LINEAR TECHNOLOGY

DESIGN NOTES

$15V_{IN}$, 4MHz Monolithic Synchronous Buck Regulator Delivers 5A in 4mm × 4mm QFN – Design Note 467

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Introduction

The LTC®3605 is a high efficiency, monolithic synchronous step-down switching regulator that is capable of delivering 5A of continuous output current from input voltages of 4V to 15V. Its compact 4mm × 4mm QFN package has very low thermal impedance from the IC junction to the PCB, such that the regulator can deliver maximum power without the need of a heat sink. A single LTC3605 circuit can power a 1.2V microprocessor directly from a 12V rail—no need for an intermediate voltage rail.

The LTC3605 employs a unique controlled on-time/constant frequency current mode architecture, making it ideal for low duty cycle applications and high frequency operation. There are two phase-lock loops inside the LTC3605: one servos the regulator on-time to track the internal oscillator frequency, which is determined by an external timing resistor, and the other servos the internal oscillator to an external clock signal if the part is synchronized. Due to the controlled on-time design, the LTC3605 can achieve very fast load transient response while minimizing the number and value of external output capacitors.

The LTC3605's switching frequency is programmable from 800kHz to 4MHz, or the regulator can be synchronized to an external clock for noise-sensitive applications.

Furthermore, multiple LTC3605s can be used in parallel to increase the available output current. The LTC3605 produces an out-of-phase clock signal so that parallel devices can be interleaved to reduce input and output current ripple. A multiphase, or PolyPhase®, design also generates lower high frequency EMI noise than a single-phase design, due to the lower switching currents of each phase. This configuration also helps with the thermal design issues normally associated with a single high output current device.

$1.8V_{OUT}$, 2.25MHz Buck Regulator

The LTC3605 is specifically designed for high efficiency at low duty cycles such as $12V_{IN}$-to-$1.8V_{OUT}$ at 5A, as shown in Figure 1. High efficiency is achieved with a low $R_{DS(ON)}$ bottom synchronous MOSFET switch (35mΩ) and a 70mΩ $R_{DS(ON)}$ top synchronous MOSFET switch.

This circuit runs at 2.25MHz, which reduces the value and size of the output capacitors and inductor. Even with the high switching frequency, the efficiency of this circuit is about 80% at full load.

Figure 2 shows the fast load transient response of the application circuit shown in Figure 1. It takes only 10μs to recover from a 4A load step with less than 100mV of output voltage deviation and only two 47μF ceramic output capacitors. Note that compensation is internal, set up by tying the compensation pin (ITH) to the internal

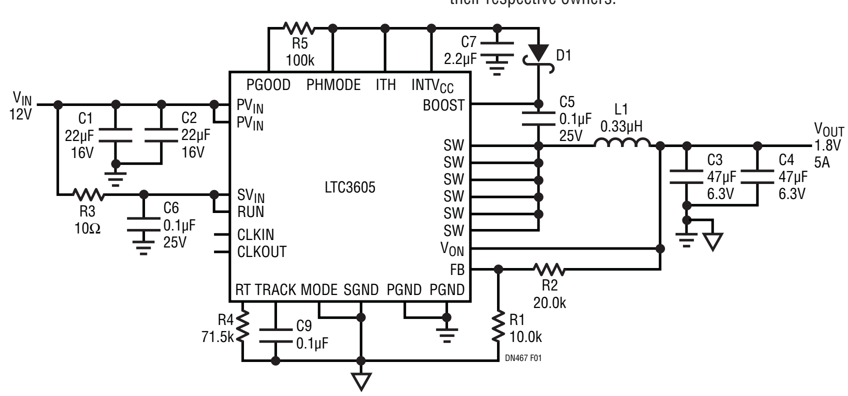

Figure 1. 12V to 1.8V at 5A Buck Converter Operating at 2.25MHz

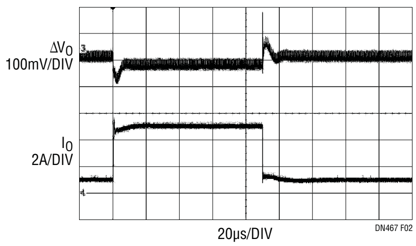

Figure 2. Load Step Response of the Circuit in Figure 1

3.3V regulator rail ($INTV_{CC}$). This connects an internal series RC to the compensation point of the loop, while introducing active voltage positioning to the output voltage: 1.5% at no load and –1.5% at full load. The hassle of using external components for compensation is eliminated. If one wants to further optimize the loop, and remove voltage positioning, an external RC filter can be applied to the ITH pin.

