What's in Your Portable Product?

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Introduction

We are all familiar with batteries these days; they are virtually ubiquitous in a myriad of products and applications. Commonplace examples include your cell phone and notebook computer; however, they are also commonly found in flashlights, cordless tools, MP3 players, portable video gaming devices, hand-held multi-meters, as well as, scientific instruments and a rapidly expanding plethora of healthcare devices.

Accordingly, it will come as no surprise to learn that the global market for portable battery-powered products was valued at an estimated $480B in 2011 and is expected to reach more than $611B in 2016. [Source: BCC Research]. Furthermore, this market is expected to continue its growth expansion through to 2020.

This market can be roughly segmented as follows:

~29% for communication products
~29% for the computer related products
~19% for medical products
~23% for cameras, toys, entertainment, timepieces, lighting, navigation and military products

This diversity has been accomplished because of a unique synergy between the product themselves, the batteries they employ, and the battery chargers and power-management systems that recharge the batteries.

Battery Chemistry & Applications

It is clear that the market for battery powered products is significant but what about the battery chemistry used inside them? Well, the predominant battery chemistry being utilized in this diverse product offering is Lithium-based, which was estimated to be valued at $22.5B in 2016. [Source: Frost & Sullivan]. North America and China have more than half the global revenues for Lithium batteries. What's more, going forward, this demand will be further fueled by key end-users from the consumer

device vendors, industrial goods manufacturers, the grid and renewable energy storage segment and automobile manufacturers. Within the industrial segment, healthcare, power tools and military applications represent the leading usage for Lithium-Ion batteries.

A typical Lithium-ion battery has a discharge profile from a high of 4.2V when fully charged, down to as low as 2.7V when fully discharged. While this is an excellent choice for smart phones and MP3 players, it may not be suitable for portable scientific instruments, power tools and medical healthcare devices. In these instances, multiple cells may be required in order to supply the necessary run-time to be of practical use. This means that 2 to 4 cells will have to be utilized, either in series or in parallel, or a combination of both. As a result, the voltage range of these battery configurations could vary from a high of 16.8V to 10.8V (4 Lithium cells in series), to 8.4V to5.4V (2 Lithium cells in series).

Battery Voltage Conversion & Layout Considerations

High power density has become a primary requirement for DC/DC converters, as they must keep up with ever increasing functional density of electronics. Likewise, power dissipation is a major concern for today's feature rich, tightly packed devices pushing the need for highly efficient solutions to minimize temperature rise. For applications where the input voltage source can be above or below the regulated output voltage, finding an efficient compact solution can be a challenge, especially at elevated power levels. Conventional design approaches, such as using a dual inductor SEPIC converter, produce relatively low efficiencies and a relatively large solution sizes.

As already discussed, power-hungry handheld devices, medical products and industrial instruments often require multicell or high capacity batteries to support their ever-increasing processing needs. Many loads require a regulated output that sits within the battery voltage range which necessitates the use of a converter that can both step-up and step-down. Although a SEPIC converter is a viable solution, its large size and modest conversion efficacy are suboptimum for use in portable or luggable products. Thus, a wide voltage range, high efficiency buck-boost DC/DC converter is the ideal solution for longer battery run times and handling multiple input sources.

From the power supply designer's perspective, it would be great if every time they powered up a prototype supply board for the very first time, it not only works, but also runs quiet and cool. Unfortunately, this does not always happen. A common problem of switching power supplies is "unstable" switching waveforms. Sometimes, waveform jitter is so pronounced that audible noise can be heard from the magnetic components. If the problem is related to the printed circuit board (PCB) layout, identifying the cause can be difficult. As a result, proper PCB layout at the early stage of a switching supply design is very critical and its importance cannot be overstated.

Of course, a power supply designer understands the technical details and functional requirements of the supply within the final product. They usually work closely with the PCB layout designer on the critical supply layout from the beginning. A good layout design optimizes supply efficiency, alleviates thermal stress, and most importantly, minimizes the noise and interactions among traces and components. To achieve these, it is important for the designer to understand the current conduction paths and signal flows in the switching power supply.

