BSIM2EKV:

BSIM3.3 to EKV2v6 Model Library File Automatic Conversion Tool

D. Stefanovic, F. Krummenacher, M. Pastre, M. Kayal

Swiss Federal Institute of Technology, Electronic Labs, STI/IMM/LEG,
Lausanne, Switzerland

BSIM2EKV converter

- Tool for automatic conversion
  of BSIM (version 3.3) model parameters
  to EKV (version 2.6) model parameters
- Standalone application (works in interaction with an external simulator)
- Basic principle of the conversion:
  - the curves needed for the parameters extraction are simulated using the BSIM model library file
  - the extraction procedure is based on the complete EKV model parameters extraction methodology

[M. Bucher, C. Lallement, C.C. Enz, "**An efficient parameter extraction methodology for the EKV MOST model**", International Conference on Microelectronic Test Structures, ICMTS 1996, 25-28 March 1996, pp: 145 – 150 **]**

EKV model

- Dedicated to the design of analog circuits
- Strongly based on device physics
- Has a small number of parameters, but very good accuracy

http://legwww.epfl.ch/ekv

EKV model

- Facilitates intuitive understanding of analog structures behavior
- Enables to find solutions for different input parameters sets without using complex numerical methods
- Enables the extraction of transistor parameters important for analog design, such as:

  inversion factor, saturation voltage, Early voltage,
  small signal parameters, parasitic capacitances,
  gm/ID ratio, transconductance efficiency factor

