Wide Input Voltage Range, Dual Step-Down Controller Reduces Power Supply Size and Cost

By Wei Gu

Introduction

The LT3742 is an easy-to-use dual non-synchronous DC/DC controller for medium power step-down applications. It offers high efficiency over a wide input voltage range (4V–30V) and a wide output voltage range (0.8V–30V). A 500kHz fixed frequency current mode architecture provides fast transient response with simple loop compensation components and cycle-by-cycle current limiting. An internal step-up regulator is used to generate the gate drive voltage, allowing the gate of the external high side N-channel MOSFET to be driven to full enhancement for high efficiency operation. The two channels operate 180° out of phase to reduce the input ripple current, minimizing the noise induced on the input supply and reducing the input capacitance requirement. The device also includes individual shutdown controls and power-good outputs for each channel. The LT3742 is available in a small 4mm × 4mm QFN package.

Figure 1 shows the LT3742 in a compact, dual-output power supply. Figure 2 shows the resulting efficiency.

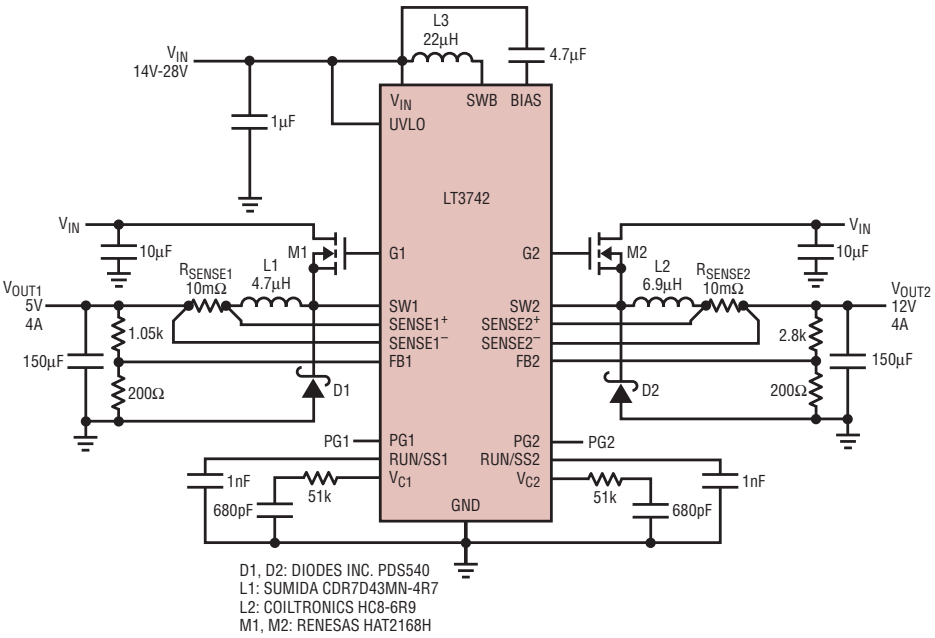

Figure 1. Compact, dual-output DC/DC converter: 14V–28V input to 12V at 4A and 5V at 4A

Internal Step-Up Bias Converter

The LT3742 integrates a DC/DC step-up converter to generate the gate drive voltage for the N-channel MOSFETs. The gate drive voltage is regulated to (V_{IN} + 7V), which permits the use of inexpensive off-the-shelf 5V gate-drive N-channel MOSFETs, offering higher efficiency than sub-logic-level gate-drive MOSFETs. The gate driver is capable of driving large, low $R_{DS(ON)}$, standard level, N-channel MOSFETS without the need for a gate drive buffer.

Integrating the step-up converter also allows low dropout and 100% duty cycle operation. This is in contrast to the commonly used bootstrap scheme, which does not allow 100% duty cycle since a minimum off-time is required to charge the bootstrap capacitor.

Continuous Inductor Current Sensing

The LT3742 offers robust short-circuit protection thanks to continuous inductor current sensing. A wide common-mode input range current sense amplifier that operates from 0V to 30V provides continuous inductor current sensing via an external sense resistor. A continuous inductor current sensing scheme does not require blanking intervals or a minimum on-time to monitor current, limitations that are common to schemes that sense the switch current.

The sense amplifier monitors the inductor current independent of the switch state, so the gate is held low until the inductor current is below the programmed current limit. This turn-on decision is performed at the start of each cycle, and individual switch cycles are skipped should an over-current condition occur. This eliminates many of the potential over-current dangers caused by minimum on-time requirements, such as those that can occur during start-up, short-circuit, or abrupt input transients. Figures 3 and 4 show the switching node voltage waveforms and inductor current waveforms in normal operation and in short circuit, respectively.

