No Heatsink Needed for 200-W Buck-Boost Supply

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A common problem power-supply designers face is how to generate an output that, at any time, can be above or below the input, particularly in battery-powered systems. Many conventional solutions — such as two-stage power converters, single-ended primary inductor converters (SEPIC) or flyback converters — suffer from bulky component requirements and low efficiency. A synchronous four-switch buck/boost controller, the LTC3780 avoids these pitfalls by using a high-efficiency single-inductor topology.[1]

The LTC3780 has four sets of integrated FET drivers for a 4-V to 30-V (36-V max) input- and output-voltage range. However, some applications, such as 48-V telecom systems and automotive systems, require even higher input or output voltage. To extend the input- and output-voltage range, a high-voltage, high-side FET driver should be used as shown in Fig. 1.

Fig. 1 shows the schematic of a design with 36-V to 72-V telecom input voltage and tightly regulated 48-V output with a maximum 4-A load, or approximately 200 W of output power. In this design, because of the high input voltage, the 100-V-rated LTC4440 high-side driver is used to drive the buck-side top FET (Q_A). Internally, the LTC3780 has about 50-ns dead time between the top-gate and bottom-gate signals to avoid the bridge FET short-through.

Because the LTC4440 gate driver has a typical 30-ns propagation delay, as shown in Fig. 2, the dead time between Q_A turn-off and bottom FET (Q_B) turn-on is reduced from 50 ns to a marginal 20 ns with the LTC4440. To compensate for the additional Q_A turn-off delay caused by the LTC4440, a simple R-C-D turn-on delay timing circuit is added to the gate of Q_B.

When the bottom-gate signal (BG2) goes up, R14 and C28 in Fig. 1 add additional delay. When the BG2 signal turns off, diode D7 can still discharge the gate of Q_B quickly. As shown in Fig. 3 with the R-C-D delay timing circuit, the dead time between Q_A turn-off and Q_B turn-on is increased from 20 ns to 93 ns.

It is necessary to point out that bottom synchronous FET Q_B is always operated in the zero-voltage-switching

