

APPLICATION NOTE 951

## Switch Allows Low-Voltage Regulator To Start Under Load

The addition of an external load-disconnect switch allows a CMOS switching regulator to start with load currents several decades higher than otherwise possible (**Figure 1**). CMOS regulators are excellent for portable applications because they have very low operating and shutdown currents (IC1 operates on 25 $\mu$ A and shuts down to 1 $\mu$ A), and they provide ample current once started. But many cannot start *under maximum load* from low supply voltages such as those provided by single-cell batteries.

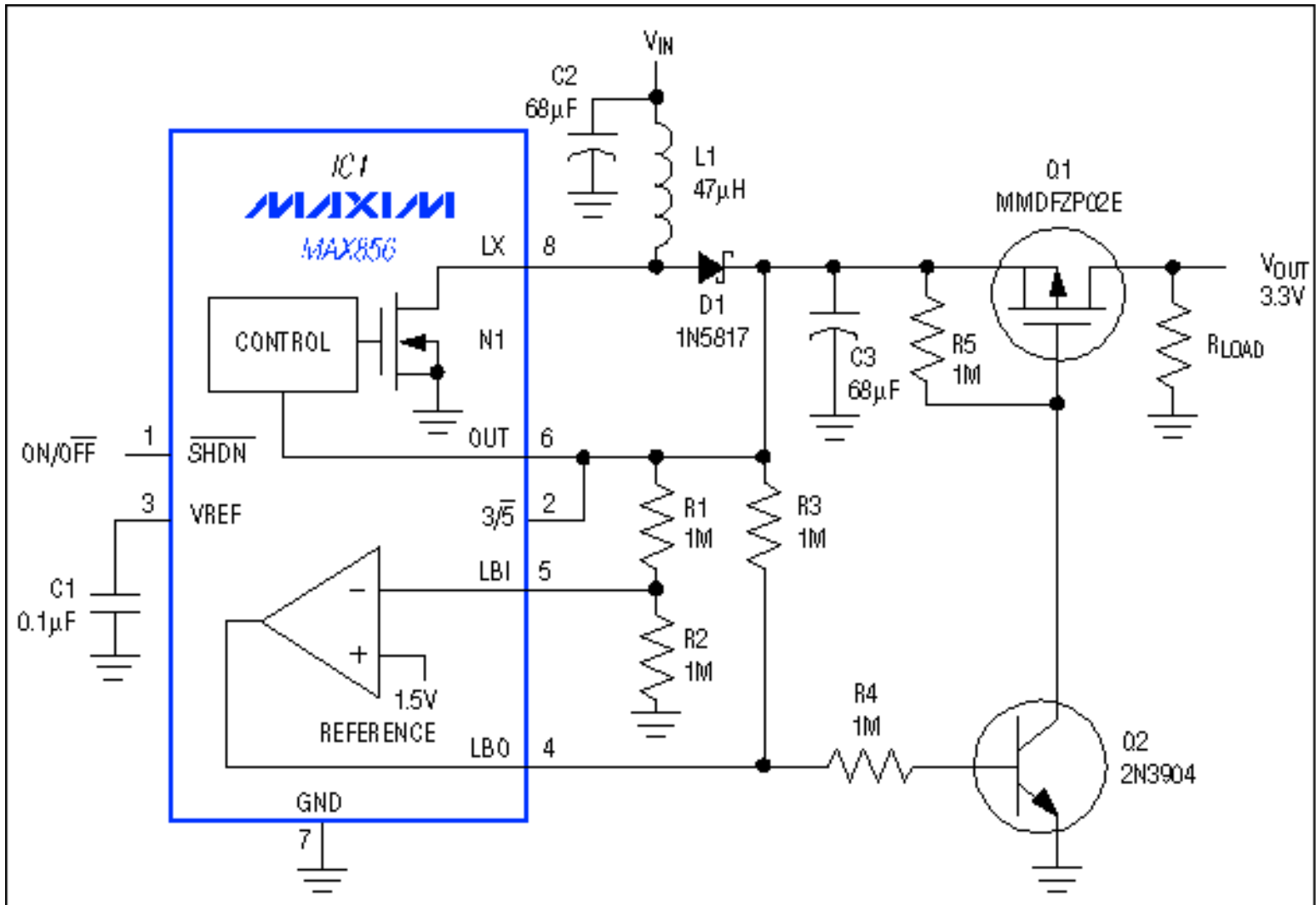


Figure 1. Load-disconnect switch Q1 allows this CMOS switching regulator to start, under load, from very low input voltages.

