500mA Output Current Low Noise Dual Mode Charge Pump

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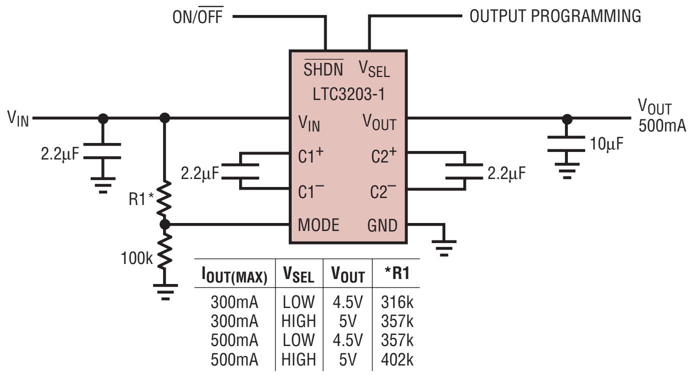
Introduction

Charge pump (inductorless) DC/DC converters are popular in space-constrained applications with low to moderate load current (10mA–500mA) requirements. The devices in the LTC3203 family are low noise, high efficiency regulating charge pumps that can supply up to 500mA of output current from a single 2.7V to 5.5V supply. The LTC3203-1 and LTC3203B-1 produce a selectable fixed 4.5V or 5V output. The LTC3203B produces an adjustable output voltage. The LTC3203-1 features automatic Burst Mode operation at light load to achieve low supply current whereas the LTC3203B and LTC3203B-1 operate at constant frequency to minimize both input and output noise. High switching frequency (1MHz) makes it possible to use only four tiny low cost ceramic capacitors and two resistors for operation. The device also has two user selectable conversion modes for optimizing the efficiency of the charge pump. Additional features include low shutdown current (<1µA), soft-start at power-on and short circuit protection. The LTC3203 family is available in a 10-lead thermally enhanced DFN package, making it possible to build a complete converter in less than $0.04in^2$. A typical application circuit is shown in Figure 1.



$I_{OUT(MAX)}$	V_{SEL}	V_{OUT}	*R1
300mA	LOW	4.5V	316k
300mA	HIGH	5V	357k
500mA	LOW	4.5V	357k
500mA	HIGH	5V	402k

Figure 1. Typical application

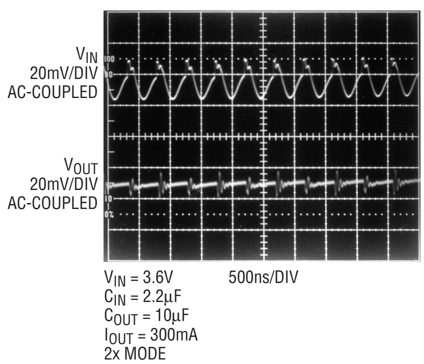


Figure 3. Input and output noise in 2× mode

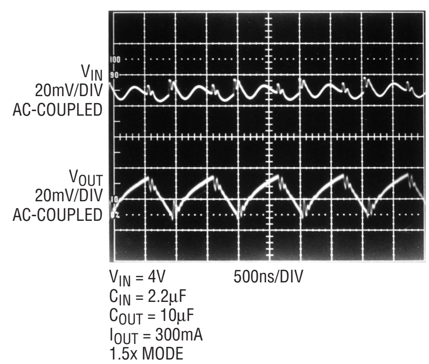


Figure 2. Input and output noise in 1.5× mode

Low Noise Operation

The constant frequency architecture achieves regulation by sensing the output voltage and regulating the amount of charge transferred per cycle. This method of regulation provides much lower input and output voltage ripple than that of burst mode regulated switched capacitor charge pumps. The LTC3203B and LTC3203B-1 make filtering input and output noise less demanding than burst mode switched capacitor charge pumps where switching frequencies depend on load current and can range over several orders of magnitude. The charge pump operates on two phases, where a break-before-make circuit prevents switch cross-conduction. The higher frequency noise due to the non-overlap "notches" is easily filtered by a small input capacitor and PCB parasitic inductance. Figures 2 and 3 shows the low input and output ripple with a 300mA load. The device is powered from a 3.6V input and produces a regulated 4.5V output. The input voltage source has 0.1Ω impedance.

Dual Mode Conversion

The LTC3203 family offers both 1.5× and 2× boost modes—selected by the mode pin. In the 2× mode, the chip works as a dual-phase regulated voltage doubler. The flying capacitors are charged on alternate clock phases from V_{IN}. While one capacitor is being charged from V_{IN}, the other is stacked on top of V_{IN} and connected to the output. The two flying capacitors operate out of phase to minimize both input and output ripple. Alternatively, in 1.5× mode, it uses a split-capacitor technique rather than doubling. The flying capacitors are charged in series during the first clock phase, and stacked in parallel on top of V_{IN} on the second clock phase. With this technique, the input current is reduced from more than twice the load current to just over 1.5 times the load current, resulting in approximately 25% less input current than what would be required for operating in 2× mode charge pump to drive the same load. Therefore, the efficiency at higher V_{IN} is increased to approximately 90% with V_{IN} at somewhere between 3V and 4V. Figure 4 shows the conversion efficiency at 300mA load current for 4.5V V_{OUT} and 5V V_{OUT}, respectively.

