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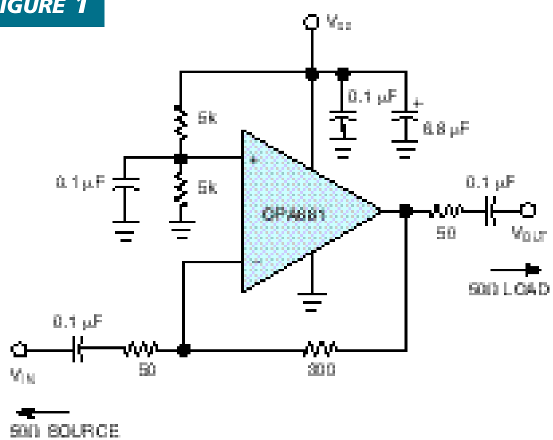
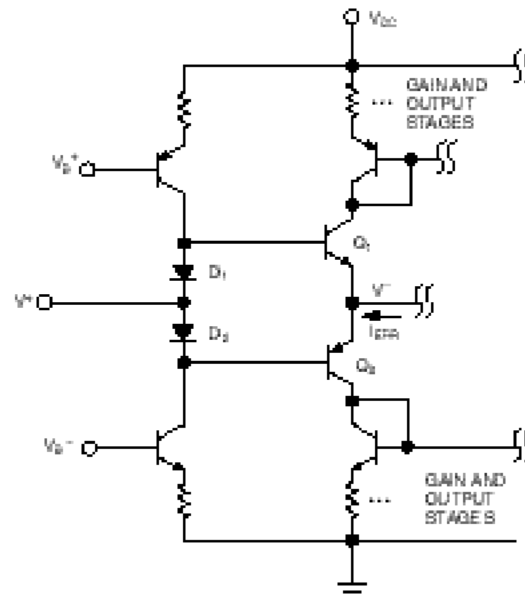
Most of the recent wideband, single-supply op amps use a voltage-feedback design. The error signal (differential input voltage) for a voltage-feedback op amp can operate over a range of common-mode input voltages, and its common-emitter output stage can provide output voltages near the supply rails. Current-feedback op amps are becoming available with wide output swings, but they still typically require at least 1.5V input head room for proper operation of the input stage's voltage buffer and inverting-node error-current

FIGURE 1



This current-feedback amplifier retains high bandwidth and a wide input-voltage swing, even with its input-stage transistors saturated.

FIGURE 2

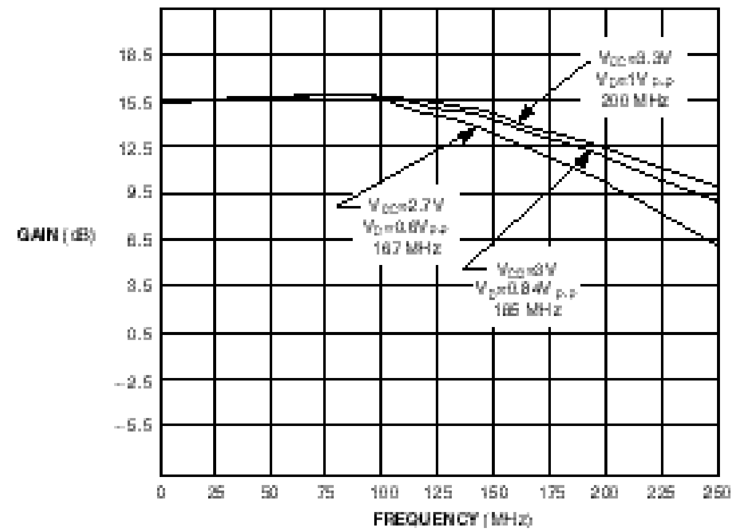


Saturation reduces the gain of Q_1 and Q_2, but the transistors still retain enough gain to provide adequate bandwidth in the amplifier.

sensing in the noninverting configuration. A current-feedback op amp offers the main advantage of wideband operation at higher gains. A subtler and previously overlooked advantage is the fact that you can operate most devices with a total supply voltage lower than the rated total input-stage head-room requirement. **Figure 1** shows a wideband, current-feedback op amp operating with a saturated input stage.

The OPA681 current-feedback op amp has a bandwidth greater than 200 MHz and a high-power output that can swing to within 1V of the supply rails. The input, however, requires 1.5V head room for proper operation. This requirement implies that, with a 3V power supply, the input stage is off while the output should still offer a 1V p-p swing. The circuit in **Figure 1** establishes a bias voltage on the noninverting input, set to the supply midpoint. The inverting signal path has an ac-coupled gain of 6. For test purposes, set the signal-input resistor to match the 50V source; the output drives a 50V matching resistor, through a dc-blocking capacitor, to a 50V load.

FIGURE 3



By ignoring the input-range specs of a current-feedback op amp, you can obtain extended wideband operation with low supply voltages.

In actual applications, you may not require this input match, and the output load may not need to be a doubly terminated line. However, the frequency response strongly depends on the selected value for the feedback resistor. Increasing it bandlimits the design; reducing it peaks the response. This circuit provides more than 150-MHz bandwidth, even for supplies lower than 3V, which would appear to violate the input-range spec. To understand this unique feature of a current-feedback topology, consider a simplified input-stage architecture in **Figure 2** .

If the noninverting input connects to $V_{CC}/2$ (**Figure 1**) and you steadily reduce the supply voltage, the first junctions to saturate are in Q_1 and Q_2. These two transistors provide the essence of the current-feedback operation. In normal operation, they provide voltage buffering for the input voltage (signal) at the noninverting input while acting as common-base stages to cascode the error-current signal into the inverting node through to the current-mirror gain stages. Consider what happens as these transistors saturate. The voltage-buffer aspect of the circuit still operates in a dc sense with a considerable drop-off in bandwidth if the signal were injected into the noninverting input. The error current still effectively cascodes through these transistors with a decreased a (the collector-emitter current gain in common-base configuration).

Under normal operation, a is nearly 1. As Q_1 and Q_2 saturate, a decreases, effectively reducing the dc open-loop gain for the forward signal path internal to the current-feedback amplifier. Because this open-loop gain is already high, an a even as low as 0.5 reduces the dc open-loop gain by only 6 dB with little effect on the open-loop frequency response. Q_1 and Q_2 can operate well into saturation, with little input on frequency response. This effect is a unique aspect of a current-feedback design, because similar operation for the differential input stage of a voltage-feedback op amp is impossible with the input-stage transistors saturated. You can use this feature to extend the range of low-voltage operation for current-feedback op amps that offer higher output swing than input range.

Figure 3 shows the results of tests with 3.3, 3, and 2.7V supplies. In each case, the output-voltage swing increased to just below the onset of gain compression. You can determine the required output-voltage head room for each supply voltage by subtracting the peak-to-peak output from V_{CC} and then dividing by two. You obtain slightly more output-voltage swing with light loads, such as an ADC input. With a 2.7V supply, the inverting-input transistors, Q_1 and Q_2 in **Figure 2**, are well-saturated, yet the amplifier still provides more than 150-MHz bandwidth with an inverting gain of 6V/V (15.5 dB from input to output), with a 0.6V p-p output swing. Small-signal operation maintains more than 100-MHz bandwidth with a supply as low as 2.2V. This bandwidth would have required an equivalent single-supply, voltage-feedback op amp with approximately 600-MHz gain-bandwidth product and a greater-than-300V/msec slew rate. (DI #2232) EDN

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