



## Use of Custom Designed Libraries for Design and Analysis of MOSFET Model Equations on MATLAB SIMULINK

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**Abstract**— This paper determines the controllability and observability in MATLAB/simulink, which is very easy way for handling complex MOSFET parametric equations. The solution of this problem is sorted by the manipulations of all the MOSFET equations like current voltage, capacitance characteristics, threshold voltage, oxide capacitance etc. Methodologies for implementation of different equations of MOSFET's based on VLSI applications are designed on the MATLAB SIMULINK. Each parameter have their individual equation and not easy to memorize all the time about the each equation. Therefore blocks provide the easy and simple way for many operation like complexity, reduction of multipart circuits, time reduction etc.

**Keywords**— MOSFET, DUAL GATE, FINFET, SIMULINK, MATLAB (R2012a).

### I. INTRODUCTION

This document is a template. An electronic copy can be downloaded from the Journal website. For questions on paper guidelines, please contact the journal publications committee as indicated on the journal website. Information about final paper submission is available from the conference website. The metal oxide semiconductor field-effect transistor or MOSFET transistors are a type of transistor used for amplifying or switching electronic signals. The process for controlling and saving the electric current with the help of transistors was first invented on 1930 by Lilien-feld and gives the basic concept of MOSFET. The MOSFET applications includes the digita integrated circuit such as microprocessors and memory devices which contains thousands to millions of integrated MOSFET transistors on each device, providing the basic switching functions required to implement logic gates and data storage [1]. The circuit designers need to develop new models for the use of circuit simulation which is further used for accuracy, continuity, scalability and simulation of different MOSFET models performances requirements for each model of MOSFET models [2]. The main advantage of a MOSFET over a regular transistor is that it requires very little current to turn on. As identified in VLSI, there are number of different MOSFET models which have their own different kind of priorities with parameters like potential, oxide capacitance, flat band voltage etc [3].

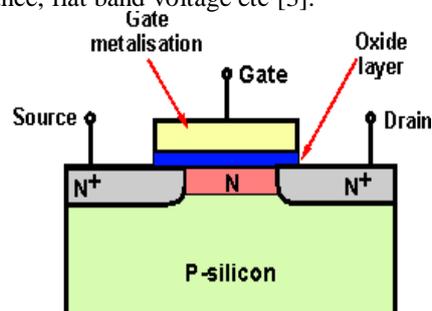


Figure 1: Schematic diagram of a MOSFET

MATLAB is recognized as one of the commonly available and most popular programming environments on educational platform for providing computer solutions to formulated problems, even of complex nature. MATLAB simulink provides a platform for designing of methodologies and for the implementation of different equations of MOSFET that are based on VLSI applications. [4]

In [3] Gurinder Pal Singh has determined controllability for handling complex VLSI circuits. As the complexity of VLSI circuits was increasing, calculations for controllability by mathematical formulas was becoming tedious job for each and every gate in a complex circuit, and further if circuit was sequential then additional mathematical calculations for flip flops were required. In [7] Balwinder Singh has proposed a new approach for VLSI testing in MATLAB. In this technique, a user library for simulink by using 2-D logic array block, D-algorithm and SPODEM is designed. This environment is useful for VLSI testing to make understand the concept of testing to students and can be used as teaching tool [8]. In [9] Cheng et al. presented the new and creative, physical and continues model for current and voltage for

short channel characteristics for circuit simulation and to describe the main non ideal effects of MOSFET. G.Pailloncy *et al.* has done the study of MOSFET with high frequency and noise for down scaling process. Under this work performance of transistor to make accuracy of power and low noise characteristics of MOSFET was done [10]. Darko Kirovski *et al.* has described the method used for new block creation which was based on the complete cut based approach. In this work emphasis was given on, to have advantages of simulation and deigns of new blocks [11].

## II. PRESENT WORK

In the design and implementation of MOSFET equations the first step is to handle the complexity level of mathematical equations and utilization of different MOSFET model equations in MATLAB and second is implementation of MOSFET equations in block form. The target is to represent that designed blocks in such a way so that if anyone interested to calculate the result for each parameter can use directly for calculation and these blocks are further targeted to be used for new circuit implementation [7].

