

# DESIGN NOTES

## LT1534 Ultralow Noise Switching Regulator Controls EMI

Design Note 178

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Today's circuit designer is often challenged to assemble a high performance system by combining sensitive analog electronics with potentially noisy DC/DC converters. Requirements for a small, efficient, cost effective solution are in conflict with acceptable noise performance—noisy switching regulators call for filtering, shielding and layout revisions that add bulk and expense. Most electromagnetic interference (EMI) problems associated with DC/DC converters are due to high speed switching of large currents and voltages. To maintain high efficiency, these switch transitions are designed to occur as quickly as possible. The result is input and output ripple that contains very high harmonics of the switching frequency. These fast edges also couple through stray magnetic and electric fields to nearby signal lines, making efforts to filter the supply lines ineffective.

The LT<sup>®</sup>1534 ultralow noise switching regulator provides an effective and flexible solution to this problem. Using two external resistors, the user can program the slew rates of the current through the internal 2A power switch and the voltage on it. Noise performance can be evaluated and improved with the circuit operating in the final system. The system designer need sacrifice only as much efficiency as is necessary to meet the

required noise performance. With the controlled slew rates, system performance is less sensitive to layout, and shielding requirements can be greatly reduced; expensive layout and mechanical revisions can be avoided.

The LT1534's internal oscillator can be programmed over a broad frequency range (20kHz to 250kHz) with good initial accuracy. It can also be synchronized to an external signal placing the switching frequency and its harmonics away from sensitive system frequencies.

### Low Noise Boost Regulator

In Figure 1, the LT1534 boosts 3.3V to supply 650mA at 5V with its oscillator synchronized to an external 50kHz clock. The circuit relies on the low ESR of capacitor C2 to keep the output ripple low at the fundamental frequency; slew rate control reduces the high frequency ripple. Figure 2 shows waveforms of the circuit as it delivers 500mA. The top trace shows the voltage on the collector of the internal bipolar power switch (the COL pins), and the middle trace shows the switch current. The lowest trace is the output ripple. The slew rates are programmed to their fastest here, resulting in good efficiency (83%), but also generating excessive high

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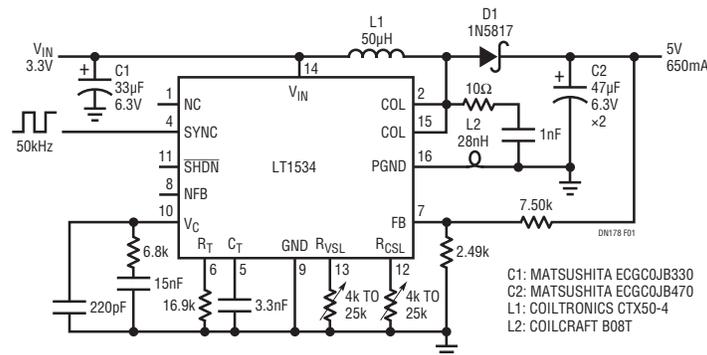
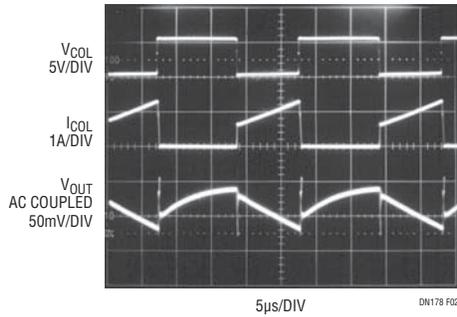


Figure 1. The LT1534 Boosts 3.3V to 5V. The Resistors on the  $R_{VSL}$  and  $R_{CSL}$  Pins Program the Slew Rates of the Voltage On the Power Switch (COL Pins) and the Current Through It



**Figure 2. High Slew Rates ( $R_{CSL} = R_{VSL} = 4k$ ) Result in Good Efficiency But Excess High Frequency Ripple**

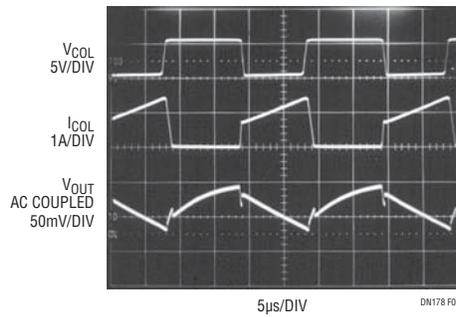
frequency ripple. Figure 3 shows the same waveforms with the slew rates reduced. The large high frequency transients have been eliminated.

### Low Noise Bipolar Supply

Many high performance analog systems require quiet bipolar supplies. This circuit (Figure 4) will generate  $\pm 5V$  from a wide input range of 3V to 12V, with a total output power of 1.5W. By using a 1:1:1 transformer, the primary and secondary windings can be coupled using capacitors C2 and C3, allowing the LT1534 to control the switch transitions at the output rectifiers as well as at the switch collector. Secondary damping networks are not required.

### Additional LT1534 Features

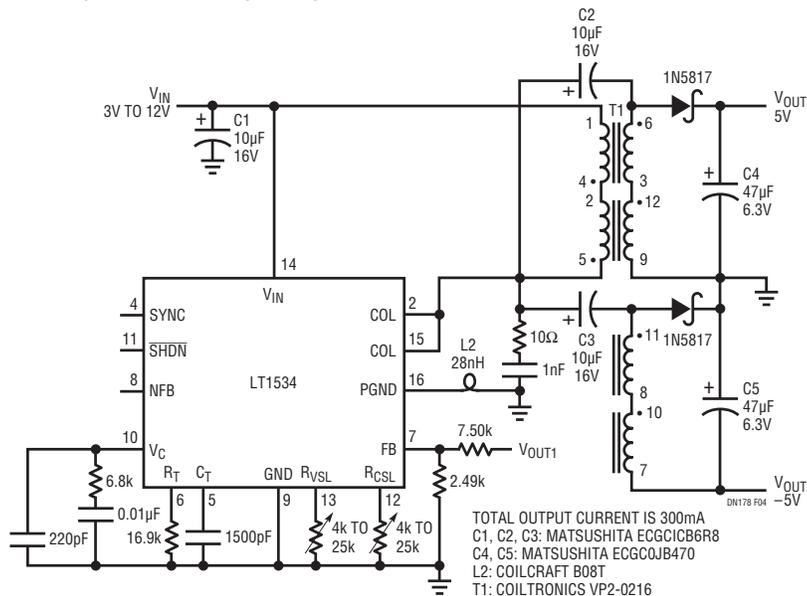
The LT1534 is a complete, low noise switching regulator with an internal 2A power switch, packaged in a



**Figure 3. Low Slew Rates ( $R_{CSL} = R_{VSL} = 24k$ ) Result in an Output Without Troublesome High Frequency Transients**

16-lead narrow plastic SO. The current mode architecture provides fast transient response and cycle-by-cycle current limit. Undervoltage lockout and thermal shutdown provide further protection. The large input range (2.7V to 23V) and high switch voltage (25V), combined with a 12 $\mu$ A shutdown mode, result in a very flexible part suitable for battery-powered operation. The LT1534 can directly regulate either positive or negative output voltages.

The LT1533, closely related to the LT1534, provides two slew rate-controlled 1A power switches. Optimized for push-pull topologies, the LT1533 provides even greater opportunity for reducing DC/DC converter noise. For further applications, consult the LT1533 and LT1534 data sheets and Linear Technology's Application Note 70.



**Figure 4. A Low Noise, Wide Input Range  $\pm 5V$  Supply**

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