Automotive switching regulators get input-transient-voltage protection

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Engineers often face difficult trade-offs when voltage regulators can encounter high-voltage transients that are well above normal input-supply operating ranges. This situation is common in automotive applications in which high-voltage transients from an alternator load dump can produce transients of 36 to 75V for durations as long as 400 msec. Designers must choose between a regulator that can withstand such maximum input voltage or use an input-protection scheme. The simple circuit in this Design Idea provides a highly cost-effective method for clamping an input voltage from a battery input with transients as high as 50V to take advantage of a 20V, 3-MHz regulator. With this circuit, your design can achieve a small total footprint with relatively low cost because of the 3-MHz operation along with lower voltage components than might otherwise be necessary to withstand 50V.

Input-protection components consist of Q_1, R_1, D_1, C_5, and one-half of D_2 (**Figure 1**). At start-up, N-channel MOSFET Q_1's source is at ground potential and turns on when R_1 applies the battery voltage to the gate. Once the input voltage is above the minimum of 2.74V on IC_1, the LM2734Z regulator starts switching, which charges the bootstrap circuit comprising D_3, D_4, and C_B. This bootstrap voltage of approximately $V_{OUT}-V_{FD}$ (forward-voltage drop) of D_3 then transfers to the gate source of Q_1. Capacitor C_5 then maintains gate drive during the bootstrap diode's off times.

Under normal operating conditions, for example, the battery voltage is 8 to 18V, D_1 does not limit conduction of Q_1, and the gate voltage tracks approximately 2.5V above the input-supply voltage for a low voltage drop from the battery voltage to the input voltage of the LM2734Z. However, when the input voltage increases above the threshold that D_1 sets, the input voltage to the LM2734Z regulates to the zener voltage (V_Z) of D_1 minus the threshold voltage of Q_1, or approximately $20-2V=18V$, well below the 24V absolute maximum of the LM2734Z. Selecting Q_1 requires careful consideration of maximum input voltage, gate-to-source-voltage threshold, and power dissipation under both steady-state and thermal-transient conditions.

Q_1, the SI1470DN N-channel MOSFET, provides 50V protection with a drain-to-source voltage (V_{DS}) of 30V+20V (zener diode D_1 voltage), has an on-resistance of 95 mΩ at a gate-to-source voltage of 2.5V, and comes in a thermally efficient SC70-6 package. For some applications, the regulator's output voltage may be insufficient to fully turn on the selected protection MOSFET, so you can increase the bootstrap voltage with a separate zener reference, as the LM2734Z's data sheet shows **(Reference 1).** EDN

REFERENCE

1. "LM2734Z Thin SOT23 1A Load Step-Down DC-DC Regulator," National Semiconductor, www.national.com/pf/LM/LM2734Z.html.

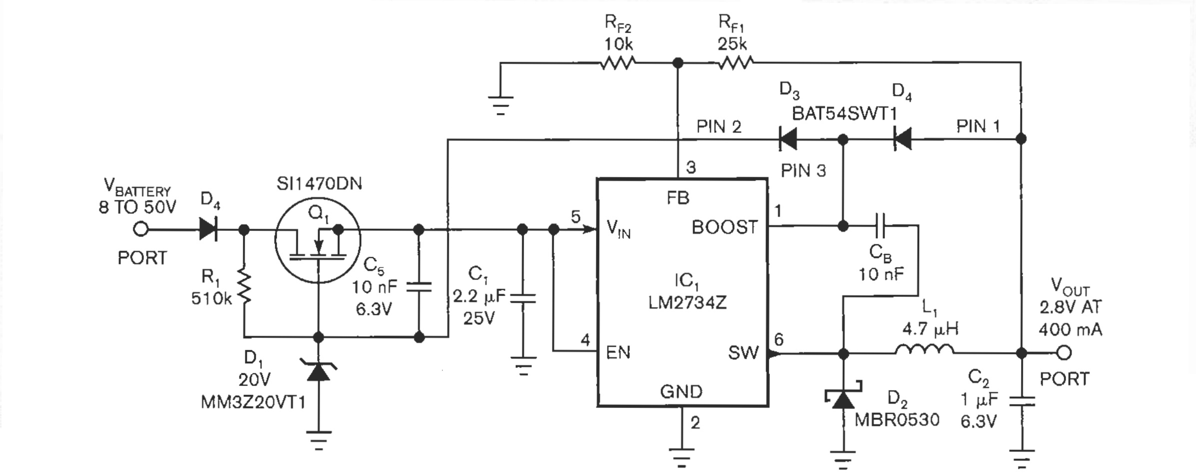

Figure 1 The N-channel MOSFET and zener diode protect the switching regulator against transient voltages as high as 50V in automotive applications.