

BSIM6: Symmetric Bulk RF MOSFET Model

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EPFL, Lausanne, Switzerland

Dec. 15, 2011

Nano-Terra Workshop, Lausanne



Why new Bulk MOS Model: BSIM6

- Harmonic Distortion
 - Output spectrum of RF signal at frequency ω should only contain fundamental frequency ω
 - Nonlinear behavior of MOS adds other frequency components (i.e. at 2ω , 3ω ...) visible above noise floor \rightarrow harmonic distortion
 - Harmonics amplitude \propto higher order derivatives of signal
 - Model must satisfy both Gummel Symmetry (for DC) and AC symmetry

- Negative capacitance from BSIM4 model may cause convergence problem



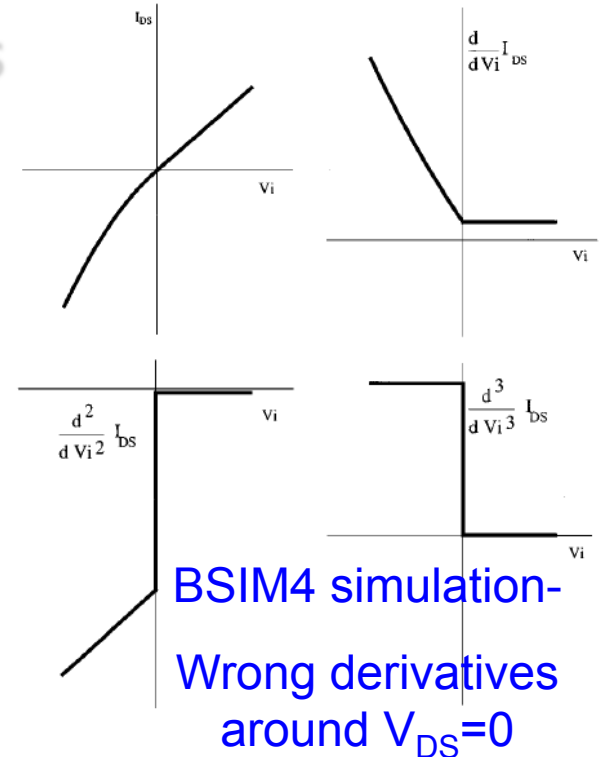
Why new Bulk MOS Model: BSIM6

Taylor Series Expansion

$$i_{out(t)} = f(V + v(t)) - f(V)$$

$$i_{out(t)} = \left. \frac{\partial f}{\partial x} \right|_{x=V} \cdot v + \frac{1}{2} \left. \frac{\partial^2 f}{\partial x^2} \right|_{x=V} \cdot v^2 + \frac{1}{6} \left. \frac{\partial^3 f}{\partial x^3} \right|_{x=V} \cdot v^3 + \dots$$

- RF design needs correct derivatives to predict harmonic distortion
- Incorrect derivatives=Wrong harmonic results
- Method of testing derivatives
 - Gummel Symmetry
 - AC Symmetry



BSIM6: Charge based MOSFET model

- BSIM6 is the next BSIM Bulk MOSFET model
- Charge based core derived from Poisson's solution
- Physical effects (SCE, CLM etc.) taken from BSIM4
- Parameter names matched to BSIM4 parameters
- Gummel Symmetry (symmetric @ $V_{DS}=0$)



