Verify your ac Spice model

A FEW YEARS AGO, the ac parameters of Spice models were almost worthless; they had little correlation with reality. Time changes many things, and now, many ac Spice models are excellent representations of data sheets and, consequently, ICs. The designer still has to verify each new model before using it to ensure that it represents the IC in the design; the following description systematically breaks down the verification procedure.

The data sheet specifies the op-amp gain for the OPA132 as 126 dB at an output-voltage swing of ±13.5V, with R_l=2 kΩ. The 126 dB equates to an open-loop gain of approximately 2(10^6). Dividing the single-ended output-voltage swing by the gain shows that the input voltage can't exceed 6.75 µV or saturation can occur. Trying to sweep a 6.75-µV source from 0.1 Hz to 100 MHz is impractical, if not impossible, in the lab; thus, you perform this type of analysis with Spice rather than with measurements (**Figure 1**). The specifications are for a load resistance of 2 kΩ, and the actual load resistance is 1 kΩ, so the maximum input voltage is limited to 5 µV. The gain plot for the op amp crosses 0 dB at approximately 10 MHz, and following the 10-MHz line down to the phase diagram reveals that the phase margin is approximately 50° (**Figure 2**).

The step voltage response can correlate with the phase margin, but you must understand two points before this possibility becomes obvious. First, the loop gain of a buffer-configured op amp is identical to the loop gain of the op amp. Therefore, you can put the op amp in a buffer configuration and use a step input to obtain its step response. Second, the circuit, when you model it as a second-order system with a phase margin of 50°, should have a step response of 16%. The phase diagram clearly shows two poles, thus second-order modeling of this system is appropriate.

The step response in **Figure 3** has 17% overshoot, which demonstrates excellent correlation between the phase and step response. The gain/phase curves match the data sheet within a few percent, so you can conclude that this model matches the data sheet and will yield data representative of the IC.□

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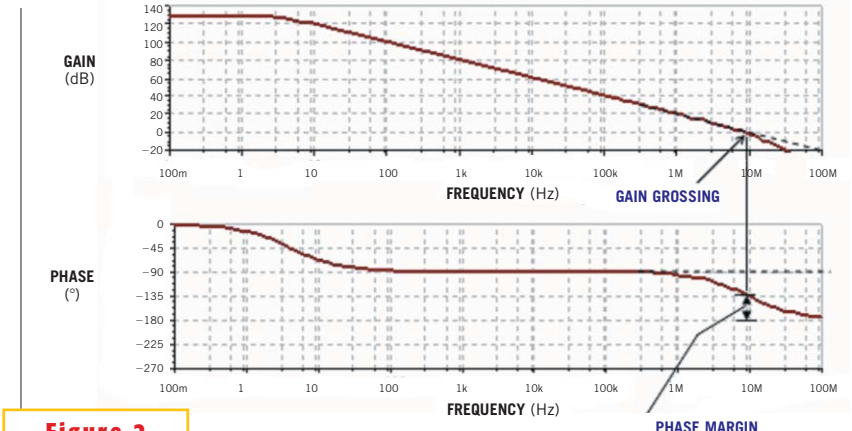
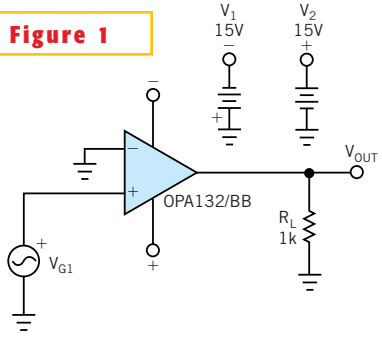
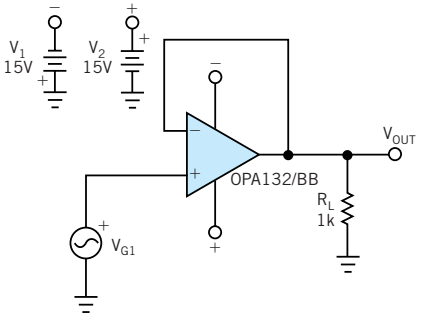


Figure 2 The gain and phase correlate with the data sheet.

Figure 1



You can use the open-loop model with Spice but not in the lab.



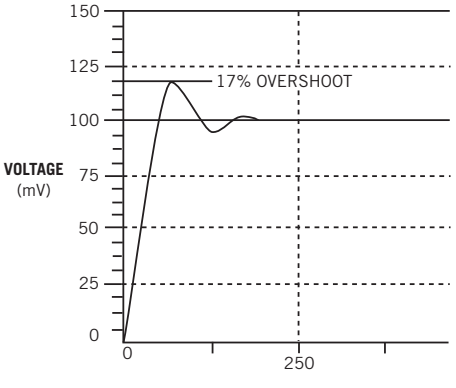


Figure 3 The step response of the op amp correlates with the 50° phase shift.