault, or other system demand, a charge reduction circuit embedded in the charger IC automatically throttles back on the charging current to maintain the integrity of the USB port.

By allowing users to use the USB port as a charging source in a variety of conditions without requiring any extra system resources to maintain the integrity of the port, this new capability helps ultraportable device designers increase functionality and reliability while maintaining the smallest product form factor with a simplified charge control. Moreover, some power semiconductor suppliers are offering these devices in packages as small as a 2.0mm x 2.1mm SC70JW.

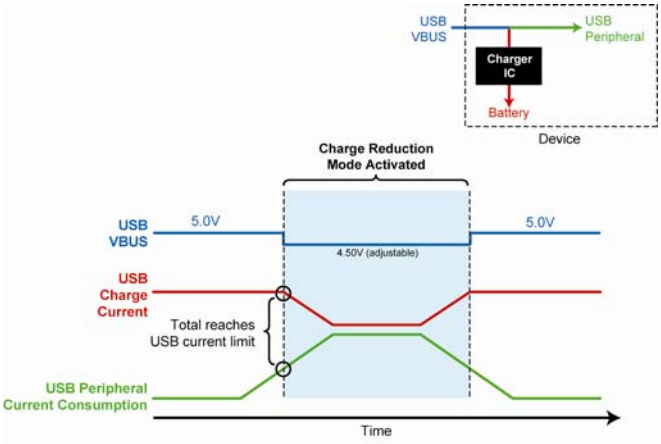

Fig. 3: USB Charge Reduction Operation

System power approaches

As designers cope with each of these power management issues, they must keep a constant eye on layout size of a design or form factor. First and foremost, ultraportable products must be small, lightweight, and portable. Obviously, designers must maximize every opportunity to shrink board space.

Power semiconductor manufacturers are helping designers achieve this goal by introducing a number of integrated system power products. These devices incorporate multiple power management functions used in an ultraportable device into a single IC package. For example, many products in this category require a battery charger to charge the battery, a DC/DC step-down converter to power the core processor, and several low dropout linear regulators to power noise-sensitive RF and audio circuits. Today, some power semiconductor manufacturers are offering all three functions in a single die.

Conclusion

The ultraportable consumer electronics market is set for dramatic growth, but with the ever-shrinking size of products to unprecedented levels, designers need new strategies for integrating traditional power management functions. As semiconductor manufacturers integrate more power functions into a single IC package, these devices will offer designers of ultraportable products new options that will play a key role in the market's success.