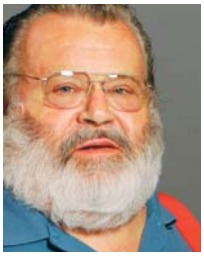

BY RON MANCINI

Beyond the Spice model's dc and ac performance

Evaluating the dc and ac performance of a Spice model before using it is mandatory for success. But the model evaluation should not stop here; designers should also know how the model performs when operating the active device in the nonlinear area and how a critical ac specification behaves. These parameters are difficult or impossible to verify with the data sheet, because no specification exists for working in the nonlinear area of an amplifier output stage that drives to the power-supply rails.

Op amps have a dc specification for the maximum and minimum output-voltage swings. First, the model should show distortion when the output voltage approaches one of the rails, because saturation distorts the output waveform (assuming non-rail-to-rail op amps). Second, operating the amplifier at the power-supply rails causes a pronounced form of distortion called clipping. The distortion data on the data sheet specifically excludes operating at rails, so designers must determine what distortion value is permissible and what distortion value occurs when operating near the rails. Gathering distortion data is a laborious lab task, but distortion is less than 2% when you cannot see it in a sine wave. So, if you can stand this distortion, your eyeball is the meter.

The OPA132 was configured as a gain-of-10 amplifier, and **Figure 1** shows the output waveform for a 1.45V input sine wave. The bad news is that clipping is just visible, so you must conclude that the sine wave contains more than 2% distortion. The good news is that the model does include circuitry that limits the output-voltage swing.

Another important parameter is CMR (common-mode rejection). An op amp configured as a differential amplifier (four resistors equal to 1 kΩ), with the common input connected to a 1V sine-wave source yields the data in **Figure 2**.

Figure 2 shows the CMR data for an OPA132 Spice model. The −100-dB low-frequency intercept correlates with the information on the data sheet. The model breakpoint occurs at 1.5 kHz, and the data-sheet breakpoint occurs at approximately 0.7 kHz. The model CMR levels off at approximately 8 MHz, and the data-sheet CMR keeps decreasing at −20 dB/decade. The Spice model deviates from the data sheet for this parameter, but before you throw away the model, consider that you probably won't use this op amp for signals containing frequencies greater than approximately 10 kHz, so the high-frequency CMR may not matter. Designers can ignore the breakpoint differences, do hand calculations, or choose another model.

No Spice model is perfect; semiconductor designers use elaborate Spice programs to design and emulate ICs, and these programs don't always yield working ICs. Spice is like any other tool, because you must account for its shortcomings. Your slide rule had a round-off and interpretation error, but it helped you design many circuits. The key to success is to know the tool's capabilities, work around its deficiencies, and keep on trucking. **EDN**

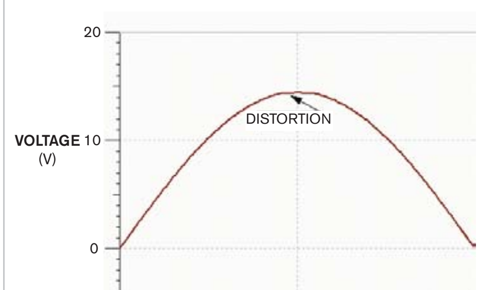

Figure 1 Clipping has caused distortion at the top of the waveform.

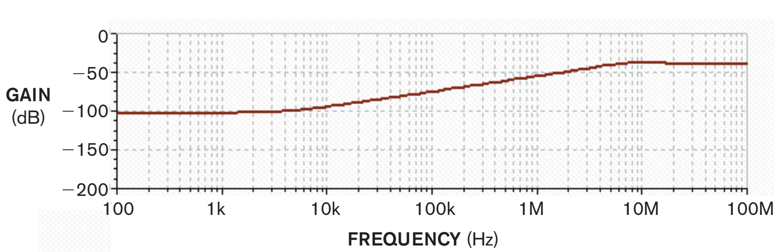

Figure 2 This inverse CMR plot for the OPA132 shows good model performance to 10 MHz.

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