In a design without external heat sinks for surface mounted power MOSFETs and inductors, it is necessary to have sufficient copper area as a heat sink. For a DC voltage node, such as input/output voltage and power ground, it is desirable to make the copper area as large as possible. Multiple vias are helpful in further reducing thermal stress. For the high dv/dt switch nodes, the proper size of the switch node copper area is a design trade-off between minimizing the dv/dt related noises and providing good heat sinking capability for the MOSFETs.

Finally, the control circuitry should be located away from the noisy switching copper areas. It is preferable to have the control circuitry located close to the Vout+ side for a buck converter and close to the Vin+ side for a boost converter, where the power traces carry continuous current. If space allows, the control IC should be populated a small distance (0.5–1") from the power MOSFETs and inductors, which are noisy and hot. However, if the space constraint forces the controller to be located close to power MOSFETs and inductors, special care must be taken to isolate the control circuitry from power components with ground planes.

Optimized Power Converter Solutions

Clearly, a power supply designer's job is no easy task. Having solutions that mitigate the risk involved with optimizing a cumbersome solution like a SEPIC converter to generate a fixed output voltage when the input can be above, below, or even equal to the input are of great benefit. Optimizing and integrating the power MOSFETs to facilitate a compact, highly efficient solution simplifies the design task. Fortunately, Linear Technology has some new converter solutions that do just that.

The LTC3119 is a synchronous current mode monolithic buck-boost converter that delivers up to 5A of continuous output current in buck mode from a wide variety of input sources, including single- or multiple-cell batteries, unregulated wall adapters as well as solar panels and supercapacitors. Even higher output currents can be supported for pulsed load applications. The device's 2.5V to 18V input voltage range extends down to 250mV once started. The output voltage is regulated with inputs above, below or equal to the output and is programmable from 0.8V to 18V. User-selectable Burst Mode® operation lowers quiescent current to only 31μA, improving light load efficiency while extending battery run time. The proprietary 4-switch PWM buck-boost topology incorporated in the LTC3119 provides low noise, jitter-free switching through all operating modes, making it ideal for RF and precision analog applications that are sensitive to power supply noise. The device also includes programmable maximum power point control (MPPC) capability, ensuring maximum power delivery from power sources with higher output impedance including photovoltaic cells. See Figure 1 for its simplified schematic.

The LTC3119 includes four internal low R_{DSON} N-channel MOSFETs to deliver efficiencies of up to 95%. Burst Mode operation can be disabled, offering low noise continuous switching. External frequency programming or synchronization using an internal PLL enables operation over a wide switching frequency range of 400kHz to 2MHz, which allows for the tradeoff between conversion efficiency and solution size. Other features include short-circuit protection, thermal

overload protection, less than 3µA shutdown current, and a power good indicator. The device's combination of tiny externals, wide operating voltage range, compact packaging, plus low quiescent current makes the LTC3119 well suited for RF power supplies, high current pulsed load applications, system backup power supplies and even lead-acid battery to 12V conversion systems.

