advertisement

DESIGN NOTES

LT1307 Single-Cell Micropower Fixed-Frequency DC/DC Converter Needs No Electrolytic Capacitors – Design Note 128

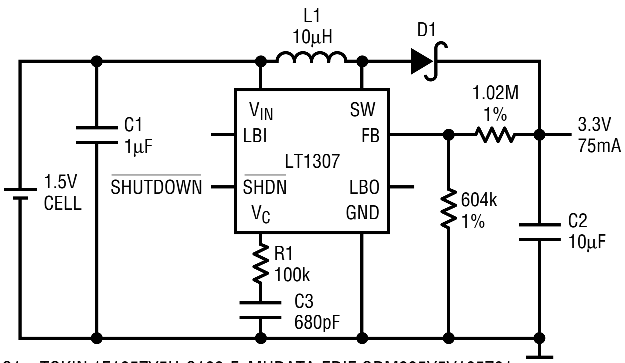
Steve Pietkiewicz

Today's low power boost converter ICs have been rejected by designers of products incorporating RF communications for two reasons. First, the converters use some form of variable-frequency control to maintain acceptable efficiency during periods of light load. Significant spectral energy in the sensitive 455kHz band can occur, introducing difficult interference problems with the system's IF amplifier. Second, large output capacitors are required to keep output ripple voltage at an acceptable level. Most battery-powered products have neither the space nor budget for the D-case size tantalum capacitor usually required. The LT®1307 current mode PWM switching regulator eliminates these concerns by using small, low cost ceramic capacitors for both input and output and by employing fixed frequency 575kHz operation to keep spectral energy out of the 455kHz band. Dense high speed bipolar process technology enables the LT1307 to fit in the subminiature MSOP package. The LT1307 consumes just 60µA at no load and includes a low-battery detector comparator with a 200mV reference voltage. The internal power switch is rated at 500mA with a V_{CESAT} of 300mV.

Single-Cell Boost Converter

A complete single cell to 3.3V converter is shown in Figure 1. The circuit generates 3.3V at up to 75mA from a 1V input. The 10µF ceramic output capacitor can be obtained from several vendors. Efficiency, detailed in Figure 2, exceeds 70% over the 1:500 load range of 200µA to 100mA at a 1.25V input. Figure 3 shows output voltage and inductor current as the load current is stepped from 5mA to 55mA. The oscillograph reveals substantial detail about the operation of the LT1307. With a 5mA load, V_{OUT} (top trace) exhibits a ripple voltage of 60mV at 4kHz. The device is in Burst Mode™ operation at this output current level. Burst Mode operation enables the converter to maintain high efficiency at light loads by turning

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



C1 = TOKIN 1E105ZY5U-C103-F, MURATA-ERIE GRM235Y5V105Z01
C2 = TOKIN 1E106ZY5U-C304-F, MURATA-ERIE GRM235Y5V106Z01
D1 = MOTOROLA MBR0520
L1 = SUMIDA CD43-100

Figure 1. Single Cell to 3.3V Boost Converter Delivers 75mA at a 1V Input

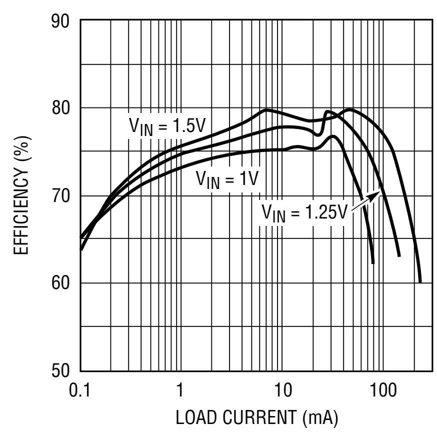


Figure 2. 3.3V Converter Efficiency

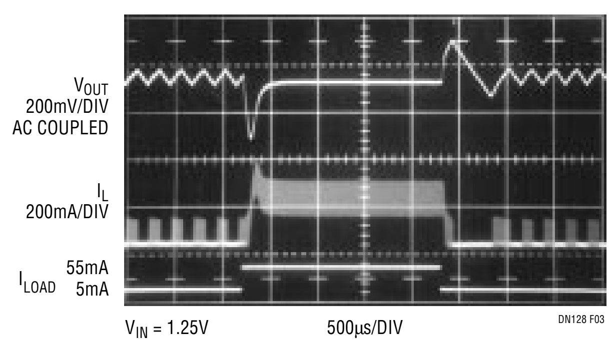


Figure 3. Transient Response with 5mA to 55mA Load Step

Circle No. 195

off all circuitry inside the LT1307 except the reference and error amplifier. When the LT1307 is not switching, quiescent current decreases to 60µA. When switching, inductor current (middle trace) is limited to approximately 100mA. Switching frequency inside the "bursts" is 575kHz. As the load is stepped to 55mA, the device shifts from Burst Mode operation to constant switching mode. Inductor current increases to about 300mA peak and the low frequency Burst Mode ripple goes away. R1 and C3 stabilize the loop.

