

DESIGN NOTES

Ultralow Power Converter's Control Scheme Eliminates Audible Switching Noise – Design Note 1019

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Introduction

An essential component of a noise-free audio device is a clean power supply, but few switching regulators can operate at high efficiency while keeping the switching frequency out of the audio band. The LTC[®]3620 fills this void. It is a high efficiency 15mA buck regulator with a programmable minimum switching frequency, making it possible to virtually eliminate audible switching noise. The internal synchronous switches and low quiescent current of this buck regulator provide the ability to maintain high efficiency, while its small footprint makes it ideal for tiny, low power audio applications.

Operation

To maximize efficiency, the LTC3620 employs a variable frequency architecture that adjusts its switching frequency to match the load current. Of course, a variable frequency scheme is a potential noise problem for an audio device if the switching frequency is allowed to enter the audio spectrum. The LTC3620 avoids this problem by locking its frequency to a user-set minimum value for low load currents. While operating within this lock range, the charge per switching cycle is adjusted to supply the appropriate amount of current. Outside of this range, at higher loads, the switching frequency increases and the charge per pulse is at its maximum value. Similarly, at

extremely light loads, the charge per switching cycle is at its minimum and the frequency decreases to maintain regulation. The load current range for frequency locking is determined by the inductor size and the programmed minimum switching frequency and therefore, may be tailored to the user's specific application.

Most regulators employ burst or pulse-skipping modes to maintain regulation at extremely light loads. These modes, while good for efficiency, suffer from relatively large output voltage ripple and indiscriminately switch in the audio range. Because the LTC3620 reduces the charge per pulse rather than the frequency, it produces low output voltage ripple while maintaining good efficiency and minimizing audio switching noise. Figure 1 shows a typical application with output ripple and efficiency.

Selecting the Minimum Switching Frequency

An internal set 50kHz clock can be used by setting FMIN/MODE to 0V. Alternatively, the user can apply the minimum frequency clock to the FMIN/MODE pin. For applications that are not sensitive to audio noise, the frequency clamp can be defeated by setting the FMIN/MODE pin high. In this mode the charge per switching cycle is constant and there is no lock range, as shown in Figure 2.

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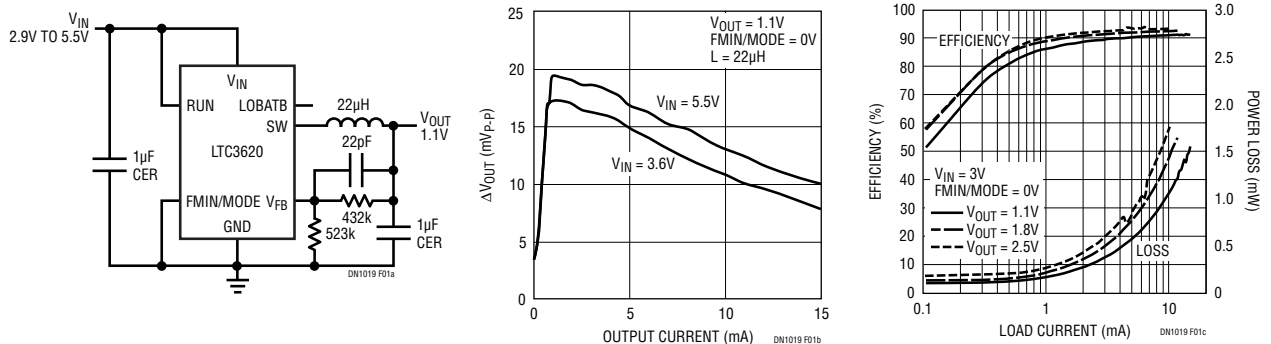


Figure 1. Typical LTC3620 Application Circuit and Associated V_{OUT} Ripple, Efficiency and Power Loss

During load step transients within the lock range, the frequency momentarily deviates from its locked value. At the same time, the charge per switching cycle adjusts to bring

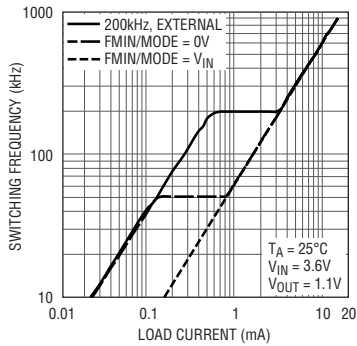


Figure 2. Switching Frequency Drops with Decreasing Load But Stays Constant at a Preset Frequency. Only at Very Light Loads Does the Switching Frequency Continue to Drop

the switching frequency back to the desired value. This allows for better load regulation during load steps. During transients outside of the lock range, only the frequency adjusts. Figure 3 shows typical switching characteristics and the spectral content of V_{OUT} while in the lock range.

