Tiny 1.25MHz Monolithic Boost Regulator Has 1.5A Switch and Wide Input Voltage Range

by Keith Szolusha

Introduction

The LT1961 is a monolithic, current-mode, boost converter with a very high switching frequency and an on-board monolithic, high-current power switch. Because the power switch is included in the tiny MSOP 8-pin exposed leadframe package, layout and board space shrink dramatically for most designs. The high 1.25MHz switching frequency further reduces the size requirement for the surrounding inductors and capacitors, by allowing the use of chip inductors and low profile capacitors and inductors. It operates within a 3V to 25V input voltage range and can be synchronized up to 2MHz. The built in 0.2Ω, 35V switch allows up to 1.5A switch current at high efficiency. In battery-powered applications the extremely low 6µA shutdown current maintains high efficiency and long battery life. The shutdown pin also provides an undervoltage lockout option to limit battery source current when low on charge.

The current-mode topology of the IC allows for fast transient response and simple loop compensation techniques that can take advantage of a variety of ceramic output capacitors to cover a wide range of output voltages. Ceramic capacitors have the advantage of smaller size and they can handle high RMS ripple current, the overriding requirement in sizing the output capacitor for boost and flyback topologies.

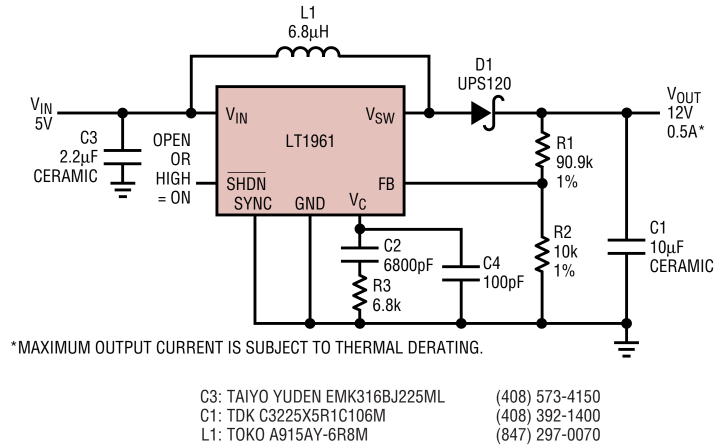

Figure 1. 5V input, 12V output boost converter with ceramic input and output capacitors

A High Efficiency 12V Boost Converter with all Ceramic Capacitors

Figure 1 shows a typical application for the LT1961; a 12V boost converter using only ceramic capacitors. This circuit provides a regulated 12V output from a typical input voltage of 5V, but can also be powered from any input voltage between 3V and 12V. The maximum load current changes as a function of input voltage. Efficiency for the circuit is as high as 87% for a 5V input, as shown in Figure 2. Figure 3 shows the extremely low 60mV$_{P–P}$ output voltage ripple at 500mA load. Low-ESR ceramic capacitors and high switching frequency help reduce the peak-to-peak output voltage ripple, even in the normally noisy boost configuration.

Low Profile 3.0mm SEPIC Has Wide Input Voltage Range

Although the LT1961 is configured as a boost, or step-up, converter, its internal low-side, asynchronous, 1.5A, 35V switch is versatile enough to be used in other applications such as a SEPIC or flyback. SEPIC solutions typically use the basic single-output flyback topology and a transformer with its two windings capacitively coupled together to generate a fixed output voltage from an input voltage that can be either above, equal to, or below the output voltage. However, much of the advantage of the LT1961's high frequency and correspondingly small external components is lost by

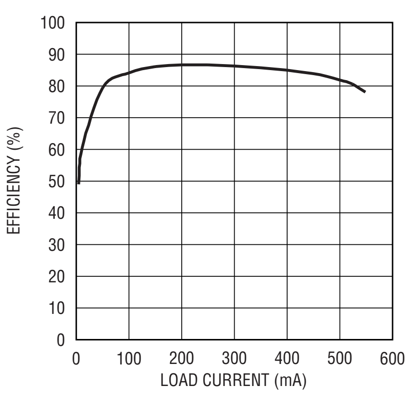

Figure 2. Efficiency of the circuit shown in Figure 1 is as high 87%.

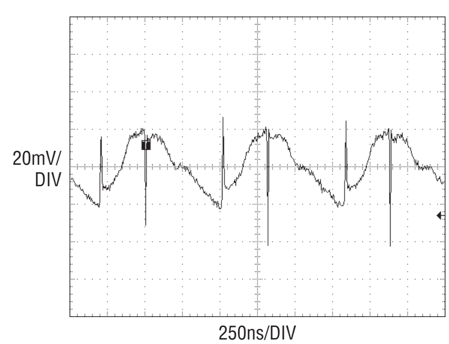

Figure 3. At 500mA load current, the output ripple voltage of Figure 1's circuit is an extremely low 60mV peak-to-peak.

