# Bipolars provide stable current source

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It's possible to implement a precise current source with a useful output at high frequencies, without using operational amplifiers. The circuit in **Figure 1a** suffers inaccuracies from both the V_{BE} drop and the finite base current of the transistor. The circuit in **Figure 1b** overcomes the base-current problem, but has two V_{BE} drops and does not perform well at high frequencies. The circuit in **Figure 1c** has no base-current problem and performs well at high frequencies, but is prone to inaccuracies from the V_{GS} of the FET. The circuit in **Figure 2** largely overcomes these problems.

The V_{BE} of Q_2 cancels that of Q_1. Because the base current of Q_1 diverts (via Q_3) as shown around the current-setting resistor R_1, I_{OUT} is simply two-thirds of V_{IN} divided by R_1. Because the circuit provides error cancellation, the values and voltages are not critical, provided you match the upper and lower components. In this example, Q_1 has a beta of 50; the circuit self-adjusts as beta varies. Neon-driver transistors are a good choice for Q_1 because Q_2 and Q_3 need neither good high-frequency performance nor high output impedance. High-beta (400 in **Figure 2**) transistors are appropriate, as they minimize errors. Insofar as possible, it is desirable to have similar, high betas for Q_2 and Q_3. At high frequencies, it may be beneficial to bypass the base of Q_1 to ground. (DI #2257).　　　　　　　　　　　　　　　　e

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(a) **(b)** **(c)**
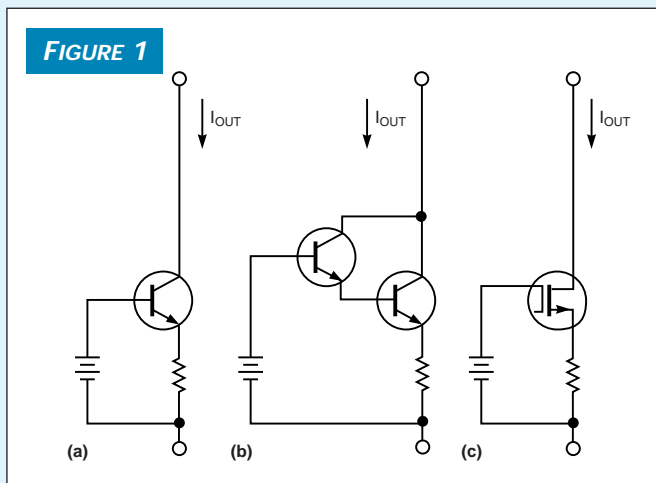
Finite base current, temperature-dependent base-emitter drop, and gate-source-voltage variations lead to errors in single-transistor current sources.

FIGURE 2
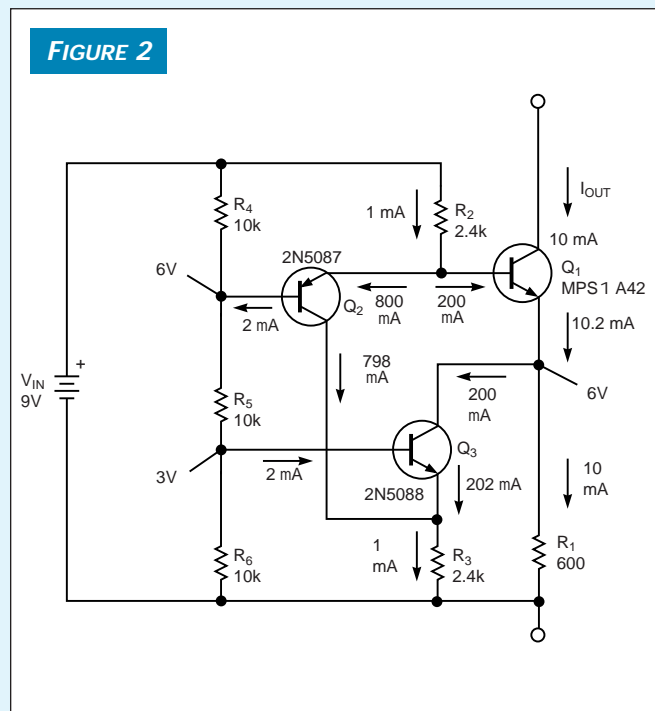
Base-emitter-voltage and base-current cancellation are the keys to a stable, predictable current source.