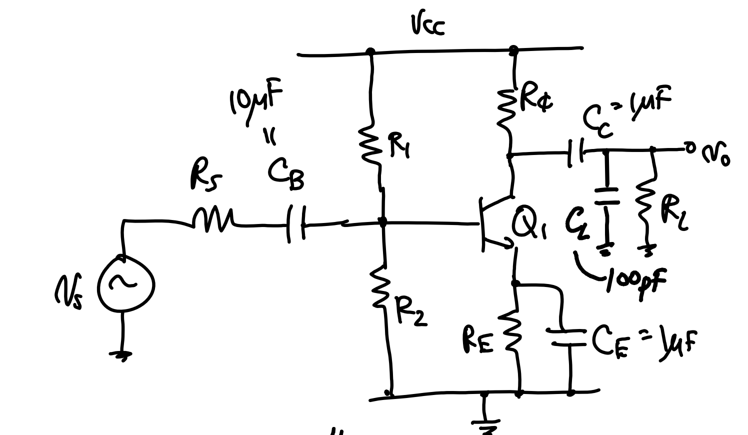
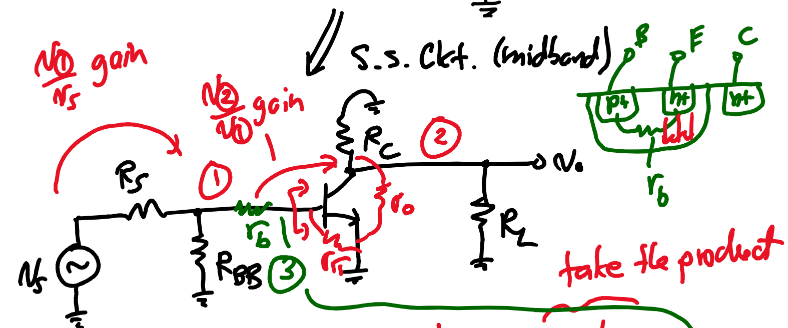
Lecture 27: Inspection Analysis & Miller Effect

- **Announcements:**
- HW#9 online and due Friday via Gradescope
- Lab#5 due Tuesday, Nov. 12, 5 p.m.
- ------------------------------------
- Lecture Topics:
  - Intro. to Inspection Analysis
  - C.E. Design Project Hints
  - Other Amplifier Configurations
  - Generally-Loaded Transistor
- ------------------------------------
- **Last Time:**
- Started introduction to inspection analysis
- Now continue with this …

Intro. to Inspection Analysis (w/ Lab#5 hints)



S.S. Ckt. (midband)



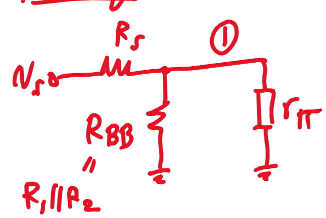
take the product

⇒ get gains from node to node, then combine

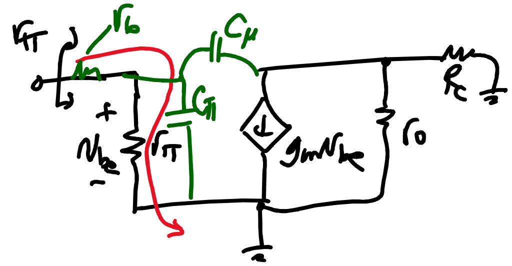
⇒ account for load resistance for each gain calculation for each stage

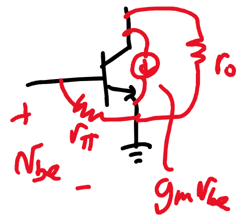
might need to account for r_b in your lab

1st Stage:



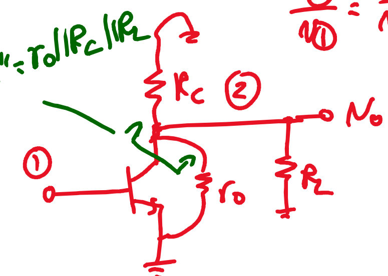
$$\frac{v_1}{v_s} = \frac{r_\pi \| R_1 \| R_2}{R_s + r_\pi \| R_1 \| R_2}$$





