Dual Output DC/DC Converter Solutions for Xilinx FPGA Based Systems

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INTRODUCTION

Xilinx FPGAs require at least two power supplies: V_{CCINT} for core circuitry and V_{CCO} for I/O interface. For the latest Xilinx FPGAs, including Virtex-II Pro, Virtex-II and Spartan-3, a third auxiliary supply, V_{CCAUX} may be needed. In most cases, V_{CCAUX} can share a power supply with V_{CCO}. The core voltages, V_{CCINT}, for most Xilinx FPGAs, range from 1.2V to 2.5V. Some mature products have 3V, 3.3V or 5V core voltages. Table 1 shows the core voltage requirement for most of the FPGA device families. Typical I/O voltages (V_{CCO}) vary from 1.2V to 3.3V. The auxiliary voltage V_{CCAUX} is 2.5V for Virtex-II Pro and Spartan-3, and is 3.3V for Virtex-II.

Each FPGA family has a specific quiescent supply current, ranging from under 100mA to about 2A. For applications with multiple FPGAs, the core supply current can be higher than 10A.

With multiple voltage rails in today's systems (FPGA, DDR memory, data converter ICs, etc.), supply sequencing and tracking are quite important for proper start-up and shutdown. Ramp time requirement should also be satisfied. For example, the recommended ramp time (t_{CCPO}) for the core voltage V_{CCINT} is less than 50ms during power-on. Some Xilinx FPGA families also have minimum V_{CCINT} ramp time requirements.

New dual output DC/DC regulators from Linear Technology, the LTC®3407, LTC3736 and LTC3708, greatly simplify the design of an optimal power supply solution for systems using Xilinx FPGAs.

LTC3407: Dual Synchronous, 600mA, DC/DC Regulator

The LTC3407 is a dual synchronous step-down DC/DC converter with integrated power switches. It provides a compact and high efficiency power solution for FPGAs with supply currents up to 600mA. The switching regulator operates from a 2.5V to 5.5V input voltage range and has an adjustable output range from 0.6V to 5V. Its internal 1A switches provide up to 96% efficiency, eliminating the need for external MOSFETs and Schottky diodes. Figure 1 is an application example for 2.5V/600mA and 1.8V/600mA supplies. Figure 2 shows the efficiency curves of the circuit vs load current.

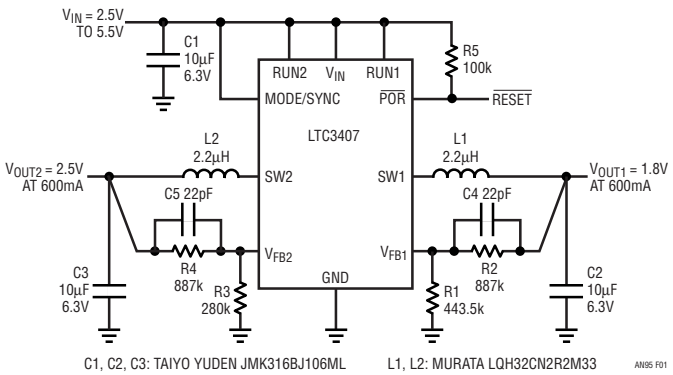

Figure 1. High Efficiency 2.5V/600mA and 1.8V/600mA Regulators

Table 1. Core Voltage Requirement for Xilinx FPGA Families

	Virtex-II Pro	Virtex-II	Virtex-E Extended Memory	Virtex-E	Virtex	Spartan-3	Spartan-IIE	Spartan-II	Spartan-XL	Spartan
V_{CCINT}	1.5V	1.5V	1.8V	1.8V	2.5V	1.2V	1.8V	2.5V	3.3V	5V

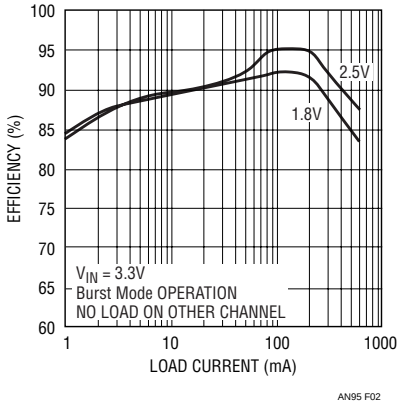

Figure 2. LTC3407 Efficiency Curve

The LTC3407 has a constant 1.5MHz switching frequency, allowing the use of tiny inductors and capacitors. Selectable Burst Mode® operation provides high efficiency at light loads. The IC has short-circuit protection and a power-on reset (power good) output. It is available in small thermally enhanced 10-lead MSOP and 3 × 3 DFN packages.

