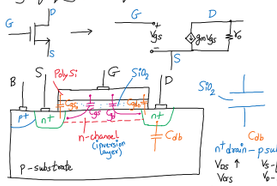
AEC 11.1 3/2/2022

✳ High frequency model of MOSFET:



C_{gs} & C_{gd} : Inter-electrode/Parasitic capacitance (~pf)

C_{gs_o} & C_{gd_o} : Overlap capacitance (~pf)

C_{db} : Drain to substrate junction capacitance (~pf)

C_{db} : n^+ drain – p substrate

V_{DB} ↑ V_{DB} ↓

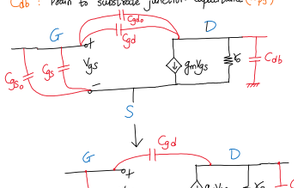
V_G - fixed
V_G - +ve voltage
V_G - ground

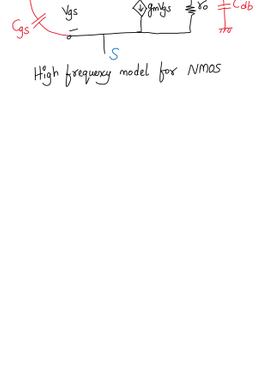
$C = \frac{dq}{dv}$

$X_C = \frac{1}{2\pi f C}$

100MHz pf

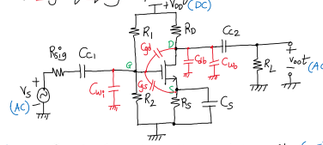
f↑ → X_C ↓





High frequency model for NMOS

✳ High-frequency response of MOSFET amplifier:



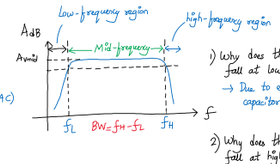
C_{C_1}, C_{C_2}, C_S : Externally connected capacitors (μF)

$C_{gs}, C_{gd}, C_{db}, C_{wi}, C_{wo}$: Inter-electrode capacitance / Parasitic capacitance / Stray capacitance (~pf)

f → v.v high

$X_C = \frac{1}{2\pi f C}$

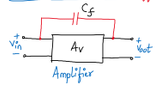
pf → MHz

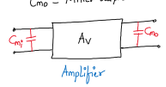


1) Why does the gain of amplifier fall at low frequency?
→ Due to externally connected capacitor (C_{C_1}, C_{C_2}, C_S) ($f_{1C_1}, f_{1C_2}, f_{1C_S}$)

2) Why does the gain of amplifier fall at high frequency?
→ Due to parasitic or stray capacitors ($C_{gs}, C_{gd}, C_{db}, C_{wi}, C_{wo}$) ($f_{1H_1}, f_{1H_2}$)

✳ Millex theorem (Miller effect):





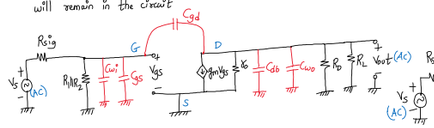
$C_{mi} = (1 - A_v) C_f$

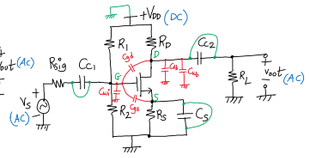
$C_{mo} = \left(1 - \frac{1}{A_v}\right) C_f$

C_{mi} – Miller input capacitance
C_{mo} – Miller output capacitance

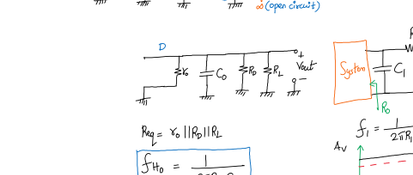
I] High-frequency equivalent circuit:

For high frequency, connected capacitors (C_{C_1}, C_{C_2}, C_S) are behaving as short-circuit, but all stray (parasitic) capacitors will remain in the circuit





II] Millerize Cgd into C_{mi} and C_{mo}

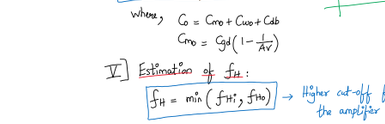


$C_{mi} = C_{gd}(1 - A_v)$

$C_i = C_{mi} + C_{wi} + C_{gs}$ — Input side parasitic capacitance

$C_{mo} = C_{gd}\left(1 - \frac{1}{A_v}\right)$

$C_o = C_{db} + C_{wo} + C_{mo}$ — Output side parasitic capacitance



III] Input side circuit (f_{Hi})

– Short circuit C_o & V_s and consider C_i

$R_i = R_1 || R_2$

$R_{eq} = R_{sig} || R_1 || R_2$

$f_{H_i} = \frac{1}{2\pi R_{eq} C_i}$

$f_1 = \frac{1}{2\pi R_i C_1}$

where, $C_i = C_{mi} + C_{wi} + C_{gs}$

$C_{mi} = C_{gd}(1 - A_v)$

IV] Output side circuit (f_{Ho})

– Short circuit C_i & V_s and consider C_o

$R_{eq} = r_o || R_D || R_L$

$f_{H_o} = \frac{1}{2\pi R_{eq} C_o}$

$f_1 = \frac{1}{2\pi R_1 C_1}$

where, $C_o = C_{mo} + C_{wo} + C_{db}$

$C_{mo} = C_{gd}\left(1 - \frac{1}{A_v}\right)$

V] Estimation of f_H:

$f_H = \min(f_{Hi}, f_{Ho})$ → Higher cut-off frequency of the amplifier

—x—