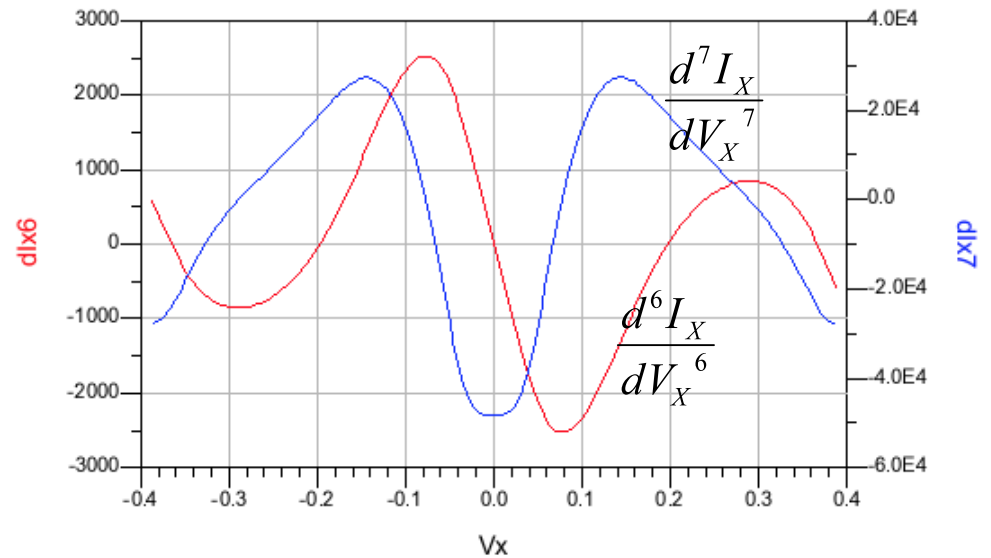
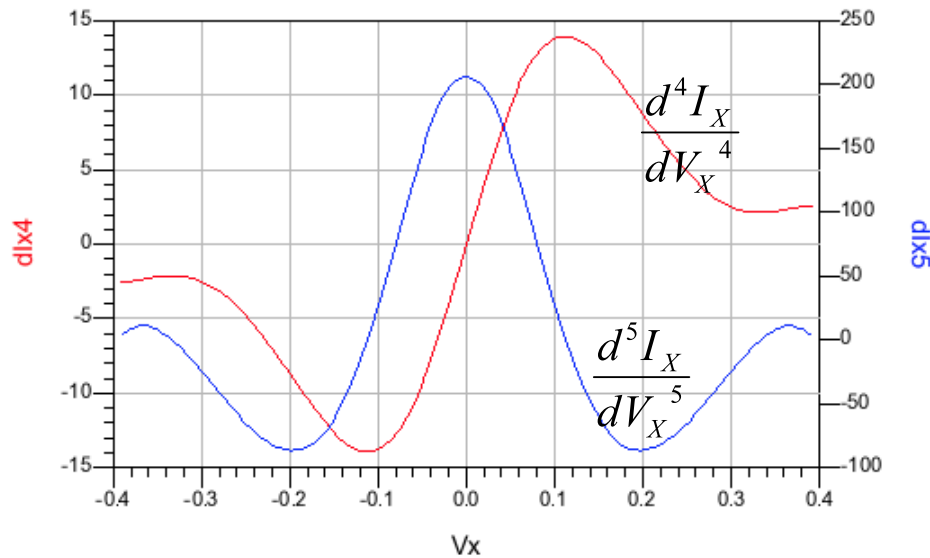
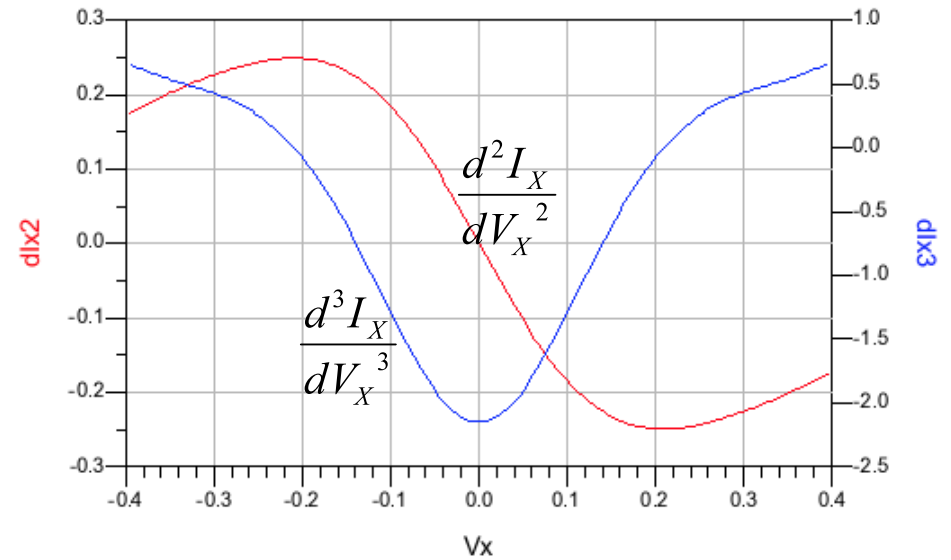
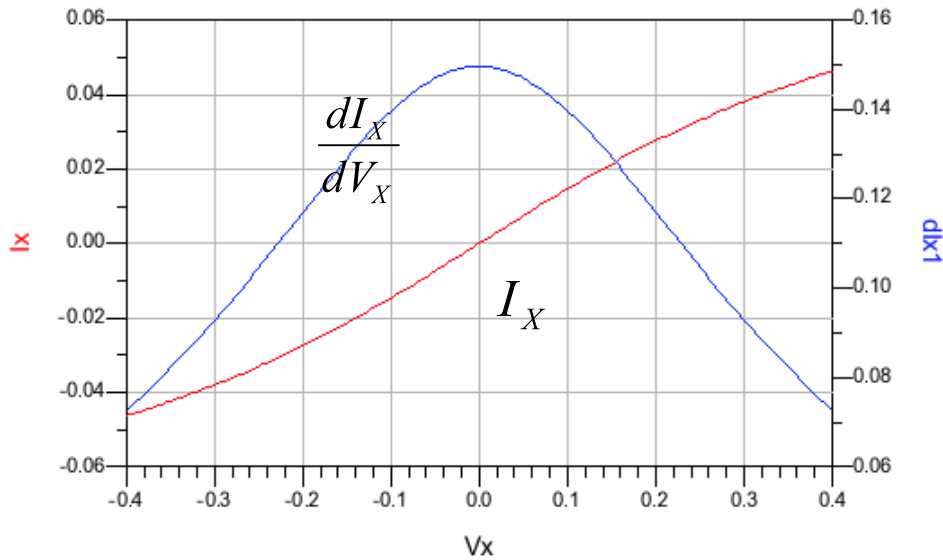
BSIM6: Charge based MOSFET model

- AC Symmetry
 - Capacitances/derivatives are symmetric @ $V_{DS}=0$
- Continuous
 - From accumulation to strong inversion
 - From linear to saturation
- Physical Capacitance model
 - Short channel CV-Velocity saturation & other effects
- No glitches – smooth current and capacitance behavior



I_{DS} vs V_X

I_{DS} - V_X Gummel Symmetry ($V_D=V_X$ & $V_S=-V_X$)



Conclusion

- BSIM6 is a charge based physical compact model
 - Physical effects are same as BSIM4
 - Smooth behavior for charges/currents and their derivatives for several orders
- Model is symmetric and continuous around $V_{DS}=0$
 - Fulfills Gummel symmetry and AC symmetry
 - Shows accurate slope for harmonic balance simulation
- Under standardization review in Compact Model Council



Acknowledgement

- Cadence
- Synopsys
- Accelicon
- ADI
- TI
- IBM
- ST
- All CMC Members