LTC3736: 2-Phase, Dual Synchronous, DC/DC Controller for 5A Loads

The LTC3736 is a 2-phase dual synchronous step down DC/DC controller. Power supplies using the LTC3736 can provide 5A at both outputs with a 5V input, meeting the load current requirements for most FPGA applications. The LTC3736 receives input from 2.7V to 9.8V and produces output voltages ranging from 0.6V to 9.5V. Figure 3 shows that up to 95% efficiency is achieved. An application example is shown in Figure 4.

In contrast to single-phase operation, the two channels of a 2-phase switching converter are operated 180 degrees out of phase. This technique interleaves the current pulses coming from the topside MOSFET switches, greatly reducing the total RMS input ripple current. This in turn allows the use of smaller and lower cost input capacitors, reduces the EMI attenuation requirement and improves operating efficiency.

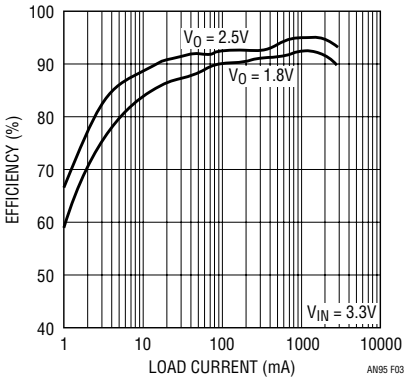

Figure 3. Efficiency vs Load Current for the LTC3736 Converter

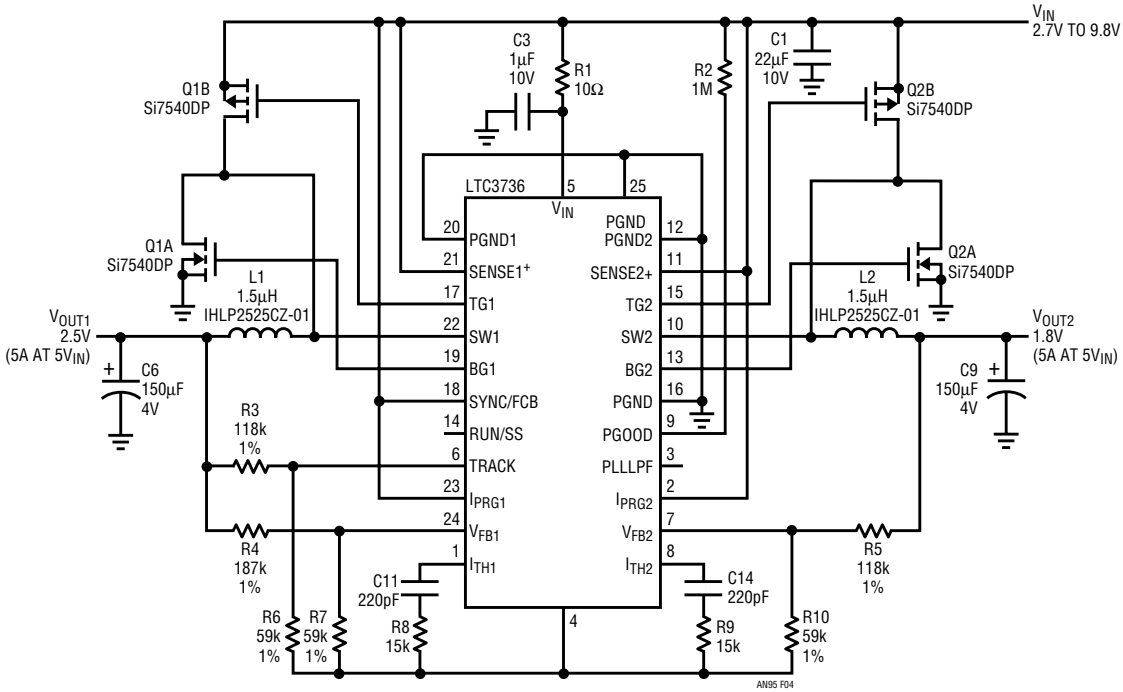

Figure 4. High Efficiency 2.5V/5A and 1.8V/5A Dual Output Converter with Output Tracking

Figure 5 compares the input waveforms for a representative single-phase dual switching converter to the 2-phase dual switching converter. Figure 6 shows how the RMS input current varies for single phase and 2-phase dual controllers with 2.5V and 1.8V outputs over a wide input voltage range. For most applications, 2-phase operation will reduce the input capacitor RMS current requirement to that of just one channel operating at maximum current and 50% duty cycle.

