Reconstruct the input current in a grounded-impedance current sensor

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You can reconstruct the small-signal current flowing into a grounded impedance, which is part of a larger circuit. This current, such as the highpass-filter output for several current-mode biquadratic filters flowing into a capacitor—and which is a working impedance of the filter—can be the summation of multiple currents.

Reconstruction of the output current by means of individually duplicating all constituent input currents through current mirrors can be error-prone, as the following **equations** show: $I_{IN}=I_1+I_2+I_3 \ldots +I_N$, and $I_O=\alpha_1 I_1+\alpha_2 I_2+\alpha_3 I_3 \ldots +\alpha_N I_N$. The current-mirroring coefficients, α_i, should ideally achieve unity to reconstruct I_{IN} accurately. All of these coefficients, however, not only deviate from their ideal values of unity but also can differ from each other because of current-mirror mismatches, including systematic mismatch due to the mirror's finite output resistance and random threshold mismatch for CMOS current mirrors. Those mismatches can cause the frequency character of the output's small-signal current—for example, a highpass response—to change. A useful technique is to sense the voltage across the impedance and then do a single-precision voltage-to-current conversion, thereby getting rid of the errors arising from multiple mirroring operations.

Figure 1 shows a small-signal current-sensing circuit that must sense the total current flowing into an impedance, Z_1. The voltage-to-current conversion requires a matched load impedance, Z_2, and is built around an operational current conveyor (**Reference 1**). Any mismatch between the loads will cause the output current to be a scaled value of the input current, where the scaling factor is the ratio of impedances; hence, the frequency character of the small-signal output current will remain unchanged.

CURRENT-MIRROR MISMATCHES CAN CHANGE THE FREQUENCY CHARACTER OF THE OUTPUT'S SMALL-SIGNAL CURRENT.

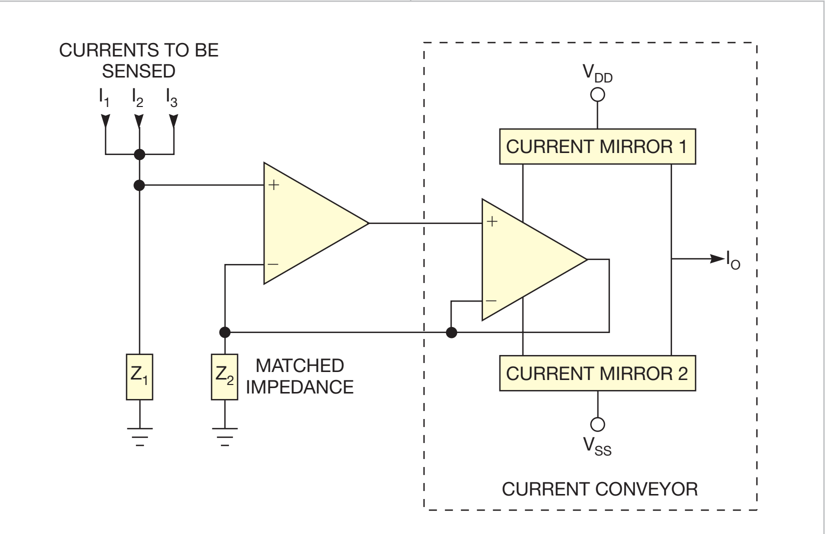

Figure 1 The current mirrors reflect the current draw of the load, Z_2, whose impedance—and, thus, its current—matches that of the impedance under test, Z_1.

The mismatch in either of the current mirrors is also of interest: Assuming that the input current of Current Mirror 1 is I_B+I_{IN} and the input current of Current Mirror 2 is I_B, then the output current is $I_O=\beta_1 I_B+\beta_1 I_{IN}-\beta_2 I_B=(\beta_1-\beta_2)I_B+\beta_1 I_{IN}$, where I_B is the quiescent current of the last stage of the amplifier and β_1 and β_2 are current-mirror mismatches. The output current has a dc-offset current, which you can easily cancel out, and a scaled value of the input's small-signal current, I_{IN}. EDN

REFERENCES

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2. Robinson, John, "New CCII Current Conveyor," Application Note 4198, Maxim Integrated Products, March 27, 2008, http://bit.ly/JVQ6rJ.