

DESIGN NOTES

High Efficiency 4-Switch Buck-Boost Controller Provides Accurate Output Current Limit – Design Note 499

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Introduction

A 4-switch buck-boost converter (Figure 1) is often a better alternative to a transformer-based topology when a converter's input voltage can be above or below the regulated output voltage and isolation is not required. A buck-boost converter provides a wider input voltage range, better efficiency and has no need of a bulky transformer. A buck-boost converter is much more efficient than a comparable SEPIC converter.

The LTC[®]3789 is a buck-boost switching regulator controller that operates in current mode at a constant switching frequency. Current mode control simplifies loop compensation and yields excellent load and line transient response with only small output and input capacitance. Furthermore, an accurate inductor current limit allows use of a small size inductor.

LTC3789 Features

The internal oscillator can be programmed by a resistor, applied voltage, or phase-locked to an external clock within a 200kHz to 600kHz frequency range. The LTC3789's wide 4V to 38V (40V maximum) input and output range and seamless, low noise transitions between operating regions is ideal for automotive, telecom and battery-powered systems. Higher input voltage is easily enabled by adding a high voltage gate driver for the input side MOSFETs, for example the LTC4444-5.

Figure 1 shows a simplified schematic of a buck-boost converter. The LTC3789 controls four external N-channel MOSFETs (A, B, C, D). The power stage uses one inductor (L), and a current sense resistor (R_{SENSE}) for current mode control and inductor current limit. Figures 2 to 4 show the switch waveforms for buck, buck-boost, and boost modes of operation.

The LTC3789 is available in low profile 28-pin 4mm × 5mm QFN and narrow SSOP packages.

12V, 5A Output from a 4V to 38V Input

Figure 5 shows a buck-boost regulator that takes a 4V to 38V input and converts it to a fixed 12V.

The LTC3789 includes two internal series regulators that provide 5.5V for gate drivers and control circuitry. During start-up the current is drawn from V_{IN} (40V maximum rating), but switches to $EXTV_{CC}$ (14V maximum rating) as soon as the voltage on $EXTV_{CC}$ exceeds 4.8V, to decrease power loss.

This 4-switch topology allows the output to be disconnected from the input during shutdown. LTC3789 features adjustable soft-start, no reverse current during start-up and 1% output voltage accuracy.

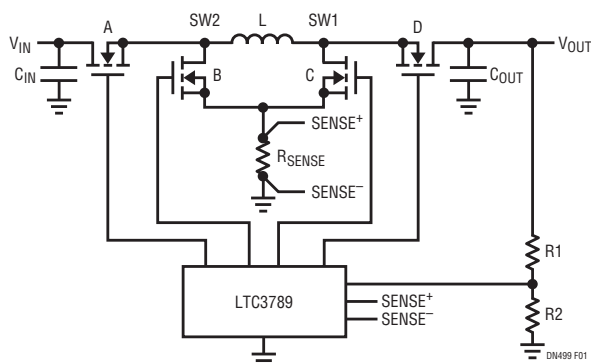


Figure 1. 4-Switch Buck-Boost Converter Using the LTC3789

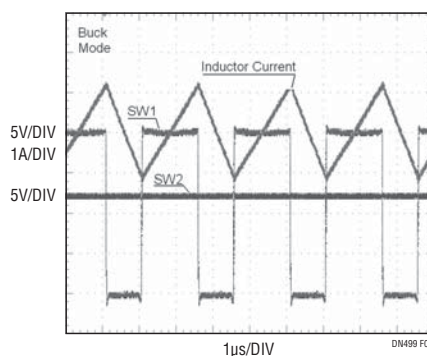


Figure 2. Buck Mode [$V_{IN} = 20V$, $V_{OUT} = 12V$]

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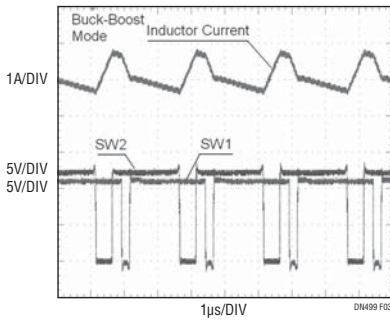