The LTC3736 has a default switching frequency at 550kHz, but can be externally synchronized from 300kHz to 750kHz. The LTC3736 provides output tracking for controlled ramp-up of two supply rails, programmable current limit, output overvoltage protection, power good output and selectable Burst Mode operation for high efficiency light load operations. The IC is available in the tiny (4mm × 4mm) thermally enhanced QFN package or the 24-lead SSOP package.

LTC3708: 2-phase, Dual Synchronous, DC/DC Controller for 15A Loads

The core supply voltages of the latest Xilinx FPGAs have decreased towards 1V. The Virtex-II pro family requires 1.5V V_{CCINT} and the Spartan-3 family needs only 1.2V V_{CCINT}. In the meantime, these FPGAs demand more current from the power supplies. Some systems use more than ten FPGAs per board so the resulting total supply current can easily exceed 10A. The LTC3708-based dual output supply is an ideal choice for such applications.

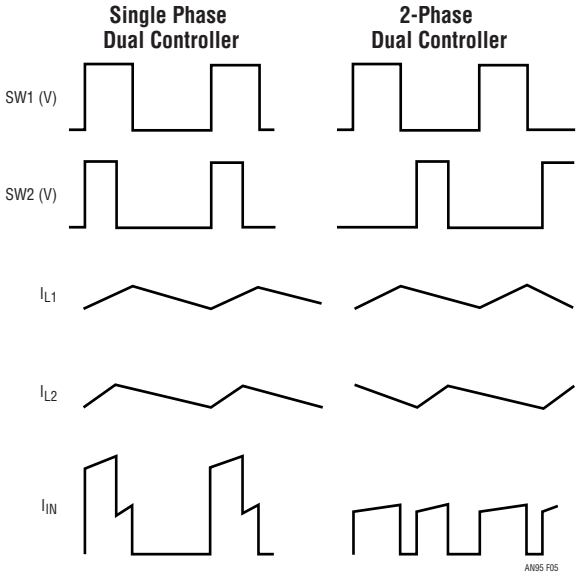

Figure 5. Example Waveforms for a Single-Phase Dual Converter vs the 2-Phase LTC3736

The LTC3708 is a 2-phase dual synchronous step-down DC/DC controller with a wide input voltage range: from 3.3V up to 36V. Its output voltage can be programmed down to 0.6V. Figure 7 shows the schematic of a dual output 2.5V/15A and 1.8V/15A converter. As shown in Figure 8, up to 95% efficiency can be achieved.

The LTC3708 has output voltage up/down tracking capability. The IC allows both coincident or ratiometric tracking, as shown in Figures 9 and 10. The ramp rate can be selected by a soft-start capacitor from RUN/SS pin to ground. Multiple LTC3708s can easily be daisy-chained in applications requiring more than two voltages to be tracked.

The 2-phase operation of the LTC3708 reduces power loss and noise, and lowers the input-filtering requirement. The constant on time, valley current mode control in the LTC3708 allows fast transient response and thus minimizes the number of output capacitors. An internal phase-locked loop allows the IC to be synchronized to an external clock for applications with more than two output rails. The LTC3708 also features programmable current limit, output overvoltage protection and power good output. The IC is available in the 5mm × 5mm QFN package.

Conclusion

An optimal power solution for multirail supply systems incorporating the latest Xilinx FPGAs should provide multiple outputs with supply tracking/sequencing. As board real estate becomes more expensive, the power supply must be more efficient and smaller while supplying higher current in high-end applications. Linear Technology's latest dual output power management ICs: LTC3407, LTC3736 and LTC3708, successfully address these challenges. For data sheets and additional information on other power solutions for Xilinx FPGAs, visit Linear Technology's web site at www.linear.com.

