CURRENT FEEDBACK AND TRANSIMPEDEANCE

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 amp 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: $V_{out} = -A \times V_{in}$  $V_{out} = -Z_{in} \times I_{in}$

"Gain" characteristic: $V/V$ (voltage gain) $V/I$ (transimpedance)

Ideal value of "gain": $A \to \infty$  $Z_{in} \to 0$

Ideal input impedance $Z_{in} \to \infty$  $Z_{in} \to 0$

Input error current, $I_{out}$, for normal $V_{out}$ when used in ideal feedback amplifier:

$(V_{in} / Z_{in}) \to 0$  $(-V_{out} / Z_{in}) \to 0$

(high impedance)  (high "gain")

Input error voltage, $V_{err}$, for normal $V_{out}$ when used in ideal feedback amplifier:

$(-V_{out} / A) \to 0$  $(I_{in} \times Z_{in}) \to 0$

(high gain)  (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.

MORE AUTHORS (continued from page 2)

David Duff (page 10) is Product Manager in Strategic Marketing at ADI’s Computer Labs Division. He received a BSE from the University of Tennessee, MSEE from Georgia Tech, and MBA from the University of North Carolina. He joined Analog Devices in 1982. In his spare time he enjoys downhill skiing and sailing.

Bill Sheppard (page 11) is a Marketing Engineer in the Interface Products Division (IPD) of Analog Devices. Since joining ADI in 1969, he has held positions as Test Supervisor and Quality-Control Supervisor. In his present position, he supports IPD’s High-Resolution Converter product line and pin signal conditioners. He received his ASET at Brevard Junior College in Cocoa, Florida. His hobbies include golf, fishing, and high-performance Buicks.

Pete Predella (page 13) is a Technical Publicity Associate at Analog Devices, in Norwood MA. Since joining ADI, in 1979, he has also been a Technician for the Component Test Systems and Memory Devices Divisions. Peter is a graduate of GTE Sylvania Technical School and is currently pursuing a BSET from Northeastern University. His interests include reading, salt-water fishing, and golf.

Bill Schweber (page 7) is a Senior Technical Marketing Engineer and Contributing Editor to Analog Dialogue; he spearheaded the Disk Selection Guide and was also responsible for several other articles in this issue. Besides having his BSEE and MSEE degrees, he has designed µP-based machine controls, been a product marketing engineer, authored numerous technical articles, and written two textbooks. He enjoys bicycling and reading.