Figure 3. Buck-Boost Mode [$V_{IN} = 11V$, $V_{OUT} = 12V$]

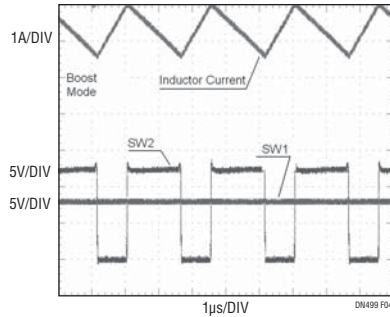


Figure 4. Boost Mode [$V_{IN} = 8V$, $V_{OUT} = 12V$]

The MODE/PLLIN pin can be used to select between pulse-skipping mode and forced continuous mode operation, or allows the IC to be synchronized to an external clock. Pulse-skipping mode offers the lowest ripple at light loads, while forced continuous mode operates at a constant frequency for noise-sensitive applications.

A power good output pin (PGOOD) indicates when the output is within 10% of its set point.

Accurate Output (or Input) Current Limit

The optional output current feedback loop shown in Figure 6 provides support for battery charging and other constant current applications, where an accurate output current limit is essential. The output current limit function provides a constant current characteristic—the output current is limited to a constant level even as the output voltage is pulled down by an overcurrent condition. Alternatively the sense resistor can simply be moved to the input side to accurately control the maximum input current.

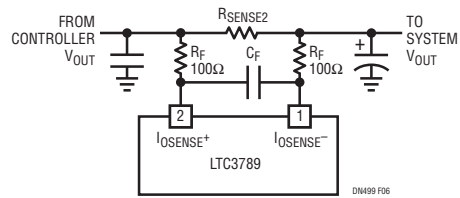


Figure 6. Optional Output Current Limit

Conclusion

The LTC3789 is a constant frequency current mode buck-boost switching regulator controller that accepts a wide 4V to 38V input voltage range. The single inductor topology yields high power density and high efficiency in a compact footprint. Its optional current-limit function is useful for applications such as battery charging, where accurate current control is necessary.

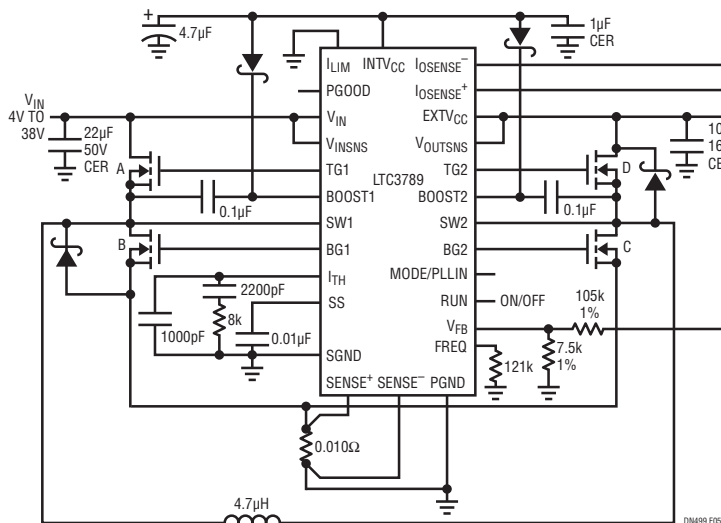
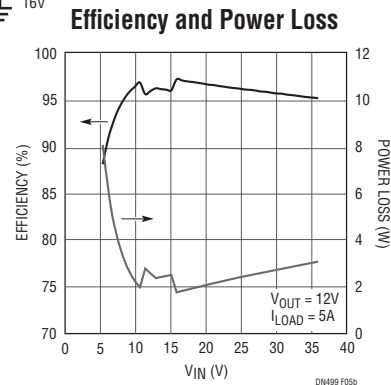


Figure 5. Regulated 12V, 5A Output from a 4V to 38V Input and Associated Efficiency and Power Loss Curves



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