Introduction
The LT1931 is the industry’s highest power SOT-23 inverting switching regulator. The on-chip 1A switch allows high output currents to be generated. In a typical 5V to –5V application, the part can deliver 350mA; a 5V to –12V application can provide 150mA. The LT1931 switches at a fixed frequency of 1.2MHz, allowing the use of tiny, low cost capacitors and inductors of 2mm or less in height. The constant switching frequency keeps the output voltage noise low and predictable, making designs with output voltage ripple less than 5mV_P-P easily achievable. An integrated shutdown feature limits the supply current to less then 1μA when the part is disabled, extending battery life. The high power and low noise LT1931 comes in a tiny 5-lead SOT-23 package, saving valuable board space. The part is pin-for-pin compatible with the LT1611, providing a simple upgrade path for users of the older parts who need more power.

Figure 1. 5V to –5V/350mA inverting converter

Figure 2. Output voltage ripple for Figure 1’s circuit

Figure 3. Transient response for Figure 1’s circuit

Figure 4. Efficiency of Figure 1’s circuit
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5V to –5V Local Supply
Figure 1 shows a 5V to –5V application that can deliver up to 350mA of output current. The output voltage ripple for the circuit is less than 3mVp-p, as shown in Figure 2. Figure 3 is an oscillograph of the transient response as the load current steps from 100mA to 200mA and back again. The output voltage and inductor current produce a nicely damped response and recover within 100µs. The voltage overshoot and undershoot is approximately 30mV. Figure 4 shows the efficiency of the circuit. The efficiency stays above 75% over a wide load range of 60mA to the full load current, reaching as high as 79% at 150mA. This solution can fit in a board area as small as 0.19in² (0.5in • 0.38in).

5V to –12V Local Supply
Figure 5 shows a 5V to –12V converter that can provide 150mA of output current. The output voltage ripple is less than 10mVp-p. The efficiency, shown in Figure 6, stays above 80% from a load current of 50mA to the full load current. This solution can fit within a 0.19in² area.

Tiny 5V to –5V Converter
In order for the previous applications to achieve high current outputs, slightly larger coupled inductors were used. Although the total solution still remained small, further reductions in size can be made if a lower maximum output current can be tolerated. Figure 7 shows such a circuit. The circuit uses tiny uncoupled inductors, enabling the solution to fit within a 0.1in² (0.33in • 0.3in) area. This circuit can provide 300mA of output current and has an output voltage ripple of only 6mVp-p.

Soft Start
In applications where soft start is required, the simple circuit shown driving the shutdown pin in Figure 8 can be used. This circuit, which consists of only a resistor, a diode and a capacitor, effectively limits how quickly VOUT can be charged. Figure 9 shows the soft-start circuit at work. After VSS is driven high, the input current slowly ramps up to a peak value of 350mA. The output voltage takes 1.6ms to reach its final value of...
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Figure 9. Soft-start waveforms of Figure 8's circuit; \( R_{SS} = 15k \), \( C_{SS} = 68nF \)

The values of \( R_{SS} \) and \( C_{SS} \) can be adjusted to obtain the desired start-up performance.

Conclusion

The LT1931 is the highest power SOT-23 inverting DC/DC converter in the industry. The circuits presented here demonstrate the high output currents and low output noise achievable with the LT1931. The high switching frequency of the part allows the total solution to fit in an area as small as 1/10th of a square inch.

Figure 9. This application circuit protects the LT1616 and its load from reversed input voltage. The LT1616 will enter shutdown mode when the input supply is disconnected.

Conclusion

The LT1616’s high switching frequency and tiny SOT-23 package result in a very small step-down switching regulator. With its current mode architecture and internal loop compensation, it provides the benefits of an all-ceramic design: low noise, small size and no concerns with tantalum reliability and availability. The 3.6V to 25V input handles power sources ranging from 5V logic supplies to unruly wall transformers and automobile cigarette lighters. The LT1616 is an ideal replacement for bulky (and potentially hot) TO-220 linear regulators.

1 Among the evils of oversized wall transformers: (a) the polarized blades and the arrangement of your outlet inevitably conspire such that plugging in the transformer covers the second outlet, locally reducing the utility of your AC power system by 50%; and (b) they fall out of the outlet under the force of gravity. I keep my Kitchen-Aid mixer pushed up against an AC adapter to hold it (the adapter) in place. I don’t know whether to blame the designer of a radio that needs such a large wall wart or the contractor who installed the outlet a quarter inch too deep in the wall. Kitchen-Aid makes a fine product: with its heavy-duty construction, high torque motor and no-slip rubber feet, the model KS55S mixer can hold even the heaviest wall transformer in place.