A CMOS Differential-Difference Amplifier With Class-AB Input Stages Featuring Wide Differential-Mode Input Range

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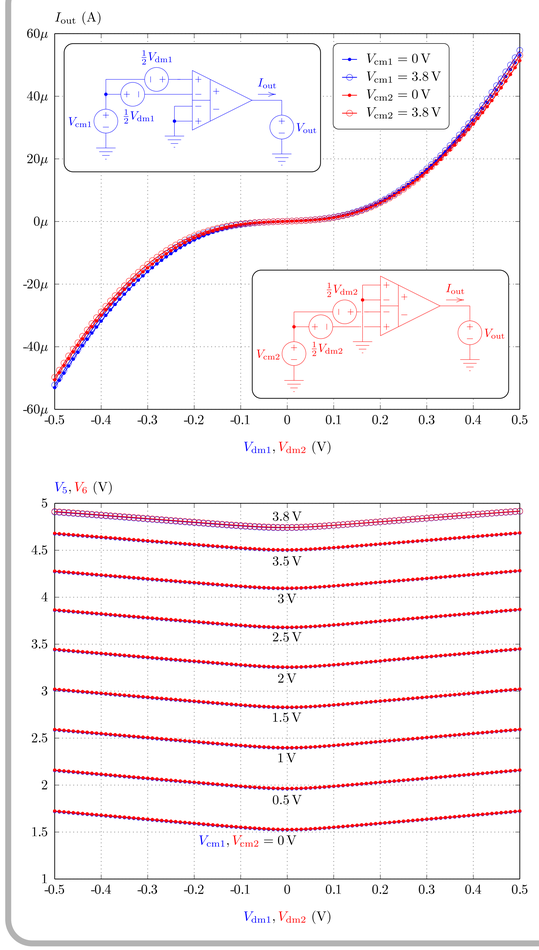
Abstract—I present a CMOS differential-difference amplifier (DDA) circuit with a pair of matched class-AB input stages that each produce a differential output current that is an expansive nonlinear function of its differential-mode input voltage. In contrast to those of the differential pair, the nonlinear current-voltage characteristics of these transconductors do not saturate and allow the proposed DDA circuit to function with a differential-mode input voltage range that is comparable to the transconductor's common-mode input voltage range. I show measurements from a prototype DDA breadboarded from transistor arrays fabricated in a 500-nm CMOS process through MOSIS.

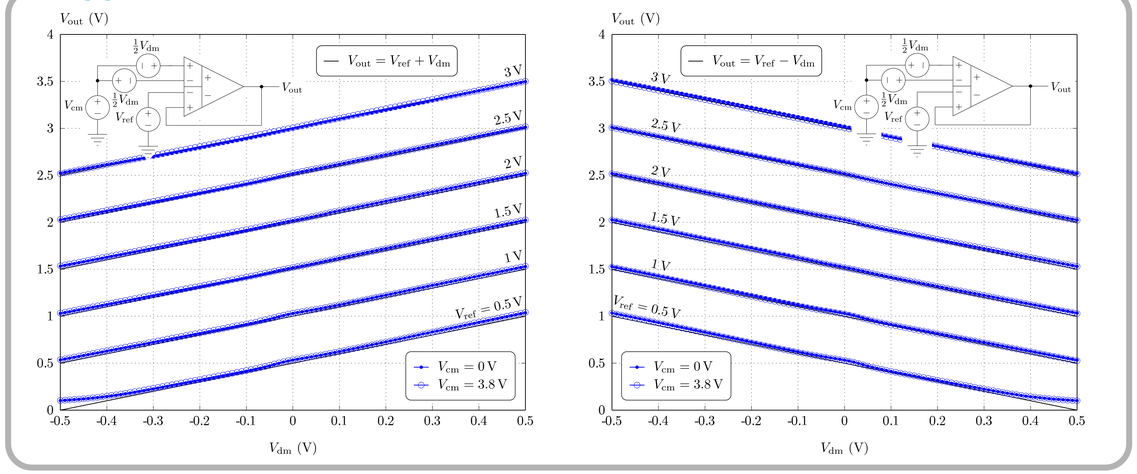
The DDA is a versatile analog building block. Negative feedback from the DDA's output terminal to one of the inverting inputs drives to zero the difference between the two differential input voltages, copying the differential input voltage that exists across one pair of inputs to the other pair. With a simple direct feedback connection between the output and one of its inverting inputs, we can make amplifiers with gains of ± 1, $+2$, and $+\frac{1}{2}$, summing amplifiers, etc.

In the DDA, two matched transconductors convert their differential input voltages into currents, which are summed to form an overall output current, so that when the output current is zero, the two differential input voltages must be equal to each other. DDA input stages are typically differential pairs, which have saturating nonlinear characteristics. However, once a transconductor has saturated, its currents contain no information about the size of the input voltage difference. That imposes a limit on the allowable differential-mode input voltage range for DDAs.

