MOS I-V characteristics

- g_m for short channel I-V characteristics

$$\Rightarrow g_m = \left(\frac{\partial V_{DS}}{\partial I_{DS}}\right)$$

$$= \mu_n C_{ox} \frac{W}{L} (V_{GS}-V_{th}) \frac{(V_{GS}-V_{th})E_c \cdot L}{(V_{GS}-V_{th})+E_c \cdot L} \; \frac{\frac{1}{2} + \frac{E_c \cdot L}{V_{GS}-V_{th}}}{(V_{GS}-V_{th})+E_c \cdot L}$$

$$= \underbrace{\mu_n C_{ox} \frac{W}{L} (V_{GS}-V_{th})}_{g_{do}} \times \underbrace{\boxed{\frac{V_{DS,sat}}{V_{GS}-V_{th}}}}_{<1} \times \underbrace{\boxed{\frac{\frac{1}{2}(V_{GS}-V_{th}) + E_c \cdot L}{(V_{GS}-V_{th}) + E_c \cdot L}}}_{<1}$$

~~in short channel.~~

- Now Let's define the ratio of g_m/g_{do} in short channel CMOS,

$$\boxed{\alpha = \frac{g_m}{g_{do}} = \frac{V_{DS,sat}}{V_{GS}-V_{th}} \; \frac{\frac{1}{2}(V_{GS}-V_{th}) + E_c \cdot L}{(V_{GS}-V_{th}) + E_c \cdot L}} < 1$$

(ex) 0.18 μm NMOS → $E_c \cdot L \simeq 1.2V$
typical overdriving → $V_{GS}-V_{th} \simeq 0.2V$
⇒ $V_{DS,sat} \simeq 171.4\,mV$
⇒ $\alpha \simeq 0.8$ (cf) for long channel, $\alpha = 1$)

Note) the constant α frequently appeared in noise expression in CMOS.