Common-Drain Amplifier

\[ I_{DS} = \mu C_{ox} \frac{W}{L} \left( \frac{1}{2} (V_{GS} - V_T)^2 \right) \]

\[ V_{GS} = V_T + \frac{2I_{DS}}{\mu C_{ox} \frac{W}{L}} \]

Weak \( I_{DS} \) dependence
Two-Port CD Model with Capacitors

Ignore $g_{mb}$

Find Miller capacitor for $C_{gs}$ -- note that the gate-source capacitor is between the input and output

Voltage Gain $A_{vCgs}$ Across $C_{gs}$

$$A_{vCgs} = \frac{R_{out}}{R_L + R_{out}} \approx 1$$

This gain is independent of $C_{gs}$

$$C_{in} = C_{gd} + C_M = C_{gd} + (1 - A_{vCgs})C_{gs}$$

$$C_{in} = C_{gd} + \frac{1}{1 + g_m R_L} C_{gs}$$

$$C_{in} \approx C_{gd}$$
Bandwidth of CD Amplifier

Input low-pass filter’s –3 dB frequency:

\[ \omega_p^{-1} = R_S \left( C_{gd} + \frac{C_{gs}}{1 + g_m R_L} \right) \]

Substitute favorable values of \( R_S, R_L \):

\[ R_S \approx 1/g_m \quad R_L >> 1/g_m \]

\[ \omega_p^{-1} \approx \left( 1/g_m \right) \left( C_{gd} + \frac{C_{gd}}{1 + B/G} \right) \approx C_{gd}/g_m \]

\[ \omega_p \approx g_m/C_{gd} > \omega_T \]

Model not valid at these high frequencies

Bandwidth of the Common-Gate Amplifier
Two-Port CG Model with Capacitors

No Miller-transformed capacitor!
Unity-gain frequency is on the order of $\omega_T$ for small $R_L$

Summary of Single-Stage Amplifiers

- **CS**: suffers from Miller-magnified capacitor for high-gain case
- **CD**: Miller transformation $\rightarrow$ nulled capacitor $\rightarrow$ “wideband stage”
- **CG**: no Miller capacitor $\rightarrow$ wideband stage (for low load resistance)