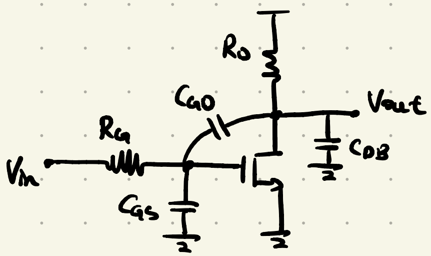
Lec 22

- Dominant-Pole Approximation
- Insights into CE/CS freq. Response
- Examples
- freq. Response of Common-Base / Common-gate Stage

Review of Lec 21



from Miller's Theorem:

$$\omega_{p,in} = \frac{1}{[(1+g_m R_D)C_{GD} + C_{GS}]R_G}$$

$$\frac{V_{out}}{V_{in}} = \frac{(C_{GD}s - g_m)R_D}{(C_{GS}C_{GD} + C_{GD}C_{DB} + C_{GS}C_{DB})R_G R_D s^2 + [((1+g_m R_D)C_{GD} + C_{GS})R_G + (C_{GD}+C_{DB})R_D]s + 1}$$

- Dominant-Pole Approximation

$$D(s) = \left(\frac{s}{\omega_{p1}}+1\right)\left(\frac{s}{\omega_{p2}}+1\right) = \frac{s^2}{\omega_{p1}\omega_{p2}} + \left(\frac{1}{\omega_{p1}} + \frac{1}{\omega_{p2}}\right)s + 1$$

$$\omega_{p1} \ll \omega_{p2} \Rightarrow \frac{1}{\omega_{p1}} \gg \frac{1}{\omega_{p2}}$$

coefficient of $s \approx \frac{1}{\omega_{p1}}$

$$\Rightarrow \omega_{p1} = \frac{1}{[(1+g_m R_D)C_{GD} + C_{GS}]R_G + (C_{GD}+C_{DB})R_D}$$

$$\omega_{p1}\omega_{p2} = \frac{1}{(C_{GD}C_{GS} + C_{GD}C_{DB} + C_{GS}C_{DB})R_G R_D}$$

then we can find ω_{p2}

A Few Points:

1. If $s=0 \Rightarrow \frac{V_{out}}{V_{in}} = -g_m R_D$
2. If $s \to \infty \Rightarrow \frac{V_{out}}{V_{in}} \to 0$
3. We have 3 caps, but a second-order response. Why?

If we have N caps (no series or parallel combinations), $\Rightarrow$ N-th order diff. equation

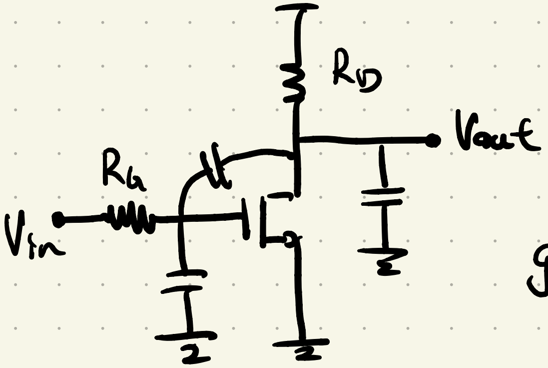
$$\alpha_1 \frac{d^n V_{out}}{dt^n} + \alpha_2 \frac{d^{n-1} V_{out}}{dt^{n-1}} + \cdots + \alpha_{N+1} V_{out} = 0$$

Needs N indep. initial conditions.

(Because we can only find 2 initial conditions)

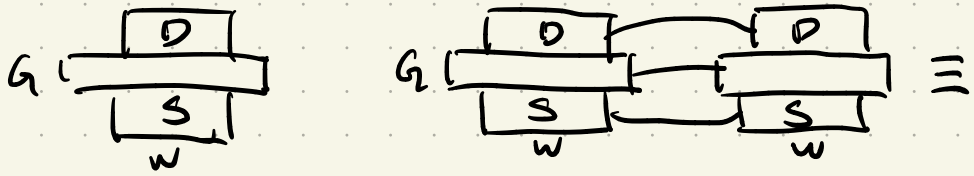
Example

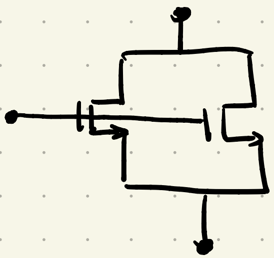
What happens if $W \to 2W$?
(but I_d is constant)

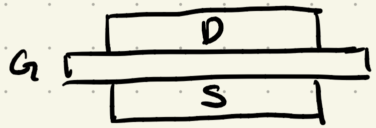


$\Rightarrow$ All transistor caps are doubled

$$g_m = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} \to \sqrt{2}\,g_m$$



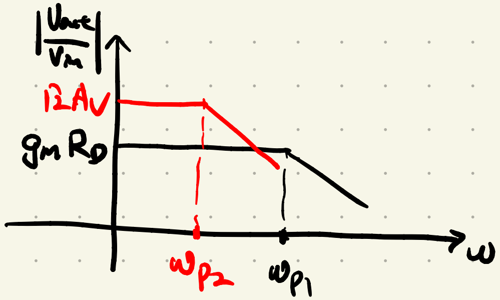




$$\omega_{p1} = \frac{1}{\left[(1+\underset{\sqrt{2}}{g_m} R_D)\underset{2}{C_{GD}} + \underset{2}{C_{GS}}\right]R_D + (\underset{2}{C_{GD}}+\underset{2}{C_{DB}})R_D}$$

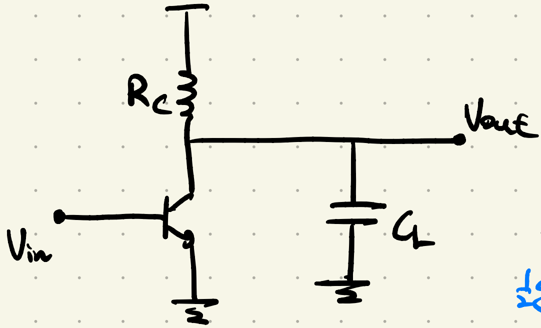
$\omega_{p1}\downarrow$ by at least a factor of 2

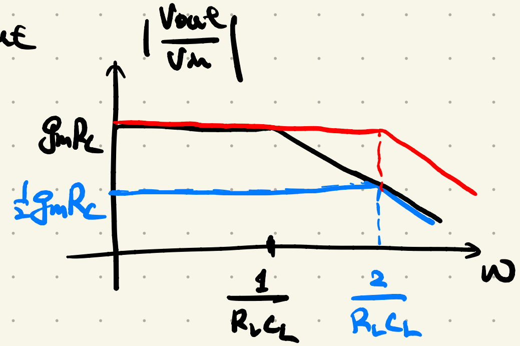
$A_v \to \sqrt{2}A_v$



Example

① If $R_C \to \frac{R_C}{2}$, what happens?
(I_C const)





Gain × BW

$$= g_m R_C \frac{1}{R_C C_L} = \frac{g_m}{C_L}$$

② $R_C \to \frac{R_C}{2}$, $I_C \to 2I_C$

$$\frac{I_C}{V_T} = g_m \to 2g_m$$

$$\text{Gain} \times \text{BW} = g_m R_C \cdot \frac{2}{R_C C_L} = 2\frac{g_m}{C_L}$$

Power cons. $= V_{CC} \cdot 2I_C$ doubled