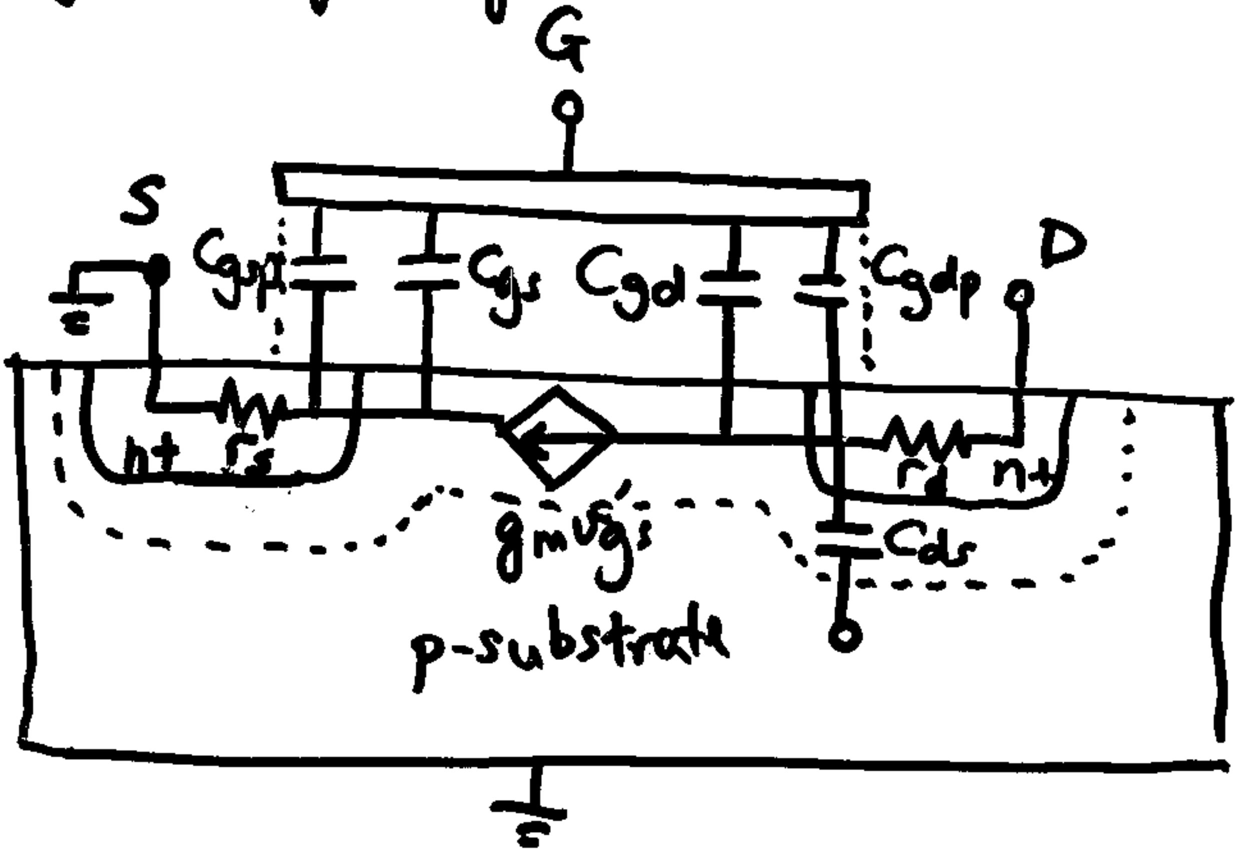
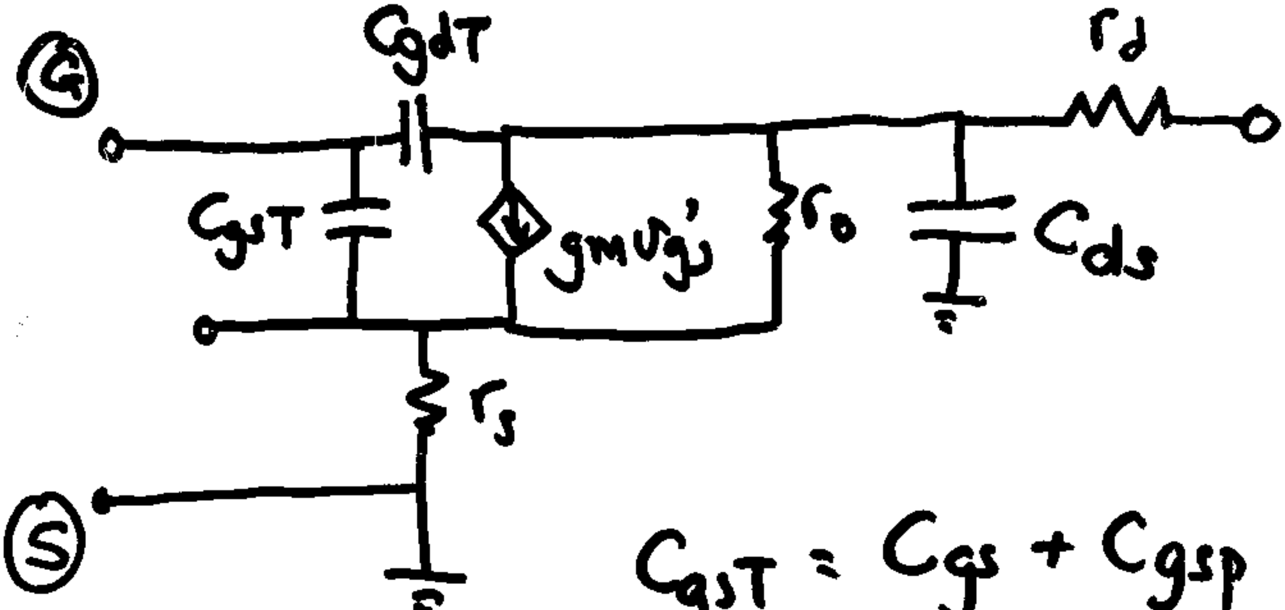
High Frequency MOSFET Transistor Model





