1.5MHz Monolithic Synchronous Step-Down Regulator Brings High Efficiency to WCDMA Cellular Telephone Applications

Introduction
To extend talk time and save battery power, new 3rd generation WCDMA cellular telephones are expected to adjust their power levels to the requirements of each transmission. The highest power levels are reserved for data transmission far from the base station; the lowest for voice transmission near the station. Power amplifiers in these phones require a DC power supply which can slew quickly from one voltage to another. To perform this function, the LTC3403 and LTC3408 provide DC/DC conversion from single lithium-ion cell voltages down to a dynamically adjustable 0.3V–3.5V, which can be easily modulated with an external DAC.

These monolithic, synchronous step-down regulators are offered in a tiny, low profile 8-lead (3mm square, 0.8mm high) plastic DFN package. Their 1.5MHz switching frequency allows the use of tiny inductors and capacitors. With power switches located on-chip, the minimal number of required external components permits an entire regulator to occupy less than 8mm$^2$ of board space. The power switches’ low 0.4Ω of on-resistance increases efficiency when delivering as much as 600mA of current; efficiency as high as 96% can be achieved in buck mode. Further efficiency gains are possible in bypass mode where $V_{\text{OUT}}$ connects directly to $V_{\text{IN}}$ through the internal bypass P-Channel MOSFET, which has an on-state resistance of 0.08Ω for the LTC3408 and 0.20Ω for the LTC3403. The LTC3403 includes a gate driver for controlling an external bypass MOSFET, providing even higher efficiency in this mode.

The regulators employ a constant frequency, current mode architecture. In forced continuous mode, they switch at 1.5MHz, permitting the use of low inductor values. Because smaller case sizes are usually offered for lower inductor values, the overall solution size is reduced. Minimal output voltage ripple is generated, since output voltage ripple is inversely proportional to the high switching frequency. Below output voltages of 0.6V, the frequency decreases linearly to 700KHz, allowing the output to reach 0.3V. In practice, the output ripple voltage is just 10mV–15mV throughout the range of output voltages.

The LTC3403 can be configured for either Burst Mode® operation or forced continuous mode. Burst Mode operation provides high efficiency and extends battery life by reducing gate charge loss at light loads. Forced continuous mode is not as efficient at light loads but it offers lower output voltage ripple in noise-sensitive applications. With no load, the LTC3403 consumes as little as 20µA in Burst Mode; both the LTC3403 and the LTC3408 draw less than 1µA in shutdown.

Because the LTC3408 uses only an internal bypass PFET and runs only in forced continuous mode, two extra terminals are available to halve the $I^2R$ losses associated with the $V_{\text{IN}}$ and $V_{\text{OUT}}$ bonding wires leading to this PFET. With all power switches contained within the device, current comparators are available to provide short-circuit protection to the main and bypass PFETs. In the presence of a short from $V_{\text{OUT}}$ to ground, the bypass PFET will immediately turn off.

Figure 1. WCDMA transmitter power supply

Figure 2. The circuit in Figure 1 (left) and an equivalent low profile version (right), which uses components with a maximum height of 1.1mm

continued on page 35
The LTC3459's operation in this application depends on the levels of \( V_{IN} \) and \( V_{OUT} \). When \( V_{OUT} \) is less than approximately 3.5V, the body of the internal synchronous P-channel MOSFET rectifier is connected to \( V_{IN} \) (forming a PNP transistor) and the SW pin rises a \( V_{BE} \) above \( V_{IN} \) when current is delivered to the load. While efficiency is lower in this mode of operation, current to the SuperCap is controlled, preventing any damaging effects of inrush current. When \( V_{OUT} \) is greater than 3.5V, normal boost mode operation and efficiency begin, with the P-channel MOSFET acting as a synchronous switch. Average input current is approximately 50mA during charging, while the current delivered to the SuperCap varies somewhat with duty cycle. Once the SuperCap is charged to 5V, the LTC3459 begins to regulate and the input current is reduced to the amount required to support the load and/or self discharge of the SuperCap.

**Conclusion**

The LTC3459 simplifies and shrinks the traditional boost converter without compromising flexibility and efficiency. The device itself takes care of typically challenging boost converter design issues such as output disconnect, inrush current limiting, and short circuit protection. The LTC3459’s wide input voltage range makes it compatible with many different battery sources, and its output voltage can be programmed to satisfy the requirements of a wide variety of applications.

---

**Notes**

1. \( L = \text{Sumida CDRH2D11 2.2\( \mu \text{H} \)} \)
2. \( C_{IN} = 2\times \text{TDK C1608X5ROJ475M} \)
3. \( C_{OUT} = \text{TDK C1608X5ROJ475M} \)