Modeling Bipolar ICs for Circuit Simulation

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In this paper, studies on new and extended device models to obtain high accuracy in the bipolar integrated circuit simulation are presented. The modeling for the high frequency characteristics, the parasitic substrate current and the device parameter variation in bipolar ICs are mainly described because they are essential in the modern bipolar IC design.

A new and accurate model of the cutoff frequency f_T in the high current region is proposed by taking account of the conductivity modulation in both the base and collector region of an integrated bipolar structure. Based on the f_T model, the high frequency model for an bipolar transistor is studied by comparing with measured S parameters. An extended high frequency model including parasitic elements is presented considering the integrated device structure and the current distribution. Excellent agreement with measured values has been obtained using the model in the simulation of a 600 MHz wideband amplifier IC.

The high frequency model for an integrated resistor is also studied. A new model including a negative capacitor in the usual π model is derived based on the RC transmission line theory.

The next, modeling of the substrate current, that is important in the Bi-CMOS circuit, is shown to obtain the accurate simulation of the saturation and substrate current characteristics.

Finally, a statistical model which predicts variations in circuit behavior is presented. The model uses eigen values and eigen vectors of the correlation matrix constructed for devices in the integrated circuit and is applied to the margin design including the parameter matching.

All the models have been implemented into a circuit simulator and highly accurate simulations of bipolar ICs have been realized.