DESIGN NOTES

Off-Line Low Noise Power Supply Does Not Require Filtering to Meet FCC Emission Requirements – Design Note 175

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Introduction

Off-line power supplies require input filtering components to meet FCC emission requirements. Additionally, board layout is usually quite critical, requiring considerable experimentation even for experienced off-line supply designers. These considerations derive from the wideband harmonic energy generated by the fast switching of traditional off-line supplies. A new device, the LT®1533 low noise switching regulator, eliminates these issues by continuous, closed-loop control of voltage and current switching times.[1] Additionally, the device's push-pull output drive eliminates the flyback interval of conventional approaches. This further reduces harmonics and smooths input

[1] In depth coverage of this device, its use and performance verification appears in LTC Application Note 70, "A Monolithic Switching Regulator with 100µV Output Noise," by Jim Williams.

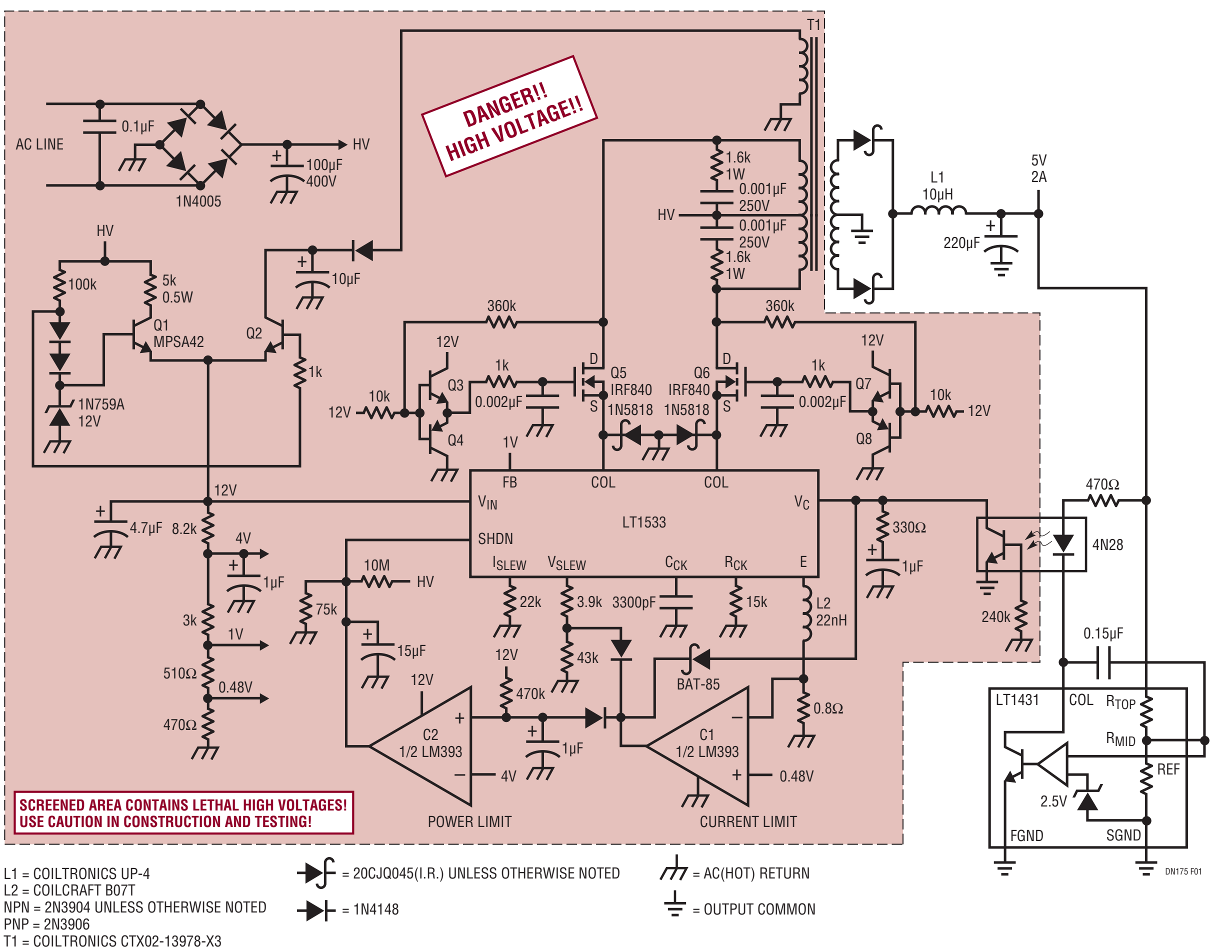

Figure 1. 10W Off-Line Power Supply Passes FCC Emission Requirements Without Filter Components

current drain characteristics. Although intended for DC/DC conversion, the LT1533 adapts nicely to off-line service, while eliminating emission, filtering, layout and noise concerns.