$$C_{gsT} = C_{gs} + C_{gsp}$$

$$C_{gdT} = C_{gd} + C_{gdp}$$

$$\approx C_{gdp}$$

will drop subscript T later on

Capacitances :

① Gate & inversion layer

$C_{gs} \cong C_{gd} \cong \left(\frac{1}{2}\right) WL\,C_{ox}$ Non-sat

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$C_{gs} \cong \frac{2}{3} WL\,C_{ox}$ SAT

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$C_{gd} = 0$ (inversion layer disappears)

$C_{gb} = WL\,C_{ox}$ cut-off

[TOX in spice]

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② Overlap capacitance

$C_{gsp} = C_{gdp} = C_{ox}\,\underbrace{LD}\,W$

[overlap in spice]

[CGSO & CGDO in spice]

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③ Junction capacitance

Drain is R.B wrt substrate

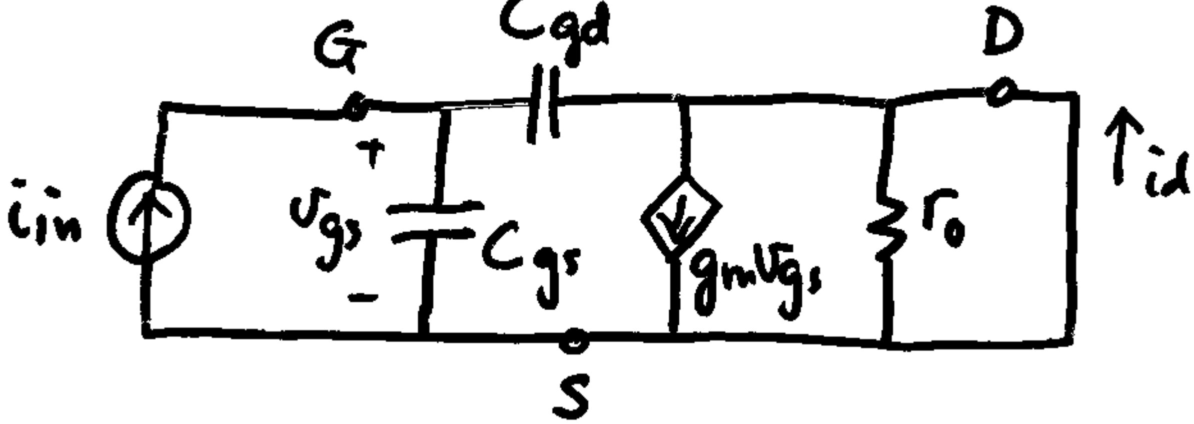
[CBD in spice]

Resistances

1. r_d : Drain resistance
   silicon resistance
   ~10Ω (RD in spice)

2. r_s : Similar to r_d (RS in spice)

Unity-gain bandwidth (Cut-off freq.)



