APPLICATION NOTE 1853

External Pass Transistor Lowers Dropout Voltage

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For linear regulators, dropout voltage ($V_{IN} - V_{OUT}$) is measured at the minimum input voltage for which regulation is sustained. Low dropout means longer battery life, because the load circuit continues to operate while the battery discharges to a lower terminal voltage. In Figure 1 the external transistor shown helps to form a linear-regulator circuit whose dropout at 100mA load current is only 10mV. (The low-dropout linear-regulator IC by itself has a 100mV dropout at that load current.) The external transistor also boosts the maximum available load current to 1A.

![Figure 1. Unusual connections enable this linear-regulator IC to regulate the transistor's base current, forming an overall linear regulator with much lower dropout voltage.](image)

Unorthodox connections enable the IC to drive Q1. Connecting pin 3 to the transistor’s base allows base current to flow through the internal switching MOSFET, out of pin 4, and through R2 to ground. The MOSFET then regulates $V_{OUT}$ by controlling Q1’s base current. Because C2 sets a dominant pole that stabilizes the loop, it should be a ceramic type or other low-ESR capacitor. C2 improves the phase margin by forming a pole-zero combination that increases the phase at crossover.

Q1 saturates when the battery voltage drops low enough for $V_{OUT}$ to drop out of regulation, and R2 limits the base current for that condition to approximately 10mA. Q1’s collector-emitter voltage at saturation, which measures 10mV with 10mA base current and 100mA collector current, sets the dropout voltage for these conditions. The measured dropout voltage varies with load current (Figure 2).
This circuit delivers as much as 1A at 3.3V. You can adjust the output from 5.5V down to 1.25V using the formula $V_{OUT} = 1.25[1 + (R3 / R4)]$, with appropriate changes to the value of R2 using the formula $R2 = (V_{IN(MIN)} - 0.7V) / 10mA$. Small component sizes (IC1 fits in a SOT23 package) allow the entire circuit to occupy less than 0.24 in² of board area.

**Related Parts**

| MAX8863 | Low-Dropout, 120mA Linear Regulators | Free Samples |

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