Save Board Space with a High Efficiency Dual Synchronous, 400mA/800mA, 2.25MHz Step-Down DC/DC Regulator

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Introduction

The ever shrinking nature of cell phones, pagers, PDAs and other portable devices drives a corresponding demand for smaller components. One way to shrink DC/DC regulator circuitry is to increase the switching frequency of the regulator, thus allowing the use of smaller and cheaper capacitors and inductors to complete the circuit. Another way is to combine the switcher and MOSFETs in one small, monolithic package. The LTC3548 DC/DC regulator does both.

The LTC3548 is a 10-lead MSOP/DFN, dual, synchronous, step-down, current mode, DC/DC regulator, intended for low power applications. It operates within a 2.5V to 5.5V input voltage range and has a fixed 2.25MHz switching frequency, making it possible to use low-profile capacitors and inductors that are only 1mm high. The LTC3548 is the latest in the LTC3407 and LTC3407-2 family of dual regulators and features an improved Burst Mode ripple and two outputs of 400mA and 800mA. It is available in small MSOP and DFN packages, allowing two DC/DC Regulators to occupy less than 0.2 square inches of board real estate, as shown in Figure 1.

Figure 1. Two DC/DC regulators occupy less than 0.2in² of board space

The outputs of the LTC3548 are independently adjustable from 0.6V to 5V. For battery-powered applications that have input voltages above *and* below the output voltage, the LTC3548 can be used in a single inductor, positive buck-boost converter configuration (see data sheet for details). Two built in 0.35Ω switch provides high efficiency at maximum output current. Internal compensation minimizes external components and board space.

Efficiency is extremely important in battery-powered applications, and the LTC3548 keeps efficiency high with an automatic, power saving Burst Mode operation, which reduces gate charge losses at low load currents. With no load, both converters together draw only 40µA, and in shutdown, the device draws less than 1µA, making it ideal for low current applications. The LTC3548 features an improved Burst Mode ripple voltage, which is only about one third of the ripple for the LTC3407 and LTC3407-2, as shown in Figure 2 and Figure 3.

The LTC3548 uses a current-mode, constant frequency architecture that benefits noise sensitive applications. Burst Mode is an efficient solution for low current applications, but sometimes noise suppression is a higher priority. To reduce noise problems, a pulse-skipping mode is available, which decreases the ripple noise at low currents. Although not as efficient as Burst Mode at low currents, pulse-skipping mode still provides high efficiency for moderate loads, as seen in Figure 4. In dropout, the internal

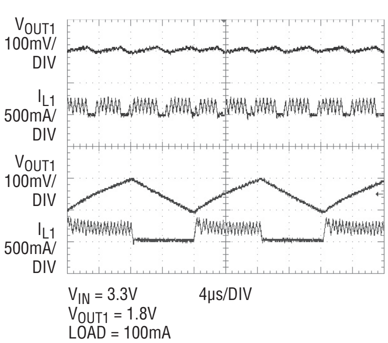

Figure 2. Comparison of ripple for Burst Mode operation of the LTC3548 and LTC3407-2.

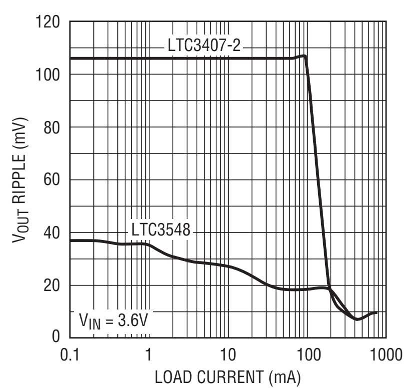

Figure 3. Burst Mode operation output voltage ripple vs load current for the LTC3548 and LTC3407-2.

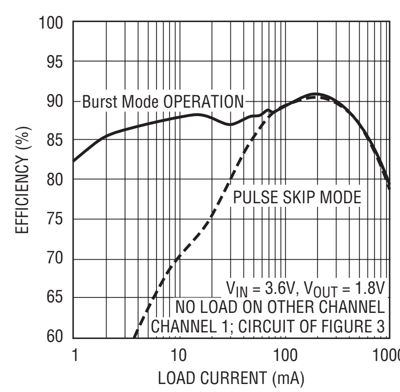

Figure 4. Efficiency of Burst Mode operation and pulse skip mode

P-channel MOSFET switch is turned on continuously, thereby maximizing the usable battery life.

A Power-On Reset output is available for microprocessor systems to insure proper startups. Internal overvoltage and undervoltage comparators on both outputs will pull the $\overline{POR}$ output low if the output voltages are not within ±8.5%. The $\overline{POR}$ output is delayed by 262,144 clock cycles (about 175ms) after achieving regulation, but will be pulled low immediately when either output is out of regulation.

