The Common Source Amplifier with Body Effect

Assume a Thévenin equivalent is made of the signal source connected to the gate. The ac signal circuit is

\[ V_{tg} \]
\[ R_{tg} \]
\[ R_{td} \]
\[ R_{in} \]
\[ R_{ts} \]
\[ V_{o} \]
\[ I_{ds}(sc) \]
\[ R_{id} \]

Because no gate current flows, it follows that \( R_{in} = \infty \).

To solve for \( V_{o} \) and \( R_{out} \), use the Norton drain circuit.
\[ v_o = -I_{d(sc)} R_{id} \parallel R_{td} \]

\[ = -G_{mg} v_{tg} R_{id} \parallel R_{td} \]

Thus the voltage gain is

\[ \frac{v_o}{v_{tg}} = -G_{mg} R_{id} \parallel R_{td} \]

where

\[ G_{mg} = \frac{1}{1 + \chi} \frac{1}{R'_{A} + R_{ts} \parallel R_o} \frac{R_o}{R_o + R_{+A}} \]

\[ R'_{A} = \frac{R_A}{1 + \chi} = \frac{1}{g_m (1 + \chi)} \]

\[ R_{id} = R_o \left( 1 + \frac{R_{ts}}{R'_{A}} \right) + R_{td} \]

The output resistance is

\[ R_{out} = R_{id} \parallel R_{td} \]

If the body connects to the source lead, not to ac ground, set \( \chi = 0 \) in the equations.
The Common Gate Amplifier with Body Effect

Assume a Thévenin equivalent is made of the signal source connected to the source. The ac signal circuit is:

\[ R_{td} \quad \text{and} \quad R_{out} \]

\[ R_{tg} \quad \text{and} \quad R_{in} \]

\[ R_{td} \quad \text{and} \quad R_{in} \]

The input resistance is given by:

\[ R_{in} = R_{td} = R_{in} \frac{R_{0} + R_{td}}{R_{in} + R_{td}} \]

where \( R_{in}' = \frac{R_{in}}{1+\kappa} = \frac{1}{g_{m}(1+\kappa)} \)
To solve for $V_o$ and $R_{out}$, use the Norton drain circuit.

\[ V_o = -i_{d(s)} \frac{R_{id}}{R_{td}} \]

\[ = -(-G_{mr} V_{t+n}) \frac{R_{id}}{R_{td}} \]

Thus the voltage gain is given by

\[ \frac{V_o}{V_{t+n}} = +G_{mr} \frac{R_{id}}{R_{td}} \]

where

\[ G_{mr} = \frac{1}{R_{td} + R_{id} || R_{n0}} \]

\[ R_{id} = R_{n0} \left( 1 + \frac{R_{td}}{R_{n0}} \right) + R_{t+n} \]

The output resistance is
\[ R_{\text{out}} = R_{d}' || R_{td} \]

If the body lead connects to the source lead, not to ac ground, set \( K = 0 \) in the equations.

**The Common Drain Amplifier with Body Effect**

Assume a Thévenin equivalent circuit is made of the signal source connected to the gate.

Because no gate current flows, it follows that \( R_{\text{in}} = \infty \).
To solve for $V_o$ and $R_{out}$, we use the Thévenin source circuit,

\[
\begin{align*}
V_{A(oc)} & \quad \text{R}_{in} \quad V_o \\
\text{R}_{in} & \quad \text{R}_{out}
\end{align*}
\]

where $V_{A(oc)}$ and $R_{in}$ are given by

\[
V_{A(oc)} = \frac{V_{tg}}{1 + \chi} \frac{R_0}{R'_A + R_0}
\]

\[
R_{in} = R'_A \frac{R_0 + R_{td}}{R'_A + R_0}
\]

\[
R'_A = \frac{R'_A}{1 + \chi} = \frac{1}{g_m(1 + \chi)}
\]

The output voltage is given by

\[
V_o = V_{A(oc)} \frac{R_{in}}{R_{in} + R_{out}}
\]

\[
= \frac{V_{tg}}{1 + \chi} \frac{R_0}{R'_A + R_0} \frac{R_{in}}{R_{in} + R_{out}}
\]

Thus the voltage gain is given by
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\[ A_v = \frac{v_o}{v_{tg}} = \frac{1}{1 + \frac{\rho_0}{\rho'_{a} + \rho_0} \frac{R_{ts}}{\rho_{a} + R_{ts}}} \]

The output resistance is given by

\[ R_{out} = R_{in} \parallel R_{ts} \]