Component Monotoncity

Probably the most important point to be made in this supplement is as follows:

MCA yielding output values greater than FMCA values, such as that shown in figures 35 & 36 on page 91, will occur whenever bipolar sensitivities are present. Further, bipolar sensitivities indicate the presence on non-monotonic components; hence non-monotonic components can be detected by calculating the normalized sensitivities, which is part of the normal tolerance analysis (TA) procedure given here.

All three occur together: (1) MCA > FMCA, (2) bipolar sensitivities, (3) non-monotonic components.

Strictly speaking, EVA/FMCA should never be used in a TA if non-monotonic components are present. MCA is then the only correct method to use. The magnitude of the errors between the two analyses is a function of the maximum absolute magnitudes of the bipolar sensistivities. For circuits such as the Butterworth low pass filter, the errors may be negligible.

Some quotes from literature on monotonicity are germane:

From "Improving the Manufacturability of Electronic Designs", IEEE Spectrum, June 1999, p.70: "Non-parametric Boundary Analysis … selects only those components in the tails of the distributions - the combinations most likely to cause yield problems - for a complete circuit simulation. An important constraint is that the functions … must be approximately monotonic… the author conjectures that the vast majority of practical circuit designs are approximately monotonic."

Present author comments: Guessing is not necessary now.

From "Tolerance Design of Electronic Circuits", 1988 (Ref 3) p.31: "Unfortunately, there is no straightforward procedure for testing whether monotonicity is obeyed."

Present author comments: True in 1988, not true in 1999.

From PSpice user's manual on worst-case analysis: "Worst-case (.WCASE) analysis … will show the true worst-case results when the collating function is monotonic with all tolerance combinations. Otherwise, there is no guarantee. Usually you cannot be certain is this condition is true, but insight into the operation of the circuit may alert you to possible anomalies."

Present author comments: Now you can be certain is this condition, i.e., non-monotonicity, is true by looking for bipolar sensitivities. See the EVA of the bandpass filter (figure 9, p.41 of the MATLAB book) for an example of "no guarantee". Note that there is no mention of the incorrect method of ac sensitivity calculations performed by Spice.