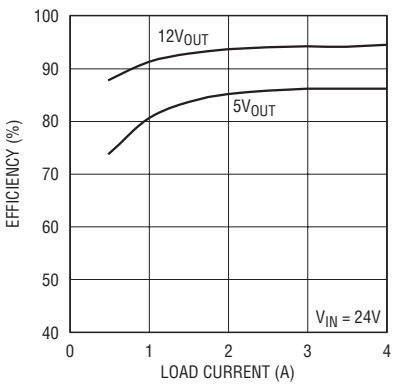

Figure 2. Efficiency of the converter in Figure 1

Precision UVLO Voltage

Input supply UVLO for sequencing or start-up over-current protection is easily achieved by driving the UVLO with a resistor divider from the V_{IN} supply. The resistor divider is set such that the divider output puts 1.25V onto the UVLO pin when V_{IN} is at the desired UVLO rising threshold voltage. The UVLO pin has an adjustable input hysteresis, which allows the IC to resist user-defined input supply droop before disabling the converter. During a UVLO event, both controllers and the gate drive boost regulator are disabled.

2-Phase Operation

When two outputs are derived from the same input source, any slight difference in the switching frequencies generates a beat frequency that is difficult to filter. To avoid this, the two output channels must be synchronized. The problem is that if the output channels are switched in unison, the input RMS current is maximized as each channel concurrently calls for current. This, of course, is counter to a designers desire to minimize input current. Minimizing RMS input current serves to minimize the input capacitance requirement, reduce power loss along the input supply path (batteries, switches, connectors and protection circuits) and reduce radiated and conducted electromagnetic interference (EMI).

The LT3742 eliminates the beat frequency and minimizes the input RMS current by interleaving the output channels. The two channels switch at the same frequency with 180° phase difference between the rising edges of G1 and G2. This 2-phase operation minimizes input RMS current, thus reducing the solution size, increasing the overall efficiency and attenuating EMI.

Soft-Start

The SS pins are used to enable each controller independently and to provide a user-programmable soft-start function that reduces the peak input current and prevents output voltage overshoot during start-up. The LT3742 employs a soft-start scheme that directly controls the DC/DC converter output voltage during start-up. The rising rate of this voltage is programmed with a capacitor connected to the SS pin. The capacitor value is chosen such that the desired $\Delta V/\Delta t$ of the output results in a 1µA charge current through the capacitor. Figure 5 shows the output voltage waveforms during start-up.

If both outputs are always enabled together, one soft-start capacitor can be used with the RUN/SS pins tied together.

Current Mode Control

The LT3742 uses a current mode control architecture, enabling a higher supply bandwidth and thereby improving line and load transient response. Current mode control also requires fewer compensation components than voltage mode control architectures, making it much easier to compensate over all operating conditions.

Conclusion

The LT3742 provides a space-saving and cost-saving solution over a wide input voltage range. The LT3742 is a versatile platform on which to build high voltage DC/DC converter solutions that use few external components and maintain high efficiencies over wide load ranges. The integrated start-up regulator facilitates true single-supply operation.

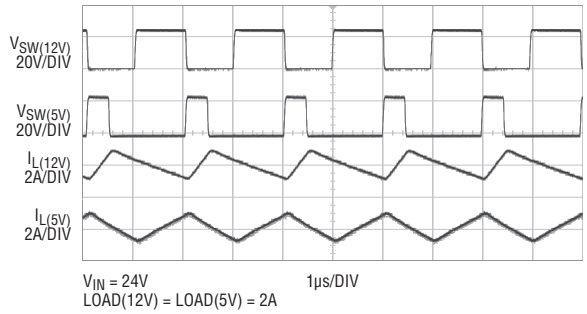

Figure 3. Switching node and inductor current waveforms (normal operation)

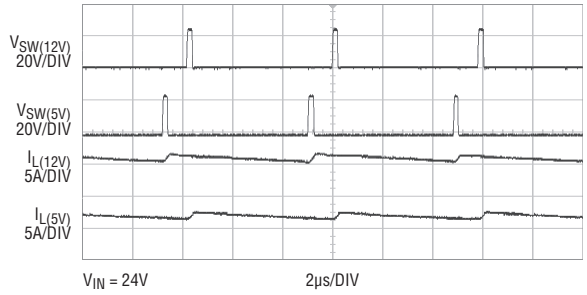

Figure 4. Switching node and inductor current waveforms (both outputs shorted)

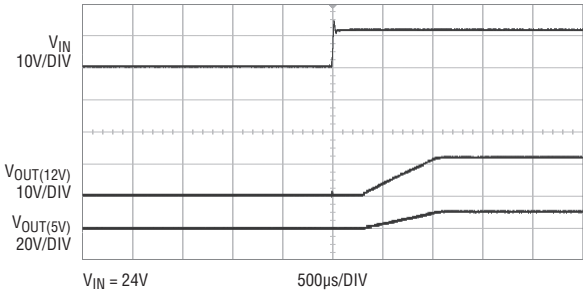

Figure 5. Start-up waveforms