

# DESIGN NOTES

## Monolithic DC/DC Converters Break Speed Limits to Shrink Board Space

Design Note 125

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In the never-ending quest for board space, operating frequency remains the most important variable in a DC/DC converter design. Higher frequency equates with smaller coils and capacitors. A new family of fast monolithic converters that allows circuit designers to reduce the size of their finished products is now available. Other improvements include quiescent currents well below those of slower converters and a new switch-drive technique that reduces dynamic losses by at least four fold over previous methods, virtually eliminating these losses as a concern in efficiency calculations.

Table 1 shows the salient features of each member of the family. Each is configured as a grounded-switch step-up converter, but is equally useful in positive and negative high efficiency buck, SEPIC, inverting and flyback circuits. The converters are all based on the LT<sup>®</sup>1372 design, which operates at 500kHz, draws 4mA quiescent current and contains a 1.5A, 0.5 $\Omega$  switch. The LT1371 is designed for higher power applications, with a 3A, 0.25 $\Omega$  switch. Supply current and operating frequency remain unchanged. Reduced quiescent current (1mA) makes the LT1373 useful in low power designs or in applications where the load current has a wide dynamic range. For the ultimate in miniaturization, the LT1377 features 1MHz operating frequency—especially helpful where post filtering is employed.

**Table 1. Family Characteristics**

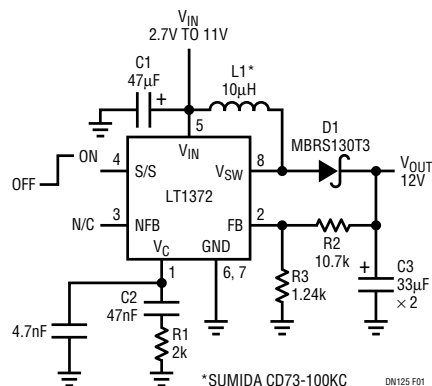
DEVICE	I <sub>q</sub>	SWITCH	FREE RUNNING FREQUENCY	SYNCHRONIZATION LIMIT
LT1371	4mA	3A	500kHz	800kHz
LT1372	4mA	1.5A	500kHz	800kHz
LT1373	1mA	1.5A	250kHz	360kHz
LT1377	4mA	1.5A	1MHz	1.6MHz

All devices share the same constant-frequency PWM core, up to 90% duty cycle and 2.7V to 30V supply range with a maximum switch rating of 35V. Unique to these devices is a synchronization input that allows the internal oscillator to be overridden by an external clocking signal. The synchronization limit for each part is also shown in Table 1. Another unique feature is a second Feedback pin that allows direct regulation of negative outputs.

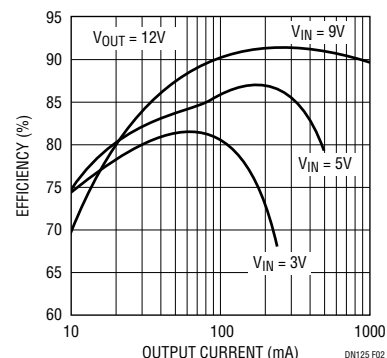
A simple boost converter using the LT1372 is shown in Figure 1. 350mA output current is available at 12V from a 5V input. Adaptive switch drive and a 0.5 $\Omega$  collector resistance result in a peak efficiency of 87%, as shown in Figure 2.

Figure 3 shows a buck-boost (SEPIC) converter built around the 3-ampere LT1371. Inputs of 2.7V to 20V are converted to a 5V regulated output at up to 1.8A (see Figure 4). In spite

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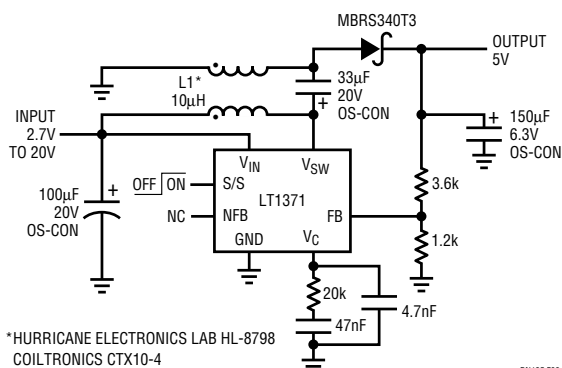
**Figure 1. Schematic Diagram: LT1372 Boost Converter**



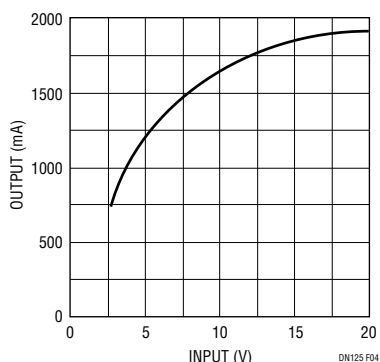
**Figure 2. Efficiency of Boost Converter Shown in Figure 1**

of handling 9W output power, the 500kHz operating frequency of the LT1371 allows a 0.37-inch toroidal core to be used for the coupled inductor, with excellent efficiency. In shutdown, the output is completely disconnected from the input source.