http://legwww.epfl.ch/ekv

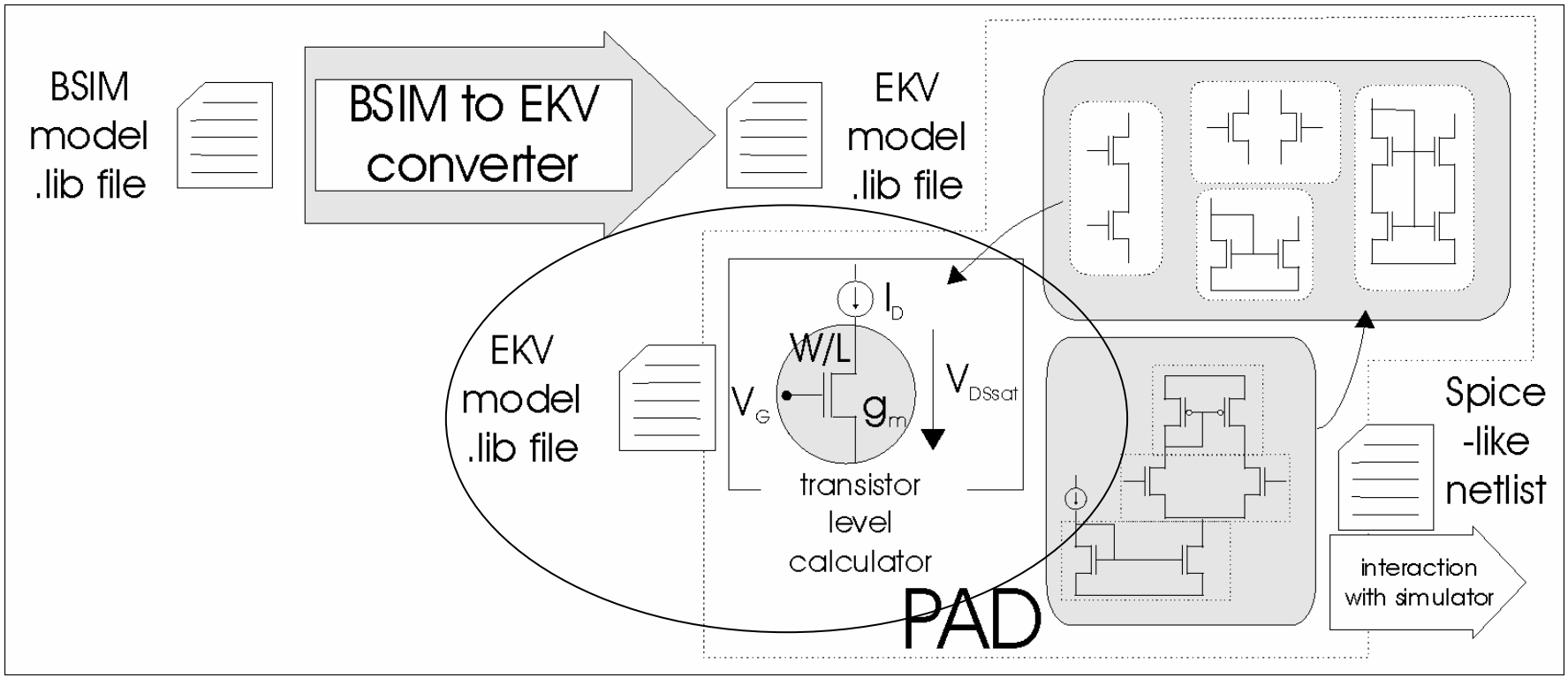
BSIM model

- Industrial standard - BSIM (version 3.3)
- Good accuracy
- Large number of parameters
- High complexity

? **Hand calculations**
Approximations
gm/ID ratio, inversion factor

http://www-device.eecs.berkeley.edu/~bsim

Procedural Analog Design



BSIM to EKV conversion

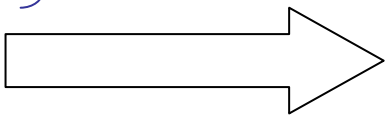
Opens new possibilities to use:

- EKV model (more extensively)
- CAD tools based on EKV model
- gm/Id design methodology

BSIM to EKV conversion

BSIM (version 3.3)

PSpice (level = 7)
SMASH (level = 49)



EKV (version 2.6), level = 5

- **intrinsic model parameters**
- **temperature parameters**
- **noise parameters**
- **overlap capacitances**
- **junction capacitance parameters**

Conversion algorithm

Basic concept:

- The curves required for the extraction procedure are simulated using the BSIM model
- Precise sequence of operations
- Minimum error propagation with the respect of fundaments of two models

Conversion algorithm

The following parameters are read from the BSIM model library file:

- nominal temperature (TNOM)
- process parameters (TOX, XJ, NCH)
- parameters needed for the initial values calculation (U0, VSAT, WINT, LINT)
- gate overlap capacitances (CGBO, CGSO, CGDO)
- junction capacitance parameters (CJ, CJSW, MJ, MJSW, PB, PBSW)

Conversion algorithm

The initial values of some parameters are calculated as follows:

GAMMA	$init = \sqrt{2q\varepsilon_{Si}(NSUB \cdot 1e6)} / COX$, $COX = \varepsilon_{OX} / TOX_{BSIM}$, $NSUB = NCH_{BSIM}$
PHI	$init = 2Vt(TNOM)\ln\left(NSUB \cdot 1e6 / ni(TNOM)\right)$
KP	$init = (U0 \cdot 1e-4)COX$, $U0 = U0_{BSIM}$
E0	$init = 0.1/(0.4 \cdot TOX)$
DW	$= -2 \cdot WINT_{BSIM}$
DL	$init = -2 \cdot LINT_{BSIM}$
UCRIT	$init = VMAX/(U0 \cdot 1e-4)$, $VMAX = VSAT_{BSIM}$