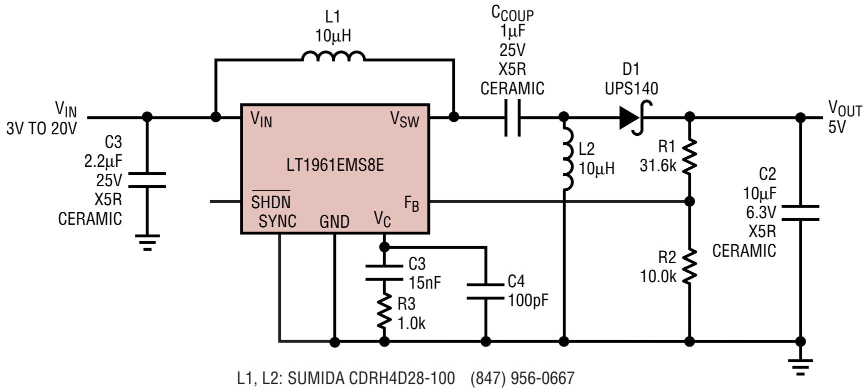

Figure 4. 3V–20V input, 5V output SEPIC saves space by using two low profile inductors and all ceramic capacitors.

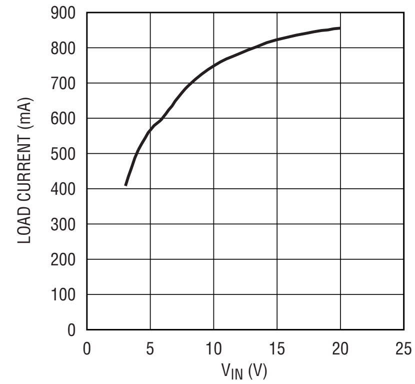

Figure 5. Maximum load current of the low profile SEPIC shown in Figure 4 increases with input voltage.

using a transformer, which is typically tall and occupies a large amount of board space. Instead, Figure 4 shows a way to use two separate inductors to create a low profile SEPIC solution with less than 3.0mm height—desirable for many of today's handheld and portable computer applications. The coupling capacitor replaces the transformer core as the low-impedance path for energy to move from the primary to the secondary side. The coupling capacitor charges up to a steady state voltage—equal to the input voltage—and has enough capacitance to maintain its charge within 5% during switch on and off-times while high ripple current passes back and forth between the primary and secondary sides.

The circuit shown in Figure 4 is a 3V–20V input to 5V output low profile SEPIC featuring the LT1961 with less than 3.0mm height and all ceramic capacitors. This is a tiny, low cost and low profile solution with a wide input voltage range. The maximum load current depends on the input voltage (see Figure 5). The two 10µH inductors limit the ripple. However, each inductor can be sized independently to increase the output current capability. Figure 6 shows that typical efficiency is over 70% and improves as the input voltage approaches the output voltage (5V). In this configuration, the two inductor currents are summed in the switch during the switch on-time and then through the catch diode and the output during the switch off-time. This effectively doubles the switch and catch diode losses compared to the typical boost application. At high input voltages, the duty cycle is low and the catch diode conducts current for a greater proportion of the overall time. At low input voltages, the duty cycle is high and the switch conducts current for a greater proportion of the overall time. The low switch V_{ceSAT} relative to the forward voltage of the catch diode is the reason for the increase in converter efficiency at lower input voltages.

Dual Polarity Output SEPIC

Figure 7 is a 5V to 9V input to ±12V dual polarity output converter. As discussed above, the low-side boost converter switch is ideal for flyback converters that usually use a transformer to couple energy from the primary (input) side to the secondary (output) side. For dual polarity output flyback converters, this transformer has at least three windings coupled together on the same core, one for the primary side, and one for each out-

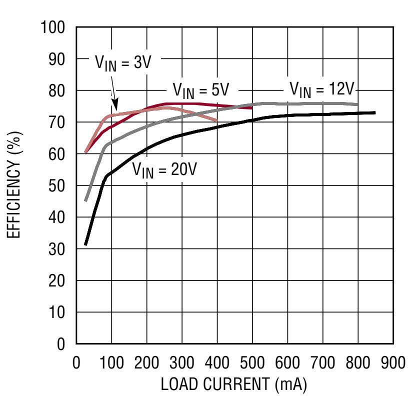

Figure 6. Efficiency of the low profile SEPIC shown in Figure 4 is as high as 76% and increases as the input voltage approaches the output voltage.