2nd Stage:

$R'' = r_o \| R_c \| R_L$



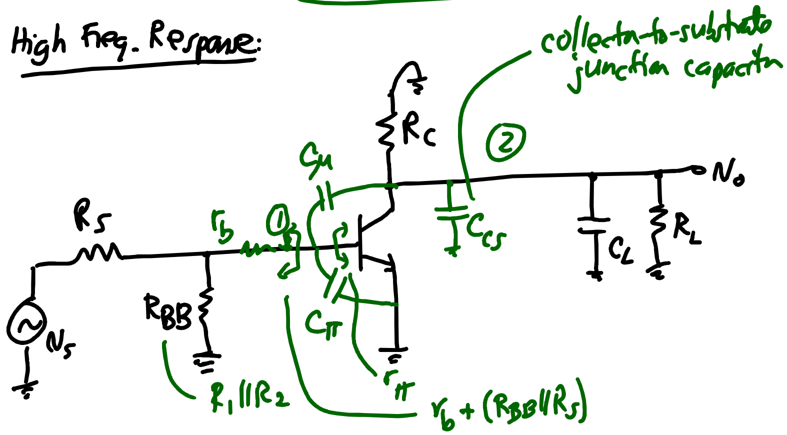
$\frac{v_②}{v_①} = \frac{v_o}{v_①} = -g_m R'' = -g_m(r_o \| R_c \| R_L)$

from memory

$[r_o = \text{large}]$ → $-g_m(R_c \| R_L)$

$$\frac{v_o}{v_s} = \frac{v_①}{v_s} \cdot \frac{v_o}{v_①} = \left(-\frac{r_\pi \| R_1 \| R_2}{R_s + r_\pi \| R_1 \| R_2} g_m (R_c \| R_L) = \frac{v_o}{v_s}\right)$$

High Freq. Response:



$$\omega_H = \frac{1}{\tau_① + \tau_② + \tau_{FB}}$$

$\tau_①$: $\tau_① = C_\pi[(r_b + R_{BB} \| R_s) \| r_\pi] = C_\pi R'$ (all resistance f/ node ① to ground)

$\tau_②$: $\tau_② = (C_{cs} + C_L)(R_L \| R_c \| r_o) \approx (C_{cs} + C_L)(R_L \| R_c)$ (all capacitance f/ node ② to ground)

$= (C_{cs} + C_L) R''$ (all resistance f/ node ② to ground)

$\tau_{FB} \to \tau_{C_\mu}$: $\tau_{C_\mu} = (R' + R'' + g_m R' R'') C_\mu$

$$\omega_H = \frac{1}{C_\pi R' + (C_{cs} + C_L) R'' + C_\mu (R' + R'' + g_m R' R'')}$$

often most important

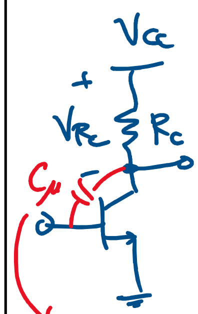
memorized! (maybe)

Lab Hints

$$\frac{v_o}{v_s} = -\frac{r_\pi \| R_1 \| R_2}{R_s + r_\pi \| R_1 \| R_2} g_m R_c$$