The problem arises because most low-voltage CMOS boost regulators are powered from their own output, which equals  $V_{IN}$  minus a diode drop at start-up. Low values of input voltage don't allow the switching transistor to become fully enhanced, so it presents a high impedance that limits the peak inductor current. As a result, the circuit cannot produce enough current to supply the load and charge the output capacitor at the same time.

You can overcome this start-up limitation with an external power MOSFET, operating in conjunction with the low-battery comparator built into many low-voltage switching regulators. Acting as a load switch, Q1 disconnects the load until  $V_{OUT}$  is high enough to fully enhance N1. The circuit can then start with much higher values of  $I_{LOAD}$  (**Figure 2**).

With the load switch in place, the circuit can start under full load with input voltages as low as 0.8V.

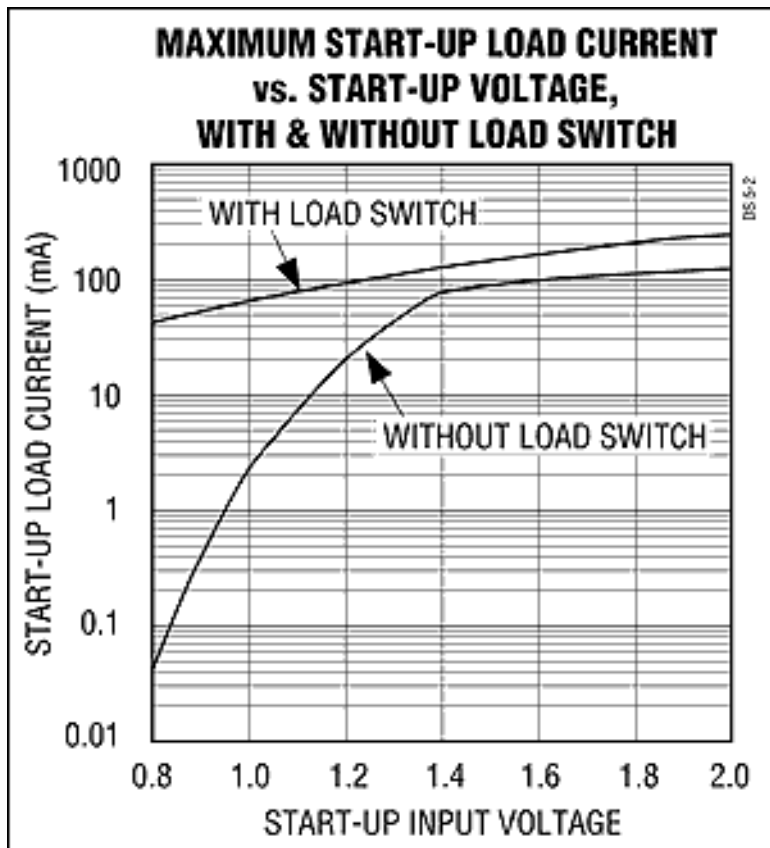


Figure 2. These curves show the highest load current permissible in the Figure 1 circuit for a given input voltage at start-up. The load switch permits several decades more load current at low input voltages.

Q1 as shown is a low-threshold power MOSFET. Because the regulator's feedback is taken before this switch, the device chosen in a given application depends on the load current and the minimum level of load regulation acceptable. Results similar to those of Figure 2 apply for a 5V regulated output, which is obtained by connecting the 3/5-bar terminal (pin 2) to ground.

Application Note 951: <http://www.maxim-ic.com/an951>

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AN951, AN 951, APP951, Appnote951, Appnote 951

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