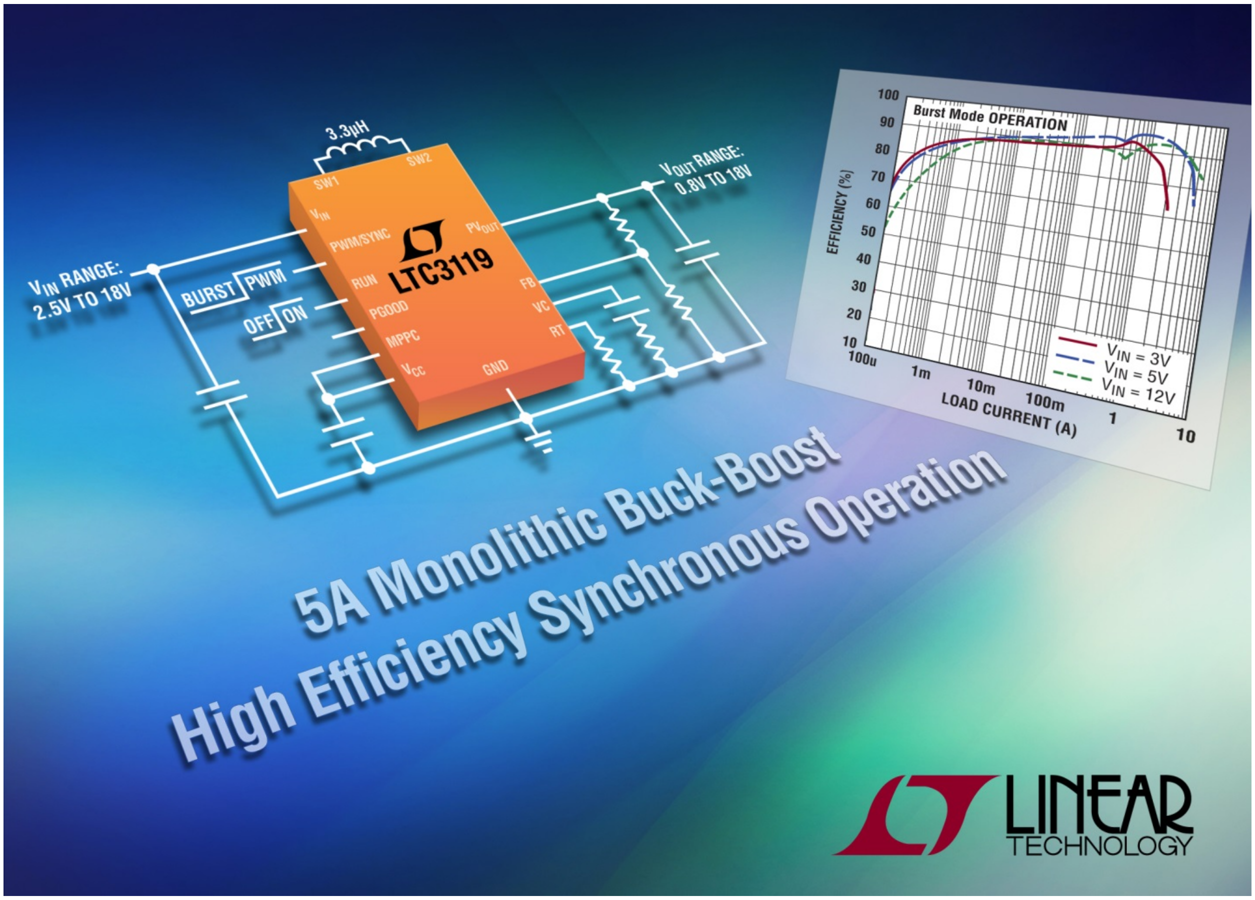

Figure 1. LTC3119 Schematic Showing a High Level of Integration & Performance

Many portable systems require being powered from multiple input sources including single or multi-call battery configurations, wall adapters and supercapacitor stacks. Another device within the same family as the LTC3119 is the LTC3118, a dual input, monolithic buck-boost with integrated lossless PowerPath™ which is capable of delivering up to 2A of continuous output current. The LTC3118 integrates the intelligence to automatically transition to the proper input source to seamlessly maintain a regulated output. Each input can operate from 2.2Vto 18V, while the output can be programmed between 2V and 18V making the part suitable for a wide variety of applications. The LTC3118 employs a low noise, current mode buck-boost topology architecture with a fixed1.2MHz switching frequency. Its unique design provides a continuous, jitter-free transition between buck and boost modes, making it ideal for RF and other noise-sensitive applications. The combination of tiny externals and a 4mm x 5mm QFN or TSSOP-28E package provides a compact solution footprint. See Figure 2 for its simplified schematic.

The LTC3118 includes four internal low RDS(ON) N-channel MOSFETs to deliver efficiencies of up to 94% from either input. User-selectable Burst Mode operation lowers input quiescent current to only 50µA, improving light load efficiency and extending battery run time. For noise-sensitive applications, Burst Mode operation can be disabled resulting in fixed frequency, low-noise operation independent of load current. Other features include soft-start, overvoltage protection, short-circuit protection, thermal shutdown and output disconnect.

