Choosing the Right Step-Up/Down Voltage Regulator for Portable Applications

Introduction

A popular power source for portable devices is a single lithium-ion cell with 4.2V at full charge and 2.8V at end of discharge. However, some functions within portable electronics, such as a SIM card and DSP, require 2.8V and 3.3V. These are normally provided by low noise LDOs. The LDOs inputs (V_CCC) must be at a slightly higher voltage than the highest LDO output. Hence, V_CCC ends up right in the middle of the lithium-ion battery’s range of operation. The use of a step-up/down voltage regulator, capable of operating from an input that can be higher or lower than the output, becomes necessary. Figure 1 shows the battery voltage (V_BAT) as the power source for a typical portable design.

In portable applications the voltage regulator efficiency is of the utmost importance, since higher efficiency translates into longer untethered operation. In this design solution we will review the available options, compare their performance, and determine the most efficient solution.

Bypass-Boost

One way to solve the problem is to use a bypass-boost converter, namely a boost converter with an extra “pass” transistor integrated between the power source, V_BAT, and the LDO input, V_CCC. Figure 2 shows the bypass-boost power train architecture and its operation table. Here the bypass transistor T3 accomplishes a “poor man’s” step-down operation.

This architecture can only regulate V_BAT voltages lower than the set V_CCC = 3.4V. For V_BAT > 3.4V, the boost converter stops regulating and the pass transistor turns on, directly connecting V_BAT to V_CCC. Figure 3 shows the battery profile discharging over time and the LDO input voltage for the bypass-boost architecture.

For the majority of the time (V_BAT > 3.4V) the pass transistor in the bypass-boost architecture literally “passes the buck” to the LDOs downstream. The LDOs bear the task of regulating the high V_BAT value down to their output set values. Since this regulation is linear the result is high power dissipation inside the LDO. This results in greater energy consumption and also requires a board design and IC selection capable of dissipating this energy.
**Case Study**

In this case study, we compare the system efficiency (from \( V_{BAT} \) to \( V_{OUT} \)) of the MAX77801 buck-boost IC to a competitor’s bypass-boost IC. Each regulator feeds a single 3.3V LDO loaded with 500mA.

**Figure 8** shows the result of the comparison. Solid lines indicate efficiency and dotted lines show battery current consumption for each solution. As expected, the efficiency of the two architectures is similar when \( V_{BAT} \) is below or near the LDO output voltage. Outside this range, and for the entire time \( V_{BAT} \) is above the LDO output voltage, the efficiency of the buck-boost (above 90%) is far superior to that of the bypass-boost (as low as 75% with full battery). This superior performance is due to the ability of the buck-boost IC to supply power to the LDO in switch mode across the entire range of operation.

**Conclusion**

The comparison of the buck-boost architecture to the bypass-boost architecture shows that, in principle, the buck-boost operates with superior efficiency. A practical comparison of the MAX77801 buck-boost solution versus a competitor’s bypass-boost architecture shows that in operation, there is an advantage of up to 17% efficiency for the Maxim device. Thus, the buck-boost IC is an ideal solution for power-stingy portable applications.

Learn more: MAX77801 High-Efficiency Buck-Boost Regulator

Design Solutions No. 1
Rev 1; May 2019

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