Conversion algorithm

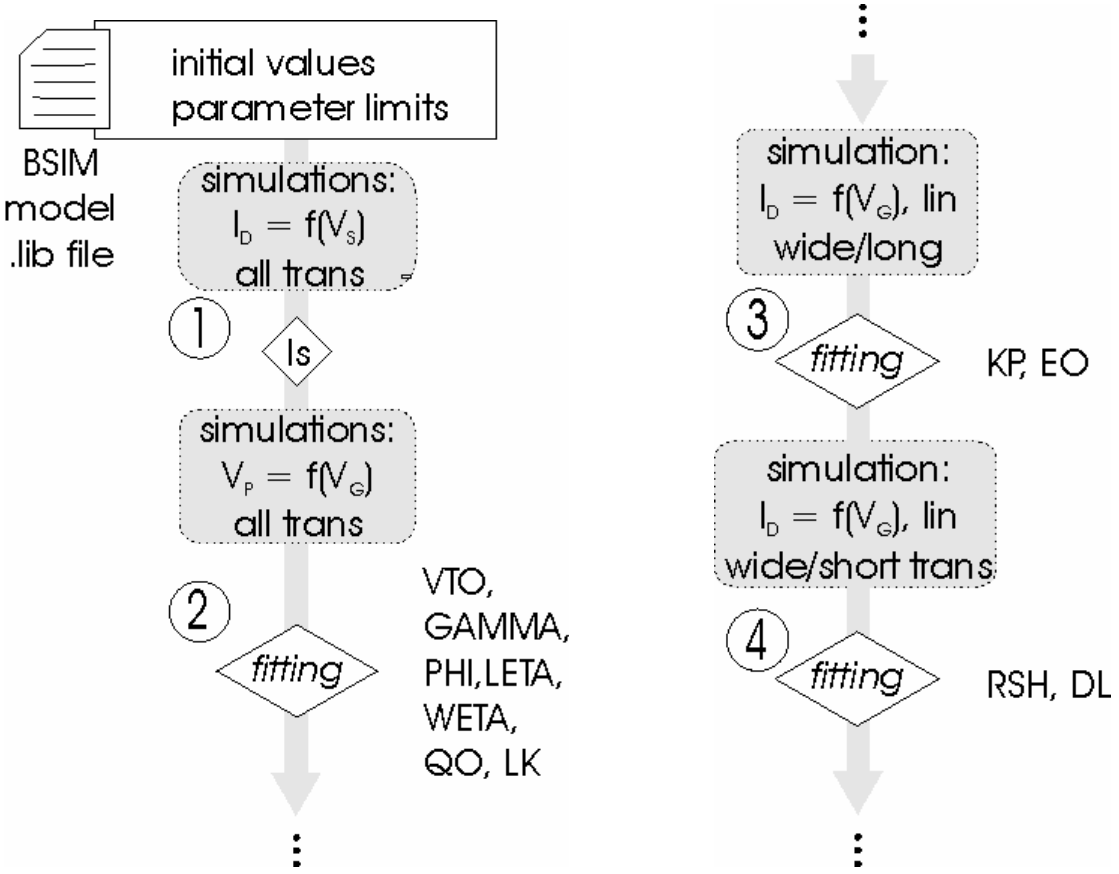
The geometrical dimensions of the transistors for simulations are determined as follows:

- wide/long transistor: Wmax/Lmax
- set of wide/short transistors: (11 transistors)
  Wmax/Lmin, 1.2Lmin, …, 2Lmin, 2.4Lmin, … 4Lmin
- set of narrow/long transistors: (2 transistors)
  Wmin, 2Wmin/Lmax