Circuitry Details

Figure 1 shows the supply. Q5 and Q6 drive T1, with a rectifier filter, the LT1431 and the optocoupler closing an isolated loop back to the LT1533. The LT1533 drives Q5 and Q6 in cascode fashion to achieve high voltage switching capability. It also continuously controls their current and voltage switching times, using the resistors at the I_{SLEW} and V_{SLEW} pins to set transition rates. FET current information is directly available, although FET voltage status is derived via the 360k–10k dividers and routed to the gates via the NPN-PNP followers. The source wave shapes, and hence the voltage slewing information at the LT1533 collector terminals, are nearly identical in shape to the drain waveforms.

Q1, Q2 and associated components provide a bootstrapped bias supply, with start-up transistor Q1 turning off once T1 begins supplying power to Q2. The resistor string at Q2's emitter furnishes various "housekeeping" bias potentials. The LT1533's internal 1A current limit is too high for effective overcurrent protection. Instead, current is sensed via the 0.8Ω shunt at the LT1533's emitter pin (E). C1, monitoring this point, goes low when current limit is exceeded. This pulls the V_C pin low and also accelerates voltage slew rate, resulting in fast limiting while minimizing instantaneous FET stress. Prolonged short-circuit conditions result in C2 going low, putting the circuit into shutdown. Once this occurs, the C1–C2 loop oscillates in a controlled manner, sampling current for about a millisecond every second or so. This action forms a power limit, preventing FET heating and eliminating heat sink requirements.

Performance Characteristics

Figure 2 shows waveforms for the power supply. Trace A is one FET source; traces B and C are its gate and drain waveforms, respectively. FET current is trace D. The cascoded drive maintains waveshape fidelity, even as the LT1533 tightly regulates voltage and current transition rates. The wideband harmonic activity typical of off-line supply waveforms is entirely absent. Power delivery to T1 (center screen, trace C) is particularly noteworthy. The waveshapes are smoothly controlled, and no high frequency content is observable.

Figure 3, a 30MHz wide spectral plot, shows circuit emissions well below FCC requirements. This data was taken with no input filtering LC components and a nominally nonoptimal layout.

Output noise is composed of fundamental ripple residue, with essentially no wideband components. Typically, the low frequency ripple is below 50mV. If additional ripple attenuation is desired a 100µH–100µF LC section permits <100µV output noise. Figure 4 shows this in a 100MHz bandpass. Ripple and noise are so low that the oscilloscope requires a 40dB low noise preamplifier to even register a display (see footnote 1).

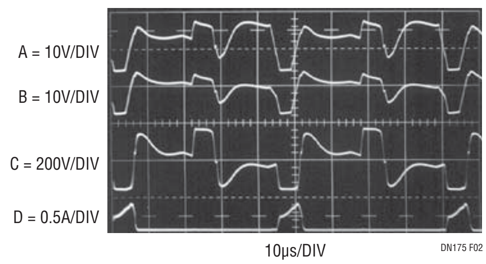

Figure 2. Waveforms for One of the Power Supplies' FETs Show No Wideband Harmonic Activity. LT1533 Provides Continuous Control of Voltage and Current Slewing. Result is Smoothly Controlled Waveshapes for FET Source (A), Gate (B) and Drain (C). FET Current is Trace D

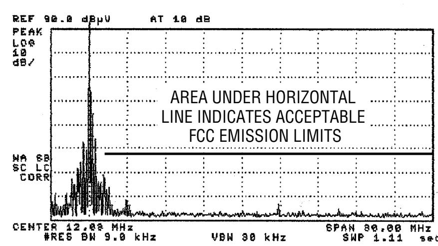

Figure 3. 30MHz Wide Spectral Plot Shows Circuit Emissions Well Below FCC Requirements Despite Lack of Traditional Filter Components

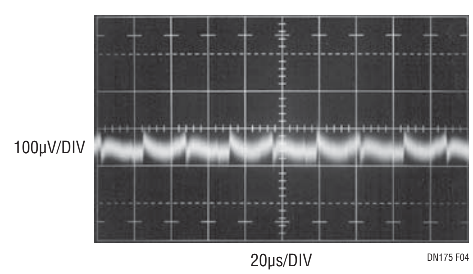

Figure 4. Power Supply Output Noise Below 100µV (100MHz Measurement Bandwidth) is Obtainable Using Additional Output LC Section. Without LC Section Wideband Harmonic is Still Absent, Although Fundamental Ripple is 50mV

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