1.2V$_{OUT}$, 10A, Dual-Phase Supply

Several LTC3605 circuits can run in parallel and out of phase to deliver high total output current with a minimal amount of input and output capacitance—useful for distributed power systems.

The 1.2V_{OUT} dual-phase LTC3605 regulator shown in Figure 4 can support 10A of output current. Figure 3 shows the 180° out-of-phase operation of the two LTC3605s. The LTC3605 requires no external clock device to operate up to 12 devices synchronized out of phase—the CLKOUT and CLKIN pins of the devices are simply cascaded,

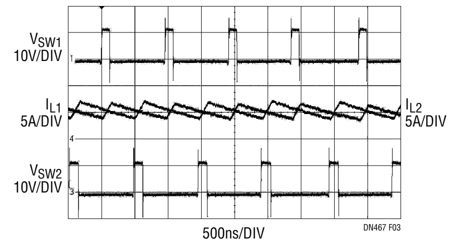

Figure 3. Multiphase Operation Waveforms of the Circuit in Figure 4. The Switch Voltage and Inductor Ripple Currents Operate 180° Out of Phase with Respect to Each Other

where each slave's CLKIN pin takes the CLKOUT signal of its respective master. To produce the required phase offsets, simply set the voltage level on the PHMODE pin of each device to $INTV_{CC}$, SGND or $INTV_{CC}/2$ for 180°, 120° or 90° out-of-phase signals, respectively, at the CLKOUT pin.

Conclusion

The LTC3605 offers a compact, monolithic, regulator solution for high current applications. Due to its PolyPhase capability, up to 12 LTC3605s can run in parallel to produce 60A of output current. PolyPhase operation can also be used in multiple output applications to lower the amount of input ripple current, reducing the necessary input capacitance. This feature, plus its ability to operate at input voltages as high as 15V, make the LTC3605 an ideal part for distributed power systems.

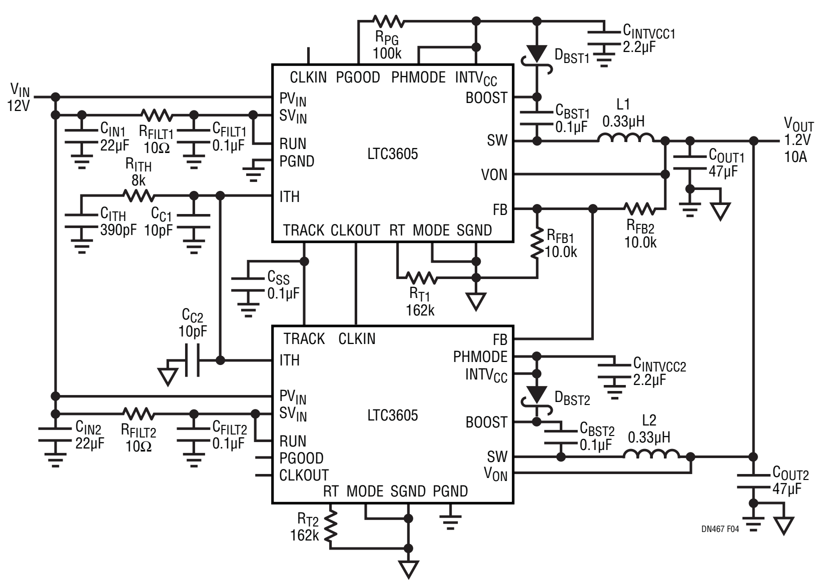

Figure 4. 12V to 1.2V at 10A 2-Phase Buck Converter

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