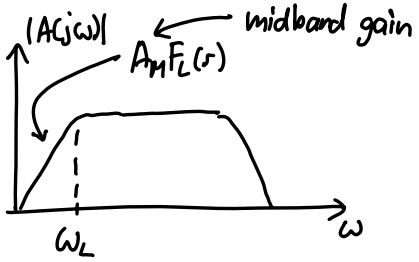
Today:

- Short-Circuit Time Constant Analysis for Low Frequency Cut-Off
- Active Loads

Last Time –



$$\omega_L \cong e_1 = \sum_j \omega_{pj} = \sum_j \frac{1}{C_j R_{js}} = \sum_j \frac{1}{\tau_{js}}$$

where $C_j \triangleq$ various large (>10nF) capacitors in the ckt. (e.g., the bypass caps.)

$R_{js} \triangleq$ driving point resistance seen between the terminals of C_j determined with:

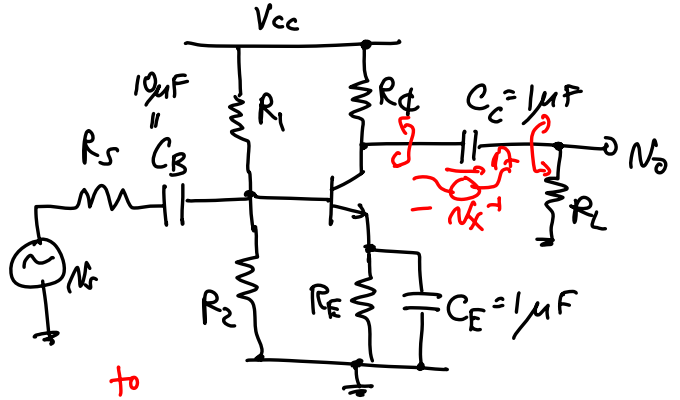
For reading, can go to Sedra & Smith

① all large capacitors short-circuited, except C_j, which is replaced by the test voltage source for R determination

② all independent sources eliminated (i.e., short voltage sources, open current sources)

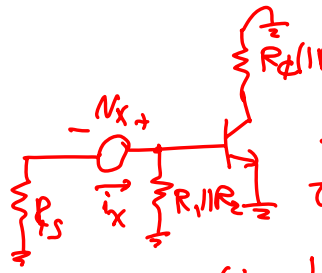
③ open all H.F. capacitors (i.e., small caps in the pF range, or < 1nF)

Ex: Determine the L.F. Response of the C.E. Amplifier



to

(a) τ due to C_B: short ckt. C_C & C_E



$R_{BS} = \frac{V_x}{i_x}$ = resistance in series w/ V_x

$\therefore R_{BS} = R_S + r_\pi \| R_1 \| R_2$

$\tau_B = R_{BS} C_B = (R_S + r_\pi \| R_1 \| R_2) C_B$

$$\omega_{pB} = \frac{1}{\tau_B} = \frac{1}{(R_S + r_\pi \| R_1 \| R_2) C_B}$$

(b) τ due to C_C: short ckt. C_B & C_E

↳ again, it will be the R in series

$\tau_C = (R_L + r_o \| R_C) C_C$

$r_o \| R_C \sim R_C$

$$\omega_{pC} = \frac{1}{\tau_C} = \frac{1}{(R_L + R_C) C_C}$$

(c) τ due to C_E: short C_B & C_C

$\frac{1}{g_m} + \frac{R_S \| R_1 \| R_2}{\beta+1}$

$R_C \| R_L$

$= \frac{r_\pi + R_S \| R_1 \| R_2}{\beta+1}$

$R_S \| R_1 \| R_2$

$R_{ES} = R_E \| \frac{r_\pi + R_S \| R_1 \| R_2}{\beta+1}$

R_E

$\tau_E = R_{ES} C_E$

R_F

$\omega_{pE} = \frac{1}{\tau_E} = \frac{1}{R_{ES} C_E}$

and finally:

$\omega_L = \omega_{pB} + \omega_{pC} + \omega_{pE}$

Active Loads

→ Why use them?

$\text{Gain} = \frac{v_o}{v_i} = -g_m R_D$

V_{DD}

V_{RD} + R_D } load (resistive)

v_o

v_i } drive device

For $\frac{v_o}{v_i}\uparrow$, must:

① Raise g_m → raise I_D

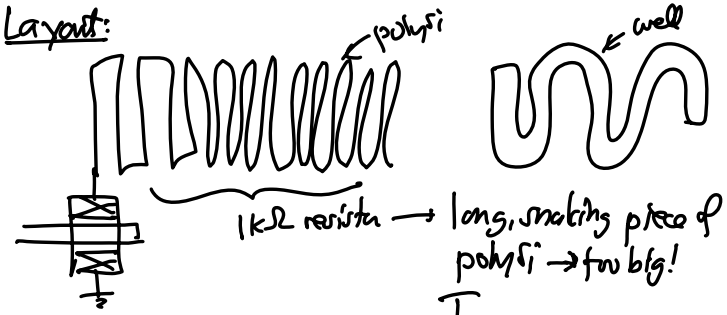
→ problem: $V_{RD}\uparrow$ → gets too large

∴ supply V_{DD} limits the amount of gain you can get

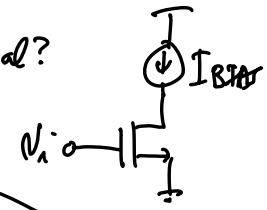
② increase R_D → but same problem

also: area ↑

Layout:

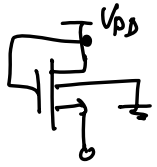


→ what would be ideal?

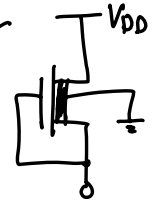


To solve these issues, use active load!

Diode-Connected Enhancement Load



Depletion Load



ancient ↓ we won't consider this

Diode-Connected PMOS Load

PMOS Current Source Load