Additional Features

The LTC3620 is equipped with a soft-start circuit to ensure smooth start-up transients. A low battery detector

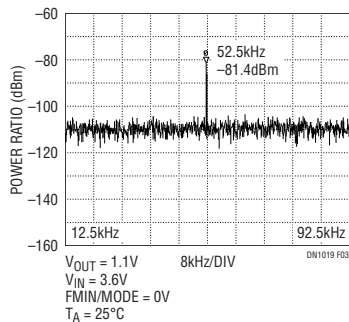


Figure 3. Switching Waveform with 1mA Load and Its Corresponding Spectral Content

provides a warning when the input voltage falls below 3.0V. An undervoltage lockout is also included to prevent battery damage by turning off the part when the input voltage falls below 2.8V.

Li-Ion to 1.1V/15mA

Figure 4 shows the LTC3620 converting a Li-Ion battery or USB input (2.9V–5.5V) to a 1.1V output at 15mA. The synchronous switches are internal to the part, which increases efficiency and eliminates the need for external Schottky diodes. The V_{FB} voltage is servoed to a 0.6V

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reference, making low output voltages possible. A fixed output version, the LTC3620-1, uses internal feedback resistors to set a 1.1V output, reducing the number of external components as well as the solution footprint.

Small Solution Size Using 0603 SMT Package Inductor

For minimum size, Figure 4 shows the LTC3620-1 (1.1V fixed output version) operating with only an inductor, an input capacitor and an output capacitor. The feedback resistors and compensation are internal to the IC, and the use of the low battery detect pull-up resistor is optional. If greater efficiency is required, other slightly larger inductors with lower ESRs may be used. One such inductor is shown in Figure 5 along with an efficiency comparison between the 0603 and the larger inductor.

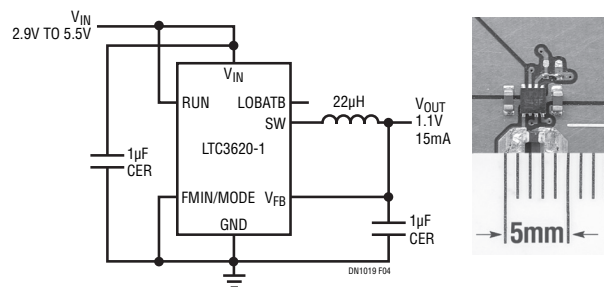


Figure 4. Schematic and Layout for LTC3620-1 Minimum Solution Size

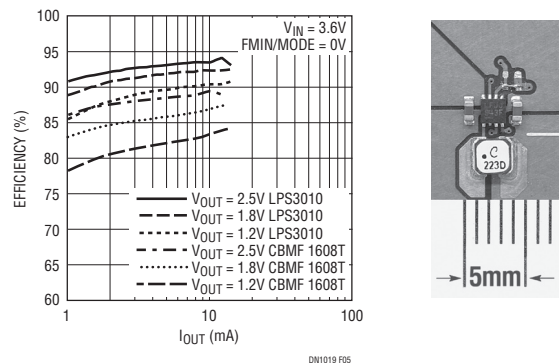


Figure 5. Larger Inductor Layout and Inductor-Dependent Efficiency Comparison

Conclusion

The LTC3620 combines two usually mutually exclusive features—high efficiency at light loads and the ability to minimize switching noise in the audio frequency range—making it ideal for low power audio applications. A complete power solution consumes minimal space because of the LTC3620's 2mm × 2mm package and need for very few external parts, all of which are available in the extremely compact 0603 component size.

For applications help,
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