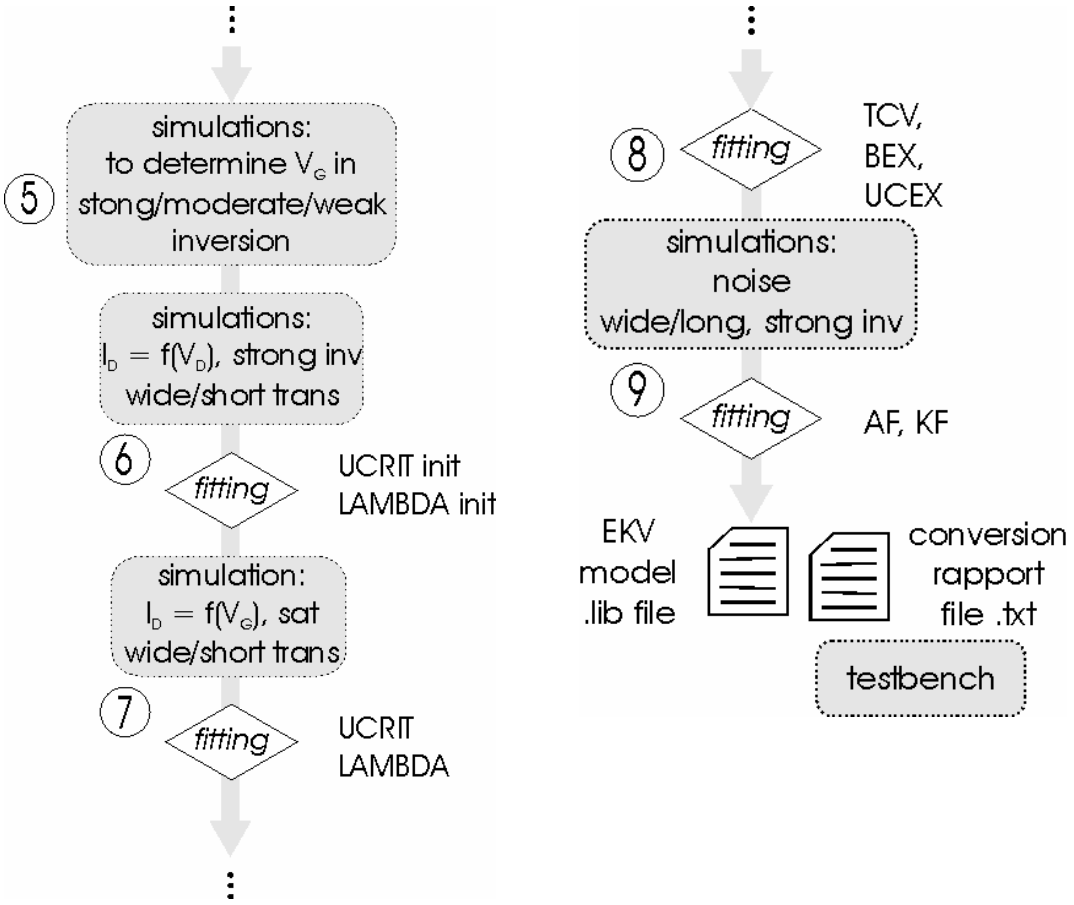
Conversion algorithm

- Alternation of simulation steps and fitting steps
- Specific order of parameter extraction
- No iteration or optimization loops
- Levenberg-Marquardt non-linear least squares method for curves fitting