voltage drop across R_c

$\frac{I_C}{V_T} R_c = \frac{I_C R_c}{V_T} = \frac{V_{R_C}}{V_T} \sim$ gain



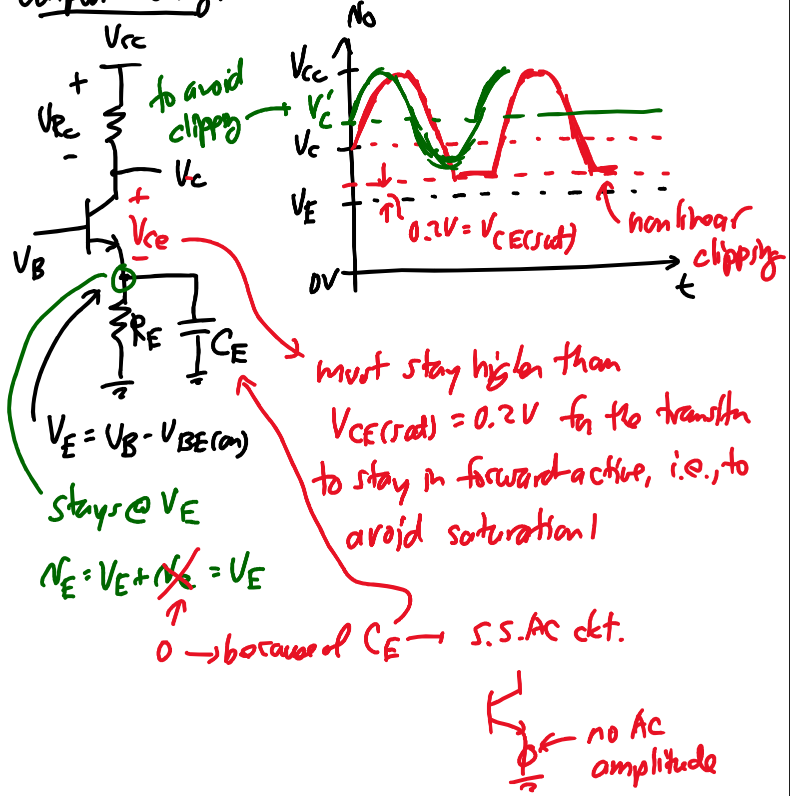
to get a certain gain, need to set V_C properly!

Want more gain } ⇒ $V_{R_C}\uparrow \to V_{CB}\downarrow \to C_\mu\uparrow \to \omega_H\downarrow$

$C_\mu = f(V_{CB}) \sim f(V_{CE})$

Freq. Response constrains gain!

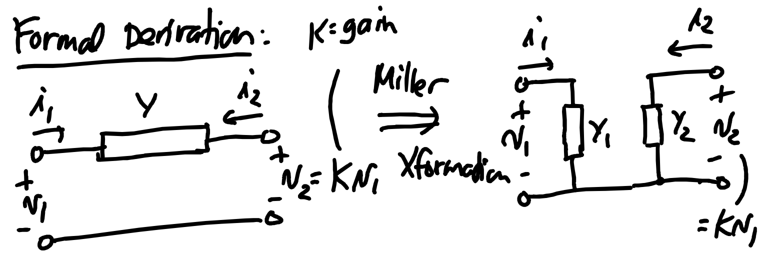
Output Swing:



The Miller Effect

⇒ useful to transform a ckt. w/ feedback into a simpler ckt. w/o feedback

Formal Derivation: K = gain



Find Y_1:

(original)

$i_1 = Y(v_1 - v_2)$

$= Y(v_1 - Kv_1)$

$= Y(1-K)v_1$

(Miller)

$i_1 = Y_1 v_1$

$$\boxed{Y_1 = Y(1-K)}$$

Find Y_2:

(original)

