Inverting Switching Regulator Delivers High Current/Low Noise Outputs in a SOT-23

by Albert Wu

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.

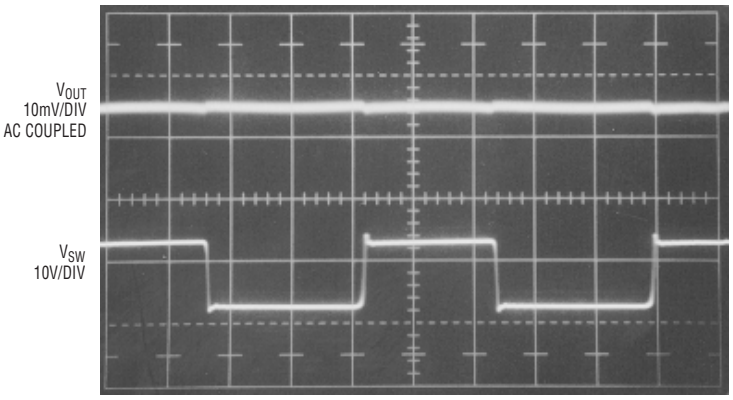

Figure 2. Output voltage ripple for Figure 1's circuit

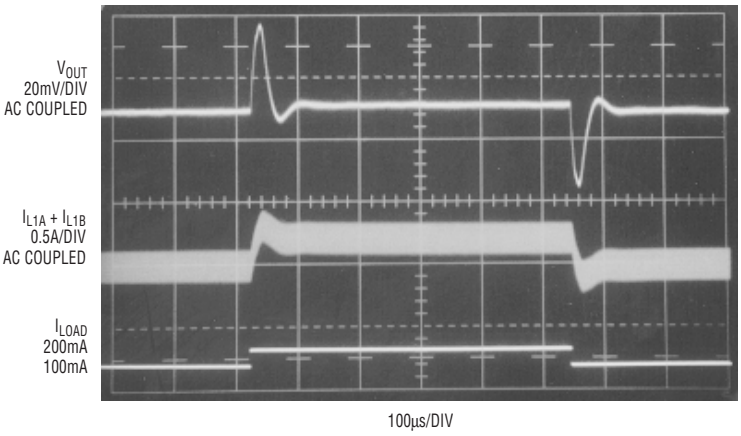

Figure 3. Transient response for Figure 1's circuit

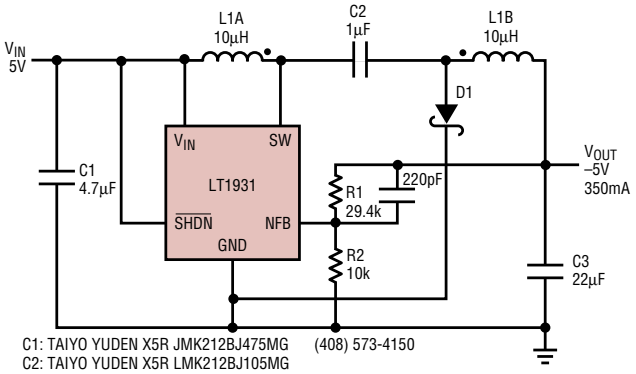

Figure 1. 5V to –5V/350mA inverting converter

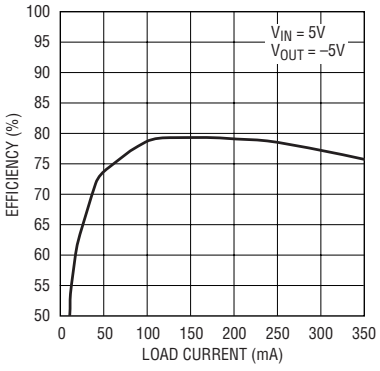

Figure 4. Efficiency of Figure 1's circuit

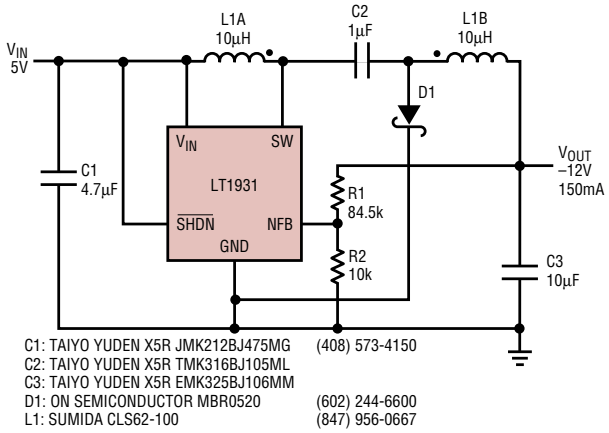

Figure 5. 5V to –12V/150mA inverting DC/DC converter

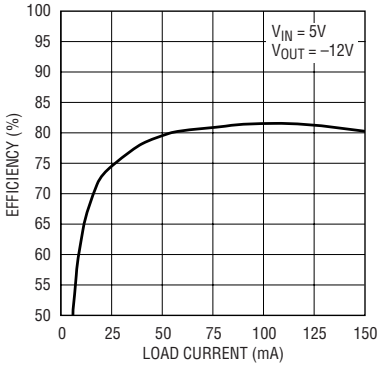

Figure 6. Efficiency of Figure 5's circuit

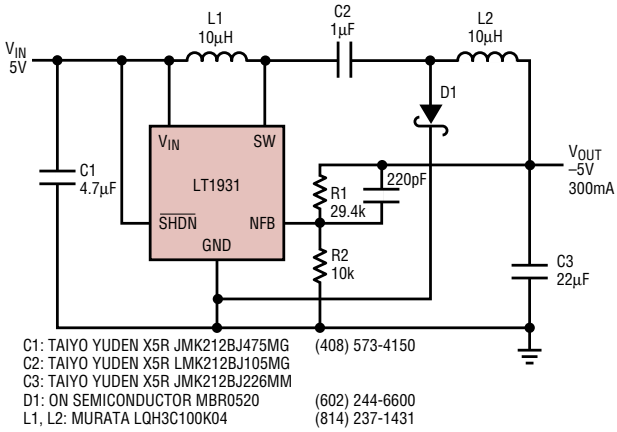

Figure 7. 5V to –5V converter fits in 0.1in²

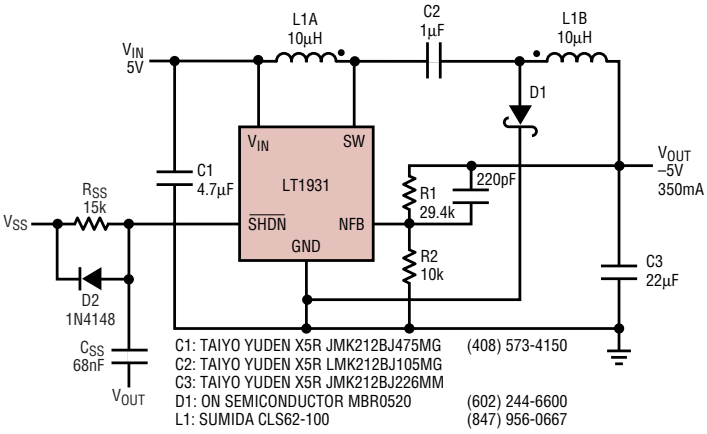

Figure 8. R_{SS} and C_{SS} at the $\overline{SHDN}$ pin provide soft start to LT1931 inverting converter

