Using Input Current Limiting to Extend Battery Life

Despite constant advances in battery technology, producing a battery still involves multiple tradeoffs between different design goals such as size, self-discharge, or capacity to name a few. In applications such as wireless sensors, a battery-powered device is intended to operate for years in the field. In that case, high-energy-density, low-discharge coin cell batteries such as the ones based on Li-$SOCl_2$ or Li-MnO_2 chemistry are often the designer's choice. The main drawback of such batteries is their high internal resistance (ESR) and limited current capability. High ESR can prevent proper startup of the system. Moreover, if a pulsed load, typical for wireless sensors, overdrives the battery, its capacity and the lifetime can be significantly reduced. Adding a buffer capacitor to the battery can help to some extent, as explained in the *Coin Cells and Peak Current Draw White Paper*. However, a relatively large capacitor is required to buffer the current peaks, adding to the system cost and size.

To accommodate variable battery voltage and to maximize efficiency, a DC/DC converter is often used to generate a fixed-voltage supply. Figure 1 shows an example of a typical power tree of a wireless sensor. A supercapacitor can be used if there is a heavy load that requires significantly larger current than the battery can provide. Such a system might operate only once a day for less than a second, for example only to measure the temperature and transmit the data. The rest of the time the system is in standby. Therefore, the load that the battery sees has a very small duty cycle, with short but high-current pulses.

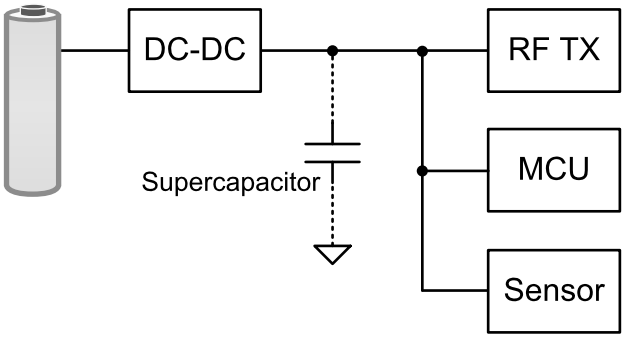

Figure 1. Power Tree of a Battery-Powered Wireless Sensor

One of the drawbacks of switch-mode converters is the inrush current generated every time the converter is turned on. If the battery ESR is not sufficiently low, the inrush current might trigger the UVLO and prevent the device from a reliable startup. This is explained in more detail in the *Achieving a Clean Startup by Using a DC/DC Converter with a Precise Enable-pin Threshold Technical Brief*. This becomes more pronounced as the battery ages and its ESR increases. Even if the start is successful, the inrush current spikes can still have detrimental effects on the battery capacity and lifetime. Having to charge a supercapacitor can further increase and prolong the inrush current pulse.

For these reasons, matching a heavy pulsed load to a weak battery requires some sort of current limiting on the converter side. With its features, the TPS63900 device is tailored for such battery-powered applications. With the output current of up to 1 A, this device supports commonly-used RF standards such as BLE, LoRa and NB-IoT. Table 1 lists the main features of the device, and Figure 2 shows the typical application circuit. Owing to the small component count, the TPS63900 is suitable for cost-sensitive battery-powered applications.

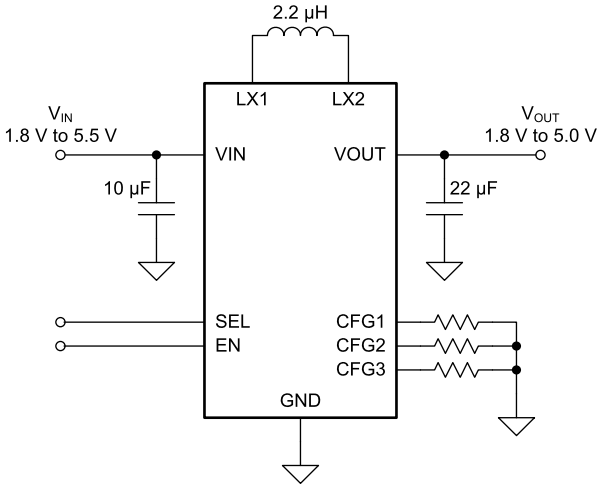

Figure 2. TPS63900 Typical Application

Table 1. TPS63900 Main Features

Input voltage	1.8 V – 5.5 V
Output voltage	1.8 V – 5 V in 100-mV steps
Output current	up to 1 A
I_Q	200 nA
Input current limit	1 mA, 2.5 mA, 5 mA, 10 mA, 25 mA, 50 mA, 100 mA, unlimited
Dynamic voltage scaling	2-level
Package	DFN, 10-pin, 2.5 mm x 2.5 mm

One of the main features of the TPS63900 device is the input current limiting. The TPS63900 can limit the current drawn from the input supply to protect the batteries that do not support high peak currents. The input current limit is active during normal operation as well as during startup. This effectively limits the inrush current, and can also be used to reliably charge heavy loads, such as a supercapacitor, from a weak battery. The converter has eight current limit settings going down to 1 mA, as listed in Table 1. As an example, Figure 3 shows the input current limit set at 50 mA which is active during startup.

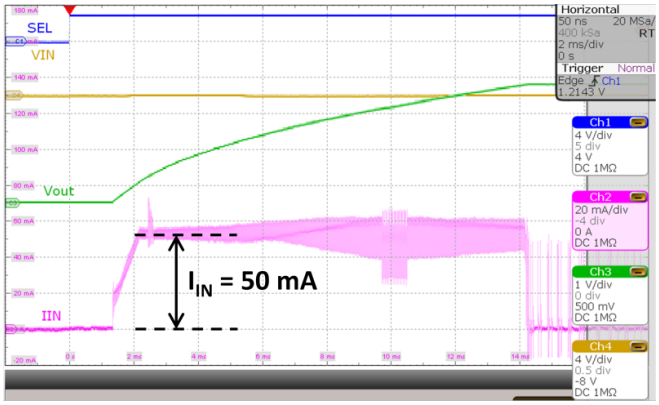

Figure 3. Inrush Current Limited at 50 mA

Besides the input current limiting, the TPS63900 has ultra-low quiescent current of only 200 nA, allowing efficiency to be above 90% even at load current of 10 µA. The dynamic voltage scaling feature allows for two different user-selectable output voltages to be dynamically changed during operation. How this can further extend the battery life is explained in the *Extending Battery Life with Low Quiescent Current and Dynamic Voltage Scaling Application Report*.

References

TPS63900 1.8-V to 5.5-V, 400-mA, 200-nA Quiescent Current Buck-Boost Converter Data Sheet

Coin Cells and Peak Current Draw White Paper

Achieving a Clean Startup by Using a DC/DC Converter With a Precise Enable-pin Threshold Technical Brief

Extending Battery Life with Low Quiescent Current and Dynamic Voltage Scaling Application Report

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