

DESIGN NOTES

Short-Circuit Protection for Boost Regulators – Design Note 154

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The basic boost regulator topology provides no short-circuit protection. When the output is pulled low, a large current can flow from the input through the inductor and catch diode, limited only by the series resistance of these parts. The result may be damage to the boost regulator, the load or the power source. This design note presents several solutions to this potential problem.

Short-Circuit Protection and Load Disconnect with the LTC1477

The LTC[®]1477 protected high side switch contains an internal, low loss NMOS power switch. It provides protection to external circuits in two ways: switch current is limited to 0.85A, 1.5A or 2A (depending on configuration) and thermal shutdown circuitry turns the switch off when power dissipation raises the die temperature to 130°C. In Figure 1, the LTC1477 protects an LT[®]1304 micropower boost regulator and its load from excessive currents. An increasing load current will first be limited to 0.85A; as more power is dissipated in the switch, the LTC1477 will cycle the switch to limit average current and dissipation to an acceptable level. The enable pin can be used to disconnect the output. In this circuit the LT1304 uses its low-battery detector to shut itself down and disconnect the load when the battery voltage drops below 2.7V.

For higher power applications, the V_{IN2} and V_{IN3} pins of the LTC1477 should also be connected to the input. This raises the current limit to 2A; switch resistance will be just 0.07Ω. The LTC1477 operates from 2.7V to 5.5V and is packaged in an SO-8. The LTC1478 is a dual version available in a 16-lead SO.

Current-Limited Boost Regulator

It may be desirable to limit, rather than interrupt, output current to a heavy load. Figure 2 shows a 2-cell to 5V boost converter with output current limited to 150mA. The LT1304 generates 5V at the source of Q1, which, with its gate grounded through R1 and R2, turns on to supply current to the output. As the load current increases, the voltage across R_{SENSE} reaches 0.6V, Q2 turns on and current through R2 raises the voltage at the feedback pin; the LT1304 begins to regulate the output current to 150mA. When the output voltage is pulled lower than the input voltage, the LT1304 is no longer able to control the output current, and Q2 regulates the current by pulling up on Q1's gate. Note that Q1 must dissipate approximately 0.4W when the output is shorted to ground. An extra transistor (Q3) will disconnect the load when the LT1304 is shut

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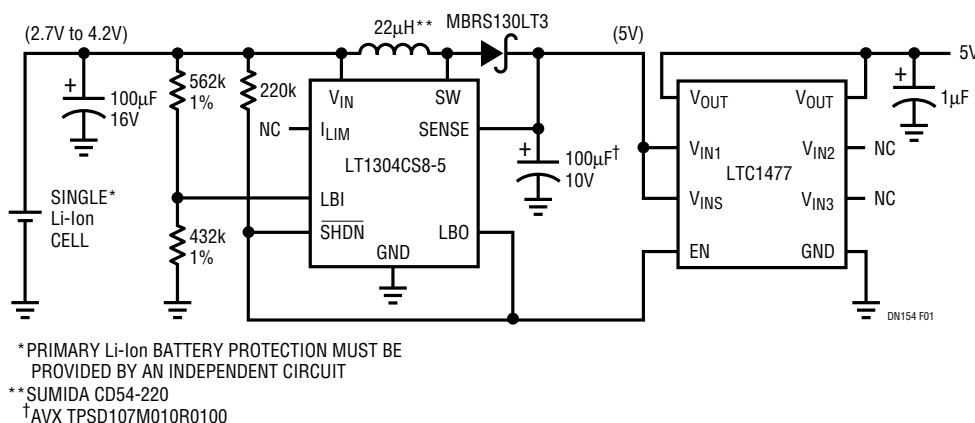


Figure 1. Boost Converter with Short-Circuit Protection and Automatic Load Disconnect

down. Although R_{SENSE} lowers the efficiency near full load, the additional circuitry has essentially no effect on the excellent light load efficiency of the LT1304.

Short-Circuit Protection at Higher Power

At higher currents, low $R_{DS(on)}$ transistors and low voltage current sensing are necessary to maintain high efficiency and manageable power dissipation. The LTC1153 circuit breaker IC drives an external high side N-channel FET and will turn off the FET when the voltage across a current sense resistor exceeds 100mV. Trip delay and reset times can be adjusted with external components.

