Build a precise dc floating-current source

D Ramirez - August 18, 2005

Although well-known to active-filter theorists and designers, GICs (generalized impedance converters) may be less familiar to analog generalists. Comprising a one-port active circuit typically comprising low-cost operational amplifiers, resistors, and capacitors, a GIC transforms capacitive reactance into inductive reactance and thus can substitute for an inductor in a filter that an RLC-transfer function describes. In addition, the flexibility of a GIC's input-impedance equation permits the design of virtual impedances that don't exist as physical components—for example, frequency-dependent resistance ([Reference 1](#)). The GIC, which its developers introduced 30 years ago, has seen its greatest application in ac-circuit and active-filter applications.

**Figure 1** shows a classic GIC circuit in which the input impedance, $Z_{IN}$, depends on the nature of impedances $Z_1$ through $Z_5$. The following equation describes the circuit's input impedance:

$$Z_{IN} = \frac{V_{IN}}{I_{IN}} = \frac{Z_1 \times Z_3 \times Z_5}{Z_2 \times Z_4}.$$  

For example, if $Z_1$, $Z_2$, $Z_3$, and $Z_5$ comprise resistors $R_1$, $R_2$, $R_3$, and $R_5$, and $Z_4$ comprises capacitor $C_4$, then the input impedance, $Z_{IN}$, appears as a virtual inductor of value $L_{IN}$:

$$L_{IN} = \frac{R_1 \times R_3 \times R_5 \times C_4}{R_2}.$$  

**Figure 2** shows the GIC circuit in its dc configuration. When you consider the GIC circuit in a purely dc environment, you can envision new applications. For example, you could replace impedances $Z_1$ through $Z_5$ with pure resistances $R_1$ through $R_5$. Instead of an ac input-voltage source, connect a precision temperature- and time-stable dc reference voltage to the input port. A simple circuit analysis using ideal op amps for IC$_1$ and IC$_2$ shows that the reference input voltage, $V_{REF}$, appears across resistor $R_5$, and, as the following equation shows, a constant current, $I_0$, flows through $R_5$.

$$I_0 = \frac{V_{REF}}{R_5}.$$  

However, op amp IC$_2$'s noninverting input diverts a small amount of current from the junction of $R_4$ and $R_5$, and $I_0$ thus also flows through $R_4$. Selecting large values for $R_4$, $R_5$, and $R_5$ helps minimize current drawn from the reference voltage. For example, the circuit can supply 2 to 10 mA to $R_4$ and draw only a few tenths of a microampere from the reference source. Using tight-tolerance and low-drift components for $V_{REF}$ and $R_5$ ensures the stability of $I_0$. Applications include providing constant-current drive for Wheatstone-bridge and platinum-element sensors ([Reference 2](#)). In addition, you can replace $R_4$ with a series of resistive sensors as in an Anderson loop ([Reference 3](#)).
References


Click [here](#) for more Design Ideas!