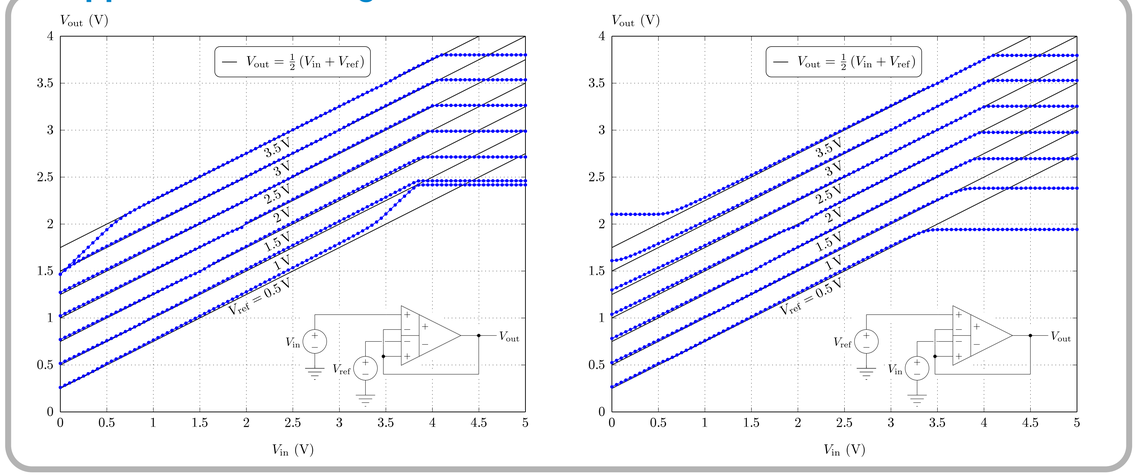
Measured Characteristics



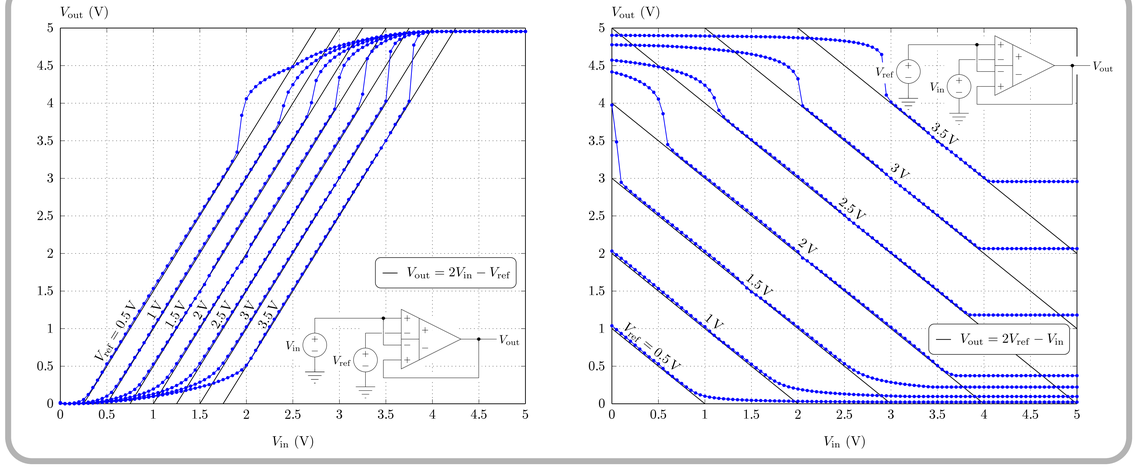
Application: Balun



Application: Averager/Common-Mode Detector

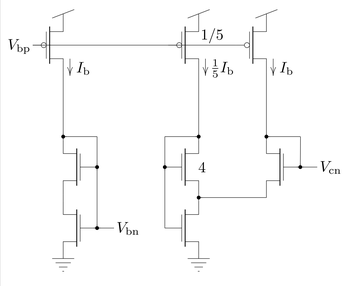


Application: Doubler/Inverter

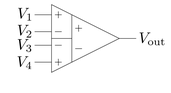


Differential-Difference Amplifier Circuit

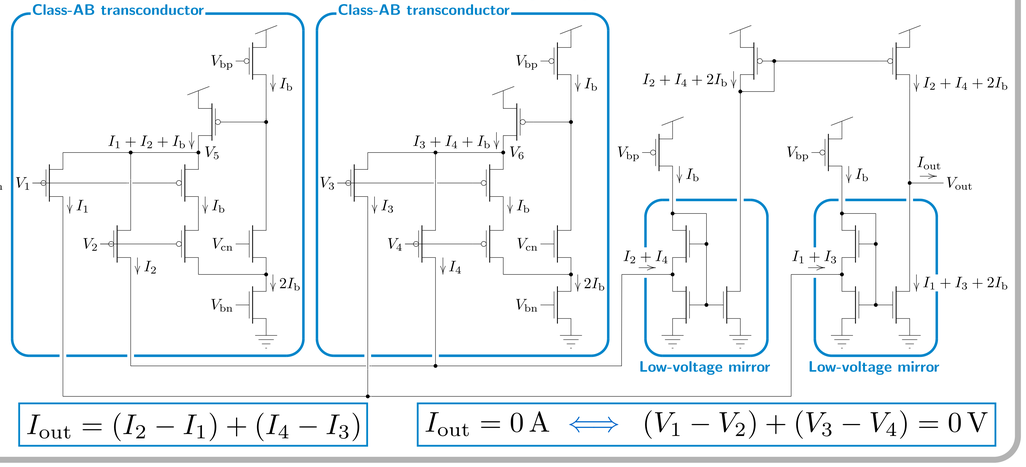
Bias circuit



DDA symbol



DDA schematic



$$I_{\text{out}} = (I_2 - I_1) + (I_4 - I_3)$$

$$I_{\text{out}} = 0\,\text{A} \iff (V_1 - V_2) + (V_3 - V_4) = 0\,\text{V}$$