AN IMPROVED PARAMETER EXTRACTION METHOD USING AN RF SOFTWARE SIMULATION

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ABSTRACT

An improved parameter extraction method using an RF software simulation is proposed. The ADS program, *Advanced Design System* (gently supplied by Agilent Brazil), which has been created to design a complete set of RF projects, has shown excellent results for this task. Several advantages can be mentioned: high accuracy, high precision and facility.

Using the ADS optimization tool, the measured data are compared, point-by-point, to the simulated data of an initial MOSFET model. After that, ADS adjusts the parameters of this model, in order to make the difference between the theoretical and measured data converge to the desired error. Any device model parameter (included in ADS) can be extracted using this approach. Results using BSIM3 MOSFET static model will be shown.

1. INTRODUCTION

The circuit simulation is of crucial importance to the integrated circuit and electronic devices development, e.g. MOSFET (Metal Oxide Semiconductor Field Effect Transistor). Based on simulation, the circuit or the device behavior can be obtained before the fabrication, which reduces design and re-design cycles. But, the task of extracting parameters of a transistor is becoming a challenge nowadays. The number of parameters has grown considerably in new models like BSIM, which makes the conventional methods unsuitable. Many techniques have been developed. The program ADS (*Advanced Design System*), which has been created to design RF projects, has shown excellent results for this task. The main advantages of this technique are the high accuracy and facility.

2. PARAMETERS EXTRACTION PROCEDURE

The basic procedure is as follows: All the previously measured data are placed in only one library file. Table 1 shows the library file structure.

The IDS (measured drain-source current) value in all curves (IDSxVDS, IDSxVGS, and log(IDS)xVGS) is a function of VDS (drain to source voltage), VGS (gate to source voltage) and VBS (bulk to source voltage) voltages. Due to this fact, all data can be placed in only one library file with five fields: *index*, VDS, VGS, VBS and IDS. Each file line represents one register, identified by the field *index*. The file can have any extension and spaces or tab characters can separate the data.

Table 1: Library file structure

BEGIN DSCRDATA				
% Index	VDS	VGS	VBS	IDS
1	(value 1)	(value 2)	(value 3)	(value 4)
2	…	…	…	…
…	…	…	…	…
End				

After that, the circuit is designed in ADS as shown in Figure 1a. The user should specify the parameters that will be extracted and their range in BSIM3_model component (Figure 1b). When the optimization (which is the most important ADS tool used for parameter's extraction) starts, ADS reads from the library file (which is specified in DAC component, Figure 1b) the measured values of IDS and the values of VGS, VDS and VBS that polarized the transistor. The same voltage values are used to polarize the designed circuit in ADS. The Agilent's program, then, gets a theoretical IDS value according to the initial model specified by the user in BSIM3_model component (Figure 1b). The values of theoretical and measured IDS are compared and ADS adjusts the model in order to make the difference between them to converge to the desired error (specified in GOAL component, Figure 1a). ADS repeats this procedure to all curves' points. Several convergence methods can be defined in OPTIM component (figure 1a) like quasi-Newton, Gradient, Random and others[1].

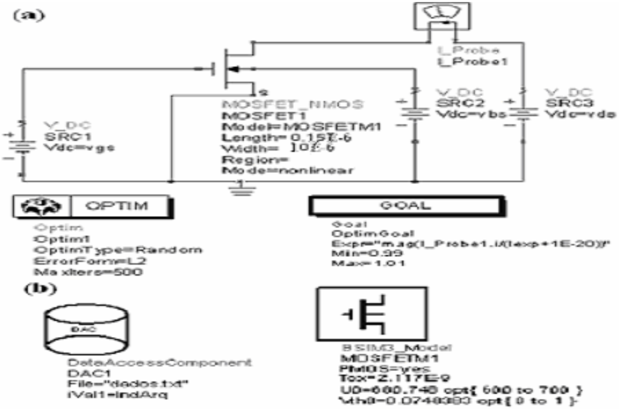

Figure 1: (a) Designed circuit and components OPTIM, GOAL and VAR. (b) BIM_3MODEL and DAC (Data Access Component) components

3. RESULTS AND DISCUSSIONS

A HP4145B and KEITLHEY 4200SCS analyzer were used to obtain the MOSFET IDSxVDS, IDSxVGS, and log(IDS)xVGS curves. Optimization results of a pMOS Transistor, which was made in IMEC (Interuniversitair Micro-Elektronica Centrum, Netherlands) with L = 0.15 µm and W = 10 µm, are shown in figure 2. These results indicate a good fitting better than 5%. This error is similar to the results reported in literature [2, 3]. The parameter extraction method presented in this article can be applied to any kind of models like BSIM4, TOM and others. Another important characteristic is that this procedure does not need a linear regression or another mathematical method, which simplifies the task. Taking in consideration all these advantages, this technique can be extended to AC, noise and S parameter analysis for CMOS and HBT devices. Some of the extracted parameters are shown in Table 2.