(Analogous to BJT with $\beta \to \infty$, $r_\pi \to \infty$

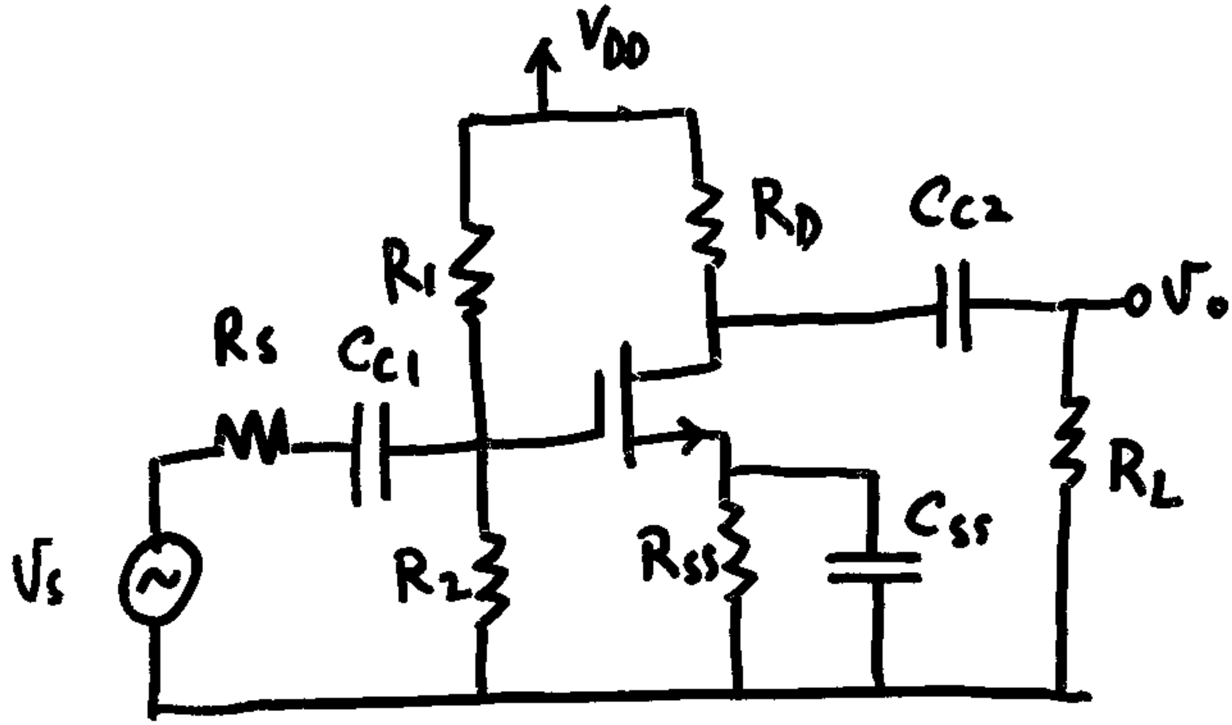
$$\omega_{T,BJT} = \frac{g_m}{C_\pi + C_\mu} \qquad \frac{\beta}{r_\pi} \to g_m \ )$$

$$i_{in} \cdot \frac{1}{j\omega(C_{gs}+C_{gd})} = v_{gs}$$

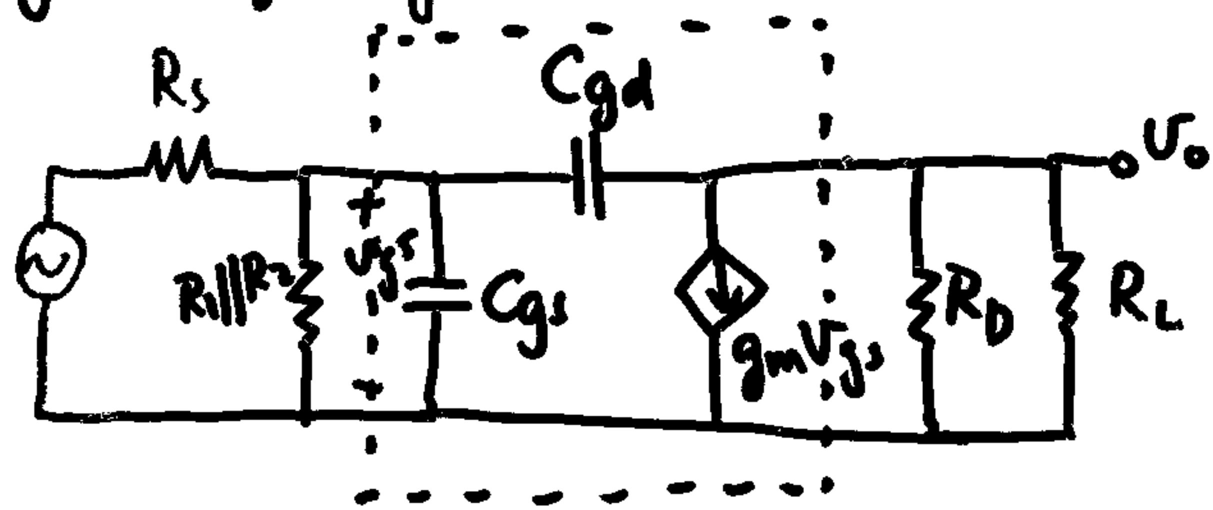
$$i_d = g_m \frac{i_{in}}{j\omega(C_{gs}+C_{gd})}$$

