Maxim > Design Support > Technical Documents > Application Notes > Power-Supply Circuits > APP 1121

Keywords: step-down, buck, DC-DC, dc dc, converters, convertors, ceramic capacitor, output ripple, ESR capacitors, voltage positioning

APPLICATION NOTE 1121

Using Ceramic Output Capacitors with the MAX1734 Voltage-Mode Buck Converter

Jun 24, 2002

Abstract: The MAX1734 voltage-mode buck DC-DC converter was design to work with medium ESR tantalum capacitors; however, by slightly changing the feedback scheme, small, low-ESR ceramic capacitors may be used. A schematic, design equations, and load-transient response waveforms are provided.

Many stepdown (buck) DC-DC controller ICs incorporate a voltage-mode control algorithm. As a result (for stable operation in continuous-conduction mode), the resulting application circuit's output capacitor is normally a high-ESR tantalum type. The circuit of **Figure 1**, however, allows use of an inexpensive ceramic output capacitor. To remove the effects of phase lag in the feedback loop, feedback is derived from the LX pin instead of the output.

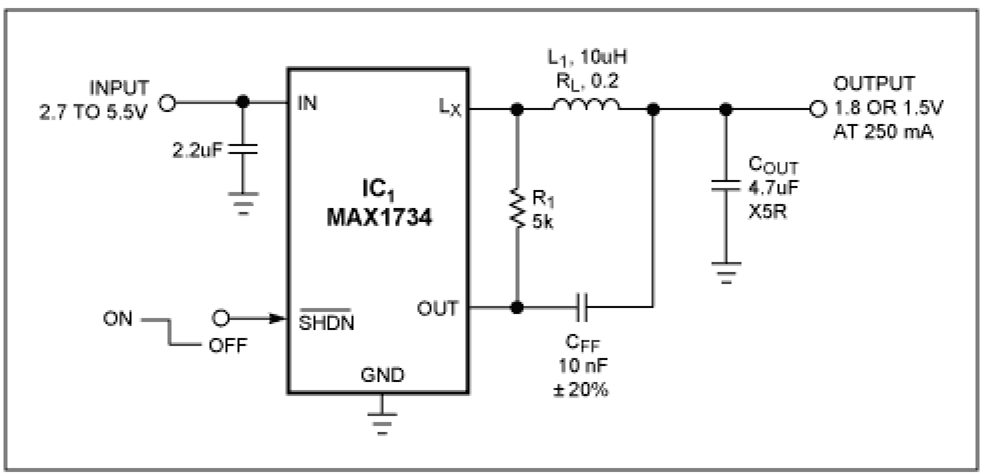

Figure 1. In this simple application circuit, a stepdown DC-DC converter operates with a ceramic output capacitor.

A ceramic-capacitor circuit offers several benefits over the standard application circuit. First, ceramic capacitors are more readily available than tantalum types. Second, (see **Figure 2**) they cause less output ripple (<5mV$_{PP}$ vs. >20mV$_{PP}$), and less load-transient overshoot (<50mV$_{PP}$ vs. >100mV$_{PP}$). IC1[1] needs 20mV$_{PP}$ or more at the OUT pin for stable operation under load. To meet this requirement, first calculate the R1 value:

$$R1 \cong \left(\frac{20mV}{2 \cdot Vout}\right)\left(\frac{L1}{Tmin}\right)\left(\frac{I_{LOADMAX}}{2 \cdot I_{OUTSENSE}}\right)$$

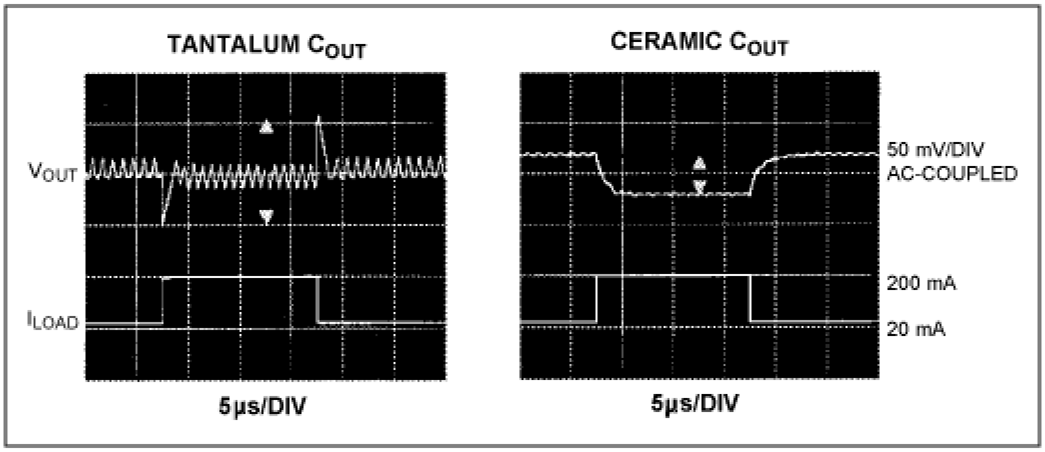

Figure 2. Load-transient response waveforms (top traces) show that a ceramic output capacitor produces lower output ripple and less overshoot.

Per the MAX1734 data sheet, V_{OUT} is 1.5V or 1.8V, L1 is 10µH, Tmin is 0.4µsec, $I_{LOADMAX}$ is 250mA, and $I_{OUTSENSE}$ is 4µA. The result is R1 = 4.3kΩ for V_{OUT} = 1.8V, and R1 = 5.2kΩ for V_{OUT} = 1.5V. R1 may therefore be rounded to 5kΩ. Next, calculate the feedforward-capacitor value:

$$Cff \leq \left(\frac{2 \cdot Vout}{20mV}\right)\left(\frac{Tmin}{R1}\right)$$

If R1 = 5kΩ and V_{OUT} = 1.5V, then Cff ≤ 12nF. Select Cff = 10nF. Choosing a much smaller value will cause excessive load-transient overshoot, and choosing a larger value will cause instability under loaded conditions. For optimized load transients, the inductor series resistance should be

$$R_L \cong \frac{L1}{R1 \cdot Cff}$$

In this case the R_L value should be about 200mΩ, which allows use of a small inductor and causes an approximate efficiency drop of only 3% at maximum load. Because the inductor time constant $L1/R_L$ is matched to the feedback time constant R1 × Cff, the short-term load-transient response equals the DC load regulation (Figure 2). If R_L is chosen less than 200mΩ, the peak-to-peak load-transient voltage will increase but the DC load regulation will decrease.

Finally, choose C_{OUT} large enough for stability:

$$Cout \geq 2 \cdot \left(\frac{\Delta I_L}{20mV}\right) \cdot Tmin$$

where ΔI_L is approximately 100mA when the MAX1734 operates with a 10µH inductor. In this case, C_{OUT} should be greater than 4µF.

[1]The MAX1734 stepdown DC-DC converter supplies a fixed 1.8V or 1.5V output at 250mA from an input voltage range of 2.7V to 5.5V. Its 5-pin SOT23 package and internal synchronous rectifier allows a small application circuit with a minimum number of external components.

A similar version of this article appeared in the June 7, 2001 issue of *EDN* magazine.

Related Parts		
MAX1734	Low-Voltage, Step-Down DC-DC Converters in SOT23	Free Samples