Circuit adds foldback-current protection

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For many applications that require power-supply currents of a few amperes or less, three-terminal adjustable-output linear voltage regulators, such as National Semiconductor's LM317, offer ease of use, low cost, and full on-chip overload protection. The addition of a few components can provide a three-terminal regulator with high-speed short-circuit current limiting for improved reliability. The current limiter protects the regulator from damage by holding the maximum output current at a constant level, I_{MAX}, that doesn't damage the regulator (**Reference 1**). When a fault condition occurs, the power dissipated in the pass transistor equals approximately $V_{IN} \times I_{MAX}$. Designing a regulator to survive an overload requires conservatively rated—and often overdesigned—components unless you can reduce, or fold back, the output current when a fault occurs (**Reference 2**).

The circuit in **Figure 1** incorporates foldback-current limiting to protect the pass transistor by adding feedback resistor R_4. Under normal conditions, transistor Q_2 doesn't conduct, and resistors R_1 and R_2 bias MOSFET Q_1 into conduction. When an output overload occurs, Q_2 conducts, reducing the on-state bias applied to Q_1 and thus increasing its drain-source resistance and limiting the current flowing into regulator IC_1, an LM317. Adding R_4 makes Q_2's bias current dependent on the output voltage, V_{OUT}, which decreases under overload conditions.

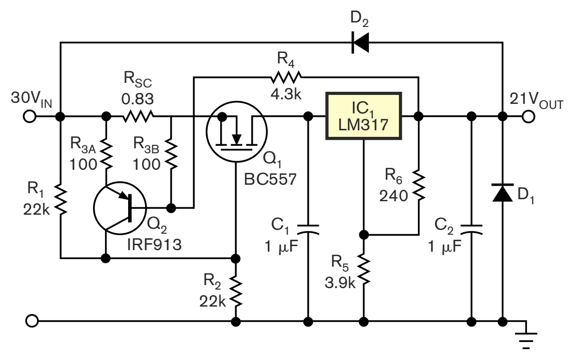

Figure 1 This circuit adds foldback-overcurrent protection to a linear regulator.

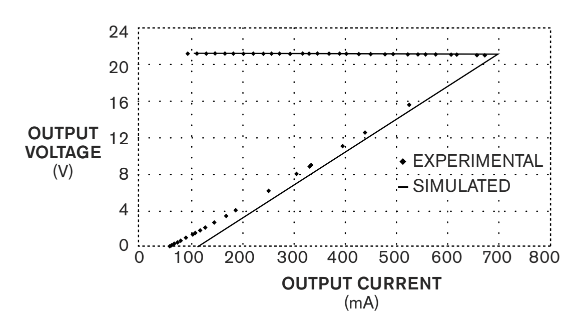

Figure 2 Simulated and measured foldback-current responses to a load resistance that varies from 200 to 0.01Ω show close agreement.

For the circuit in **Figure 1**, you can calculate the maximum foldover and short-circuit currents, I_{KNEE} and I_{SC}, respectively, as follows:

$$I_{KNEE} = \frac{(R_3+R_4)\times V_{SENSE}}{R_{SC}\times R_4} - (V_{IN}-V_{OUT})\times\frac{R_3}{R_{SC}\times R_4}. \quad (1)$$

$$I_{SC} = \frac{(R_3+R_4)\times V_{SENSE}}{R_{SC}\times R_4} - V_{IN}\times\frac{R_3}{R_{SC}\times R_4}. \quad (2)$$

In a practical design, you select values for I_{KNEE} and I_{SC} and equal values for R_{3A} and R_{3B} and then use **equations 1** and **2** to calculate resistors R_{SC} and R_4. For the circuit in **Figure 1**, the output's maximum and short-circuit currents are fixed at 0.7 and 0.05A, respectively. With R_{3A} and R_{3B} set to 100Ω, solving the equations yields values of 0.73Ω for R_{SC} and 4.3 kΩ for R_4. You can demonstrate the circuit's performance by applying a variable-load resistor that's adjustable from 0 to 200Ω. As **Figure 2** shows, the output's simulated and measured voltage-versus-current characteristics, V_{OUT} and I_{OUT}, respectively, are in close agreement. **EDN**

REFERENCES

1 Hulseman, Herb, "MOSFET enhances voltage regulator's overcurrent protection," *EDN*, March 3, 2005, pg 74.

2 Galinski, Martin, "Circuit folds back current during fault conditions," *EDN*, Nov 28, 2002, pg 102.