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 $3mV_{P-P}$, 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 $0.19in^2$ (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 $10mV_{P-P}$. 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 $0.19in^2$ 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 $0.1in^2$ (0.33in • 0.3in) area. This circuit can provide 300mA of output current and has an output voltage ripple of only $6mV_{P-P}$.

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 V_{OUT} can be charged. Figure 9 shows the soft-start circuit at work. After V_{SS} 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

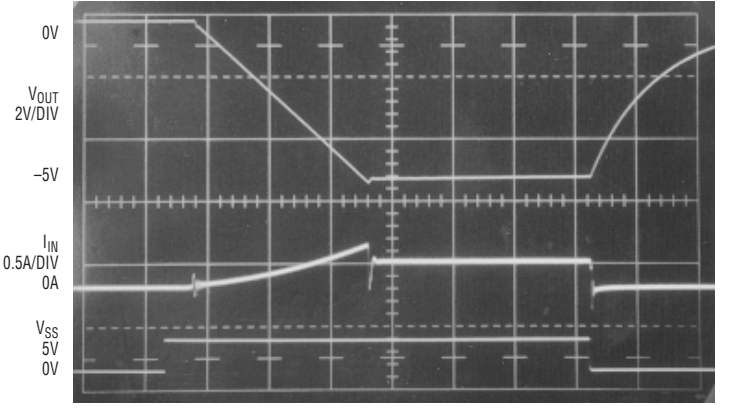

Figure 9. Soft-start waveforms of Figure 8's circuit; R_{SS} = 15k, C_{SS} = 68nF

–5V. 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.