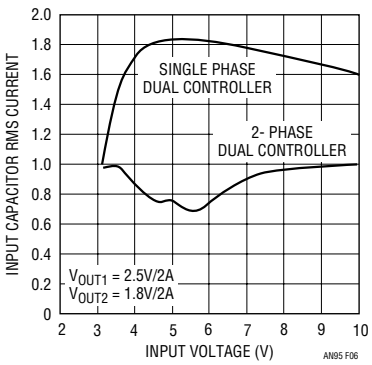

Figure 6. RMS Input Current Comparision

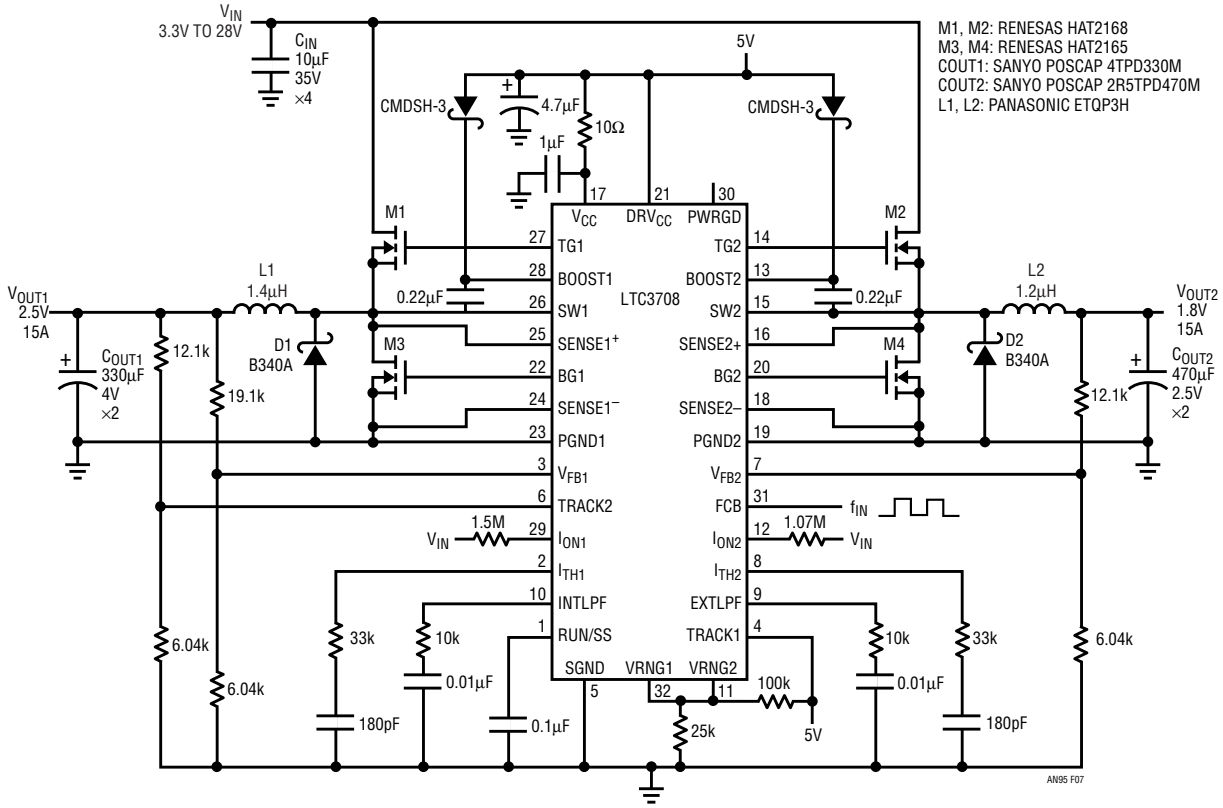

Figure 7. High Efficiency 2.5V/15A and 1.8V/15A Dual Output Converter with Output Tracking

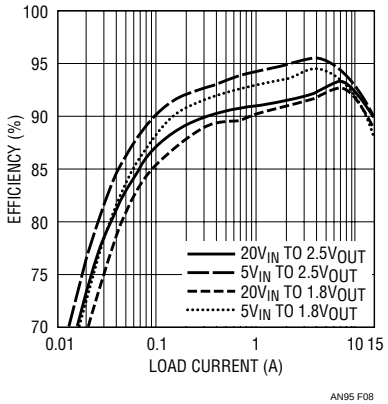

Figure 8. Efficiency vs Load Current for the LTC3708 Converter

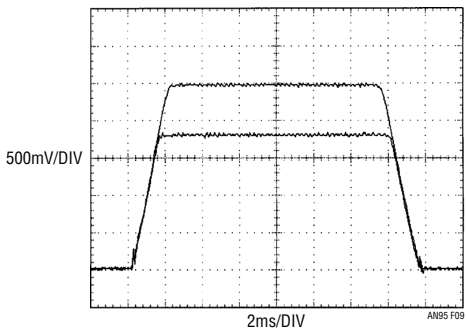

Figure 9. Up/Down Coincident Tracking

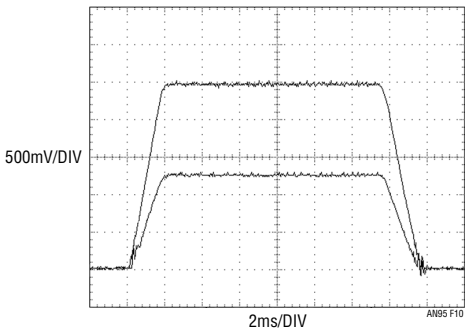

Figure 10. Up/Down Ratiometric Tracking

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