A charge based compact flicker noise model including short channel effects

A. S. Roy[1] C. C. Enz[1,2]

[1]Ecole Polytechnique Fédérale de Lausanne (EPFL)
Laboratoire d'Electronique Générale (LEG), CH-1015 Lausanne, Switzerland

[2]Swiss Center for Electronics and Microtechnology (CSEM)
CH-2007 Neuchâtel, Switzerland.

WCM, 2007

Introduction

- How to model flicker noise in MOSFET
- BISM3 based models [K. Hung et al., T-ED March 1990]
- Flat band perturbation technique $S_{\Delta I_D^2} = g_m^2 V_{FB}$ [G. Ghibaudo, SSE July 1989]
- Both methods were believed and even 'proved' to be valid in all bias condition
- But even in a long channel MOSFET two methods gives different result !
- Flat band perturbation technique holds only at $V_{DS} = 0$ and a clear link exists between the two methods [A. S. Roy et al., ESSDERC 06, T-ED Oct 2006]

Limitation of BSIM3 based noise models

- BSIM3 based flicker noise PSD expression is derived using constant mobility
- PSD expressions for field dependent mobility
- $I = g(V,E)dV/dx \Longrightarrow S_{\Delta I_D^2} = \frac{1}{(\int_0^L F(x)dx)^2} \int_0^L F(x)^2 S_{\delta i_n^2} dx$
  $F(x) = g/(g + \frac{\partial g}{\partial E} E)$ [A. S. Roy, et al., T-ED Feb 2006]
- Field dependent mobility changes noise PSD expression by 2 independent mechanism
- First, by changing the impedance field
- Second, by changing the charge or surface potential profile

Charge based PSD expresion

$$S_{I_D^2}(q_s, q_d, \lambda_c) = \frac{2\mu^2 W^2 S_{Q_t^2} U_T^2}{L^3} \cdot$$

$$\frac{(q_s^2 + q_s) - (q_d^2 + q_d)}{(1 + \lambda_c(q_s - q_d))^3} \log \left(\frac{q_s + \frac{1}{2} - \frac{\lambda_c\left((q_s^2+q_s)-(q_d^2+q_d)\right)}{2(1+\lambda_c(q_s-q_d))}}{q_d + \frac{1}{2} - \frac{\lambda_c\left((q_s^2+q_s)-(q_d^2+q_d)\right)}{2(1+\lambda_c(q_s-q_d))}} \right)$$

- $\lambda_c = 2U_T/E_C L$ indicates the extent of mobility degradation
- $S_{Q_t^2} = \frac{q^2 \cdot N_T(E_f) \cdot k \cdot T}{f \cdot W \cdot \gamma}$ is the bias independent part
- q_s and q_d are normalized terminal charge
- L is the length of velocity non saturated region

Conclusion

- Flat band perturbation method gives incorrect bias dependence
- Present compact flicker noise expression are based on constant mobility approximation
- Field dependent mobility can change the noise PSD by factor of 2-3
- This effect needs to included in future compact models