A reference current source needs high accuracy, low temperature drift, and high output impedance. Available IC current sources come with some of these features. However, at current levels greater than 1 mA, their output impedance decreases to less than 10 MW. **Figure 1** shows a composite 10-mA current-source configuration that has a compliance voltage of 5 to 42V, a set-current error of less than 1%, a temperature drift of less than 45 ppm/°C, and an output impedance of greater than 100 MW. One application of this accurate 10-mA current source with high impedance is as a 4- to 20-mA current-loop calibration reference that has a maximum loop voltage of 40V and that operates over the -40 to +85°C industrial-temperature range.

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**IC1**'s $V_{REF}$ output and $R_1$ set $I_{OUT}$. $I_{OUT}$ equals $V_{REF}/R_1$ plus **IC1**’s bias current, which is typically 50 µA. This bias current is a small error of less than 0.05% at $I_{OUT}=10$ mA and changes by only 10 µA over -40 to +85°C. Changes in $V_{REF}$ and $R_1$ over temperature more directly contribute to $I_{OUT}$’s accuracy and temperature coefficient. Inexpensive resistors with 0.1% tolerances and 25 ppm/°C drift over temperature are common. The LM4130 has a $V_{REF}$ grade of 0.05% and 20 ppm/°C over -40 to +85°C. Thus, the worst-case current-setpoint error is within 0.15% and 45 ppm/°C, which results in an upper limit on the current error over temperature of 0.45%, or 45 µA.
The circuit's high performance would degrade if its output impedance were not very high. The circuit's output impedance is an undesirable parasitic in parallel with $I_{OUT}$. The product of $IC_1$'s line regulation times $IC_2$'s line regulation determines the current source's output impedance. $IC_1$'s 1.2V output sets $IC_1$'s input-minus-output to a near constant. $IC_1$'s $V_{REF}$ over $R_1$ sets $I_{OUT}$, which is twice removed from $V_{IN}$. $V_{REF}$ of $IC_1$ has an overtemperature line regulation of 500 ppm/V, and $IC_2$'s output has an overtemperature line regulation of 350 ppm/V. Output impedance is greater than 300 MW, which is good, if you calculate it using only the line-regulation effects. Although line regulation is the dominant source of output impedance, other thermal errors beyond line regulation degrade the potential of keeping very high output impedance over temperature. Bench measurements made on the composite showed output impedance greater than 300 MW at 25°C and 100 MW over -40 to +85°C. (DI #2544)