Precision current source is software-programmable

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With the addition of a few inexpensive miniature components, the hard-wired, voltage-controlled current source of yesterday becomes a software-programmable voltage-controlled current source (Figure 1). A digital potentiometer, IC₁, in conjunction with a precision op amp, IC₂, sets current through a pass transistor, ISET, and a shunt regulator, IC₃, provides a constant reference voltage across the digital potentiometer. By operating in its linear region, the transistor controls load current in response to the applied gate voltage. Each incremental step of the digital potentiometer increases or decreases the wiper voltage, VIN+, at the op amp's noninverting input. Thus, VIN+, varies with respect to the reference voltage, which in turn remains stable with respect to the supply rail:

\[
\frac{V_{IN+}}{V_{REF}} = \left( \frac{R_{TOTAL(DP)}}{(TOTAL\, NO.\, OF\, STEPS)} \right) \left( \frac{R_{TOTAL(DP)}}{R_{TOTAL(DP)}} \right).
\]

Many types of digital potentiometer are currently available, and the interface to these devices, besides the hard-wired type, can be one, two, or three wires. IC₁, for example, has a three-wire SPI interface, and provides an end-to-end resistance of 50 kΩ with 256 incremental settings. Thus, each increment of the digital potentiometer changes VIN+ by:

\[
V_{IN+} = \frac{3V(CC - VIN+)}{50\, k\Omega} = 11.72 \, mV.
\]

Op amp IC₂ regulates current through the pass transistor, and the digital potentiometer sets current through the RSENSE resistor. The voltage across RSENSE determines current through the pass transistor, ISET: ISET = (VCC - VIN+)/RSENSE.

The circuit can provide any current level for which the external components, RSENSE and the pass transistor, can handle the associated power dissipation (P=IV). Because the ratio setting of digital potentiometers is good, with a typical ratiometric resistor temperature coefficient of 5 ppm/°C), precision and stability for the current source depend primarily on the precision and stability of IC₃ and RSENSE combined.

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