Lecture 33: Purposeful Design

- Announcements:
- HW#10 online and due Friday Nov. 22
- Lab 6 online and due 5 p.m., Friday, Dec. 13
- Graded Midterm 2 coming back today w/ solutions
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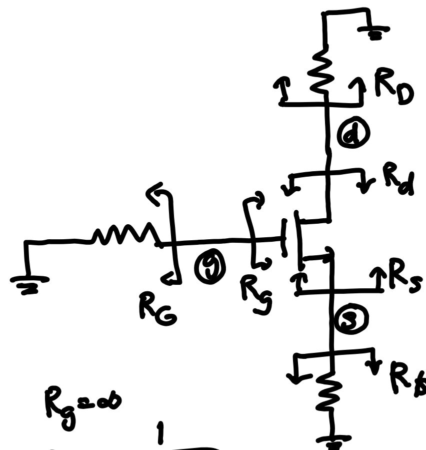
- Lecture Topics:
  - MOS Inspection Analysis
    - —High Frequency
  - Purposeful Design
  - Cascode Amplifier
- -------------------------------------
- Last Time:
- Did midband MOS inspection analysis
- Now, continue w/ high frequency analysis …
- Then, consider design with a purpose
  - Very much needed for your Lab#6

MOS Inspection Formulas w/ Substrate Grounded



only difference from "substrate tied to source" case is that g_m is replaced by g_m+g_{mb} in some of the formulas — particularly ones where the source is involved!

$R_g = \infty$

$R_s = \frac{1}{g_m+g_{mb}}$

$R_d = r_o[1+(g_m+g_{mb})R_S]$

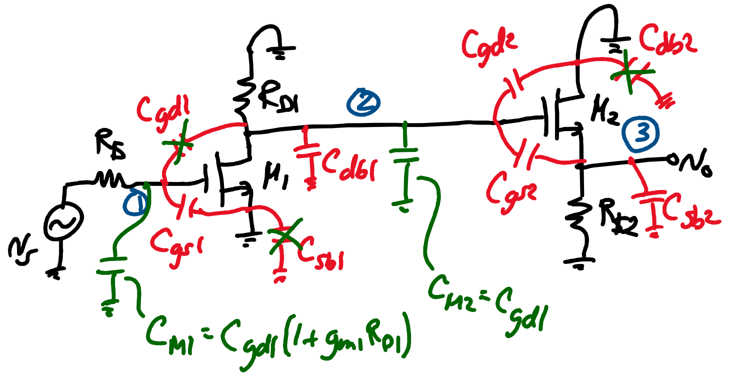
$\frac{v_d}{v_g} = -G_m R_{(d)}$, $G_m = \frac{g_m}{1+(g_m+g_{mb})R_S}$

$\frac{v_d}{v_s} = -G_m R_{(d)}$, $G_m = -(g_m+g_{mb})$

$\frac{v_s}{v_g} = \frac{g_m R_S}{1+(g_m+g_{mb})R_S}$

Remark: When the substrate is tied to the source, $g_{mb}=0$.

High Frequency Inspection Analysis



$$\tau_1 = [C_{gs1} + C_{gd1}(1+g_{m1}R_{D1})]R_S$$

$$\tau_2 = [C_{gd1} + C_{db1} + C_{gd2}](~~r_{o1}~~ \| R_{D1})$$

$$\tau_3 = C_{sb2}\left(\frac{1}{g_{m2}+g_{mb2}} \| R_{S2}\right)$$

X $$\tau_{gs2} = C_{gs2}\left(\frac{R_{D1}+R_{S2}}{1+(g_{m2}+g_{mb2})R_{S2}}\right)$$

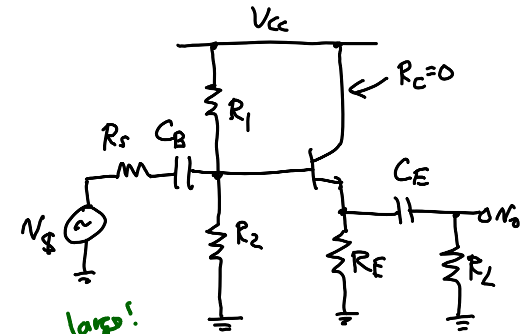
actually $+ g_{mb2}R_{D1}R_{S2}$ — small → ignore

$$\omega_{3dB} = \frac{1}{\tau_1 + \tau_2 + \tau_3 + \tau_{gs2}}$$

ignore since signal across C_{gs2} is tiny (since the gain across it is ≈1)