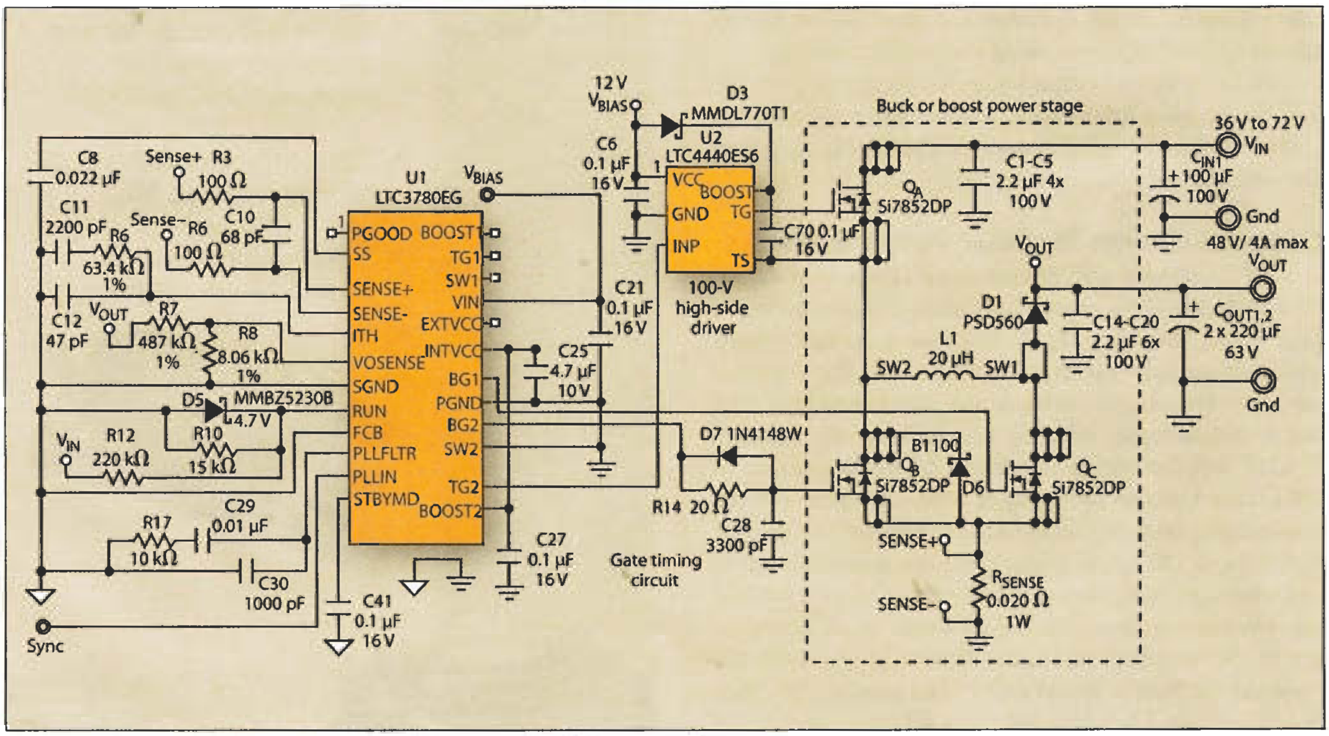

Fig. 1. *The addition of a 100-V high-side driver extends the input- and output-voltage range of the LTC2780 controller to create this buck-boost converter with 36-V to 72-V input and 48-V output.*

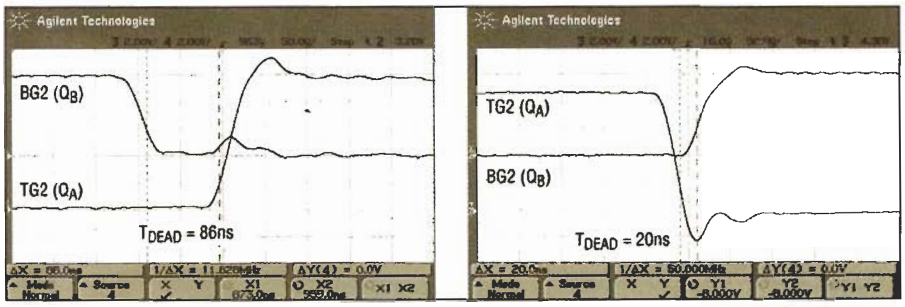

Fig. 2. *Buck-side FET gate timing with the external LTC4440 FET driver. The LTC4440 gate driver adds a 30-ns typical propagation delay, reducing the dead time between the top FET Q_A turn-off and bottom FET Q_B turn-on from 50 ns to a marginal 20 ns with the LTC4440.*

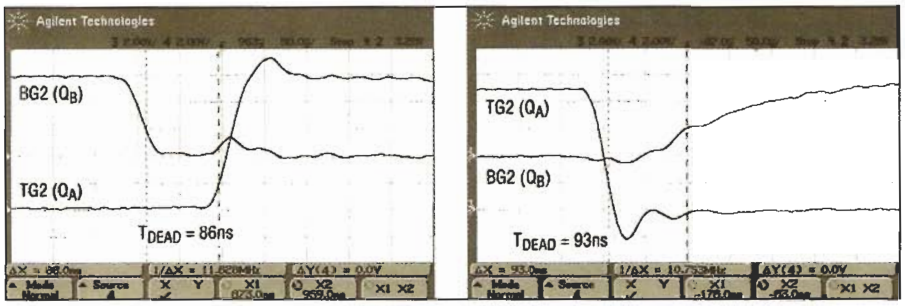

Fig. 3. *The addition of an R-C-D turn-on delay circuit on the Q_B gate compensates for the additional Q_A turn-off delay caused by the LTC4440.*

mode; therefore, the R-C-D delay circuit does not increase the switching loss of Q_B significantly.

On the output boost side, synchronous boost switch D (not shown in Fig. 1) can be replaced with 60-V-rated Schottky diode D1. As a result, neither an external high-side driver nor a delay-time circuit are needed. Because the output voltage is 48 V, the impact on the converter efficiency by using the Schottky boost diode is less than 1%.

Unfortunately, if switch D is needed with LTC4440 for better efficiency, the R-C-D delay circuit is not desirable for boost switch Q_C, because of the increased switching loss. In this case, an LTC4440 high-voltage dual FET driver is needed on the boost side.

With three Si7852 SO-8 PowerPAK MOSFETs, one 5-A/60-V Schottky diode PSD560, a 14-mm × 14-mm inductor, the converter has higher than 95% efficiency over a wide load range and a 36-V to 72-V input range. At 48-V input and 200-W output, the efficiency is as high as 97.2%. A graph of the measured efficiency of this 48-V buck-boost converter appears in the online version of this article.

Thermal measurements taken on power MOSFETs Q_A, Q_B, Q_C and boost-side Schottky diode D1 are also shown in the online version of this article. The pictures are taken at 36-V, 48-V and 72-V input with 48-V/200-W output. The ambient temperature is 25°C.

Without any heatsink or forced airflow, the maximum FET/diode case temperature rise is just 47.6°C at 48-V input and 54.5°C at 72-V input worst-case condition. Because of its high efficiency and fast overcurrent protection, the LTC3780 supply has low thermal stresses, which enhance reliability. **PETech**

References

1. "LTC3780 High Efficiency, Synchronous, 4-Switch Buck-Boost Converter Data Sheet," www.linear.com.