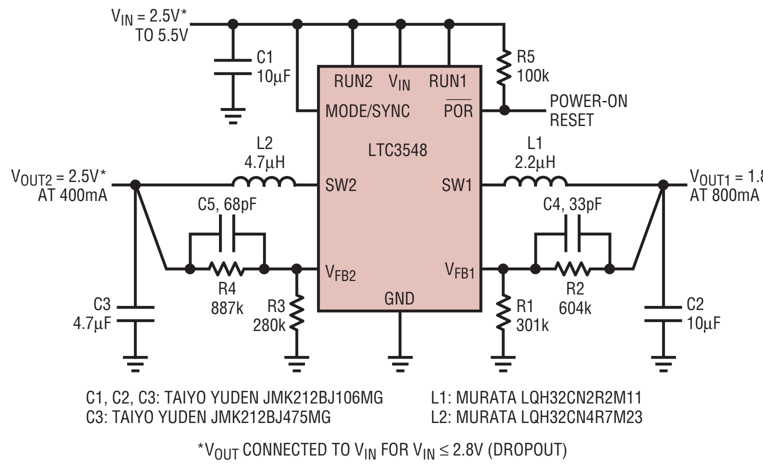

Figure 5. Dual output step-down application yields 1.8V at 800mA and 2.5V at 400mA.

A High Efficiency 2.5V and 1.8V Step-Down DC/DC Regulator with all Ceramic Capacitors

The low cost and low ESR of ceramic capacitors make them a very attractive choice for use in switching regulators. In addition, ceramic capacitors have a benign failure mechanism unlike tantalum capacitors. Unfortunately, the ESR is so low that it can cause loop stability issues. A solid tantalum capacitor's ESR generates a loop zero at 5kHz–50kHz that can be instrumental in giving acceptable loop phase margin. Ceramic capacitors, on the other hand, remain capacitive to beyond 300kHz and usually resonate with their ESL before the ESR becomes effective. Also, inexpensive ceramic capacitors are prone to temperature and voltage effects, requiring the designer to check loop stability over the operating temperature range. For these reasons, great care is usually needed when using only ceramic input and output capacitors. The LTC3548 was designed with ceramic capacitors in mind and is internally compensated to handle these difficult design considerations. High quality X5R or X7R ceramic capacitors should be used to minimize the temperature and voltage coefficients.

Figure 5 shows a typical application for the LTC3548 using only ceramic capacitors. This circuit provides a regulated 2.5V output and a regulated 1.8V output, at up to 400mA and 800mA, from a 2.5V to 5.5V input.

Conclusion

The LTC3548 is a dual monolithic, step-down regulator that switches at 2.25MHz, minimizing component costs and board real estate requirements for DC/DC regulators. The small size, efficiency, low external component count, and design flexibility of the LTC3548 make it ideal for portable applications.

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can be tuned to 110kHz (maximum f_0 = 800kHz/[0.707 • 10]).

A Tunable Bandpass Filter

The –3dB bandwidth of a second order filter is equal to the center frequency (f_{CENTER}) divided by the Q value (bandwidth = f_{CENTER}/Q). The sensitivity of the second order bandpass filter to the tolerance of the integrator's RC values is proportional to the filter's Q. Typically with a Q ≤ 4, using a ±1% R and a ±5% C for the filter's two integrators is practical for a second bandpass filter. The sensentivity of the second order bandpass filter with Q > 4 increases rapidly for each unit of Q increase and the filter's two integrators should use ±1% RC components.

Figure 4 shows the bandpass filter of Figure 1 tuned from 2kHz to 16kHz using a 2kHz integrator frequency (R = 205k, ±1% and C = 390pF, ±5%) and an LTC6912-2 with gain settings 1, 2, 4, and 8. The tuned center frequencies responses of Figure 4 are 2.73% lower than the design values of 2kHz, 4kHz, 8kHz and 16kHz and equal to the error of the circuit's RC values of the two integrators (measured values of aproximatelly 206k for each R and 403pF for each C). The gain error at 16kHz is due to the filter's f_0 frequency approaching the maximum f_0 for a Q = 4 and a PGA gain equal to 8 (maximum f_0 = 25kHz = 800kHz/{4 • 8]). The maximum f_0 frequency is a function of the gain-bandwidth product of the LTC6912-X op amps.

Other Filter Options

Figure 5 shows an example of a second order notch filter. The notch filter's integrator frequency is 500Hz (1/[2π • 316kΩ • 1000pF]) and with PGA gains 1, 2, 4 and 8 the notch frequency is tuned to 500Hz, 1kHz, 2kHz and 4kHz respectively. Any of the filters discussed above can be made into SPI-tunable fourth order filters by cascading two second order circuits.

Notes

[1] SPI is a synchronous communication protocol using a 3-wire interface between a microprocessor and a peripheral device