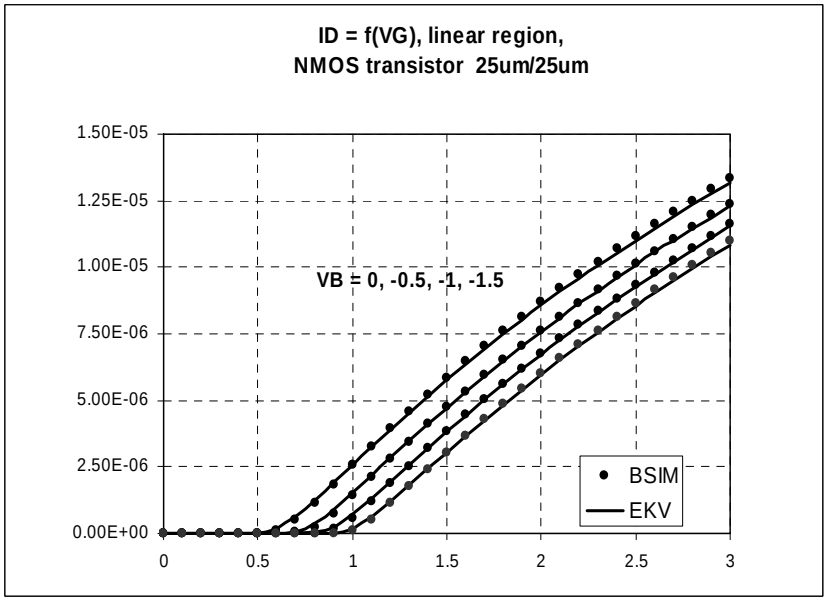
Conversion algorithm

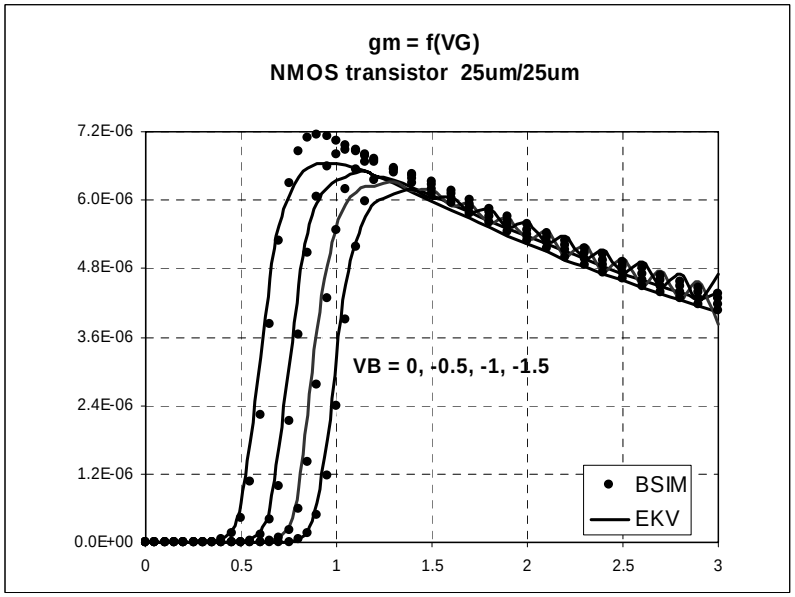


Conversion algorithm



Conversion example (CMOS 0.5 µm technology)





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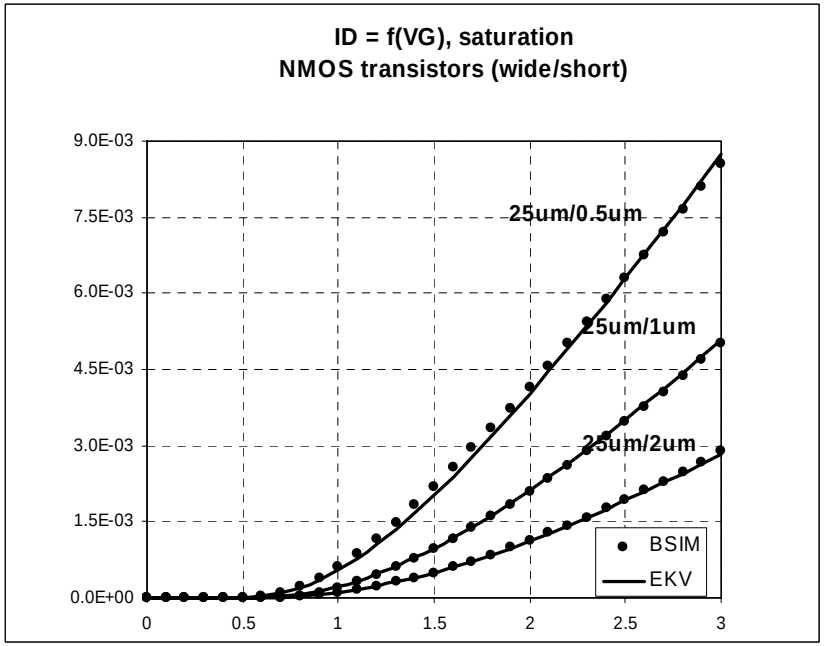

