FLEXIBLE PARAMETER IDENTIFICATION TOOL FOR SEMICONDUCTOR DEVICE DESIGN

H. NGUYEN XUAN, L. GERBAUD, N. ROUGER and J-C. CREBIER

Grenoble Electrical Engineering Lab (G2ELab), UMR 5529 BP 46 - 38402 Saint-Martin-d’Hères Cedex, FRANCE, Tel: +33 (0)4 76 82 64 77/Fax: +33 (0)4 76 82 63 00
E-mail: Laurent.Gerbaud@g2elab.grenoble-inp.fr

Abstract. This paper presents an efficient parameter identification approach for the simulation of semiconductor devices. In the first part, a methodology to generate the parameter identification tool is proposed for behavioural simulations. This methodology is then implemented and validated on an integrated lateral MOSFETs. The approach presented here allows an accurate parameter identification, which can be used for an efficient optimization of integrated semiconductor devices.

Keywords: Automatic differentiation tool, least square curve fitting method, parameter identification methodology, genetic optimization algorithms, semiconductor device design.

INTRODUCTION

The simulation of semiconductor devices is always a requirement while designing and optimizing such components [2]. As far as power semiconductor devices are concerned, the monolithic integration of advanced functions (eg. control) within high voltage devices gives a high stress on the design [1] and the modelling for both the integrated functions and the main high power switch. The stress on the modelling here deals with the big size of model and the computation power. The parameter identification approach (PIA) for an integrated low voltage function in a high power device is proposed in this paper. This approach provides the analytical model with the best fit to the made device characteristics for an accurate behavioural simulation. In order to achieve this inverse problem, the PIA has to be an efficient, flexible and reliable tool, which can allow to change easily the model equations and to identify the parameter values. This approach allows here to easily identify the model parameters of different function components.

STATE OF THE ART

In the design framework of power semiconductor devices, the designer can use numerical methods such as Finite Elements or Finite Difference Methods in order to solve the differential equations of the semiconductor physics in all the simulated dimensions. Although, these numerical simulations are accurate, two major drawbacks are associated with these methods: the resource requirements and the difficulty to simulate several physics in all the simulated dimensions. Although, these numerical simulations are accurate, two major drawbacks are associated with these methods: the resource requirements and the difficulty to simulate several physics in all the simulated dimensions. Although, these numerical simulations are accurate, two major drawbacks are associated with these methods: the resource requirements and the difficulty to simulate several physics in all the simulated dimensions. As a consequence and in order to provide an efficient tool for the parameter identification tool, the static characteristic modelling and the parameter identification results with different approaches of a lateral MOSFET are presented in order to validate this approach.

IDENTIFICATION METHOD

In this identification tool, the least square curve fitting Levenberg Marquardt (LM) method of the non linear problem is used. The principle of this method is to minimize the following quantity $S(\theta)$ [3]:

$$S(\theta) = \sum_{i=1}^{n} (y_i - f(x_i, \theta))^2 = \sum_{i=1}^{n} r_i^2$$

where $y_i$, $x_i$ are the measurement points, $f(x_i, \theta)$ is the analytical model with a set of unknown parameters $\theta$. The algorithm and the principle of this method will be developed in the full paper. To minimize the quantity $S(\theta)$, LM method requires the function $f(x_i, \theta)$, the measurement points $(x_i, y_i)$, the partial derivatives of $f(x_i, \theta)$ with respect to its parameters $\theta_j \in \Theta$ and also the initial values of unknown parameters $\theta_j$.
A semiconductor model is always complicated, with many unknown parameters and conditions. Therefore, the partial derivative definition in the direction of its parameters is difficult to determine symbolically. On the other hand, the initial unknown parameters values $\theta_0$ are not simple to determine in the case of many parameters. Wrong values of $\theta_0$ can lead to divergence problems. With the aim of solving these particular problems, an automatic differentiation tool and an identification strategy are proposed in the paper. The partial derivatives generation is gotten automatically by code generation [4]. Then, the identification tool can be applied on first result given by the ES(Evolution strategies) [5], RTS(Restricted Tournament Selection) [6] optimization algorithm in CADES[4] (as in Fig. 2).

APPLICATION AND RESULT

The PIA is applied on the static model of an integrated lateral MOSFET (NMOS) in Fig. 3. Additional details of the developed model of this NMOS will be presented in the full paper. Two generic optimization algorithms (ES, RTS), and LM method are used to identify the unknown parameters of the NMOS model. Two results of the ES algorithm (with 1000 generations, 100 populations and 15 individuals), two results of the RTS algorithm(with 1000 generations, 100 populations and 0.1 probability mutation) and one result of LM method are compared in Tab. 1 by the minimal quantity $S(\theta)$ and the model parameter values.

In these results, RTS algorithm provides the best result with $S(\theta) = 2,4019.10^-6$. In the first identification of the LM method, the result is not better than the RTS algorithm by reason of the initial parameter values. So, in the next identification step, the best result of the ES and the RTS algorithm are used as the starting point for the LM algorithm. This chaining gives better minima of $S(\theta)$. RTS-LM gets a best result. This best result of parameter identification is shown in Fig. 4. In the full paper, the parameter values and the differences between these results will be fully discussed.

CONCLUSION

In the paper, a methodology of a flexible parameter identification tool is presented to generate an analytical model through the accurate characteristic component in the numerical simulation for the semiconductor component design. An autonomous identification tool integrated into CADES framework is implemented which allow a generic use of the implemented method. Integrated NMOS analytical model is developed. The parameter identification tool is used to identify the parameters of an NMOS.

REFERENCES


