DESIGN NOTES

A High Efficiency 500kHz, 4.5A Step-Down Converter in an SO-8 Package – Design Note 181

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Reducing board space and improving efficiency are key requirements in many systems, especially at higher currents, where component size and power losses generally increase. Linear Technology has addressed these issues with the new LT®1374, a 500kHz, 4.5A monolithic buck converter designed to meet the needs of higher current applications. The LT1374 contains the power switch, logic, oscillator and all the control circuitry necessary to make a compact, high efficiency buck converter. The topology is current mode for fast transient response and good loop stability, with the added benefit of full cycle-by-cycle current limit.

The device is available in three package options: SO-8, DD and TO-220. For the most space-sensitive applications, the SO-8 retains the full 4.5A switch rating and is ideal for medium power applications with high peak loads. The DD package is intended for surface mount applications with continuous high current; the TO-220 is for high power, high ambient temperature systems.

A switching frequency of 500kHz allows the use of small, low value surface mount components to reduce board area. To further reduce power consumption, the LT1374 has two shutdown modes. A precise 2.38V threshold on the shutdown ($\overline{SHDN}$) pin keeps the internal reference alive but disables switching. This mode can be used as an accurate input undervoltage lockout, as shown in Figure 1. Grounding the $\overline{SHDN}$ pin takes the part into complete shutdown, reducing supply current to only 20μA.

For noise-sensitive applications, the $\overline{SHDN}$ pin can be replaced by SYNC (LT1374-SYNC), enabling the internal oscillator to be synchronized to an external system clock in the range of 580kHz to 1MHz. Both adjustable and fixed 5V output voltage parts are available. The LT1374, together with a minimum of small surface mount components, produces a 4.5A step-down regulator that is efficient in both power and board space.

High Efficiency, 25V, 0.07Ω Switch

High efficiency is the result of a fast bipolar process and a unique transistor layout that produces a high voltage switch with only 0.07Ω typical on-resistance. This permits the LT1374 to operate over an input voltage range of 5.5V to 25V with switch currents up to 4.5A. Figure 1 shows an example of the LT1374-5 in a typical 5V output step-down application. Efficiency for a 10V input is shown in Figure 2. Note that efficiency remains at over 88% from 0.5A up to the circuit's maximum 4A load current.