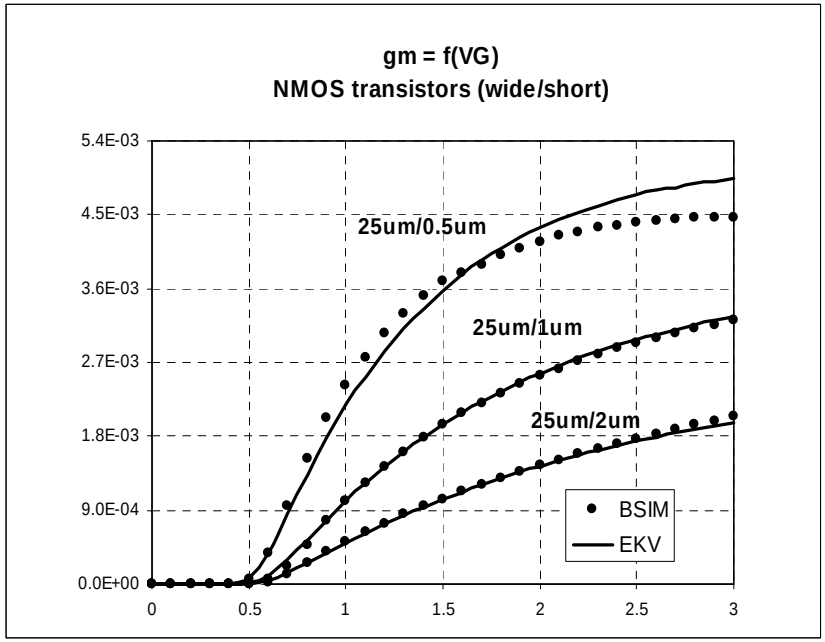

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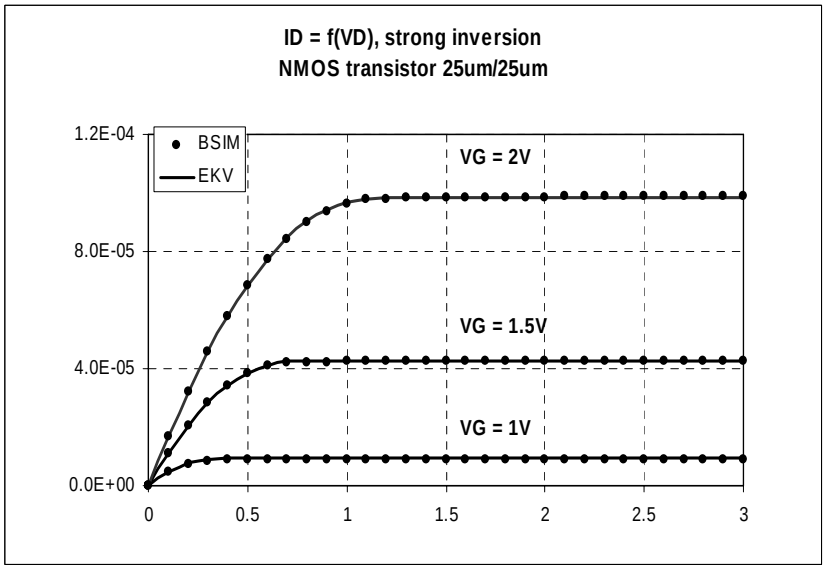