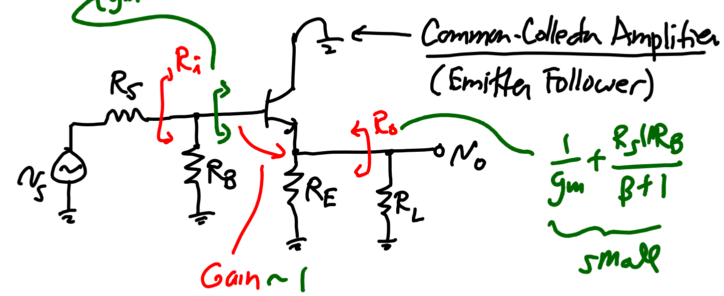
Popular Amplifier Configurations → Building Blocks

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

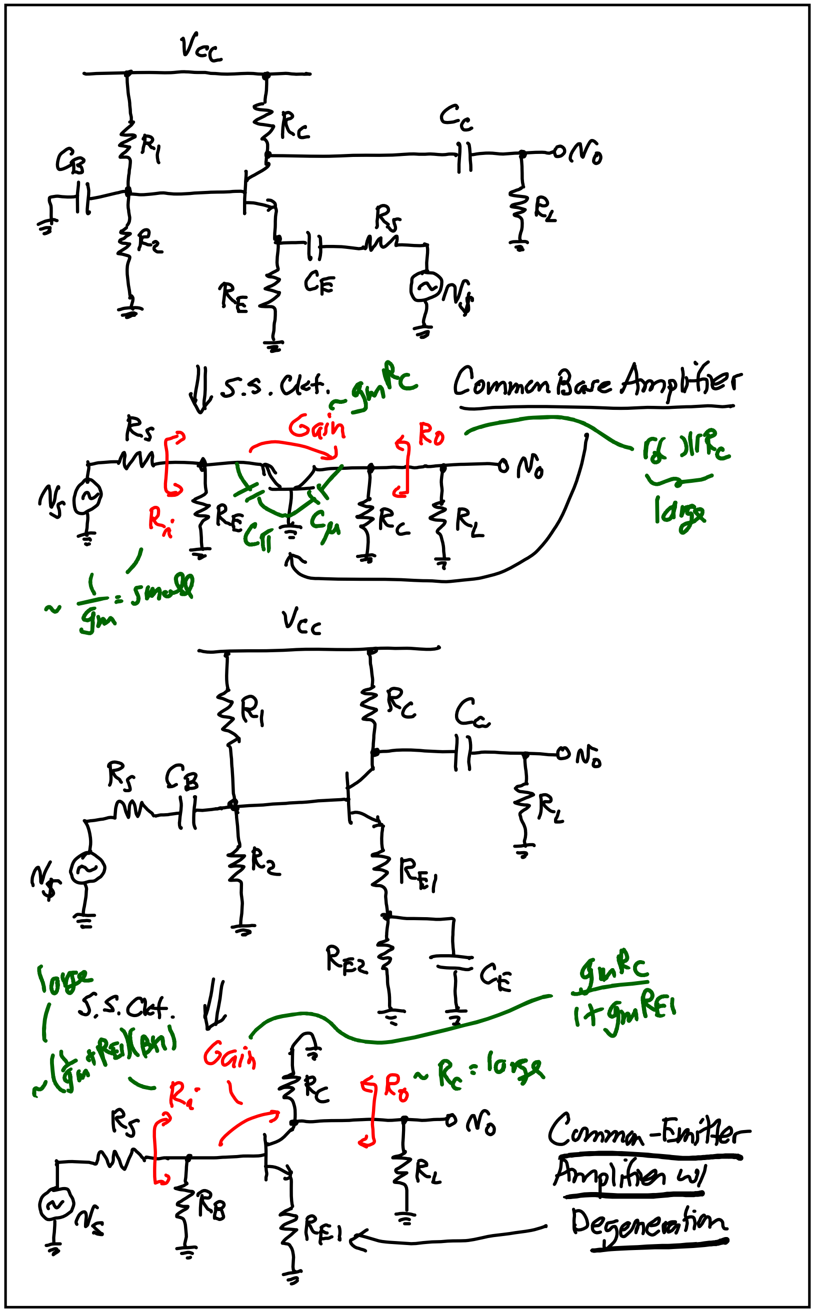


large!
$\left(\frac{1}{g_m}+R_E\right)(\beta+1)$

⇓ s.s. ckt.



$\frac{1}{g_m} + \frac{R_s \| R_B}{\beta+1}$ — small



Multi-Stage Amplifier Design Guidelines

(for voltage amplifiers) (i→i amps, etc., would have different charts)

	Ideal Voltage Amp	C.E.	C.E. w/ R_E	C.C.	C.B.
R_i	∞	med. ✗	large ✓	large ✓	small ✗
R_o	0	large ✗	large ✗	small ✓	large ✗
a_v	∞	large ✓	med ✗	small ✗	large ✓
f_H	∞	small ✗	med. ✗	large ✓	large ✓

To Get Better Performance → Cascade Amplifiers

⇒ for a good voltage amplifier: