2-Phase Controller for High Current, High Step-Down Ratio Applications

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Introduction

One of the biggest challenges in designing power supplies for high speed digital systems is achieving high step-down ratios at high load currents, all while maintaining high efficiency and meeting stringent transient response and board space requirements. Designers can easily meet this challenge by using the LTC3709 dual phase, synchronous step-down switching regulator.

The LTC3709 uses a constant on-time with phase locked loops (PLLs), valley current control architecture to deliver very low duty cycles and does not require an output current sense resistor. Figure 1 shows the LTC3709 in a step down circuit that features fast transient response and high efficiency over wide load range.

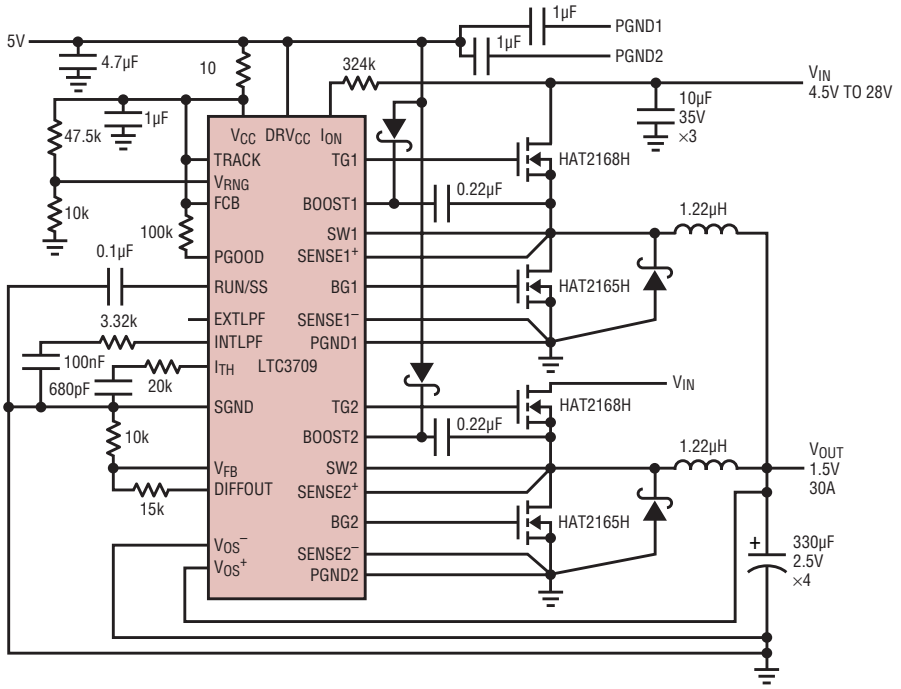

Figure 1. This high current, 2-phase power supply is efficient and responds quickly to load transients.

High Current *and* High Efficiency

Power losses, and the resulting heat, are significant problems in high current systems, so power supplies must be as efficient as possible. The LTC3709 guarantees high efficiency from light load to heavy load, especially important in high power portable computers (Figure 2).

Much of the efficiency of an LTC3709-based circuit is a result of its 2-phase architecture, which enables supply currents over 30A. The two channels operate out of phase, thus minimizing the input RMS current and the power loss along the input supply path.

The LTC3709 also senses current through the bottom MOSFET, so there is no added power loss from sense resistors, and the powerful onboard synchronous MOSFET drivers effectively suppress conduction losses.

The LTC3709 also offers Stage Shedding™ mode to boost the efficiency at light load. In Stage Shedding mode, the second channel is turned off at light loads, which halves the light load switching losses.

If the load current further drops very low, no reverse inductor current is allowed and the switching frequency drops down as low as necessary to maintain regulation, while keeping the efficiency high.

Constant On-Time Architecture and Fast Transient Response

Modern power supply designs often require a high step down ratio (low duty cycle) and fast operation frequency at the same time. This means a very short on-time feature is indispensable for an excellent controller. Unlike traditional constant frequency controllers that have minimum on-times of several hundreds of nanoseconds, the LTC3709 has a minimum on-time of only 50ns, which makes it a good choice for high current power designs. The constant on-time, valley current control architecture of the LTC3709 has an inherently fast transient response. The LTC3709 responds to a load transient immediately, without the clock latency typical of traditional constant frequency controllers.

Anti-Phase Operation and External Clock Synchronization

The two channels of the LTC3709 operate 180 degrees out of phase. A

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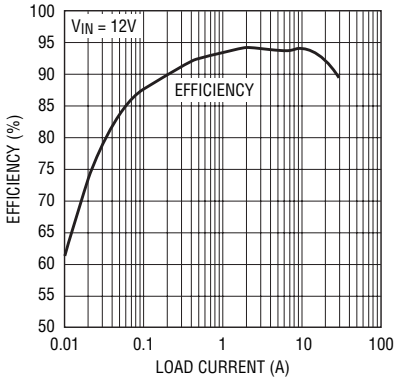

Figure 2. The circuit in Figure 1 has high efficiency over a wide load current range.

the LT1935, reducing the maximum input current during start-up.

The $\overline{SHDN}$ pin is driven through an external RC filter to create a voltage ramp at this pin. Figure 3 shows the start-up waveforms with and without the soft-start circuit. Without soft-start, the input current peaks at ~3A. With soft start, the peak current is reduced to 1A. By choosing a large RC time constant, the peak start-up current can be reduced to the current that is required to regulate the output, with no overshoot. (The value of the resistor should be chosen so that it can supply 100µA when the $\overline{SHDN}$ pin reaches 1.8V.)

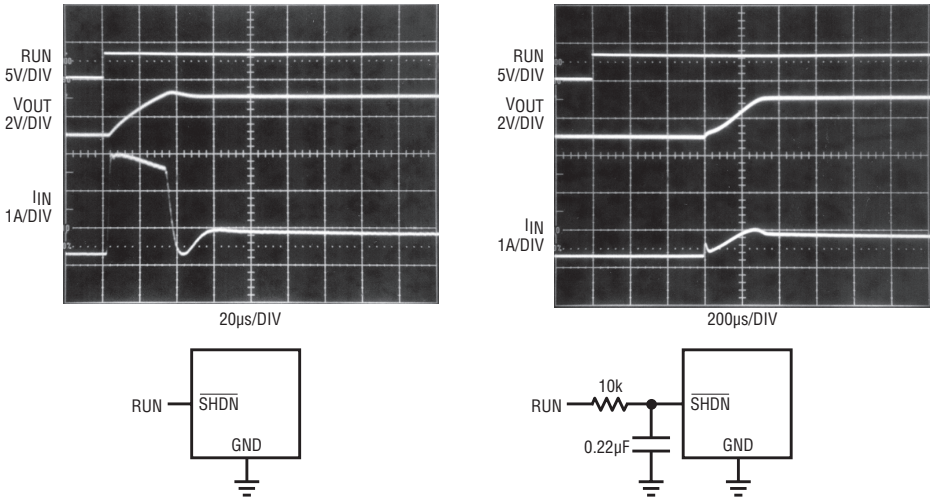

Figure 3. The $\overline{SHDN}$ pin can be used to soft start the LT1935 reducing the peak input current during start up.

More Power for Larger LCD Panels

TFT LCD display panels continue to grow in size in every type of product from cell phones to televisions. Power requirements grow as well, but the basic need for three supply voltages remains. In Figure 4 the LT1935 produces three outputs using a single inductor. From a 3.3V input, the boost circuit produces the main output of 8V at 450mA. Two discrete charge pumps produce the secondary outputs of 16V and –8V.

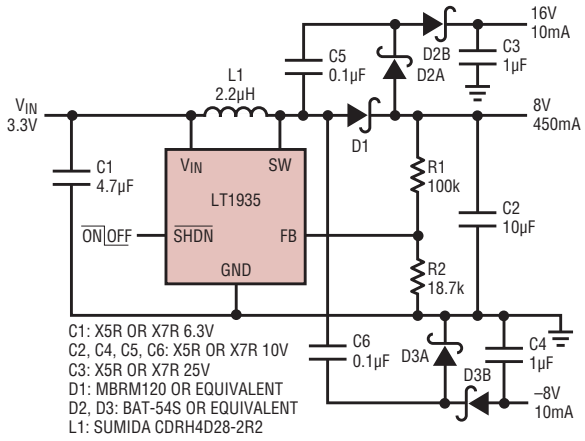

Figure 4. This TFT-LCD supply produces three outputs using a single inductor.

Conclusion

By integrating a high frequency, current mode control with 2A, 90mΩ switch in a SOT-23, the LT1935 delivers outsized power in a small space. The 40V switch rating and the wide input range (2.3V to 16V) allow a wide variety input sources, output voltages and circuit topologies, unlike many regulators with restrictive 5V ratings.

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PLL monitors the switching of the two channels and forces the switching frequency of the second channel to follow that of the first channel. The interleaved operation of two channels minimizes the input RMS current and power loss along the input supply path.

A second PLL is provided for external clock synchronization. The LTC3709 is synchronized by adjusting its on-time, indirectly adjusting its switching frequency. When synchronized, the LTC3709 combines the advantages of constant frequency and constant on-time architectures. The switching frequency stays constant despite the changes of input voltage, output voltage (if programmable) and load current. The LTC3709 can still respond to load transients without clock latency because of the indirect adjustment of switching frequency during synchronization. The time constant of the PLL is much longer than the load transient duration, so the switching frequency of the LTC3709 is temporarily altered to take advantage of a constant on-time architecture.

Other Features

The LTC3709 has a differential amplifier for remote sensing of both the high and low sides of the output voltage. An output tracking function makes the LTC3709 easy to use in multiple power supplies applications. The LTC3709 also has a short-circuit shutdown timer which is easily defeated.

Conclusion

The LTC3709 employs a constant on-time with PLLs and a valley current control architecture. It has fast transient response, very short minimum on-time and high efficiency from light to full load. The LTC3709 is well suited to high output current, high step-down ratio applications.