Extraction of MOSFET Effective Channel Length and Width Based on the Transconductance-to-Current Ratio

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ACM model

Simple expressions valid in all operating regions

\[ I_D = I_S (i_f - i_r) \]

\[ I_S = \mu C_{ox} n \frac{\phi_f^2}{2} \frac{W}{L} \]

\[ V_P - V_{S(D)} = \phi_t \left[ \sqrt{1 + i_{f(r)}} - 2 + \ln \left( \sqrt{1 + i_{f(r)}} - 1 \right) \right] \]

\[ V_P = \frac{V_G - V_{T0}}{n} \]

\[ \frac{g_m}{I_D} = \left( \frac{g_m}{I_D} \right)_{\text{max}} \left( \sqrt{1 + i_f} + \sqrt{1 + i_r} \right) \]
Extraction of VT

\[ V_{DS} = \frac{\phi_f}{2} \]
Extraction of VT

Using $V_D = \phi_t/2$, we find $i_r = 2.112$ for $i_f = 3$ and

$$\frac{g_m}{I_D} = 0.5310 \left( \frac{g_m}{I_D} \right)_{\text{max}}$$
Extraction of specific current

For $V_D = \phi_f/2$, $i_f = 3$ and $i_r = 2.112$ becomes:

$$\frac{g_m}{I_D} = 0.5310 \left( \frac{g_m}{I_D} \right)_{\text{max}}$$

At this point $I_D = I_D^*$ and $I_S = 1.135 I_D^*$
Extraction of the $\Delta L$ and $\Delta W$

\[ \frac{W}{I_S} \propto L \]

\[ L I_S \propto L \]

$\Delta L = 0.032 \text{ um}$

$\Delta W = 0.20 \text{ um}$
Conclusions

• Very simple methodology for determining the MOSFET threshold voltage

• Negligible influence of parasitic resistance, transversal field degradation and short-channel effects.

• Effective channel length and width determined from the specific current.