Across The Editor's Desk

CURRENT FEEDBACK AND TRANSIMPEDANCE

A reader writes:

> *"I read with interest the article on page 13 of Analog Dialogue 22-2. I have recently been working with transimpedance amplifiers and do not understand them. I have been using the conventional op amps in the current feedback mode and have assumed that this is the same as a transimpedance amplifier. After reading your description of the AD846, I wondered what characteristics an amplifier must have to be called as a transimpedance amplifier. Can you enlighten me as to what a good transimpedance amplifier should do and whether capacitance on the null junction has any effect on the bandwidth?"*

A *current-feedback amplifier configuration* is one in which the feedback signal is developed as a current, which is added to or subtracted from a current in the input stage. A simple example of a current-feedback amplifier is a single FET connected as a *source follower* with a resistive load; it feeds back a current equal to the output voltage divided by the load resistance. A source follower is characterized by high input impedance, very nearly unity gain, and low impedance at the feedback point; its output voltage is essentially independent of load variations. Many kinds of current-feedback circuits are possible.

A *transimpedance operational amplifier* is a special kind of op amp that responds to a current at its normal inverting input and produces a voltage at the output. That's different from the more familiar op amp, which responds to *voltage* and has a voltage output. Here is how their properties compare:

"Gain" relationship	$V_{out} = -A\ V_{in}$	$V_{out} = -Z_t\ I_{in}$
"Gain" characteristic	V/V (voltage gain)	V/I (transimpedance)
Ideal value of "gain"	$A \to \infty$	$Z_t \to \infty$
Ideal input impedance	$Z_{in} \to \infty$	$Z_{in} \to 0$
Input error current, I_{in}, for normal V_{out} when used in ideal feedback amplifier	$(V_{in}/Z_{in}) \to 0$ (high impedance)	$(-V_{out}/Z_t) \to 0$ (high "gain")
Input error voltage, V_{in}, for normal V_{out} when used in ideal feedback amplifier	$(-V_{out}/A) \to 0$ (high gain)	$(I_{in} \times Z_{in}) \to 0$ (low impedance)

Both types of amplifier will make a good op amp, because both maintain zero input voltage and current. The principal difference is as follows: the voltage-to-voltage op amp works by using voltage feedback to maintain a voltage null (while its net input current, being zero because of near-infinite input impedance, forces all currents to flow only among the operational impedances); the transimpedance op amp works by using current feedback to maintain a current null (while its input voltage, being zero because of near-zero input impedance, forces the summing node to be at "ground" potential).

From this it can be inferred that transimpedance amplifiers have the potential advantage that they tend to be less sensitive to capacitance at the summing point because of the inherently low impedance level.

While the above discussion is qualitative and somewhat intuitive, we hope our reader(s) will find it helpful as a first step towards understanding (a) the difference between transimpedance op amps and normal voltage-gain op amps, and (b) that the transimpedance op amp is an amplifier optimized for current-feedback circuits.

P.S. Does this discussion help you understand that a conventionally designed high-input-impedance op amp (especially a FET-input type) *can't* be used in the current feedback mode (connecting only to its usual terminals, and with non-floating supplies) because it responds to *voltage* and sees current only as a leakage? Nevertheless, it can be programmed through its external *operational circuitry* to perform all sorts of current transformations, V-to-I, I-to-V, and current amplification—but these properties derive from *voltage-feedback* operations. ◘

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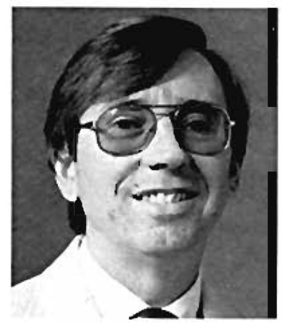

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