

# DESIGN NOTES

## 4-Phase Monolithic Synchronous Boost Converter Delivers 2.5A with Output Disconnect in a 5mm × 5mm QFN Package

Design Note 332

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### Introduction

The LTC<sup>®</sup>3425 is the industry's first 4-phase, monolithic synchronous boost converter. It can start up with as little as 1V and operate with inputs up to 4.5V. The output voltage range is 2.4V to 5.25V, making it well suited for battery-powered applications as well as point-of-load regulation in low voltage systems. The 4-phase architecture allows for an effective switching frequency of up to 8MHz, which in turn reduces output ripple current and peak inductor current by a factor of four (over an equivalent single-phase circuit). This allows the use of small, low cost, low profile inductors and ceramic capacitors even at high load currents.

Integrated output disconnect allows  $V_{OUT}$  to go to 0V in shutdown while eliminating the high inrush current typical of traditional boost converters during start-up.

With 5A peak current capability and an effective switch  $R_{DS(ON)}$  of 40m $\Omega$  (NMOS) and 50m $\Omega$  (PMOS), the LTC3425 is capable of efficiently delivering 2.5A load current from a 0.8mm maximum profile, 32-pin 5mm × 5mm QFN package.

### Multiple Operating Modes Optimize Performance in Different Applications

The LTC3425 can be configured for automatic Burst Mode<sup>®</sup> operation, fixed frequency mode with forced continuous conduction or fixed frequency mode with pulse skipping. Programmable automatic Burst Mode operation is ideal for portable applications, where the load current can vary over a wide range and efficiency is paramount. A quiescent current of just 12 $\mu$ A in

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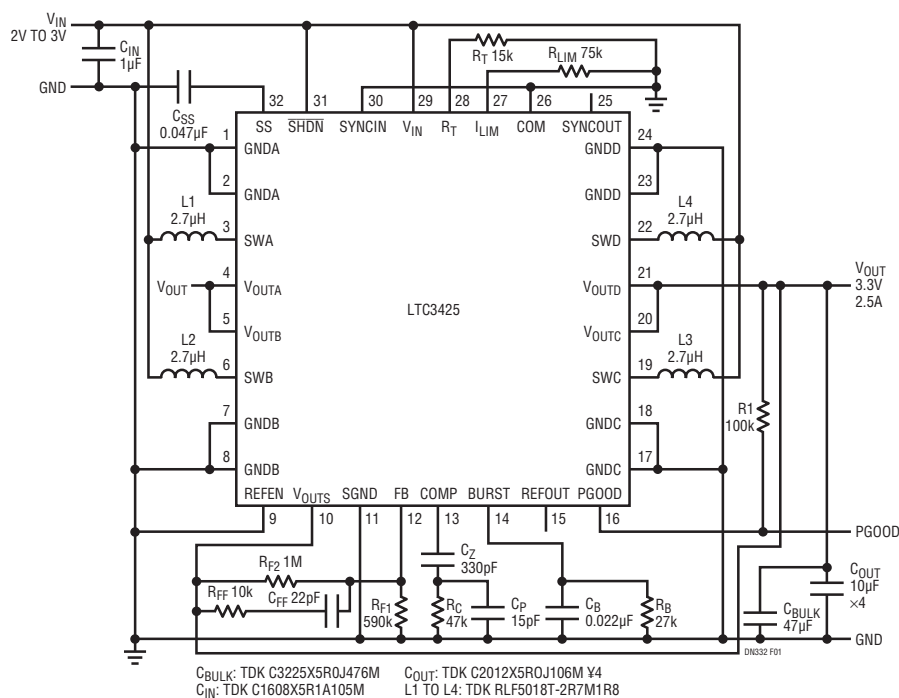


Figure 1. 2-Cell to 3.3V/2.5A Boost Converter

Burst Mode operation extends battery life during light load operation. For noise-sensitive applications fixed frequency mode can be selected, with either forced conduction for low noise at light load or pulse skipping for improved light load efficiency. Quiescent current in shutdown is less than 1 $\mu$ A.

### Fault Protection

The LTC3425 includes short-circuit protection, programmable peak current limit and thermal shutdown.

### High Power and High Efficiency in a Small Package

Figure 1 shows an LTC3425 application using all ceramic capacitors and low profile inductors to deliver 2.5A load current at 3.3V from a 2-cell input ( $V_{IN}$  of 2V to 3V). Maximum component profile is only 2.5mm. In this example, the oscillator frequency is programmed for 4MHz (1MHz/phase), resulting in 10mV<sub>P-P</sub> output ripple at full load (see Figure 2). The burst resistor is selected to automatically transition from Burst Mode operation to fixed frequency mode when the load exceeds 100mA for optimal efficiency (peaking at 96%) over the load range (see Figure 3). No-load input current is only 39 $\mu$ A at 2.4V.

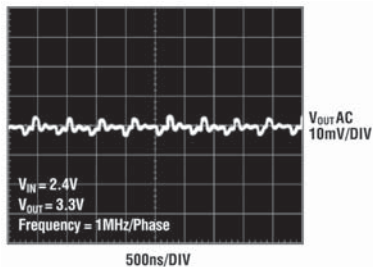


Figure 2. Output Voltage Ripple at 2.5A Load for Converter of Figure 1

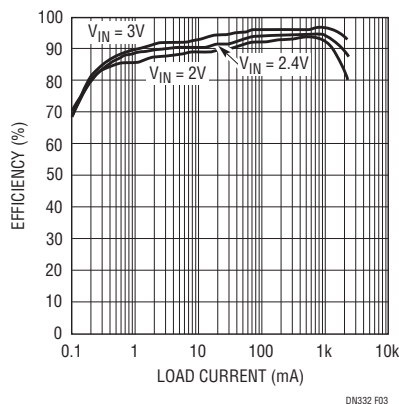


Figure 3. Efficiency vs Load of the Converter in Figure 1

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The current mode architecture results in excellent transient response during a load step (see Figure 4). The use of a small feed-forward RC network across the top feedback resistor provides improved transient response and reduced output ripple in Burst Mode operation, especially when using low output capacitor values. The feed-forward capacitor also compensates for the effect of stray capacitance at the FB pin when using large value feedback resistors.

The open-drain PGOOD output goes low when  $V_{OUT}$  is 11.5% below its regulated value and goes high when  $V_{OUT}$  is within 9% of its regulated value.

### Conclusion

The LTC3425's multiphase architecture makes it possible to deliver high power in a small, low profile package with very low output ripple. It offers features that are demanded in high performance portable applications, including output disconnect, automatic Burst Mode and high efficiency over a wide load range. It also offers flexible design features, including its programmable soft-start, current limit and oscillator frequency, external compensation and multiple available operating modes.

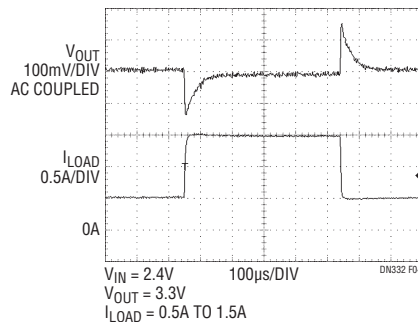


Figure 4. Response of the Circuit in Figure 1 to a 1A Load Step

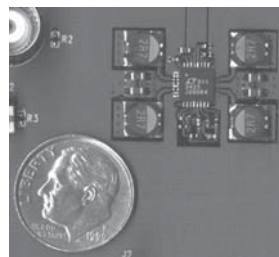


Figure 5. The LTC3425 Can Deliver 10W in a Low Profile 0.7in<sup>2</sup> Footprint

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