$i_2 = (v_2 - v_1)Y$

$= (v_2 - \frac{1}{K}v_2)Y = (1 - \frac{1}{K})Yv_2$

$[v_1 = \frac{1}{K}v_2]$

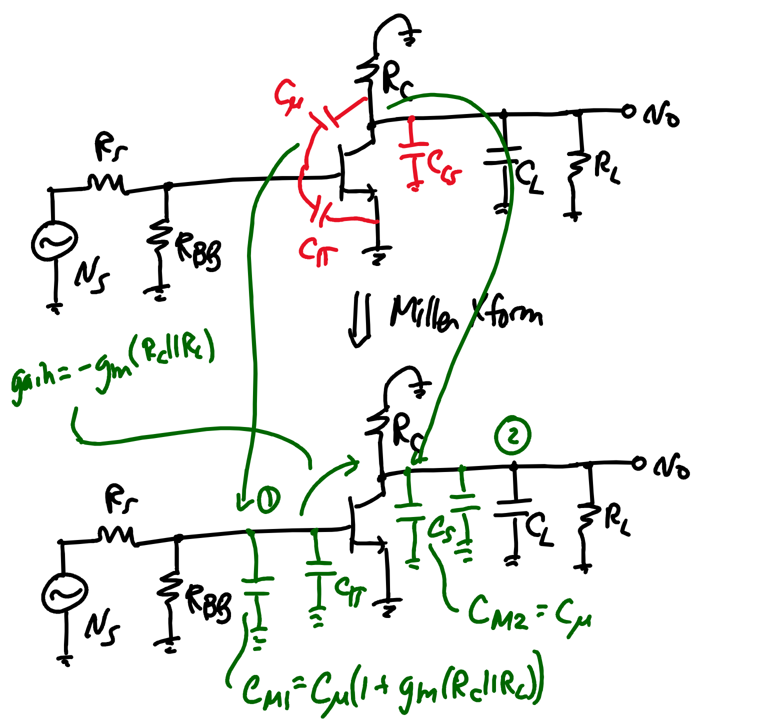
(Miller)

$i_2 = Y_2 v_2$

$$\boxed{Y_2 = Y(1 - \frac{1}{K})}$$

⇒ no longer have FB → easy...

C.E. Inspection Analysis for HF Using the Miller Effect



$$\tau_① = [C_\pi + C_\mu(1 + g_m(R_C \| R_L))](r_\pi \| R_{BB} \| R_s)$$

R'', R'

$$\tau_② = (C_L + C_{cs} + C_\mu)(R_C \| R_L)$$

R''

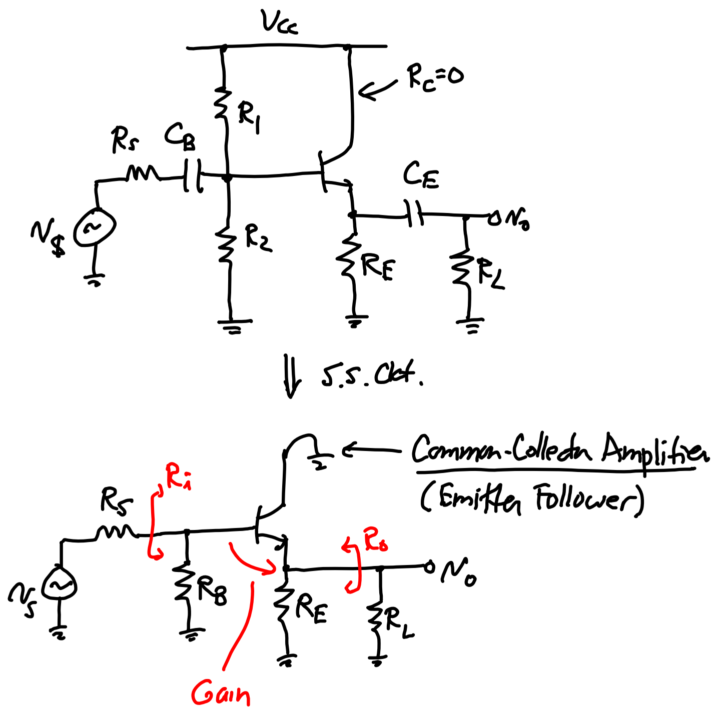
$$\omega_H = \frac{1}{\tau_① + \tau_②}$$

