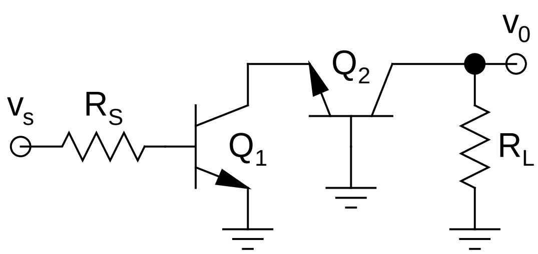
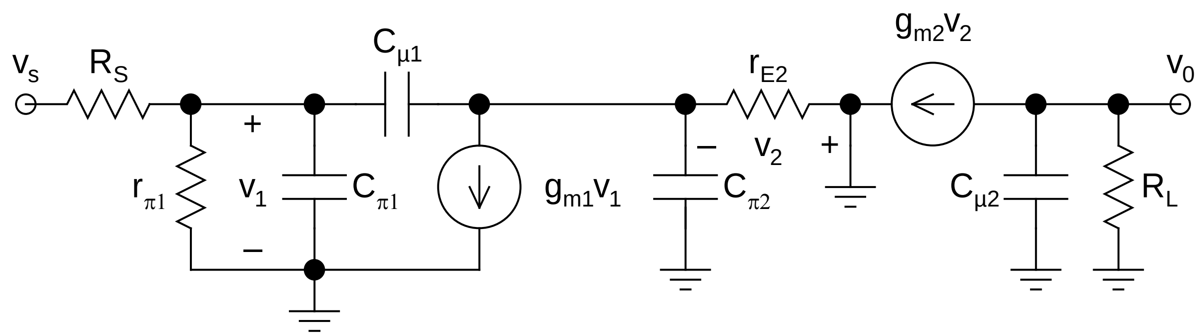
- ***npn Cascode***:



ac Schematic



High-Frequency Equivalent

- ***Looks intimidating***, but ***extremely easy to solve*** (***just by inspection***)
- Also known as ***Wideband*** (or ***Broadband***) ***Amplifier*** due to its ***superb frequency response***

- ***Reason***:
  - ***The circuit does have an input-output coupling capacitor*** ($C_{\mu 1}$)
  - ***Miller Effect Multiplication Factor*** (MEMF) of $C_{\mu 1} = (1 - A_{v1})$

    A_{v1} = ***voltage gain of*** Q_1 $= - r_{E2}/r_{E1} = -1$

    (***since*** Q_1 ***and*** Q_2 ***are biased with the same*** I_C)

    $\Rightarrow$ Thus, the ***MEMF of*** $C_{\mu 1}$ ***is only 2***
  - For ***NMOS Cascode*** stage, the ***MEMF of*** C_{gd1} of M_1 (***CS stage***) will be $[1 + 1/(1 + \chi_2)]$ (***verify this expression***), which is ***even less than 2***

- ***$C_{\pi 1}$***:
  - ***By inspection***:

    $$R_{\pi 1}^{0} = R_S \parallel r_{\pi 1} \quad \Rightarrow \tau_1 = R_{\pi 1}^{0} C_{\pi 1}$$

- ***$C_{\mu 1}$***:
  - Can be easily identified as the ***Three-Legged Creature***

    $$\Rightarrow R_{\mu 1}^{0} = R_{\pi 1}^{0} + r_{E2} + g_{m1} R_{\pi 1}^{0} r_{E2}$$

    $$\Rightarrow \tau_2 = R_{\mu 1}^{0} C_{\mu 1}$$

- ***$C_{\pi 2}$***:
  - ***By inspection***:

    $$R_{\pi 2}^{0} = r_{E2} \quad \Rightarrow \tau_3 = R_{\pi 2}^{0} C_{\pi 2}$$

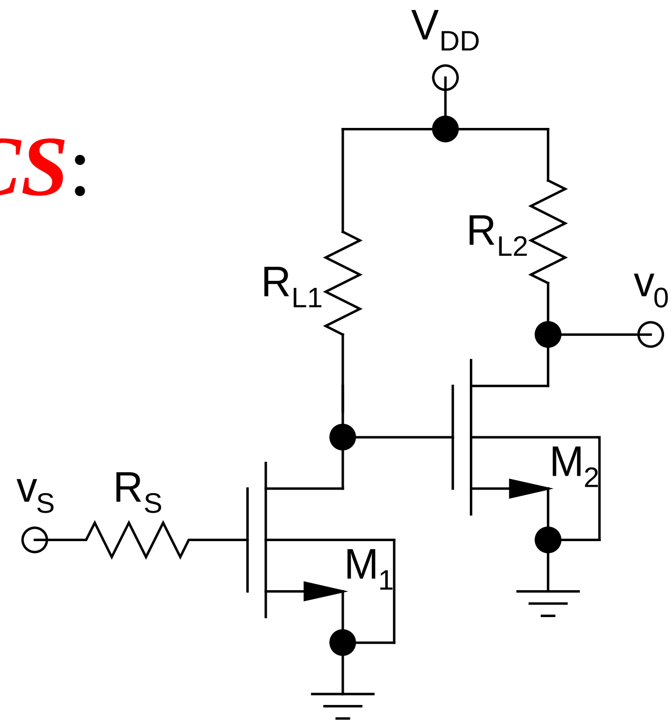
- ***$C_{\mu 2}$***:
  - ***By inspection***:

$$R^{0}_{\mu 2} = R_L \quad \Rightarrow \tau_4 = R^{0}_{\mu 2} C_{\mu 2}$$

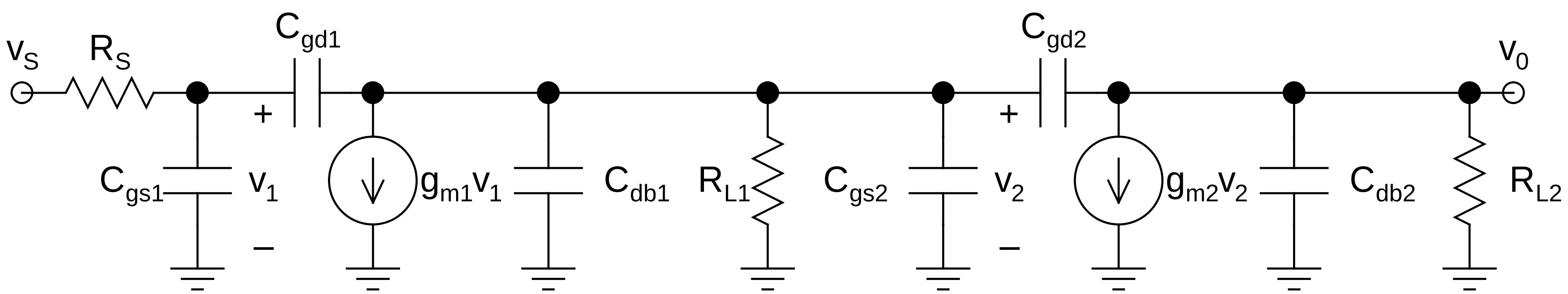
- Generally, for this circuit, $C_{\pi 1}$ is the ***dominant capacitor*** that determines f_H, since it sees the ***largest resistance***
- The ***resistance seen by $C_{\mu 1}$***, which is the ***largest for CE stage***, ***becomes quite small here***, ***due to the low gain of Q_1***
- Note how ***simple*** it is to use this ***technique*** even for ***multi-stage amplifiers***!

- ***NMOS 2-Stage Cascaded CS***:
  - *Except C_{sb}, all other capacitors will be present for both devices*
  - *6 capacitors*

    $\Rightarrow$ *6 time constants*



ac Schematic



High-Frequency Equivalent

- ***Note***: An ***exact analysis*** would have required ***solving*** a ***6^{th}-order equation in ω***!
- Let's perform a ***quantitative analysis*** of this circuit
- ***Data***: g_{m1} = 3 mA/V, g_{m2} = 6 mA/V, C_{gs1} = 5 pF, C_{gs2} = 10 pF, $C_{gd1} = C_{gd2}$ = 1 pF, $C_{db1} = C_{db2}$ = 2 pF, R_S = 10 kΩ, R_{L1} = 10 kΩ, and R_{L2} = 5 kΩ.
  - ***C_{gs1}***:

$$R_{gs1}^0 = R_S = 10\ k\Omega \quad \Rightarrow \tau_1 = R_{gs1}^0 C_{gs1} = 50\ ns$$