15V$_{IN}$, 4MHz Monolithic Synchronous Buck Regulator Delivers 5A in 4mm × 4mm QFN

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Introduction

The LTC3605 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.

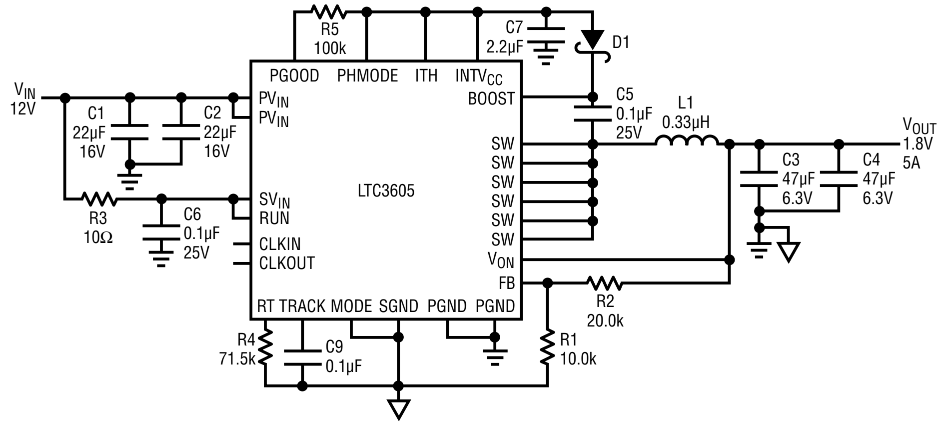

Figure 1. 12V to 1.8V at 5A buck converter operating at 2.25MHz

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 12VIN-to-1.8VOUT 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 3.3V regulator rail (INTV$_{CC}$).

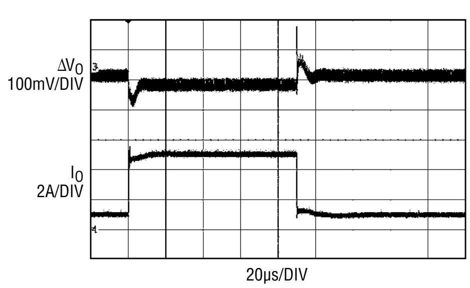

Figure 2. Load step response of the circuit in Figure 1

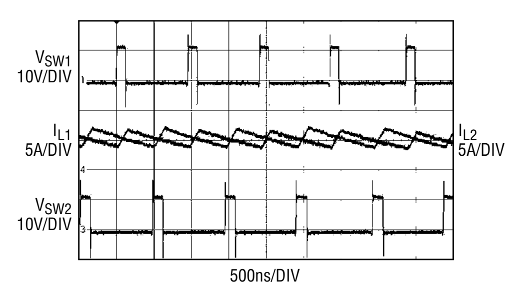

Figure 3. Multiphase operation waveforms of the circuit in Figure 4. The switch voltage and inductor ripple currents operate 180° out of phase with respect to each other.

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, 2-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 $1.2V_{OUT}$ 2-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, 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.

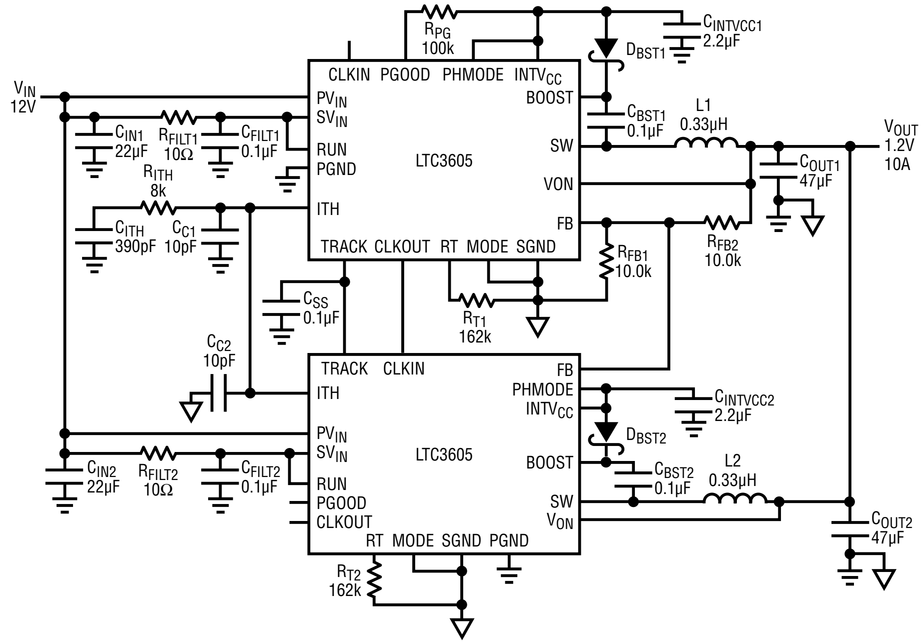

Figure 4. 12V to 1.2V at 10A 2-phase buck converter

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.

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Conclusion

The LT8410/-1 is a smart choice for applications which require low standby quiescent current and/or require low input current, and is especially suited for power supplies with high impedance sources. The ultralow quiescent current and high value integrated feedback resistors keep average input current very low, significantly extending battery operating time. The LT8410/-1 is packed with features without compromising performance or ease of use and is available in a tiny 8-pin 2mm × 2mm package.

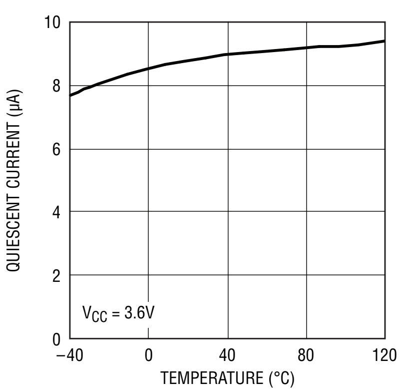

Figure 4. Quiescent current vs temperature (not switching)

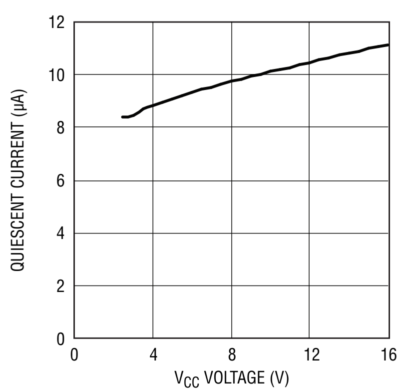

Figure 5. Quiescent current vs V_{CC} voltage (not switching)

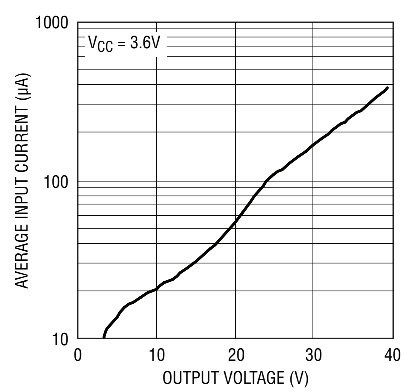

Figure 6. Average input current in regulation with no load