Today’s Voltage Regulators Enable High Efficiency and Space Savings in Portable Applications

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As demand for longer battery life in portable devices increases, engineers are continually challenged to design highly efficient point-of-load (POL) converters while maintaining or reducing board space. Adding to the challenge is the fact that many portable devices like laptop computers have wide input voltage variation. Wide input voltage variation typically impacts controller stability and efficiency which contributes to power loss. Higher power losses translate to shorter battery life and in many cases may also translate into complex thermal management implementation in order to maintain temperatures within reasonable limits, resulting in more components and larger board space.

Two of the most important items that determine the efficiency of most POL solutions are; the control architecture and MOSFET switches. Hysteretic Constant on-time (COT) controllers with diode emulation have become the product of choice for mobile POL applications, but selecting the right device for a given solution is only half the effort. The other half and potentially more important part of the design effort involves selecting switches that have the optimal balance of charge and on-state resistance.

Hysteretic COT control is an ideal method to address the demands stated above because the topology inherently manages wide input voltage variation and does not require external compensation circuitry. From a high level, the COT control scheme compares the output voltage ripple to the internal reference voltage to maintain output voltage regulation. The on-time is inversely proportional to the input voltage. Thus, when input voltage increases, the on-time deceases and vise versa. This scheme regulates the control of the output voltage as the input voltage changes. During normal operation mode or continuous conduction mode (CCM), the low side switch is turned on after the high side switch turns off with the addition of some dead-time in between in order to avoid shoot through. Since COT controllers typically use a comparator instead of an error amplifier to compare the output voltage ripple to the internal reference, external compensation networks are generally not required. This reduces component count and complexity of the overall design.

Diode emulation or discontinuous conduction mode (DCM) is a feature that reduces power losses during light load conditions. Controllers that incorporate this feature typically detect when the inductor current is at zero to trigger an event that turns off the low side switch. Turning the low side switch off prevents the current stored in the output capacitor from flowing through the inductor, thereby reducing conduction loss and improving system efficiency. In order to maintain output

voltage regulation during this period, the switching frequency decreases proportionally with the output current, which reduces switching and conduction losses further improving efficiency.

Since the MOSFET switches are one of the highest power loss contributors in POL converters, careful selection of these switches is a very crucial part of the overall solution design effort. In applications such as laptop computers that typically operate from high input voltage and require low operating voltages the high side switch operates with a low duty cycle and the low side switch operates with a high duty cycle. For example, in an application with an input voltage of 20 V and an output voltage of 1V, the high side duty cycle is 5 percent whereas the low side duty cycle is 95 percent. Since there is a large disparity in the operating conditions of the two devices special care must be taken to select switches that are properly optimized to their respective operating conditions. In general terms the high side MOSFET must have very low charge characteristics in order to minimize switching losses and the low side MOSFET must have very low RDS(ON) characteristics in order to minimize conduction losses.

Selecting the proper POL controller and MOSFETs for mobile applications that require maximum efficiency for improving battery life can be a daunting and time consuming effort for engineers. The layout effort for placing the MOSFETs in the most optimal location with respect to the controller while minimizing space also adds complexity to the overall design effort.

Semiconductor manufacturers are addressing the challenge facing engineers to deliver very high efficiency POL converters in mobile environments while minimizing space. As an example, International Rectifier’s IR3870M SupIRBuck device combines a hysteretic constant on-time controller with diode emulation and two benchmark HEXFET MOSFET switches in a single 5 mm x 6 mm power QFN package. Its COT topology eliminates the need for external compensation circuitry and it eliminates the MOSFET selection and placement effort, making the device easy to use. In addition, the device has an input voltage range of 3 V to 26 V and is capable of delivering up to 10 A in typical laptop environments that climb to ambient temperatures as high as 60°C. It has a precise 0.5V reference (+-1 percent) for low voltage sockets, and offers PGOOD and Enable pins plus safety features.