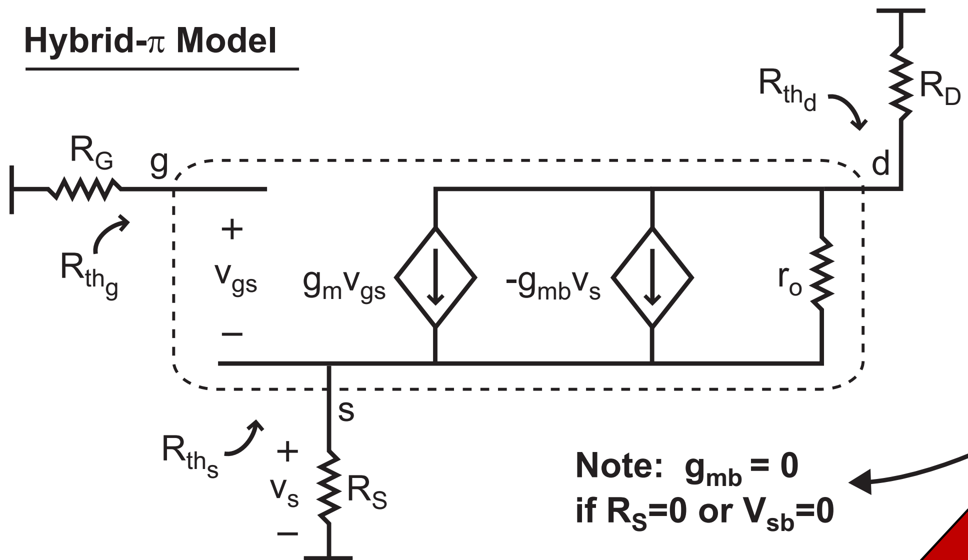
Summary Sheet for CMOS Thevenin Modeling

Hybrid-π Model

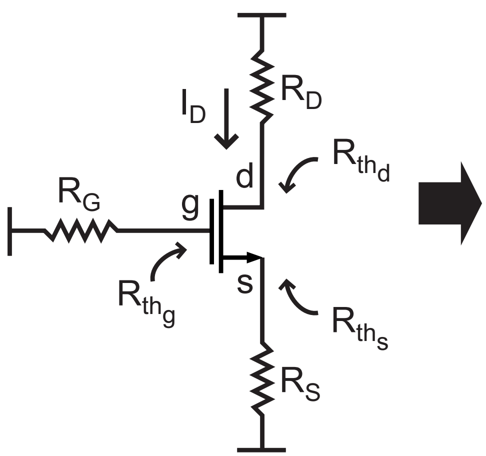


Note: $g_{mb} = 0$ if R_S=0 or V_{sb}=0

Key Small-Signal Parameters

Parameter	Strong Inversion	Weak Inversion
g_m	$\sqrt{2\mu_n C_{ox}(W/L)I_D}$	$\frac{qI_D}{nkT}$
g_{mb}	$\frac{\gamma g_m}{2\sqrt{2\lvert\Phi_F\rvert + V_{SB}}}$	$\frac{(n-1)qI_D}{nkT}$
r_o	$\frac{1}{\lambda I_D}$	$\frac{1}{\lambda I_D}$

Thevenin Resistances



Exact

$$R_{th_d} = r_o\,(1+(g_m+g_{mb})R_S)+R_S$$

$$R_{th_g} = \text{infinite}$$

$$R_{th_s} = (1+R_D/r_o)\left(r_o \,\Big\|\, \frac{1}{g_m+g_{mb}}\right)$$

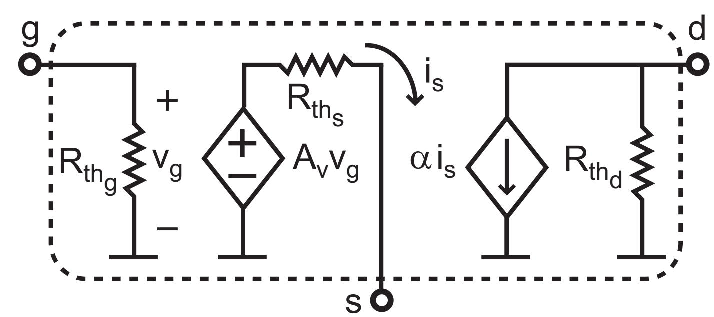
Approximation
($g_{mb} << g_m$, $g_m r_o >> 1$)

$$R_{th_d} = r_o\,(1+g_m R_S)$$

$$R_{th_g} = \text{infinite}$$

$$R_{th_s} = \frac{1+R_D/r_o}{g_m} \approx \frac{1}{g_m} \quad \textbf{(}R_D << r_o\textbf{)}$$

Proposed Small Signal Transistor Model



Exact

$$A_v = g_m r_o \,\Big\|\, \frac{g_m}{g_m+g_{mb}}$$

$$\alpha = 1+R_D/R_{th_d}$$

Approximation

$$A_v = 1 \quad \textbf{(}g_{mb}<<g_m,\ g_m r_o>>1\textbf{)}$$

$$\alpha = 1 \quad \textbf{(}R_D<<R_{th_d}\textbf{)}$$