

DESIGN NOTES

New Charge Pumps Offer Low Input and Output Noise

Design Note 243

Sam Nork

Charge pump (inductorless) DC/DC converters are quite popular in space-constrained applications where low to moderate load currents must be supplied. Such converters are available in small packages, operate with very low quiescent current and require minimal external components. However, noise generation is one undesirable characteristic of most charge pumps.

Unwanted noise can create a variety of problems. Noise generated at the power input can interfere with RF transmission and reception in wireless applications. Noise at the output can couple onto sensitive circuits or even create audible noise. The new LTC[®]3200 family of boost charge pumps employs a new architecture designed to minimize noise at the input and output to mitigate such unwanted behavior.

Burst Mode™ Operation vs Constant Frequency

Most regulating charge pump DC/DC converters operate using a Burst Mode architecture. Such regulator architectures provide the lowest quiescent current, but generate the highest levels of both input and output noise. With Burst Mode parts, the charge pump switches are either delivering maximum current to the output or are turned off completely. A hysteretic comparator and reference control the turn-on and -off of the charge pump to provide output regulation. Low frequency ripple appears at the output and is required for regulation (see Figure 1). This bursting on and off also results in large input ripple current that must be supplied by the input source. Any impedance in the input source creates voltage noise at the input. This noise must then be rejected by the rest of the circuitry powered from the same source.

The LTC3200 and LTC3200-5 have been designed to minimize both input and output noise. These parts are regulating boost charge pumps that can supply up to 100mA of output current. The LTC3200-5 produces a regulated 5V output and is available in a 6-lead SOT-23 package. The LTC3200 produces an adjustable output voltage and is available in an 8-lead MSOP package. Both parts use a constant-frequency architecture that

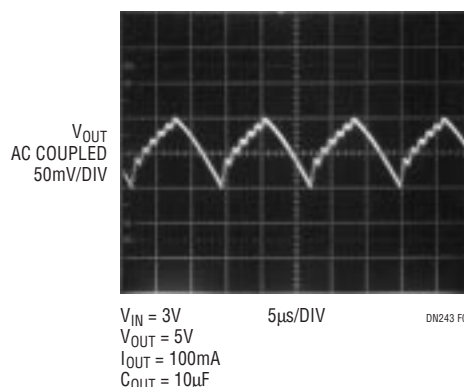


Figure 1. Typical Burst Mode Output Ripple

eliminates low frequency output noise. Charge pump switching is continuous, even with no load, and a linear control loop regulates the amount of charge transferred to the output on each clock cycle. Since the output regulation loop is linear, the peak-to-peak output ripple can be approximated as $V_{RIPPLE} = (I_{LOAD}/C_{OUT}) / (2 \cdot f_{OSC})$, with no additional ripple due to regulator hysteresis.

The parts' 2MHz oscillator frequency allows low output ripple to be achieved even with small output capacitors. Figure 2 illustrates the output ripple achievable with the LTC3200-5 supporting a 100mA load with different values of output capacitance.

LTC and LT are registered trademarks of Linear Technology Corporation. Burst Mode is a trademark of Linear Technology Corporation.

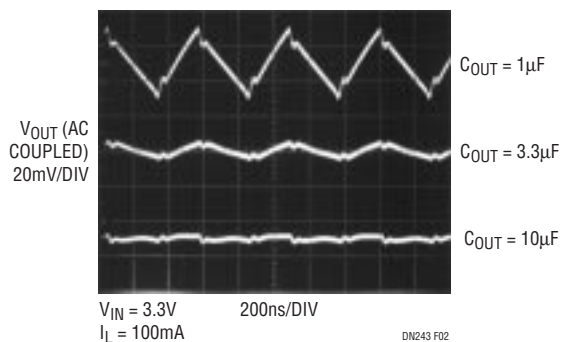
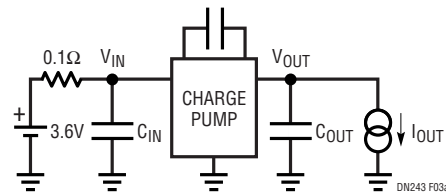


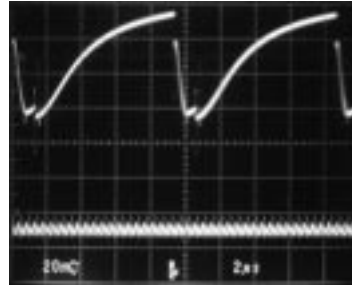
Figure 2. LTC3200-5 Output Ripple

Input Noise Reduction

Although constant frequency generation alone provides substantial input noise improvement, the LTC3200 family goes one step further. A unique internal control circuit regulates the input current on both phases of the charge pump clock. This technique prevents RC current decay during one or both half-clock cycles of the charge pump oscillator, thereby minimizing the input-referred ripple due to changing input current. Figure 3 shows the difference in input noise between the LTC3200 and a typical Burst Mode charge pump. Both parts are shown producing a regulated 5V output at 100mA of output current from a 3.6V input. 0.1Ω of input impedance is used for testing purposes. The typical Burst Mode part uses 10μF ceramic capacitors at both the input and the output. The LTC3200 uses 1μF ceramic caps of the same dielectric. As shown in Figure 3, significant improvements in input noise are achieved with the LTC3200—even with one-tenth the bypass capacitance.



V_{IN} , Burst Mode
CHARGE PUMP
 $I_{OUT} = 100\text{mA}$
 $C_{IN} = C_{OUT} = 10\mu\text{F}$
20mV/DIV



V_{IN} , LTC3200
 $I_{OUT} = 100\text{mA}$
 $C_{IN} = C_{OUT} = 1\mu\text{F}$
20mV/DIV

DN243 F03b

Figure 3. Input Noise Test Circuit

Typical Applications

Charge pumps are commonly used to provide low power boost conversion inside handheld devices such as cellular phones and PDAs. Such devices, particularly those which contain RF communication, tend to be very sensitive to noise. A popular application for a low noise charge pump in such products is powering white LEDs used for back-

lighting a small color LCD display. The circuit shown in Figure 4 produces a low noise boosted supply for driving up to six white LEDs. The LTC3200's FB pin is used to regulate the LED current flowing through each ballasted LED. By using the LTC3200, the user can provide boosted power to the backlight circuit directly from the battery without the cumbersome problem of filtering low frequency noise.

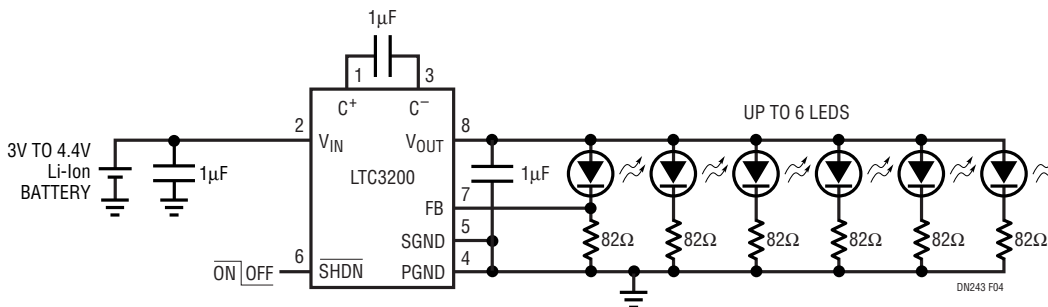


Figure 4. Low Noise White LED Driver with LED Current Control

Data Sheet Download

<http://www.linear-tech.com/go/dnLTC3200>

For literature on our Charge Pumps,
call **1-800-4-LINEAR**. For applications help,
call (408) 432-1900, Ext. 2377