455kHz Noise Considerations

Switching regulator noise is a significant concern in many communication systems. The LT1307 is designed to keep noise energy out of the 455kHz band at all load levels while consuming only 60µW to 100µW at no load. At light load levels, the device is in Burst Mode operation, causing low frequency ripple to appear at the output. Figure 4 details spectral noise directly at the output of Figure 1's circuit in a 1kHz to 1MHz bandwidth. The converter supplies a 5mA load from a 1.25V input. The Bust Mode fundamental at 5.1kHz and its harmonics are quite evident, as is the 575kHz switching frequency. Note, however, the absence of significant energy at 455kHz. Figure 5's plot reduces the frequency span from 255kHz to 655kHz with a 455kHz center. Burst Mode low frequency ripple creates sidebands around the 575kHz switching fundamental. These sidebands have low signal amplitude at 455kHz, measuring $-55dBmV_{RMS}$. As load current is further reduced, the Burst Mode frequency decreases. This spaces the sidebands around the switching frequency closer together, moving spectral energy further away from 455kHz. Figure 6 shows the noise spectrum of the converter with the load increased to 20mA. The LT1307 shifts out of Burst Mode operation eliminating low frequency ripple. Spectral energy is present only at the switching fundamental and its harmonics. Noise voltage measures $-5dBmV_{RMS}$ or $560\mu V_{RMS}$ at the 575kHz switching frequency, and is below $-60dBmV_{RMS}$ for all other frequencies in the range. By combining Burst Mode operation with fixed frequency operation the LT1307 keeps noise away from 455kHz making the device ideal for RF applications where the absence of noise in the 455kHz band is critical.

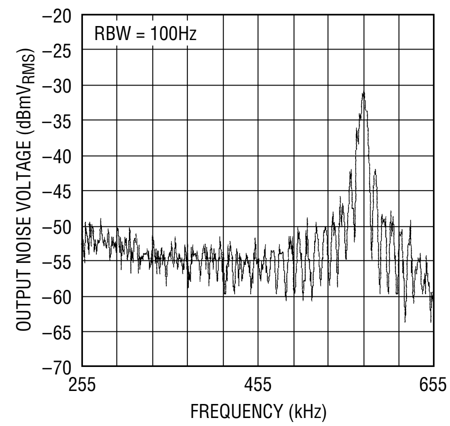


Figure 5. Span Centered at 455kHz Shows $-55dBmV_{RMS}$ ($1.8\mu V_{RMS}$) at 455kHz. Burst Mode Operation Creates Sidebands 5.1kHz Apart About Switching Fundamental of 575kHz

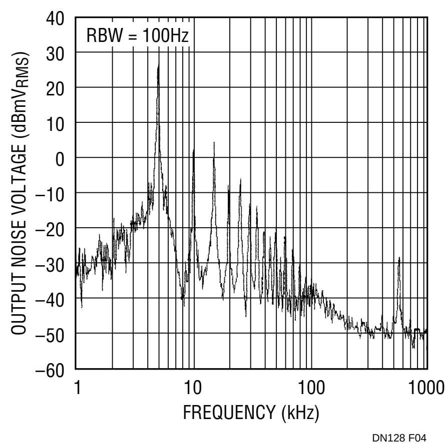


Figure 4. Spectral Noise Plot of 3.3V Converter Delivering 5mA Load. Burst Mode Operation at 5.1kHz is $23dBmV_{RMS}$ or $14mV_{RMS}$. Switching Fundamental at 575kHz is $-31dBmV_{RMS}$ or $28\mu V_{RMS}$

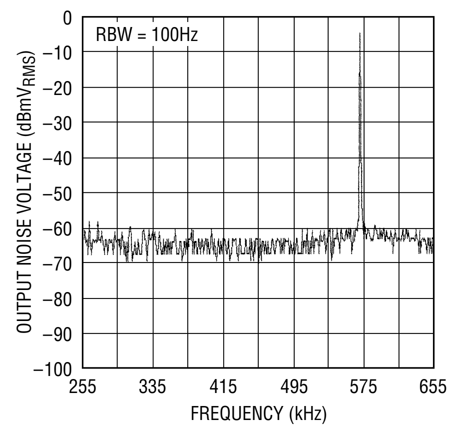


Figure 6. With Converter Delivering 20mA, Low Frequency Sidebands Disappear. Noise is Present Only at the 575kHz Switching Frequency and its Harmonics

For literature on our DC/DC Converters, call **1-800-4-LINEAR**. For applications help, call (408) 432-1900, Ext. 2361

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • TELEX: 499-3977

LT/GP 0496 185K • PRINTED IN THE USA

LINEAR TECHNOLOGY
© LINEAR TECHNOLOGY CORPORATION 1996