

On the compact modelling of induced gate noise in the MOS Transistor

A. S. Roy¹ C. C. Enz^{1,2}

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

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

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- Induced gate noise has a considerable impact on RF noise parameters B_{opt} , G_{opt} and F_{min}
- $G_{opt} = \omega C_{gs} \sqrt{\frac{\beta_{sat}}{\gamma_{sat}} (1 - c_g^2)}$
- $B_{opt} = -\omega C_{gs} \left(1 - c_g \frac{\beta_{sat}}{\gamma_{sat}}\right)$
- $F_{min} = 1 + 2\gamma_{sat} \frac{\omega}{\omega_t} \sqrt{\frac{\beta_{sat}}{\gamma_{sat}} (1 - c_g^2)}$
- $S_{id^2} = 4kT \gamma_{sat} g_m$ $S_{ig^2} = 4kT \beta_{sat} \frac{(\omega C_{gs})^2}{g_m}$
- Long channel device in saturation
 $\gamma_{sat} = \frac{2n}{3}$ $\beta_{sat} = \frac{4}{15n}$ $c_g = 0.4$
- Inductive degenerated LNA : Presence of induced gate noise gives an optimum input Q for noise figure

Modelling of Induced gate noise: Transfer function

- Very general expression of current:

$$I(x) = g\left(V, \frac{dV}{dx}\right) \cdot \frac{dV}{dx}$$

- PSD and cross PSD can be expressed as

$$S_{i_d^2} = \frac{1}{I \cdot L_c^2} \int_{V_S}^{V_D} \frac{g_c(V)^2}{g(V)} \cdot S_{\delta i_n^2} dV.$$

$$S_{i_g^2} = \frac{-\omega^2 W^2}{I^5 L_c^2} \int_{V_S}^{V_D} \left(\int_{V_S}^{V_D} g_c(V') (Q_g(V') - Q_g(V)) dV' \right)^2 \frac{g_c(V)^2}{g(V)} S_{\delta i_n^2} dV$$

$$S_{i_d i_g} = \frac{j\omega W}{I^3 L_c^2} \int_{V_S}^{V_D} \left(\int_{V_S}^{V_D} g_c(V') (Q_g(V') - Q_g(V)) dV' \right) \frac{g_c(V)^2}{g(V)} \cdot S_{\delta i_n^2} dV.$$

- Does not need *closed form* inversion of $\frac{dV}{dx}$ in terms of V and I
- Valid from any kind of noise mechanism

Modelling of Induced gate noise: Noise source

- Nonequilibrium situation: $D = \frac{kT_n}{q} \mu$
- In general, $T_n \neq T_L$ or T_C
- When the distribution is displaced Maxwellian $T_n = T_C$ and in MOS channel high inversion charge density makes the distribution Maxwellian
- Extract the T_C from low field mobility relation $\mu = \mu_0 \sqrt{\frac{T_L}{T_C}}$
- $T_n = \left(\frac{\mu_0}{\mu}\right)^2 T_L$

Conclusion

- Carrier heating and mobility reduction increases γ and β
- Carrier heating and mobility reduction decreases c_g
- All of the effects individually degrades F_{min}
- S_{id^2} is relatively insensitive to the mobility model used because carrier heating and mobility degradation have *opposite* effect.
- Gate noise related parameters are very sensitive to the mobility model because carrier heating and mobility degradation have *same* effect