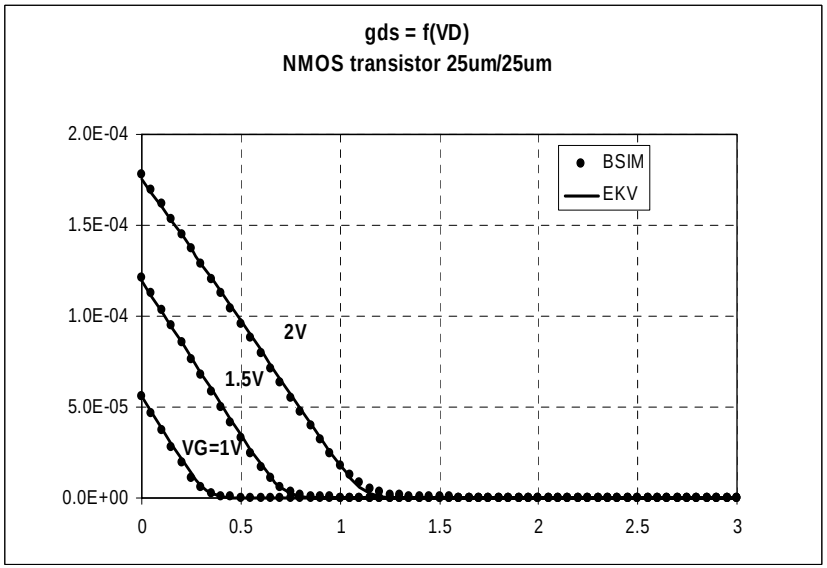

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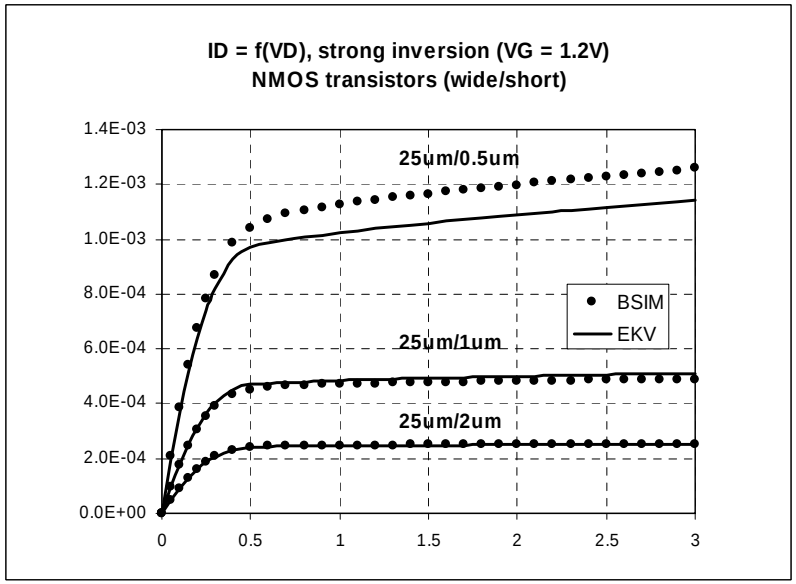
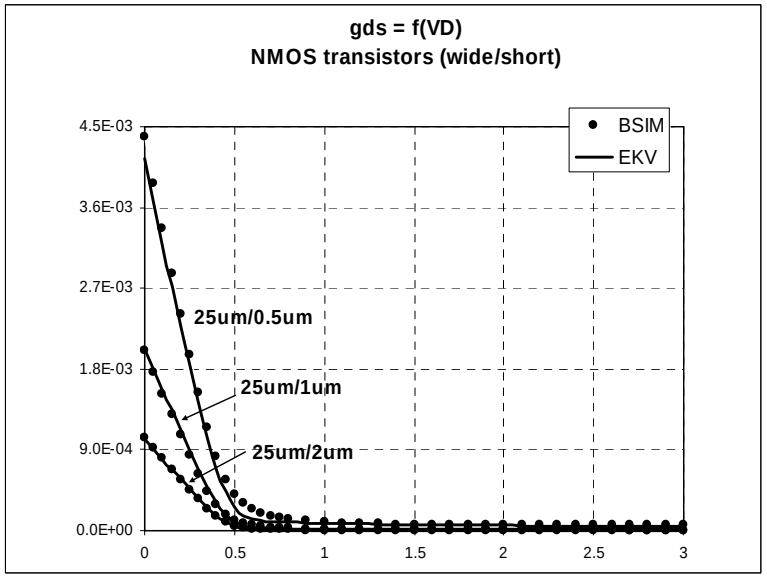
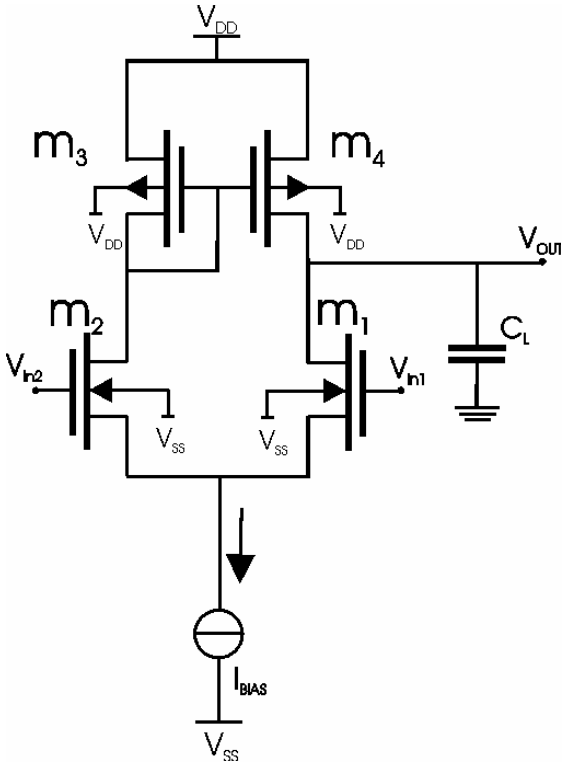
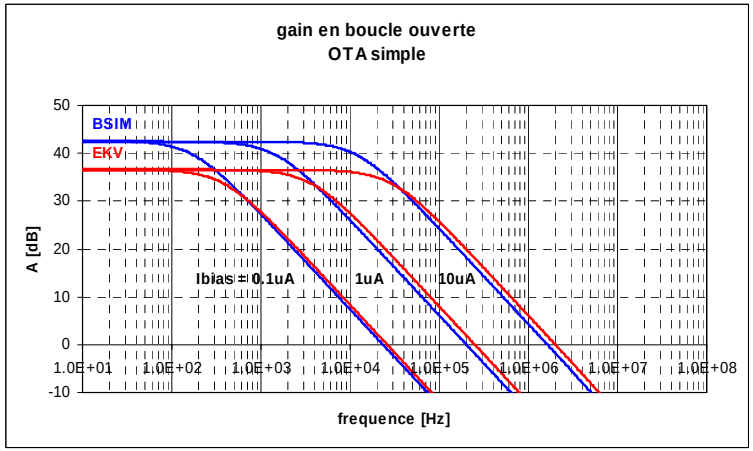