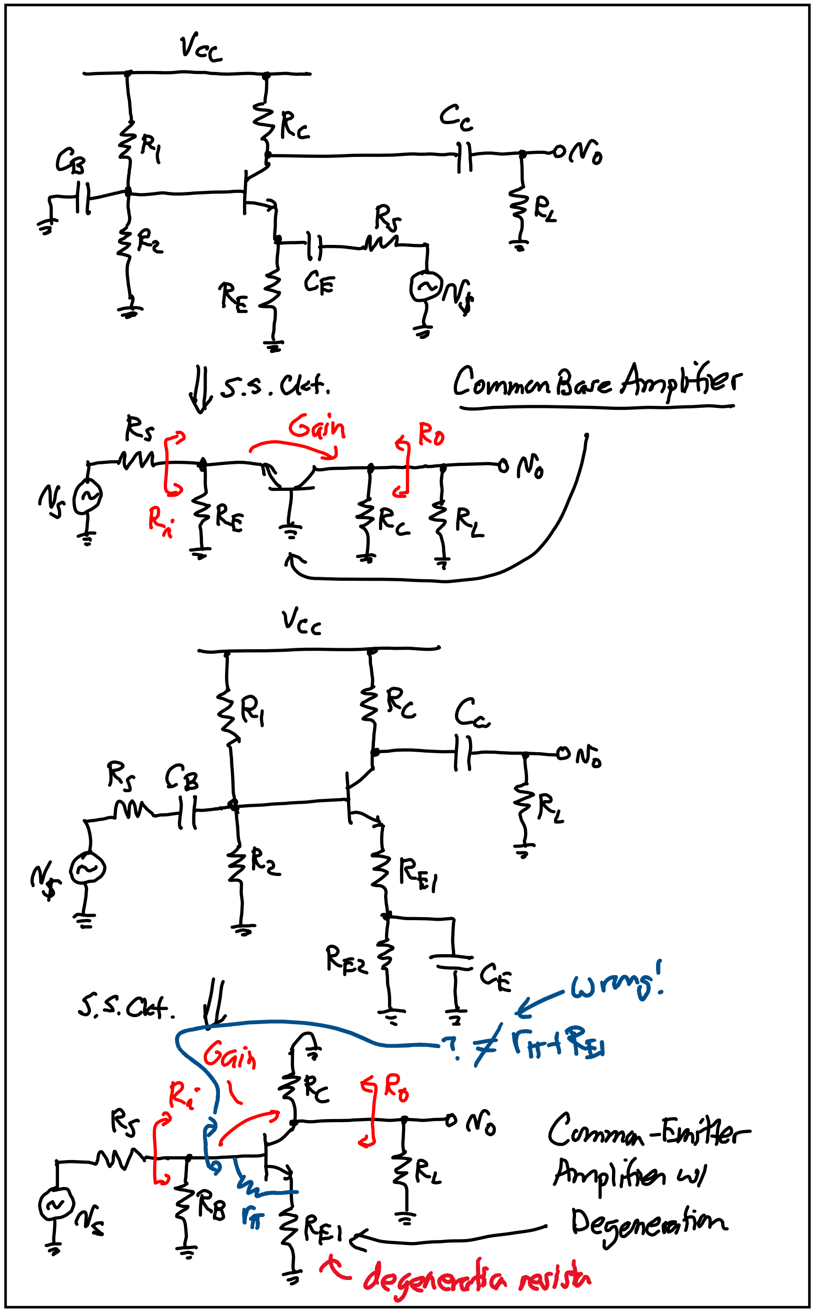
→ captures everything from the previous analysis (except r_b since we neglected it here)

same answer → no need to deal w/ FB

Other Popular Amplifier Configurations

- By merely altering the placements of input/output signals and bypass/coupling capacitors, one can realize other amplifier configurations
- Some examples:




Vcc
Rc
Cc
R1
CB
R2
RL
Rs
RE
CE
vs
S.S. Ckt.
Common Base Amplifier
Gain
Ro
Ri
Common-Emitter
Amplifier w/
Degeneration
wrong!
degeneration resistor