Current gain $\dfrac{i_d}{i_{in}} = \dfrac{g_m}{j\omega(C_{gs}+C_{gd})}$

Unity-gain bandwidth, $\omega_T = \dfrac{g_m}{C_{gs}+C_{gd}}$



High frequency model

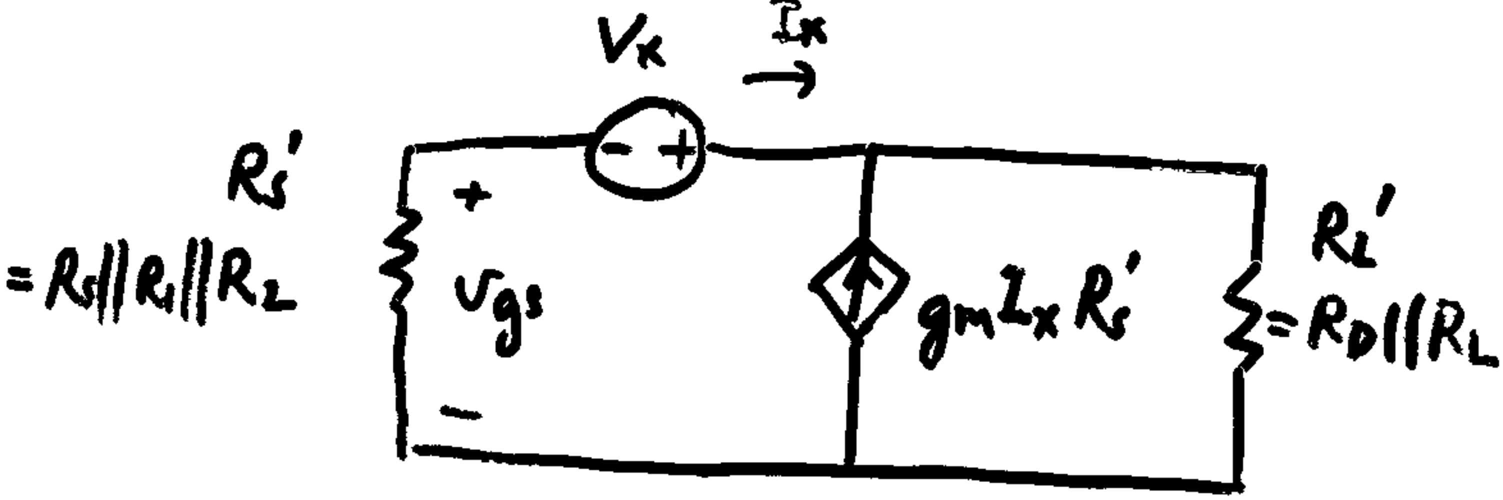


Similar to BJT with $r_\pi = \infty$

$C_\pi = C_{gs}$

$C_\mu = C_{gd}$

R_{gd} : Thevenin Equiv. Resistance seen by C_{gd}



$$V_x = [I_x + g_m I_x R_s'] R_L' + I_x R_s'$$

$$R_{gd} = \frac{V_x}{I_x} = (1 + g_m R_s'] R_L' + R_s'$$

$$= R_s'(1 + g_m R_L') + R_L'$$

$$\tau_{gd} = R_{gd} C_{gd} = R_s' \underbrace{(1 + g_m R_L') C_{gd}}_{(1 - A_{v_i}) C_{gd} = C_M} + R_L' C_{gd}$$

$$R_{gs} = R_s || R_1 || R_2$$

$$\tau_{gs} = (R_s || R_1 || R_2) C_{gs}$$

$$\omega_H \cong \frac{1}{\tau_{gs} + \tau_{gd}}$$