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New precise SPICE macromodels for the current-feedback operational amplifier

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Abstract

Two new linear, frequency-dependent macromodels for the Current-Feedback Operational Amplifier (CFOA) are introduced. Both macromodels simulate the actual performance of typical CFOAs for a wide range of frequencies. The first proposed macromodel suits manual calculations due to its relatively simple mathematical model. The second proposed macromodel shows more accurate results but is described through a more complex set of mathematical equations. Both macromodels present performance advantages over previously introduced macromodels. © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The CFOA has emerged as one of the most important building blocks in the analog design library. Recently, the use of the CFOA as a four-terminal active building block has been highlighted [1] and used efficiently in developing many application based on the CFOA as the active building block. Testing the developed circuits is done usually using SPICE (Simulation Program with Integrated Circuit Emphasis) with a company specific model for the CFOA.

With the increasing complexity and shorter design cycles of today's designs, computer modeling with SPICE is becoming more popular. This is especially true with high-speed designs utilizing the latest in CFOAs. The need thus for accurate macromodels to model the actual performance of CFOAs have evolved as one of the growing needs both to obtain a trusted simulation of the required circuit and also to understand the limitations imposed on the operation due to the presence of parasitic effects. A simple macromodel that counts only for the currents and the voltage tracking errors was used [2–4] to model the actual performance of the CFOA. This model imposes no frequency limitations and its performance is far from the actual performance. Another model that counts for the basic parasitics was developed [5–7]. The model follows the actual performance for a limited range of frequencies. At low and high frequencies, the performance of the macromodel largely deviates from the actual performance. A third model that closely describes typical CFOAs was presented [8]. The model in [8] is fairly accurate for a good range of frequencies although it deviates from the actual performance at low frequencies. In this paper two new SPICE generic macromodels for the CFOA are presented. Both models use a lower number of elements than in [8] thus offers a shorter simulation time. The first proposed macromodel also is suitable for manual calculations due to the fairly simple mathematical equations used in describing the macromodel.

SPICE models are widely used to simulate circuit performance [8–13], but there is always the question of how well does the SPICE simulation results resemble the real responses. The most accurate model that can be trusted to a great extent is the transistor level model, a mapping of the amplifier internal structure actually manufactured using the parameters of the used technology of fabrication. A device-level model can accurately model all the practical aspects usually found in real life such as the variation of the performance with temperature, even the effects of devices mismatch and fabrication tolerances can be predicted using the Monte Carlo (MC) and the Worst Case (WC) analysis offered by SPICE.

It seems thus that the answer to the previous question is to use a device-level model.

2. The philosophy of macromodeling

Usually the philosophy involved in creating a

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