Cascode MOSFET increases boost regulator's input- and output-voltage ranges

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Targeting use in portable-system applications that require raising a battery's voltage to a higher level, IC boost regulators often include output transistors that can drive storage inductors. However, most boost regulators' absolute-maximum input-voltage rating typically doesn't exceed 6V, an adequate level for battery operation. In addition, breakdown voltage of the regulator's output transistor limits the regulator's absolute-maximum output voltage to 25 to 30V, which may be too low for some applications.

You can extend a boost regulator's output-voltage range by adding an external transistor that has a higher breakdown voltage than the regulator. However, the internal design of a typical boost regulator's control circuitry often prevents direct drive of an external transistor's base or gate. As an alternative, you can add an external higher voltage transistor by connecting it in a cascode configuration.

Most boost regulators feature a peak-current-control method that reduces the number of external components and thus shrinks the overall pc-board area of the converter circuit. **Figure 1** shows a boost regulator based on a TPS61040 boost controller, IC_1, which uses peak-current control.

Applying input voltage V_{IN} to IC_1's V_{CC} pin and to one leg of inductor L_1 turns on IC_1's internal MOSFET switch, Q_1, allowing a gradually increasing amount of current to flow from V_{IN} through L_1, Q_1, and internal current-sense resistor R_1. The circuit's internal controller monitors the volt-

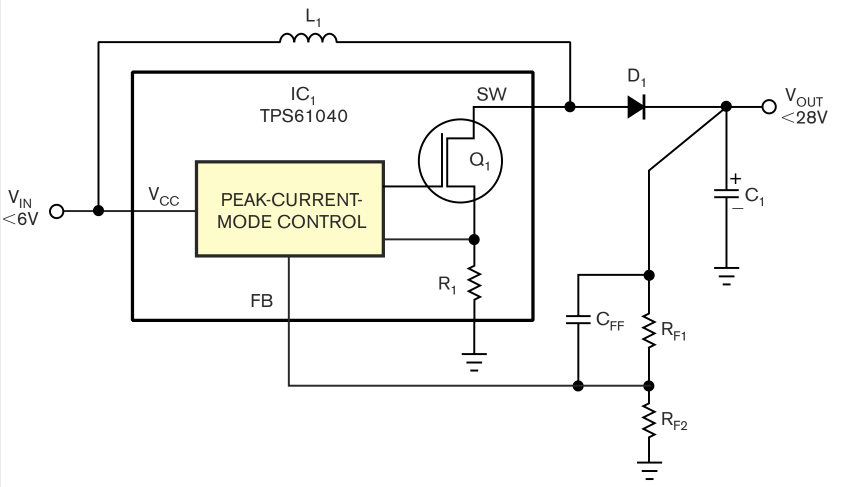

Figure 1 Based on the "barefoot" TPS61040, this dc/dc boost converter delivers output voltages only within IC_1's ratings.

age across sense resistor R_1 and, upon reaching a predetermined current limit, turns off Q_1.

Interrupting the current through L_1 raises the voltage across the inductor and applies forward bias to diode D_1, which conducts and charges output capacitor C_1 to a higher voltage than would be available from the input voltage alone. The input voltage, L_1's inductance, and the preset peak current through R_1 all affect Q_1's on-time, and the output voltage sensed by IC_1's FB (feedback) pin and its external components determines Q_1's off-time. To maintain operation and set Q_1's off-time, IC_1's internal controller must monitor current through L_1 using Q_1 and R_1.

You can add a higher voltage MOSFET transistor, Q_2 (**Figure 2**), for applications that require an output voltage higher than the internal transistor's breakdown voltage. To maintain the circuit's current-flow path through L_1 and IC_1's SW pin, you connect the external transistor in a cascode, or common-gate, configuration.

Q_2 comprises a low-on-resistance, low-gate-voltage-threshold MOSFET with the addition of diode D_2 between Q_2's gate and source. To ensure the circuit's proper operation, V_{CC}—5V in this example—must exceed Q_2's gate-threshold turn-on voltage. In operation, IC_1's internal control circuit turns on Q_1, which pulls Q_2's source close to ground level and turns on Q_2 with almost 5V of gate-to-source potential.

Current flows through inductor L_1, external transistor Q_2, internal transistor Q_1, and sense resistor R_1, and IC_1's control circuit "sees" no difference with the installation of Q_2. Once the inductor current reaches its preset limit, Q_1 turns off, leaving Q_2 with no path for current to flow from its source. The voltage on Q_2's drain rises rapidly to the desired output voltage plus the voltage drop across D_1. As the drain voltage rises, Q_2's drain-to-source capacitance attempts to pull the MOSFET's floating source above 5V, which forward-biases D_2, connects IC_1's SW pin voltage to 5V plus one diode drop, and clamps Q_2's source to the same voltage.

A boost converter delivers a 180V output at 4 mA (V_{OUT}) to bias a laser circuit from a 9V power supply (V+). In this application, the 5V input supply need provide only enough current—typically, a few milliamperes—to drive IC_1's internal logic and the gate of cascode MOSFET Q_2. You can use a dropping resistor and zener-diode voltage regulator (not shown) to supply the 5V requirement from the 9V supply. You can drive the inductor and IC_1 from a common power supply or from a separate source that's within Q_2's breakdown-voltage rating. The cascode circuit also can produce any output voltage that's within Q_2's drain-to-source breakdown-voltage rating. Specify other components with an appropriate voltage rating—for example, breakdown-voltage ratings of inductor L_1 and capacitor C_1 should safely exceed the desired output voltage. EDN

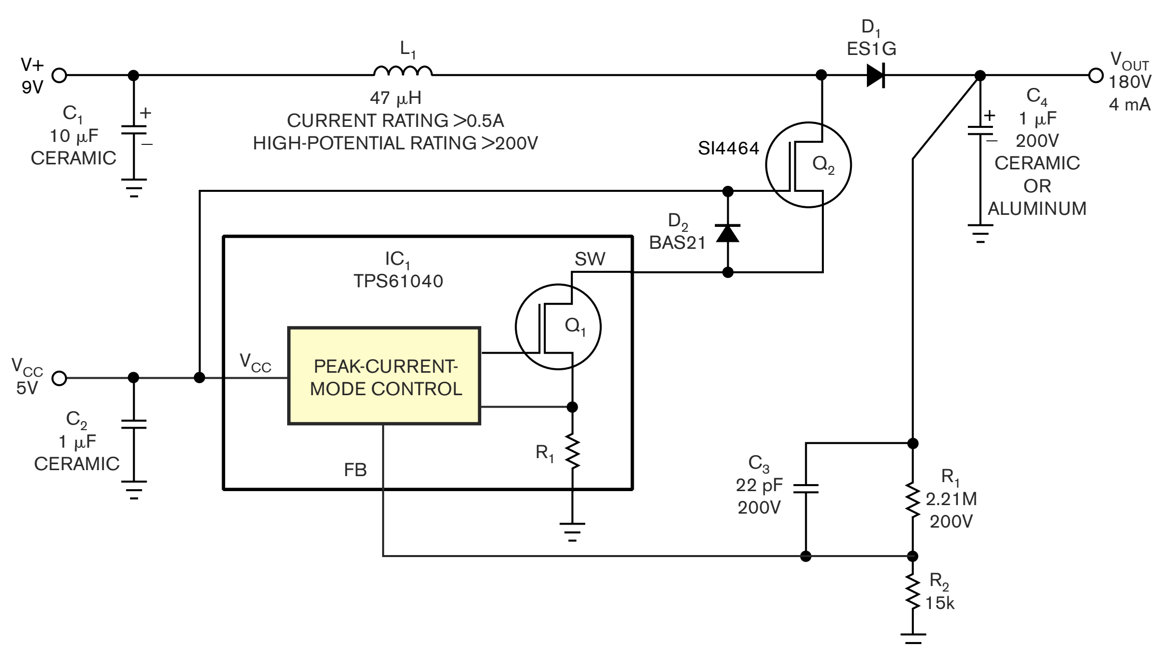

Figure 2 Adding an external cascode-connected MOSFET transistor, Q_2, with higher breakdown-voltage ratings, enables the circuit to produce higher output voltages.