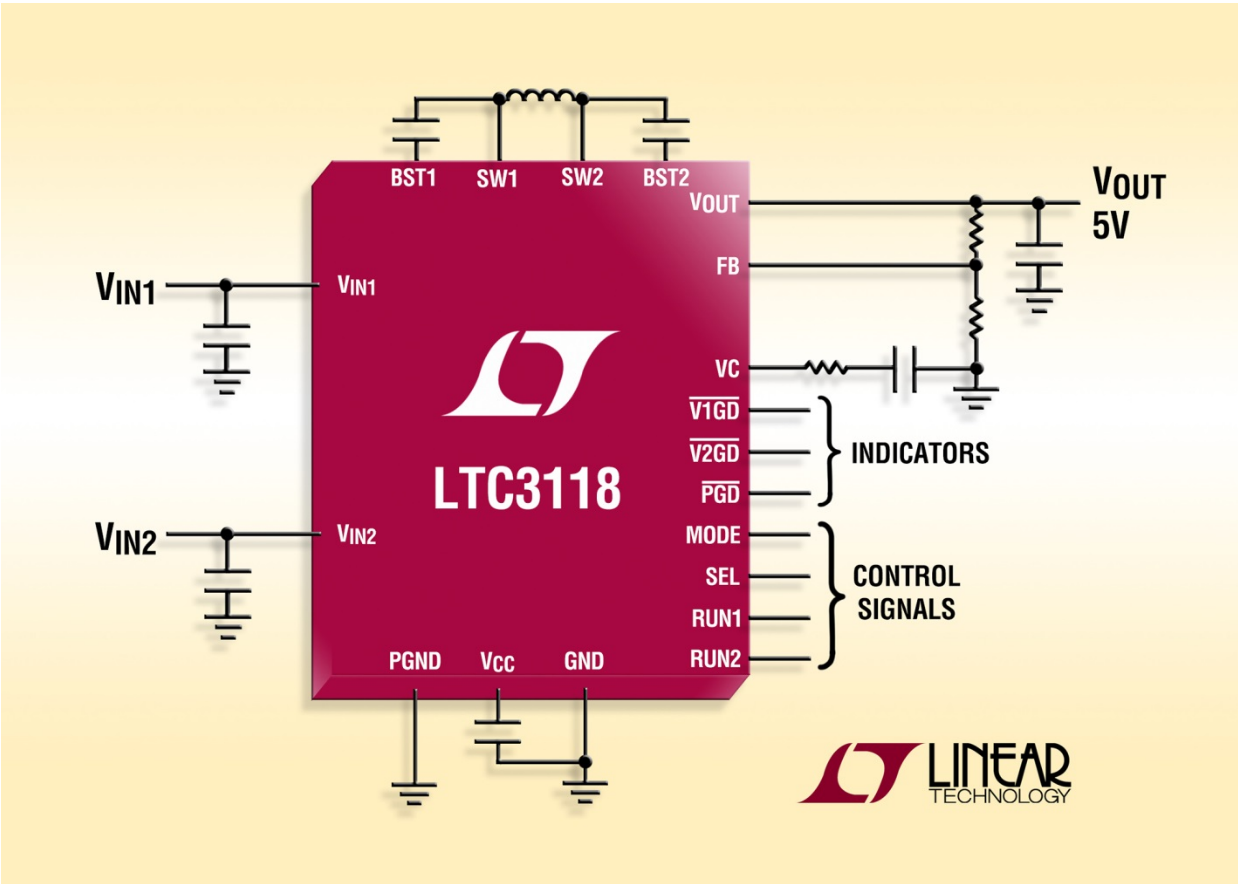

Figure 2. LTC3118 Schematic with PowerPath Section between Two Inputs

Conclusion

A large opportunity has presented itself for designing a wide range of battery powered portable products to meet the growing appetite for communications, medical and computer related products. System designers have faced some difficult challenges in selecting the right power conversion solution that meets the key design objectives, including spanning the input-to-output voltage constraints, power levels and ease of design, without compromising efficiency, run time and solution size.

Designing a solution that meets the system goals without a performance impact can be a daunting task. Fortunately, there are a growing number of buck-boost converter solutions from Linear Technology, which simplify the design, offer best-in-class features and have the ability to maximize run times in-between battery recharging cycles due to their high efficiency operation across a wide range of laods.