LINEAR TECHNOLOGY

DESIGN NOTES

Boost Regulator Makes Low Profile SEPIC with Both Step-Up and Step-Down Capability – Design Note 317

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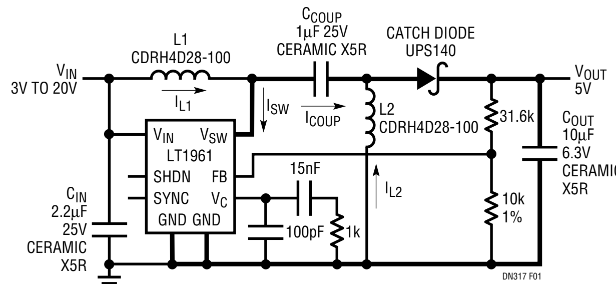
Introduction

Automotive, distributed power and battery-powered applications often operate at a voltage that is derived from a widely variable bus voltage. Frequently the operating voltage falls somewhere in the middle of the bus voltage range, such as a 12V automotive operating voltage, from a 4V to 18V bus. These applications require a DC/DC converter that can step up or step down, depending on the voltage present on the bus. Flyback and SEPIC designs are commonly used single-switch solutions for this problem, but both of these solutions typically use a transformer which poses layout and height problems for applications where space is at a premium.

One alternative to a transformer-based topology is to use two low profile inductors and a SEPIC coupling capacitor which transfers the energy between the two inductors much like the core of a transformer. The coupling capacitor provides a low impedance path for the inductor currents to pass either from the input (primary) inductor through the catch diode and to the output, or from the output (secondary) inductor back through the switch to ground. Both inductors act continuously and independently, making their selection easier than selecting the transformer for a flyback or a typical SEPIC circuit. The inductors are not restricted to having the same inductance and can be individually picked for peak currents and allowable ripple.

3V to 20V Input, 5V Output, 3mm Maximum Height SEPIC

Figure 1 shows a 3V to 20V input, 5V output 3mm maximum height SEPIC using the LT®1961, a 1.25MHz, current mode, monolithic, 1.5A peak switch current, boost converter. The output current capability of this circuit varies with input voltage (see Figure 3). At 3V input, the converter can supply up to 410mA of load current and as high as 830mA of load current at 20V input. The tiny coupling capacitor used here is large enough to handle the RMS ripple current transferring between the primary and



HIGH ΔI/Δt DISCONTINUOUS CURRENT PATH INDICATED IN BOLD FOR LAYOUT

Figure 1. LT1961 in a 3V to 20V Input to 5V Output All Ceramic SEPIC (3mm Maximum Height)

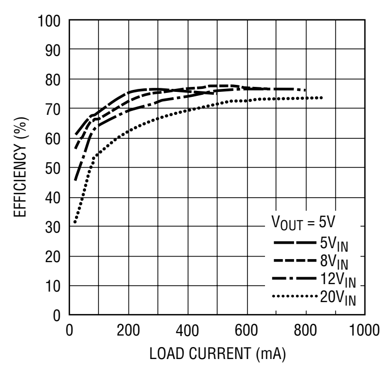


Figure 2. Efficiency of the Circuit in Figure 1

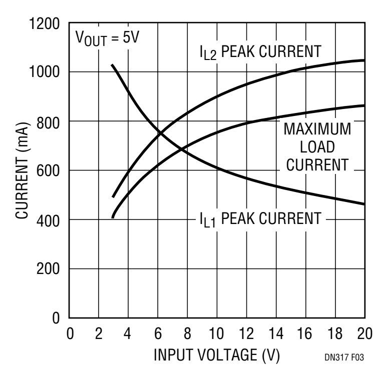


Figure 3. The Peak Inductor Currents in L1 and L2 Sum to 1.5A, the Peak Switch Current. Maximum Output Current is the Average Current in L2 at Peak Switch Current

secondary sides of the circuit, and to maintain a voltage equal to the input voltage in order to provide good regulation and maximum output power. The current mode control topology of the LT1961 and the small 10µF ceramic output capacitor provide excellent transient response over the wide input voltage range.