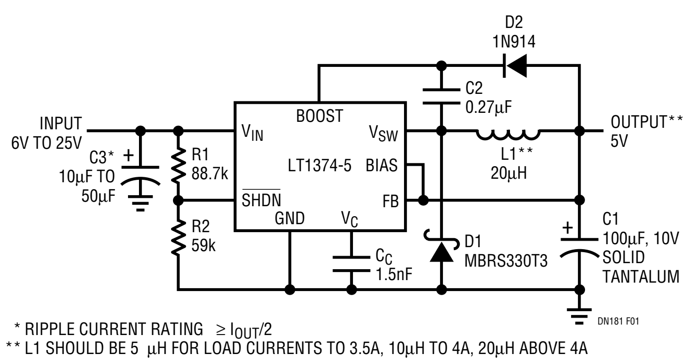


Figure 1. 5V Buck Converter

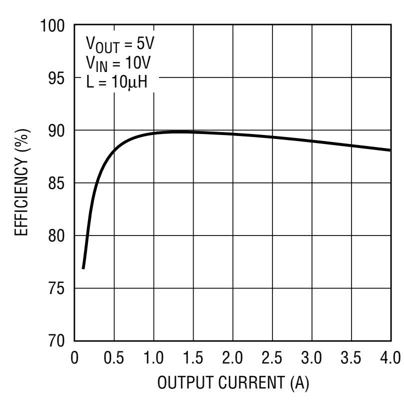


Figure 2. 5V Efficiency vs Output Current

4.5A in an SO-8

The output switch of the LT1374 is designed to minimize power dissipation from both switch resistance and switch drive current. This allows the use of the SO-8 packaged LT1374 in applications that would have previously required a power package, especially when selection is defined by high dynamic load currents. Typical static and dynamic thermal characteristics for various load currents are shown in Figures 3 and 4. These measurements were made in still air with the LT1374 SO-8 placed on a 4in^2 double-sided circuit board. Multiple vias conduct heat from the board's topside to a continuous copper plane on the bottom side. A typical application for the SO-8 package is supplying a motor driver. The motor may require 4A at start-up but only 2.5A when running. With a 60°C ambient temperature, the SO-8 package can provide 4A of load current for up to seven seconds, followed by 2.5A of continuous current. If 4A of continuous current were required, the surface mount DD package (θ_{JA} = 30°C/W) could be used; for even higher power, use the TO-220 (θ_{JC} = 4°C/W).

Dual Output SEPIC Converter

The circuit in Figure 5 generates both positive and negative 5V outputs from two windings on a single core. The converter for the 5V output is a standard buck converter. The –5V topology would be a simple flyback winding coupled to the buck converter if C4 were not present. C4 creates a SEPIC (single-ended primary inductance converter) topology, which improves regulation and reduces ripple current in L1. Without C4, the voltage swing on L1B compared to L1A would vary due to relative loading and coupling losses. C4 provides a low impedance path to maintain an equal voltage swing in L1B, improving regulation. In a flyback converter, during switch on-time, all the converter's energy is stored in L1A only, since no current flows in L1B. At switch off, energy is transferred by magnetic coupling into L1B, powering the –5V rail. C4 pulls L1B positive during switch on-time, causing current to flow and energy to build in L1B and C4. At switch off, the energy stored in both L1B and C4 supplies the –5V rail. This reduces the current in L1A and changes L1B's current waveform from square to triangular.

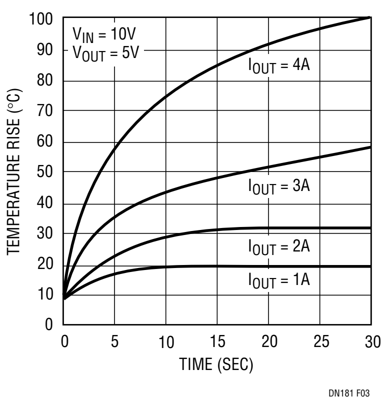


Figure 3. Temperature Rise vs Time

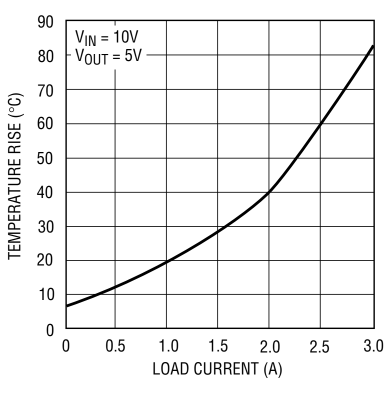
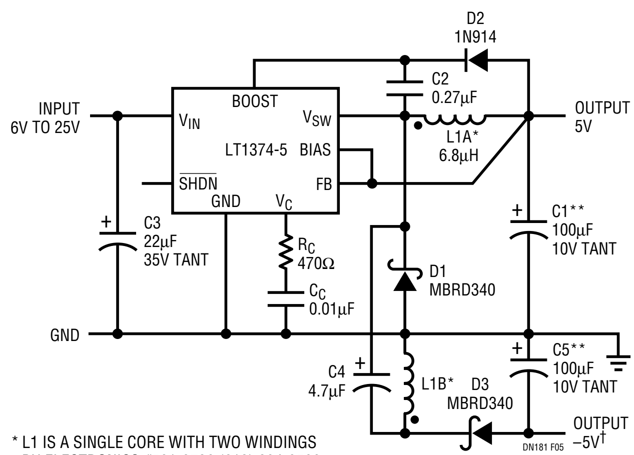


Figure 4. Temperature Rise vs Load Current



* L1 IS A SINGLE CORE WITH TWO WINDINGS
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† IF LOAD CAN GO TO ZERO, AN OPTIONAL PRELOAD OF 1k TO 5k MAY BE USED TO IMPROVE LOAD REGULATION

Figure 5. Dual Output SEPIC Converter

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