BSIM6: Symmetric Bulk RF MOSFET Model

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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 → 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

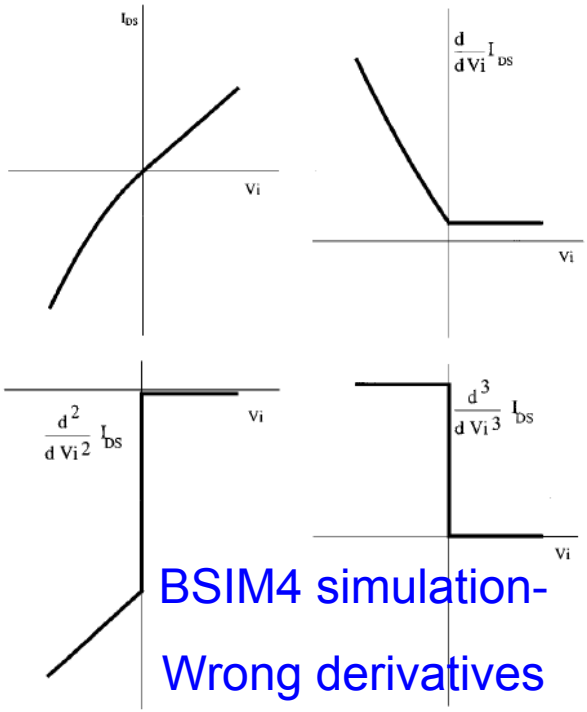
Why new Bulk MOS Model: BSIM6

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

Taylor Series Expansion

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

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



BSIM4 simulation-

Wrong derivatives around V_{DS}=0

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)

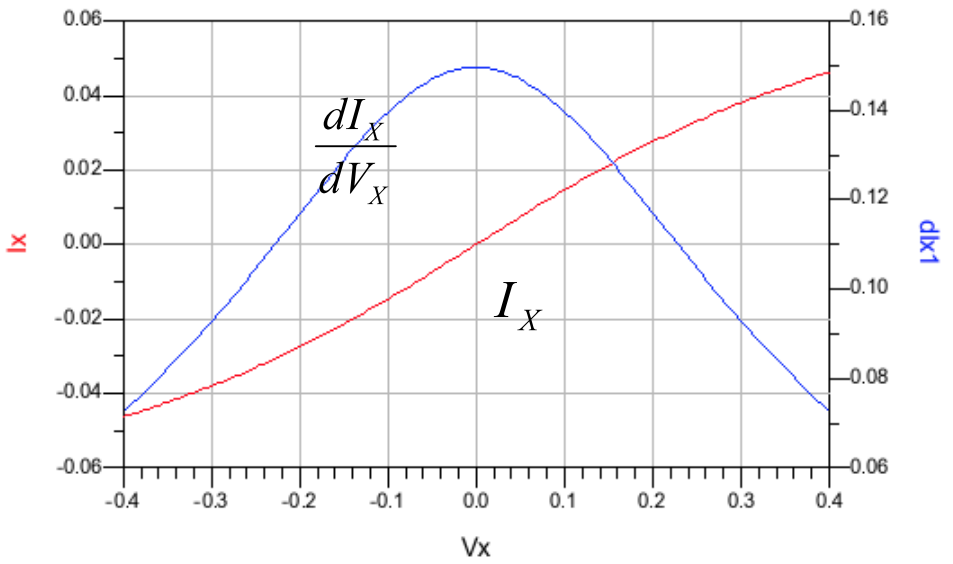
BSIM6: Charge based MOSFET model

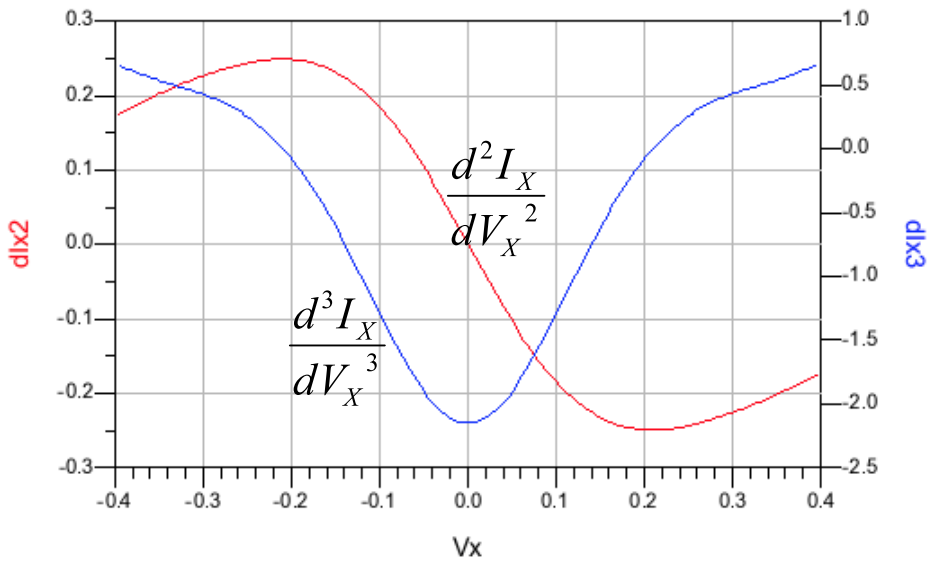
- AC Symmetry
  - Capacitances/derivatives are symmetric @V_{DS}=0
- Continuous
  - From accumulation to strong inversion
  - From linear to saturation
- Physical Capacitance model
  - Short channel CV–Velocity saturation & other effects
- No glitches – smooth current and capacitance behavior

