Keywords: boost, buck regulator, invert, sequencing

APPLICATION NOTE 1910

-12V to -5V/400mA Regulator Ensures Sequencing with 5V Rail

Sep 01, 1998

Abstract: This circuit uses a negative buck regulator to regulate -5V from a -12V input. The -5V output is only allowed to rise after the system main +5V has come up, and it automatically shuts down the -5V when the +5V goes down.

The circuit in **Figure 1** steps down a nominal -12V to a regulated -5V. It allows -5V to come up only after a separately regulated +5V has come up, and if the +5V collapses, it automatically shuts down the -5V. This is useful in ±5V supplies for A/D and D/A converters, which often require such power-supply sequencing to avoid latchup.

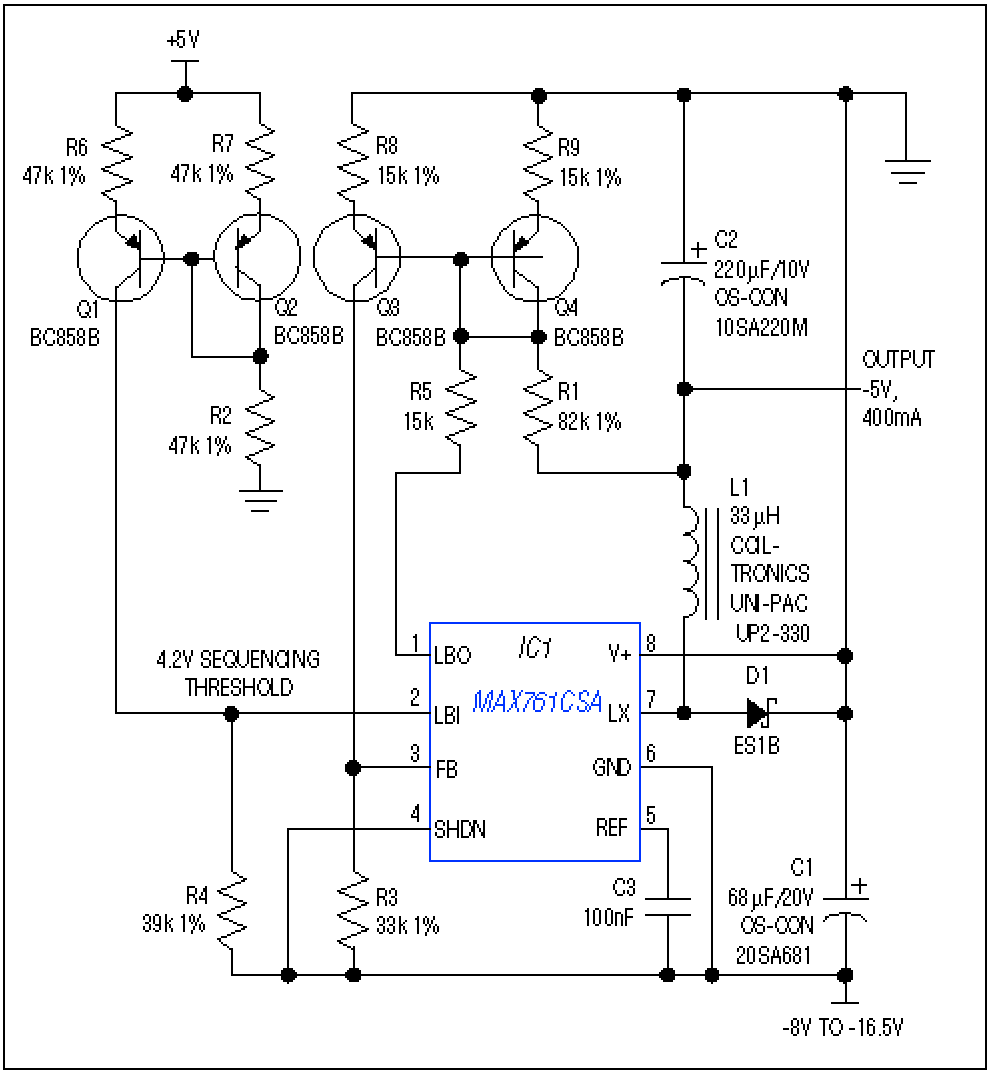

Figure 1. This negative buck regulator generates -5V from a nominal -12V supply and presents it in proper sequence with an independent +5V supply during power-up and power-down.

IC1 is a conventional boost regulator, but the overall circuit is a negative buck regulator. The boost-regulator topology is correct for the switching control, but the regulator's feedback signal—which monitors an output voltage referred to the converter's positive rail and compares it with a reference voltage referred to the converter's negative rail—requires a level shift. The Q3/Q4 current mirror provides this shift, with emitter resistors R8 and R9 included to minimize the V_{be}-mismatch error.

IC1 includes a comparator and a 1.5V reference, normally used for low-battery detection via LBI and LBO, which monitors the +5V rail as follows: the current in Q1, mirrored by Q2, flows through R4 and develops a voltage proportional to the +5V rail. If this rail falls below a nominal 4.2V, the LBO output pulls R5 to the negative rail. That connection causes a current increase in the diode-connected Q4 which, mirrored by Q3 and flowing in R3, causes a rise in FB voltage to the regulator.

Feedback as described above tells the regulator that no additional output energy is required, so it complies with a shutdown in which the internal pulse-frequency modulation (PFM) suspends all power-conversion cycles. Connecting a minimum load of 10kΩ will prevent leakage through D1 from charging up the output capacitor (C2) while in this state. When IC1 operates with a +5V input and as a boost converter (as intended), it delivers about 150mA from a +12V output. The buck-regulator configuration, on the other hand, delivers 400mA at -5V using similar high-current components.

Efficiency vs. load current measures 85% at 100mA, 89% at 250mA, and 90% at 400mA. The measured peak-to-peak ripple is less than 25mV for any load. Output-voltage accuracy depends on the 2%-accurate reference in IC1 and the tolerance of feedback-path resistors R1, R3, R8, and R9.

Any difference in V_{be} for transistors Q3 and Q4 introduces an additional error. V_{be} measures about 550mV for the transistors used, and the maximum V_{be} difference measured among Q1–Q4 was 9mV. With respect to the Q3–Q4 base voltage (-1.24V), this 9mV contributes another 0.75% error in the output voltage. To match the V_{be} drops to within 1mV and eliminate the R6–R9 resistors, substitute a dual transistor such as the Rohm UMT1N (available in a SOT23-6 package).

A similar idea appeared in the 9/98 issue of Electronics World & Wireless World (UK).

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