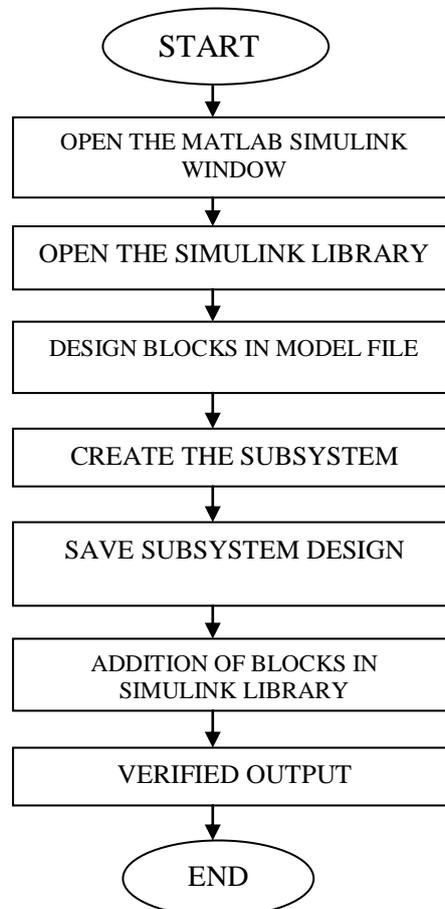


Figure 2: Flow chat of design system in simulink library

## III. RESULT & DISCUSSION

By taking space charge width as an example a simulink model is designed for controllability and observability. This model is designed in MATLAB/simulink. The use of complete design for different blocks for the analysis and calculation of different MOSFET parameters is presented. From simulink library user can directly pick the block of equation that are required and directly put the value of input parameters to get the final result of that equation. A display block is added which shows the output of MOSFET parameter.

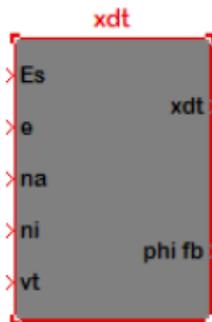
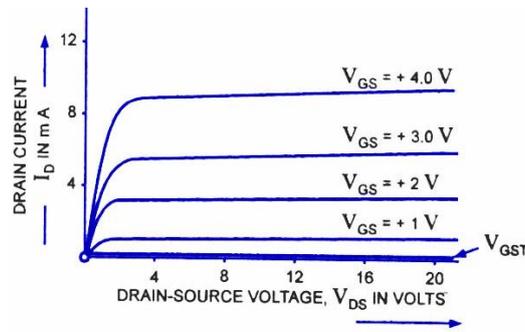


Figure 3: Block formation of  $x_{dt}$  (space charge width) equation



Drain Characteristics

Figure 4: MOSFET Current-Voltage characteristics

**Current-Voltage Characteristics**

The figure 4 shows the effect of the gate-to-source voltage and the drain-to-source voltage upon the drain current [21].

$$I_d = 0.21 \text{ mA/V}^2 [2(V_{GS} - V)v_{ds} - v_{ds}^2] \quad (3.1)$$

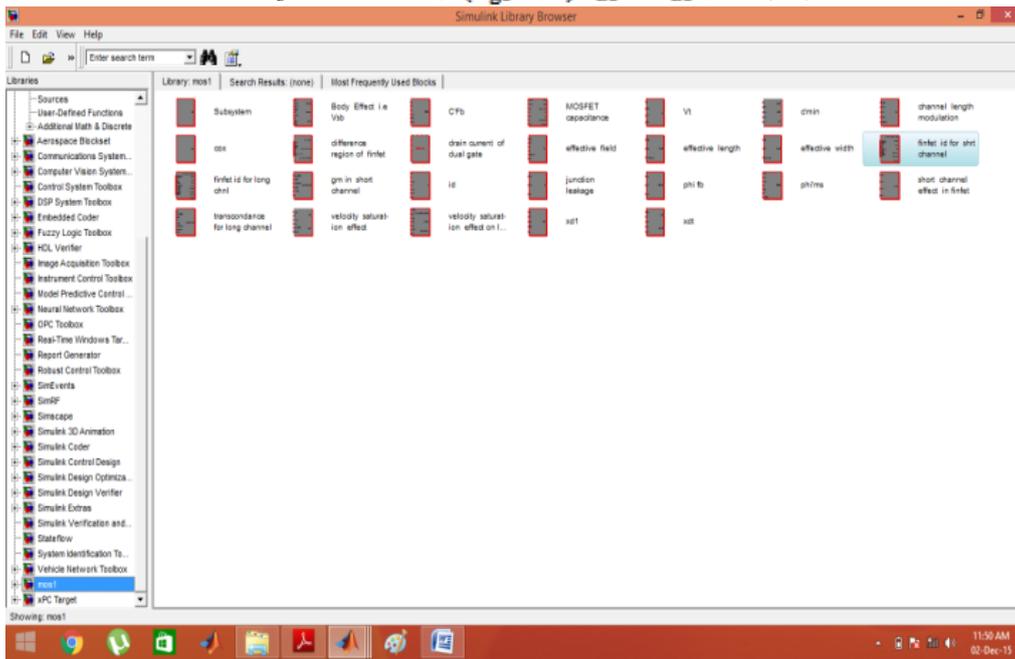


Figure 51: Updated Simulink Library

Using a circuit as shown in figure 6, is taken for verification of the user-designed library. In this the blocks are directly loaded into workspace from simulink browser, in which our newly designed library exists as shown in figure 5.