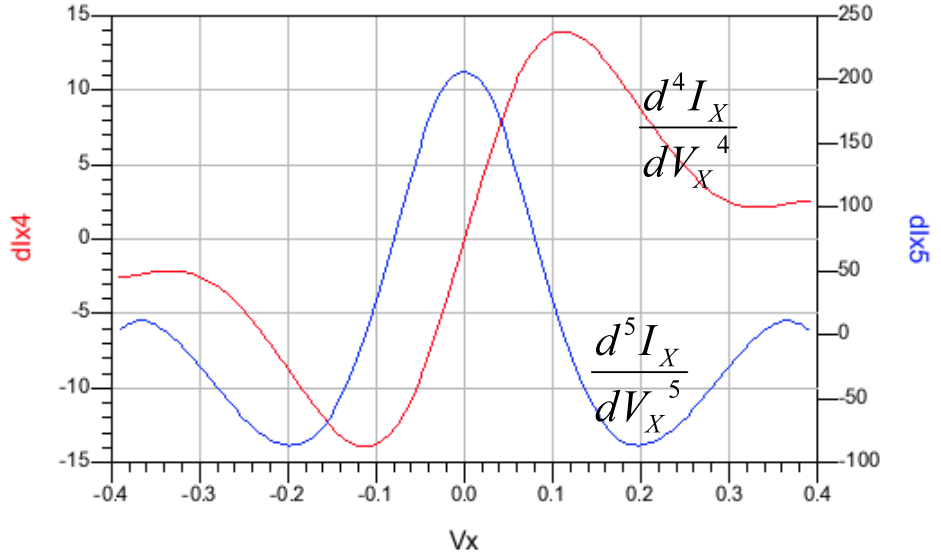
I_{DS}-V_X Gummel Symmetry

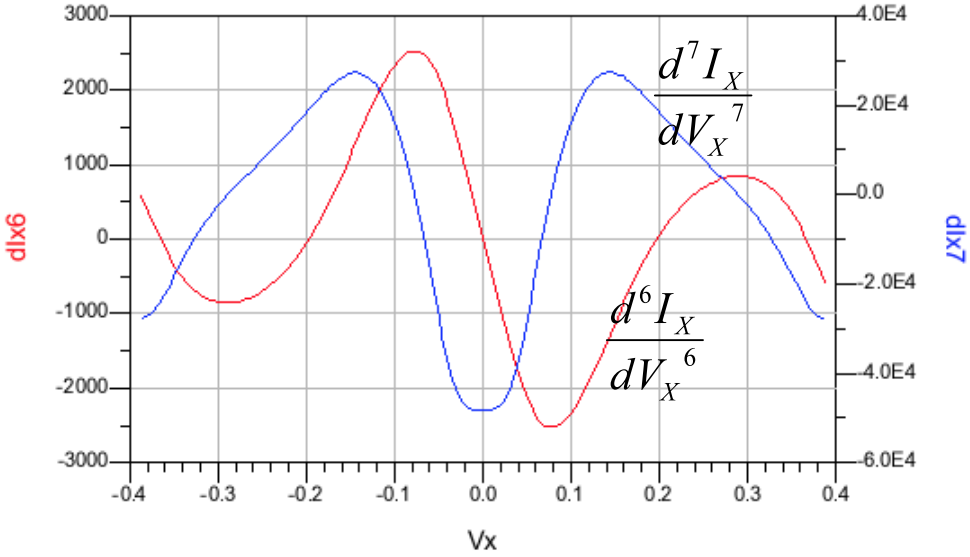
I_{DS} vs V_X

(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

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