Keywords: capacitor, dcdc, dc-dc, DC-DC, MOSFET, laser, inrush current

APPLICATION NOTE 1198

Off-The-Shelf Transformer Limits Capacitor Inrush Current

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Energy stored in a high-voltage capacitor activates many applications, including radiological sensors, pulsed lasers, particle-beam generators, and automotive direct fuel-injection systems. In the last case, the fuel injector discharges the capacitor as it sprays fuel directly into the car's combustion chamber. The speed and control required for this application can be achieved using a standard, inexpensive transformer.

The capacitor must be recharged quickly during each engine cycle, but in a controlled way that minimizes noise and voltage transients in the electrical system. Control of the charging waveform also allows a finer tuning of cost/performance trade-offs when selecting circuit components.

An inexpensive, off-the-shelf, 6-winding transformer (**Figure 1**) can be used to limit the capacitor's inrush current without the expense of added feedback and control circuitry, and without the efficiency loss associated with a traditional inrush-current limiter. T1 is configured as an autotransformer in which three windings in parallel form the primary between V_{IN} and the MOSFET drain, and three windings in series form a secondary between V_{IN} and D2. The turns ratio is 1:4.

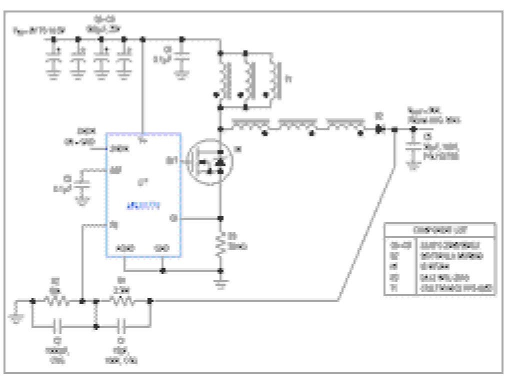

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Figure 1. The autotransformer in this boost converter reduces inrush to the discharge capacitor, allows use of a smaller capacitor, and reduces the MOSFET's required voltage rating.

When feedback to the step-up DC-DC controller (IC1) detects a drop in the capacitor voltage, the controller turns on the MOSFET and allows current in the primary to ramp up and generate magnetic flux in the transformer's core. When this current reaches a 3.3A threshold set by the current-sense resistor (R3), IC1 interrupts the current by turning the MOSFET off.

In accordance with Lenz's Law, the transformer opposes the instantaneous change in magnetic flux by generating a voltage surge that forces current through the output diode. The resulting current in the transformer secondary is $I_{SEC} = I_{PRI}/N = 3.3A/4 = 0.83A$. Thus, the transformer causes a 75% reduction in the peak instantaneous current flowing from the output diode to the discharge capacitor. It also reduces the maximum MOSFET-drain voltage by 75%.

The 75% reduction in the instantaneous secondary-winding current limits the inrush of charging current by forcing a proportional reduction in the maximum average output current. The result is a well-controlled charging ramp (**Figure 2**). By relaxing ESR requirements for the capacitor, it also allows use of a 30µF polyester-film capacitor to save size and cost. The lower maximum voltage at the MOSFET drain allows use of an inexpensive 60V MOSFET with lower $R_{DS(ON)}$, which improves efficiency.

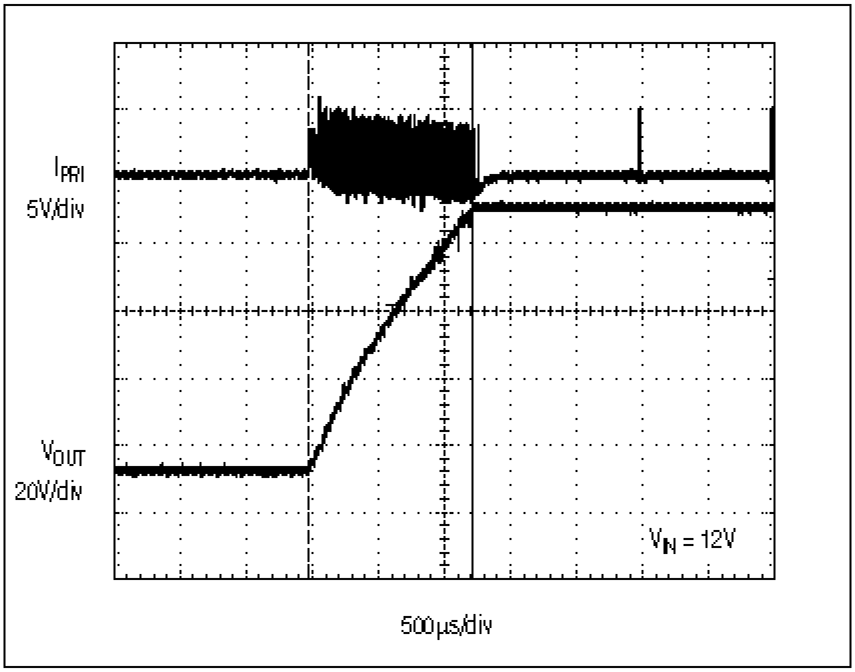

Figure 2. By limiting the peak instantaneous output current to 25% of the instantaneous primary current, the autotransformer in Figure 1 limits the capacitor's inrush current to a well-controlled ramp during charging.

A similar idea appeared in the 6/22/98 issue of Electronic Design.

Related Parts		
MAX1771	12V or Adjustable, High-Efficiency, Low I_Q, Step-Up DC-DC Controller	Free Samples

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