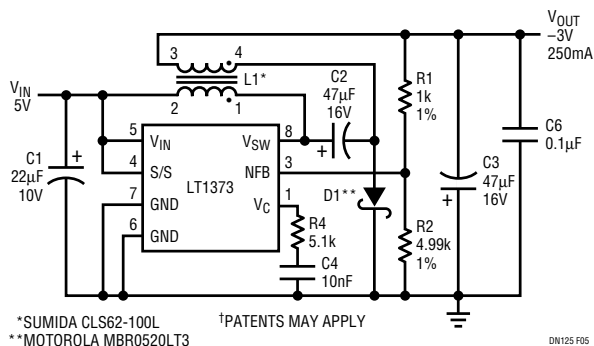
The latest generation of disk drives has adopted magneto-resistive (MR) read-write heads. These operate with a low noise bias supply of  $-3V$ . Figure 5 shows a Cuk-configured LT1373 capable of generating  $-3V$  at 250mA. This converter topology exhibits inherently low output ripple and noise and



**Figure 3. 5V, 9W Converter Operates Over Wide Input Range with Good Efficiency**



**Figure 4. Maximum Available Output Current of LT1371 9W Converter (Figure 3)**

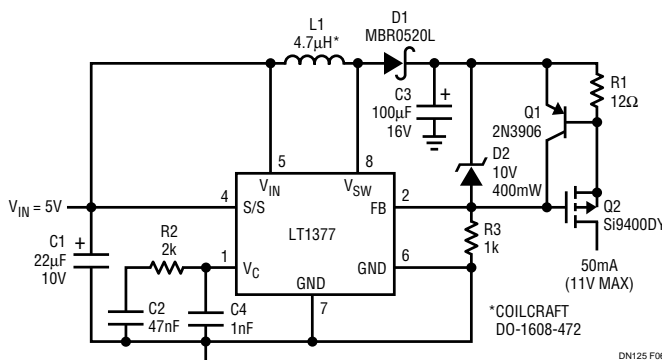


**Figure 5. Low Ripple 5V to  $-3V$  "Cuk" Converter**

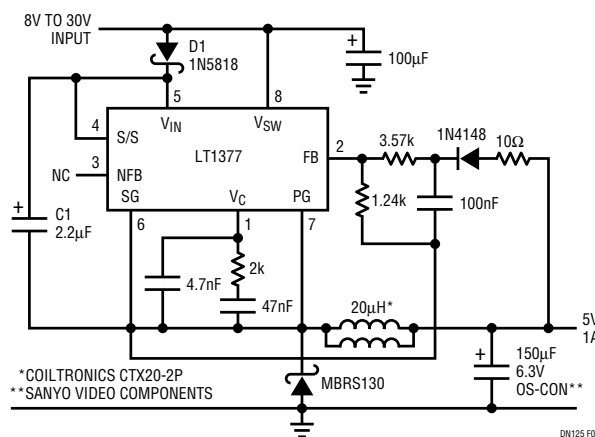
uses a single-core coupled inductor. Operating at 250kHz allows the use of relatively small filter components. The speed-to-power ratio of the LT1373 is quite high; with only 1mA quiescent current, it maintains higher efficiency at light loads.

At the other end of the spectrum is the 1MHz LT1377. It has the same high speed-to-power ratio as the LT1373. In Figure 6 the LT1377 is used as a 50mA charger for 4 to 6 NiCd cells, operating from a 5V input. The charger is clamped against excessive output voltage at 11V, and maintains constant output current from 0V to 11V.

1MHz operation is also useful in radio applications where a 455kHz IF is present, as it gives one octave separation from that critical frequency. Figure 7 shows the LT1377 configured as a high efficiency buck converter, with a 5V, 1A output. A 20µH inductor is used in this application to maintain a low ripple current (10%), thus easing output filtering requirements.



**Figure 6. Battery Charger**



**Figure 7. 1MHz LT1377-Based Buck Converter**

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