Ceramic Capacitors Replace Tantalum Capacitors in LDOs

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ABSTRACT

With the proper considerations, ceramic output capacitors can be used with low dropout linear regulators (LDO) and DC/DC switching converters that require tantalum output capacitors.

Many internally compensated linear regulators and switching converters require some equivalent series resistance (ESR) in the output capacitor, C_{OUT}. The control loop for these tantalum C_{OUT}-only converters relies on the zero that is created by the product of the output capacitance, C_{OUT}, and the ESR for stability. Converter data sheets typically provide a minimum (and possibly maximum ESR) value for a given output capacitance or the required frequency of the zero. For example, the data sheet for the TPS769xx family of linear regulators provides a curve of ESR versus output current for different output voltages(Figure 1).

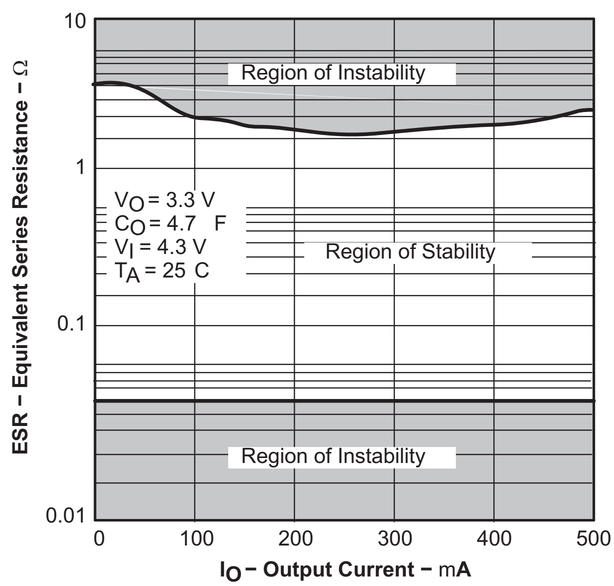

Figure 1. Typical Region of Stability ESR Versus Output Current

For various reasons including lower cost, smaller size, and/or reliability, some system engineers prefer to use ceramic capacitors instead of tantalum capacitors in their applications. A low-ESR ceramic output capacitor with a discrete series resistor can be used to replace a tantalum output capacitor. The schematic in Figure 2 shows such an implementation, using a 0.060-Ω series resistor and 4.7-µF ceramic output capacitor. This series combination of parts meets the TPS76933 ESR requirements shown in Figure 1; therefore, the linear regulator will be stable over the load range. No further testing is required. While a 1/4-watt resistor is acceptable for simulating the output capacitor ESR of most linear regulators, a resistor with larger power rating may be necessary for switching converters because the inductor ripple current, ΔI, flows through the resistor, dissipating $\Delta I^2 * R$ watts of power in the resistor.

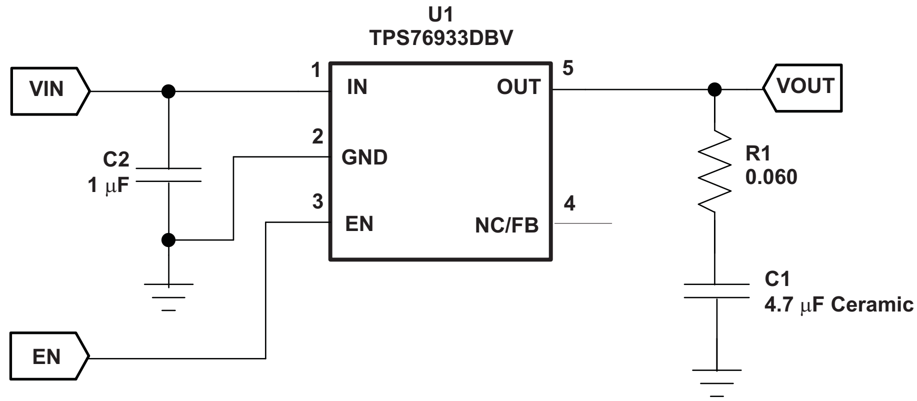

Figure 2. TPS76933 Implementation using R1 to provide ESR

To minimize load transient dips caused by ESR, use only the smallest required ESR. In this example, even though the minimum ESR was 0.050 Ω, a 0.060-Ω resistor was selected to allow some margin for resistor tolerance over temperature. Because it is the ESR and C_{OUT} product that is important, choosing a larger C_{OUT} allows a smaller ESR to be chosen.