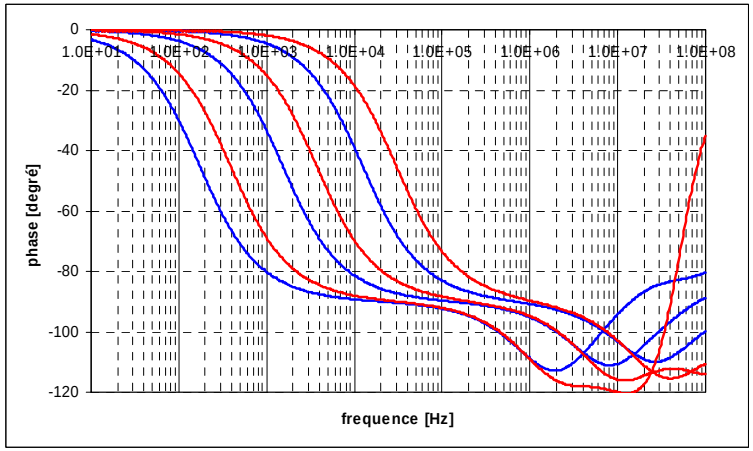


Testbench: open-loop gain, simple OTA



W1,2 = 100Lmin / L1,2 = 2Lmin
W3,4 = 20Lmin / L3,4 = 10Lmin
Cl = 10pF, Ibias = 0.1uA, 1uA, 10uA





Conclusion

- EKV model – model dedicated to the design of analog circuits
- BSIM model – empirical model, widely used
- BSIM2EKV – enables to generate the EKV model parameters from BSIM model parameters (within several minutes) and opens new possibilities to use:
  - ✓ EKV model
  - ✓ PAD
  - ✓ gm/Id design methodology