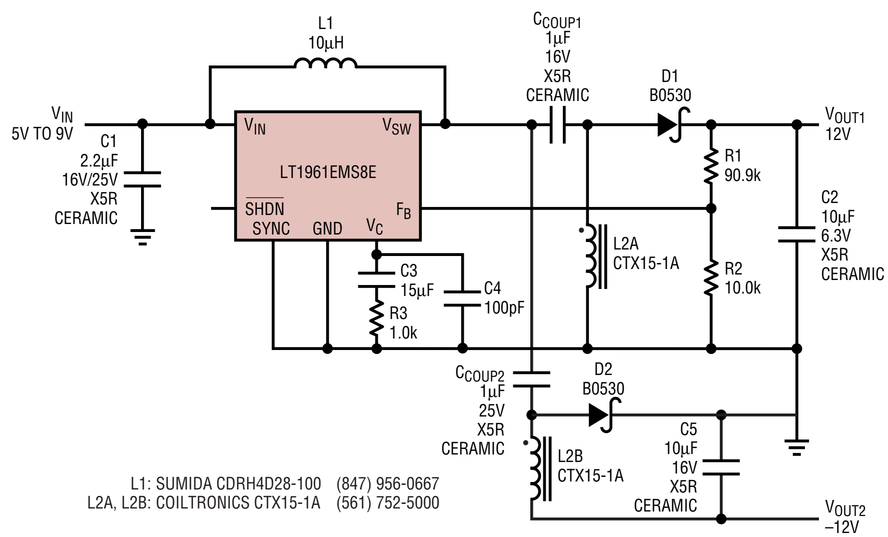

Figure 7. Dual polarity output SEPIC for 5V–9V input to ±12V output. This circuit uses one low profile inductor and one 1:1 off-the-shelf transformer for the two outputs.

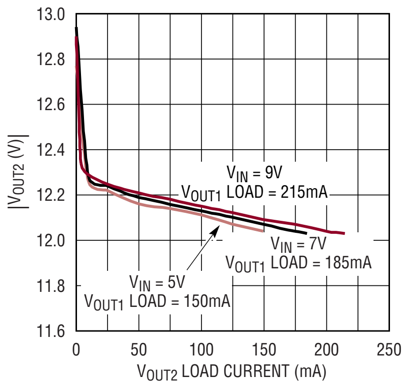

Figure 8. Cross-regulation of Figure 7's circuit with fixed V_{OUT1} load current and varying V_{OUT2} load current.

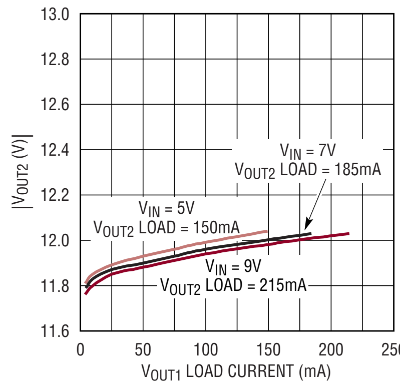

Figure 9. Cross-regulation of Figure 7's circuit with fixed V_{OUT2} load current and varying V_{OUT1} load current.

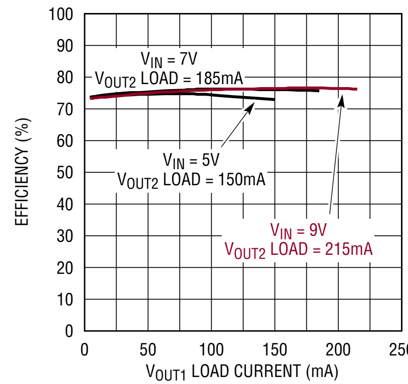

Figure 10. Efficiency of the circuit shown in Figure 7 is typically 75%.

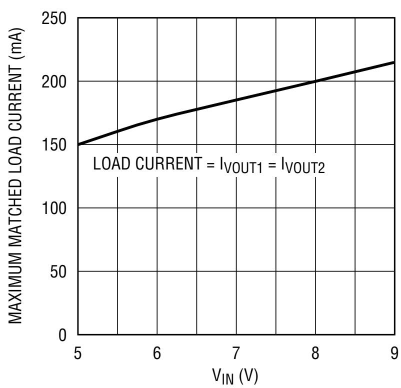

Figure 11. Maximum individual output load current (with equal loads on V_{OUT1} and V_{OUT2}) for the circuit of Figure 7, at various input voltages.

put. Such a transformer, at the power level required (1.5A total parallel current and 3.3µH to 22µH per winding), negates most of the space savings provided by the high frequency LT1961. The solution is to capacitively couple energy from the input to the output transformer like the single output of the low-profile SEPIC using two separate inductors. This not only gets the job done, but reduces the height of the inductive components and provides layout flexibility. 1:1 transformers with only two windings are more readily available and much smaller than transformers with at least three windings.

Cross-regulation is excellent in this converter as shown in Figures 8 and 9. With only a single feedback pin, the positive output voltage always maintains regulation, but the negative output voltage (V_{OUT2}) regulation changes as a function of the difference in the load currents of the two outputs. As one output becomes heavily loaded and other lightly loaded, cross-regulation can become slightly compromised due to differences in losses in the catch diodes and inductors. Figure 8 shows that extremely light loads on V_{OUT2} can result in a loss of regulation, so a preload may be required. However, Figure 9 shows that V_{OUT1} can go to zero load current without a loss in regulation on V_{OUT2}. The overall converter efficiency remains high for a flyback or SEPIC-type design as shown in Figure 10. The maximum load current on each output varies as a function of the load on the other output. Figure 11 shows the maximum matched load current (the same load current on both outputs). If one load current is decreased, the other can be increased without exceeding current limit.

Conclusion

The LT1961 is a tiny, monolithic, 1.5A boost converter with a wide input voltage range that can be used in many applications. Its high switch frequency and onboard switch help minimize circuit size and cost.