4V to 18V Input, 12V Output, 3mm Maximum Height SEPIC

12V buses are often derived from sources with a wide input voltage range. For instance, automotive solutions can have steady-state operating voltages as high as 18V and as low as 4V for cold-crank conditions. Figure 4 shows a simple, low cost and low profile (≤3mm) solution that avoids the high cost of using both a boost and buck converter and maintains 12V system power during cold-crank conditions.

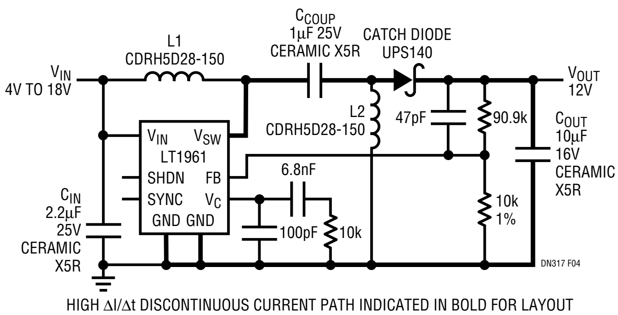


Figure 4. LT1961 in a 4V to 18V Input to 12V Output 3mm Maximum Height All Ceramic SEPIC

The catch diode has a 40V reverse breakdown voltage rating in order to handle the voltage induced across it during the switch off-time which is equal to the output voltage plus the input voltage. The 35V maximum switch voltage rating of the LT1961 allows the input voltage to go up as high as 18V. With a DC voltage equal to the input voltage, the coupling capacitor raises the voltage at the switch node to a level equal to the input voltage plus the output voltage. Tiny voltage spiking present on the switch node of any switching converter requires a few volts of headroom between the maximum switch voltage rating and the sum of the input and output voltages. The switching spikes are reduced to a minimum by keeping the high ΔI/Δt discontinuous current path (indicated in bold in Figures 1 and 4) as short as possible. The placement of the two power inductors is not crucial which makes it easier to create a power supply layout that fits confined spaces.

Efficiency, as shown in Figure 5, is typically greater than 75% and as high as 80%. This is better than average for 12V SEPICs and not much less than a similarly priced and sized 12V buck converter solution which is limited to greater than 14V input. Maximum load current increases with input voltage, as shown in Figure 6. 500mA load current is possible at 12V input and up to 600mA at 18V. The maximum switch current of the LT1961 is 1.5A and is the sum of the peak current in L1 and L2. Higher output voltage raises the current in the input inductor.

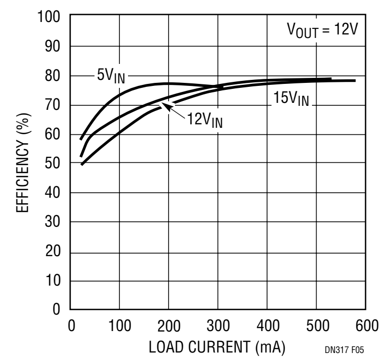


Figure 5. Efficiency of the Circuit in Figure 4

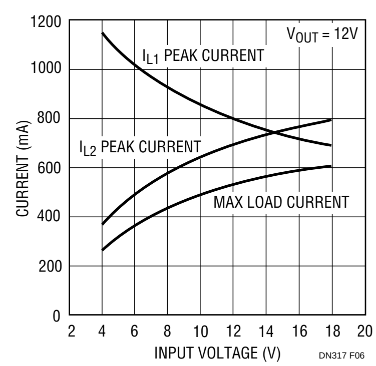


Figure 6. The Peak Inductor Currents and Maximum Load Current of the Circuit in Figure 4

Conclusion

The LT1961 fits into SEPIC solutions for applications with wide input voltage ranges. The solutions are small, simple and low profile. All ceramic capacitors and tiny components help keep power supply costs to a minimum. The 2-inductor SEPICs shown here eliminate the use of a tall transformer and offer layout flexibility to fit tight design constraints.

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