Interactive tool for quick calculation of design oriented MOSFET parameters

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A design problem
How to find an experienced analog designer

Give two designers an analog design problem:

Then see who goes to the simulator first
A design problem

The magic simulator funnel
A typical design flow

- Design Specifications
  - Gain
  - Area
  - Power budget
  - Speed

- Topology Selection
  - Gain stages
  - Voltage/Current references
  - Buffers

- Device sizes
  - Bias voltages & currents
  - “Pen and Paper” Calculations

- Simulation
  - DC
  - AC
  - Transient
  - Etc.
The simulator funnel
A second look
The simulator funnel
A second look

Netlist
Device sizes
Bias conditions
Circuit topology

“Pen & Paper” calculations needed
“Pen and Paper” calculations
The designers are on their own

- Model Developer
- Modeling Engineer
- EDA vendor

Design

Device Model
Model Card
Simulator

"Pen and Paper" calculations
The designers are on their own
“Pen and Paper” calculations
The designers are on their own

Design
- Model Card
  - Model Developer
- Simulator
  - EDA vendor
- Pre-simulation calculator
  - ?
“Pen and Paper” calculations
The designers are on their own

What do the designers typically use?

• Pen and Paper!

• Spreadsheets

• Mathematical software
  • Octave
  • Matlab

• The simulator itself
“Pen and Paper” calculations
The designers are on their own

What do the designers typically use?

• Pen and Paper!
• Spreadsheets
• Mathematical software
  • Octave
  • Matlab
• The simulator itself

What are the limitations?

• Sub-micron to sub-100-nm technologies are being used
• Operating points are often in moderate to weak inversion
What are the limitations?

- **Sub-micron to sub-100-nm technologies are being used**

- **Operating points are often in moderate to weak inversion**

- **Simple Level 1 equations cannot be used to accurately determine relevant small-signal parameters**

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**B.1.6 Drain Current Expression**

\[
I_{ds} = \frac{I_{ds}(V_{dseff})}{1 + \frac{R_{ds}I_{ds}(V_{dseff})}{V_{dseff}}}
\left(1 + \frac{V_{ds} - V_{dseff}}{V_{A}}\right)\left(1 + \frac{V_{ds} - V_{dseff}}{V_{ASCBE}}\right)
\]

\[
I_{ds0} = \frac{W_{eff}L_{eff}C_{ox}V_{gsseff}(1 - A_{bulk})V_{dseff}}{L_{eff}[1 + V_{dseff}/(E_{satL_{eff}})]} \frac{V_{dseff}}{2(V_{gsseff} + 2V_{t})}
\]

\[
V_{A} = V_{Asat} + (1 + \frac{P_{swg}V_{gsseff}}{E_{satL_{eff}}})(\frac{1}{V_{ACLM}} + \frac{1}{V_{ADBLC}})^{-1}
\]

\[
V_{ACLM} = \frac{A_{bulk}E_{satL_{eff}} + V_{gsseff}}{P_{CLMA}} \frac{V_{ds} - V_{dseff}}{l_{it}}
\]

\[
V_{ADBLC} = \frac{(V_{gsseff} + 2V_{t})}{\theta_{sat}(1 + P_{DMBCB}V_{bseff})} \left(1 - \frac{A_{bulk}V_{dsat}}{A_{bulk}V_{dsat} + V_{gsseff} + 2V_{t}}\right)
\]

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BSIM3v3 Manual Appendix B
“Pen and Paper” calculations
The designers are on their own

What do the designers typically use?

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- Spreadsheets
- Mathematical software
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- The simulator itself

What are the limitations?

- Sub-micron to sub-100-nm technologies are being used
- Operating points are often in moderate to weak inversion
- Simple *Level 1 equations* cannot be used to accurately determine relevant small-signal parameters
- There is no information about process variability
“Pen and Paper” calculations

The designers are on their own

What do the designers typically use?

- Pen and Paper!
- Spreadsheets
- Mathematical software
  - Octave
  - Matlab
- The simulator itself

What are the limitations?

- Typical overhead to simulate a parameter is about 30 seconds
  - Long time in an iterative process
- Limited number of licenses
  - Further delays
A pre-simulation calculation tool

Requirements

• Calculates the relevant small-signal parameters for elements available in a fab process

• Easy to use interactively

• Calculates the numbers quickly (< 1 s)

• Use the same model set as used in the simulator

• No license restrictions
  • (at least less severe restrictions than commercial simulators)
ams MOS dashboard
An interactive tool for MOS sizing and biasing calculations
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An interactive tool for MOS sizing and biasing calculations
A pre-simulation calculation tool
Who is the designers’ friend

- Pre-simulation Calculator
- Device Model Developer
- Modeling Engineer
- EDA vendor

Design

Pre-simulation Calculator • ?

Model Card

Simulator
Thank you

Please visit our website www.ams.com