The conversion mode should be chosen based on considerations of efficiency, available output current and V_{OUT} ripple. With a given V_{IN}, the 1.5× mode gives a higher efficiency at lower available output current. The 2× mode gives a higher available output current at lower efficiency. Moreover, the output voltage ripple in the 2× mode is lower due to the out-of-phase operation of the two flying capacitors. Typically, at low V_{IN}, the 2× mode should be selected, and at higher V_{IN}, the 1.5× mode should be selected.

The MODE pin has a precision comparator. By connecting a resistive divider from V_{IN} to the MODE input pin, the user can accurately program

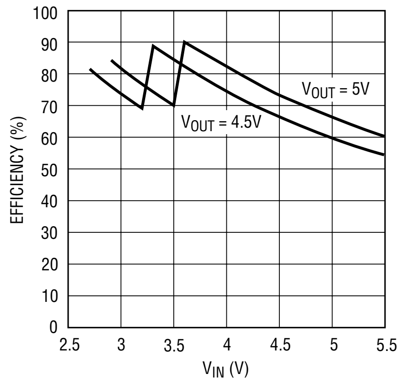


Figure 4. Efficiency vs V_{IN} at 300mA load current

the V_{IN} threshold at which the charge pump will switch from 1.5× mode to 2× mode as V_{IN} falls and vice versa. The 10% hysteresis on the MODE pin prevents the chip from hunting between the two modes.

Conclusion

With low operating current, low external parts count and robust protection features, the LTC3203 family is well suited for low power step-up/step-down DC/DC conversion. The shutdown, dual mode conversion, selectable output voltage and low noise operation features provide additional value and functionality. The simple and versatile LTC3203 family is ideal for moderate power DC/DC conversion applications.

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power than a slot with a 20% accurate circuit breaker.

Detect Insertion Events via the $\overline{\text{ENABLE}}$ Pin

The $\overline{EN}$ pin can be used to sense the insertion of a board when the LTC4215 is used in backplane resident application. A short pin on the connector pulls $\overline{EN}$ to ground once the other, longer pins have already been connected. Once the $\overline{EN}$ pin crosses its falling 1.107V threshold the LTC4215 turns on the external switch after a 100ms debounce delay. Because a falling edge on the $\overline{EN}$ pin corresponds to the insertion of a new board, the LTC4215 clears the fault register (except for the $\overline{EN}$ Changed State bit) so that a previously recorded fault does not prevent the new board from starting up. Whenever the $\overline{EN}$ pin rises or falls, the $\overline{EN}$ Changed State bit in the FAULT register is set to indicate that a board has either been inserted or removed. A STATUS register bit contains the complement of the state of the $\overline{EN}$ pin to indicate if a board is present. When the board is unplugged, the short $\overline{EN}$ pin is the first to disconnect. The $\overline{EN}$ pin pulls up with an internal 10µA current source until the voltage reaches the rising 1.235V threshold, at which point the external switch is turned off with a 1mA current.

Conclusion

The LTC4215 is a smart power gateway for hot swappable circuits. It provides fault isolation, closely monitors the health of the power path and provides an unprecedented level of control over the inrush current profile. It logs faults, provides real-time status information, and can interrupt the host if necessary. Meanwhile an internal 8-bit ADC continuously monitors board current and voltages. These features make the LTC4215 an ideal power gateway for high availability systems.

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DC/DC converter may be dynamically programmed by sourcing or sinking

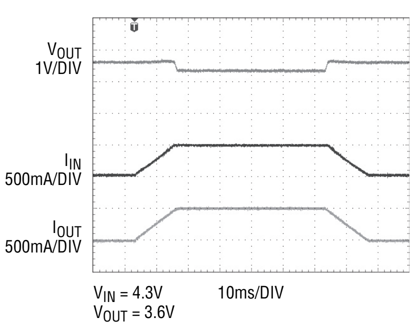

Figure 10. As load increases, the input current is clamped to 500mA using the circuit of Figure 9

current at the FB node. Referring to Figure 9, the equation for the input current clamp level is:

$$I_{CLAMP} = \frac{1.22V}{R3} \bullet \frac{R1}{R2}$$

Figure 10 shows V_{OUT} dropping when input current reaches 500mA as the load increases. In USB applications where the input voltage is nominally 5V, a Schottky diode is used to limit peak voltages on the SW1 pin.

Conclusion

Linear Technology's new LTC3532 synchronous buck-boost converter simplifies the design of Lithium-Ion or multi-cell powered handheld electronics. With a highly efficient automatic Burst Mode operation, the converter maximizes battery life in portable devices with widely varying load requirements. Soft start, programmable switching frequency and external compensation make the LTC3532 suitable to a wide variety of applications. Two package options, an MS10 leaded package and a 3mm × 3mm DFN, plus the ability to operate efficiently at high frequency, enable the designer to minimize board area and component height.