The LT1270 boost converter can generate 2A at 12V from a 5V input (Figure 3). Protection against a shorted output is provided with an LTC1153 programmed to trip at 2.5A.

At start-up, the LTC1153 drives the gate of Q1 through a filter (R1 and C1). This limits dV/dt at the output, controlling the inrush current to the capacitive load. When the LTC1153 senses a voltage drop across R_{SENSE} exceeding 100mV, the gate of Q1 is grounded through diode D1. The FET will remain off for a period determined by the capacitor tied to the C_T pin. With this reset period set longer than the trip delay (60 μ s max) and the turn-on time of Q1 (~R1 C1), the average output current will be much lower than the peak current; this keeps power dissipation of the FET and the load at a safe level. An open collector at the STATUS pin of LTC1153 indicates the state of the circuit breaker. The output can be disconnected by setting the IN pin low. The LTC1153 operates from 4.5V to 18V and is available in an 8-lead PDIP or SO.

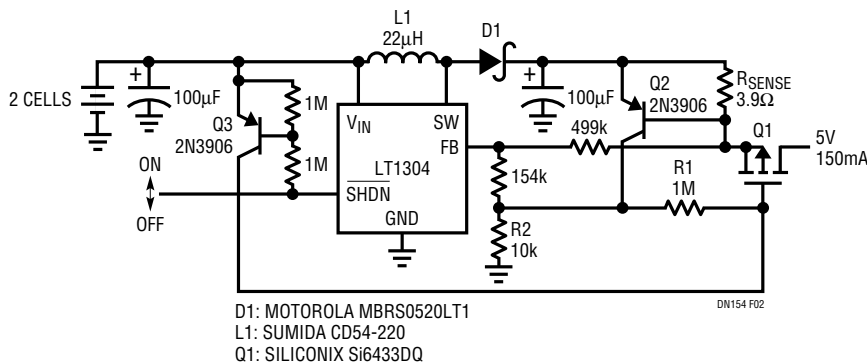


Figure 2. Current Limited Boost Converter with Load Disconnect

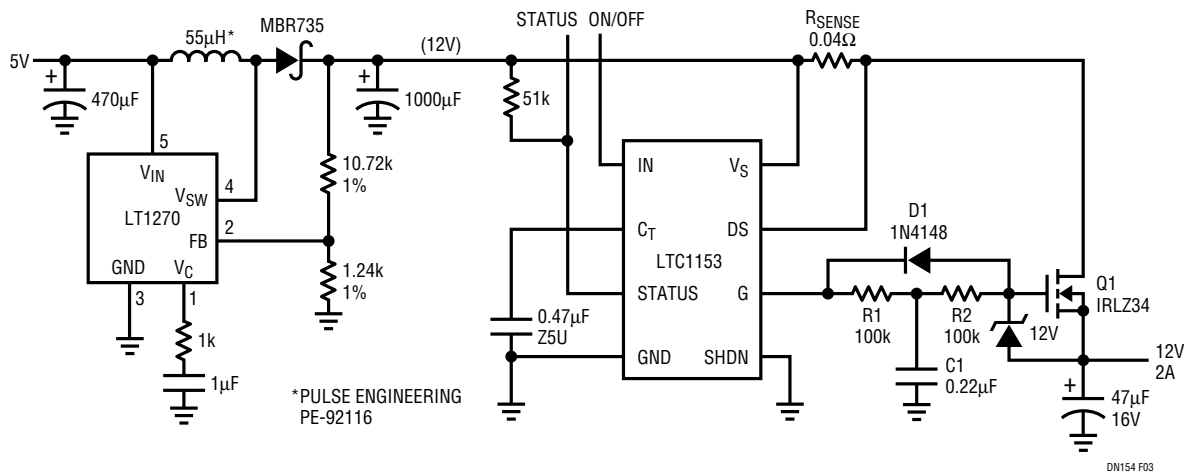


Figure 3. 2A/12V Step-Up Regulator with Circuit Breaker (Post Regulator), Breaker Status Feedback and Ramped Output

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