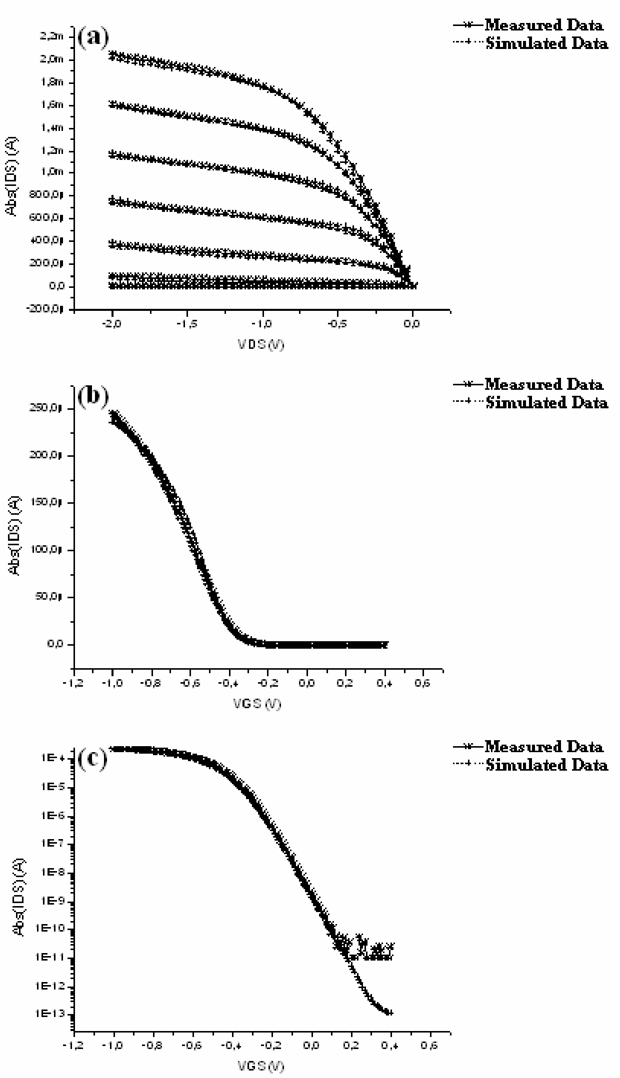

Figure 2: Comparisons between theoretical and experimental curves pMOS(L = 0.15µm /W = 10 µm) transistor. (a) IDSxVDS. (b) IDSxVGS. (c) Log(IDS)xVGS.

Table 2: Some Extracted Parameters (L=0.15 µm, W =10µm)

Vth0=7.848E-2 V	U0=6.801E2 cm^2/V.s
Nfactor=1.837E1	Voff = -1.604E-1 V
K1=5.300E-1 V^1/2	Dvt0 = 3.431E0
Vsat = 1.834E5 m/s	Ags = 4.026E0 1/V
Ua = 8.569E-9 m/V	Dvt1 = 5.300E-1
Gamma1 = 4.508E-1 V^0.5	Gamma2 = 4.205E-1 V^0.5

Where Vth0 is the zero-bias threshold voltage, U0 the low-field mobility, Nfactor the subthreshold swing factor, Voff the threshold voltage offset, K1 the first order body effect coefficient, Dvt0 the short channel effect coefficient 0, Vsat saturation velocity, Ags the gate bias coefficient of Abulk, Ua the linear Vgs dependence of mobility, Dvt1 the short channel effect coefficient 1, Gamma1 the body effect coefficient near interface and Gamma2 the body effect coefficient in the bulk.

4. CONCLUSION

An improved parameter extraction method using an RF software simulation has been proposed. The ADS program has shown excellent results for this task with high accuracy, high precision and facility, even with very small transistors (L= 0.15 um and W= 10 um). Good fitting results better than 5% were obtained. Any device model parameter (included in ADS) can be extracted using this approach.

5. REFERENCES

[1]Advanced Design System 2003C documentation

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