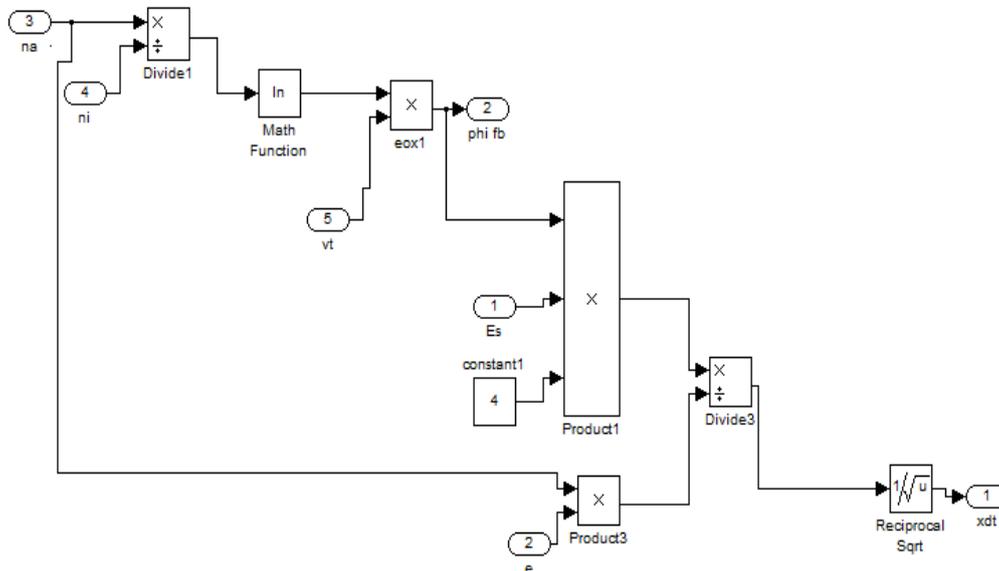


Figure 6: Simulink Block Model of (x<sub>DT</sub>) space charge width

Result for Designed Blocks:

A number of parameters are involved in these equations and the Values of these parameters equations are given in below table 1.

Table 1: Different Parameters in MOSFET

Sr. No.	Parameter	Values
1	(work function) $\Phi'_{ms}$	$E_g = 1.11\text{V}, e = 1.6 \cdot 10^{-19}\text{V}$ $\chi = 3.25\text{V}, \Phi_m = 3.20$
2	(Flat Band Voltage) $v_g$	$v_g = 6.278e^{0.08}\text{V}$
3	(Threshold voltage) $V_{Tn}$	$V_{Tn} = 6.95 \cdot 10^{13}\text{V}$
4	(oxide capacitance) $C_{ox}$	$E_{ox} = (3.9)(8.85 \cdot 10^{14})\text{F}$ and $T_{ox} = 500 \cdot 10\text{A}$
5	(Current Voltage Characteristic) $I_d$	$\mu_n = 600\text{cm}^2, C_{ox} = 7.10 \cdot 10^{-8}\text{F/cm}^2, L = 2\mu\text{m},$ $V_t = 1.0\text{V}, W = 20\mu\text{m},$ $V_{gs} = 2.0\text{V}$

The parameters which are involved in design of MOSFET are displayed in table 1. These values are given to the designed blocks in MATLAB Simulink as input and then the output of the display block is compared with the theoretical results. The results obtain are equal as theoretical results [7]. Using these MOSFET simulink library make environment more attractive, easy and reduction of time.

Table 2: Comparison between the Theoretical and Practically Calculated Values in Simulink

Sr. No	Parameter	Applied Equation	Theoretical Result	Practical Result
1	$\Phi'_{ms}$	$[\Phi'_m - (\chi + \frac{E_g}{2e} + \Phi_{fb})]$	$0.83 \cdot 10^{19}\text{V}$	$8.39e^{-0.18}\text{V}$
2	$v_g$	$\Phi_{ms} - \frac{-Q'_{ss}}{C_{ox}}$	$0.347\text{V}$	$0.34373\text{V}$
3	$V_{Tn}$	$(Q'_{sd}(max)/C_{ox} + V_{fb} + 2\Phi_{fp})$	$6.95 \cdot 10^{13}\text{V}$	$3.695e^{+0.14}\text{V}$
4	$C_{ox}$	$E_{ox}/t_{ox}$	$6.28 \cdot 10^8\text{V}$	$6.278e^{0.08}\text{V}$
5	$I_d$	$\frac{W\mu_n C_{ox}}{2L} [(V_{gs} - V_t)^2]$	$0.021 \cdot 10^{-10}\text{A}$	$2.1e^{-0.12}\text{A}$

It has been clearly verified that the practical results are same as the theoretical. It is clear that level of complexity has been decreased during the calculation of controllability and observability. The reason includes the use custom libraries instead of using the formulas for these parameters that make the calculations easier. The results are shown in tabular form in table 1 and table 2.

IV. CONCLUSION

In this paper, with the purpose of testing and calculation of different MOSFET equations for different transistor technologies, a new methodology is explained. The different MOSFET equations are designed by using inbuilt functions and modules of MATLAB/SIMULINK. In this work, just by applying the input to parameters at designed blocks, simulink give direct results. It has reduced the level of calculation and complexity for each MOSFET equation. By implementing blocks of different MOSFET equations for different models in simulink library makes the MATLAB environment more attractive, easy and reduction of time.

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