

MOS I-V characteristics

(2)

(2) Saturation region

$$V_{DS} \geq V_{GS} - V_{th} = V_{DS, sat} = \Delta$$

channel
length
modulation

$$\Rightarrow I_{DS} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2$$

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\Rightarrow Effective dynamic channel resistance

$$r_o = \left(\frac{\partial V_{DS}}{\partial I_{DS}} \right) = \frac{1}{\lambda \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2} \approx \frac{1}{\lambda I_D}$$

\Rightarrow Transconductance, g_m

$$\begin{aligned} g_m &= \frac{\partial I_{DS}}{\partial V_{GS}} = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th}) \\ &= \sqrt{2 \mu_n C_{ox} \frac{W}{L} I_{DS}} \\ &= \frac{2 I_{DS}}{V_{GS} - V_{th}} \end{aligned}$$

\Rightarrow For long channel CMOS, $g_m = g_{do}$.

\Rightarrow g_{do} plays important role in noise analysis.