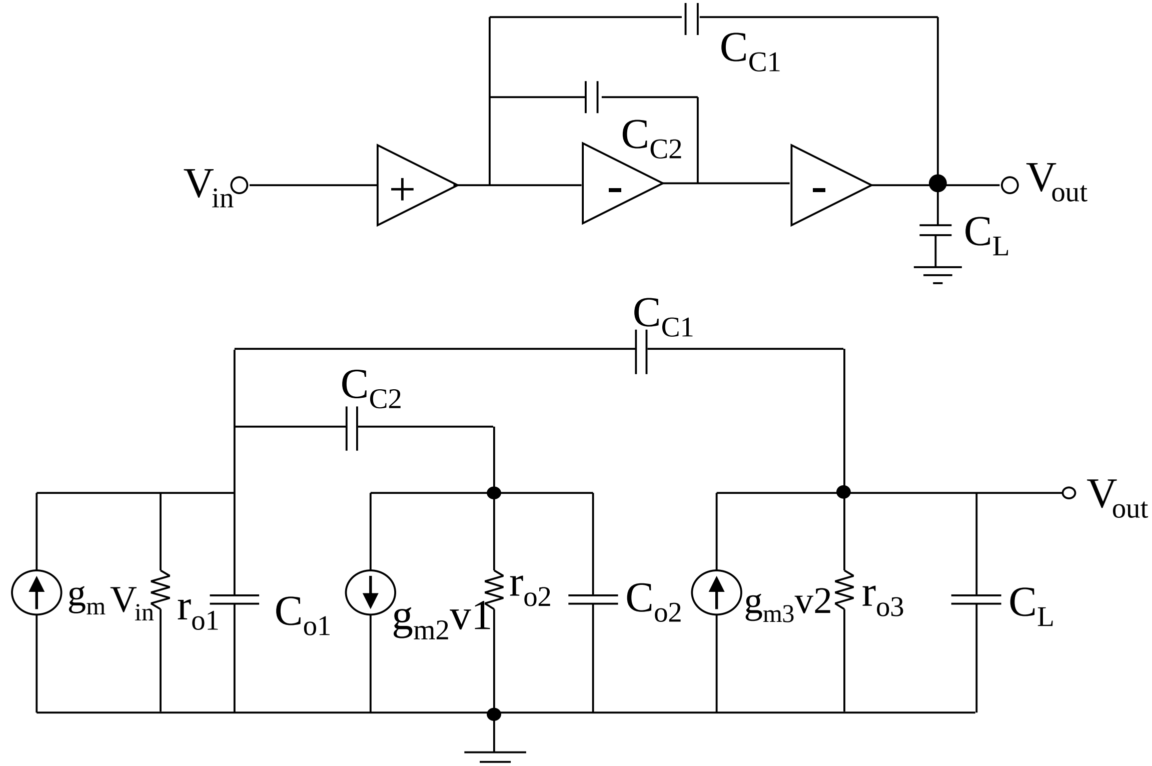
REVERSED NESTED MILLER COMPENSATION AMPLIFIERS

ELEN 607 (ESS)

Analog and Mixed-Signal Center, TAMU

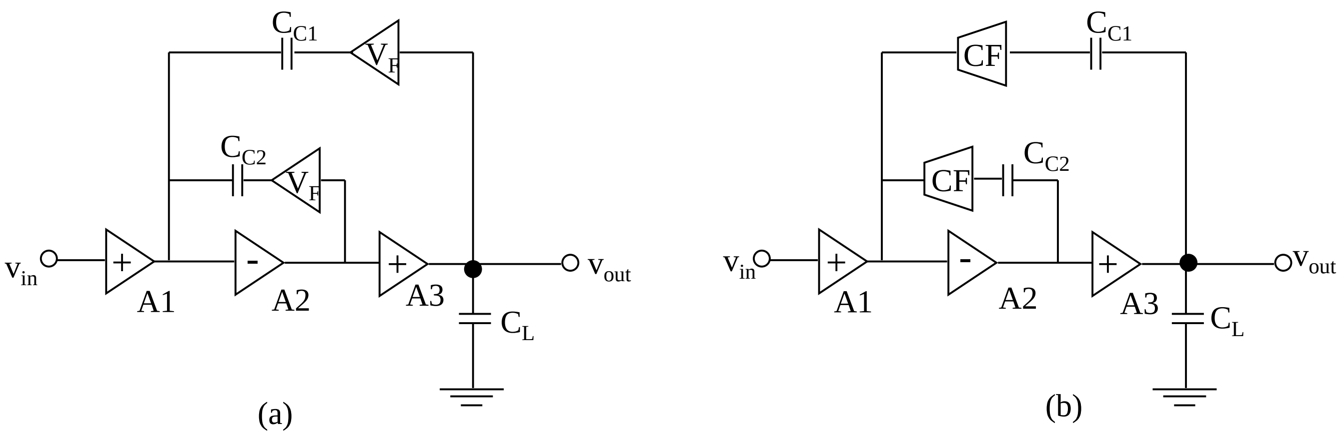


Three-stage amplifier with reversed nested Miller compensation

$$A(s) = A_o \frac{1 - \left(\frac{C_{C2}}{g_{m2}} + \frac{C_{C1}}{g_{m2} g_{m3} r_{o2}} \right) s - \frac{C_{C1} C_{C2}}{g_{m2} g_{m3}} s^2}{\left(1 + \frac{s}{\omega_{p1}} \right) \left[1 + \left(\frac{C_{C2} C_L}{g_{m3} C_{C1}} - \frac{C_{C2}}{g_{m2}} + \frac{C_{C2}}{g_{m3}} \right) s + \frac{C_{C2} C_L}{g_{m2} g_{m3}} s^2 \right]}$$

where A_o is the DC open-loop gain equal to $A_1 A_2 A_3 = g_{m1} r_{o1} g_{m2} r_{o2} g_{m3} r_{o3}$ and ω_{p1}

$$\omega_{P1} \approx \frac{1}{r_{o1} A_2 A_3 C_{C1}} = \frac{1}{r_{o1} g_{m2} r_{o2} g_{m3} r_{03} C_{C1}}$$



Techniques for the RHP-zero elimination: a) with voltage followers, b) with current followers.

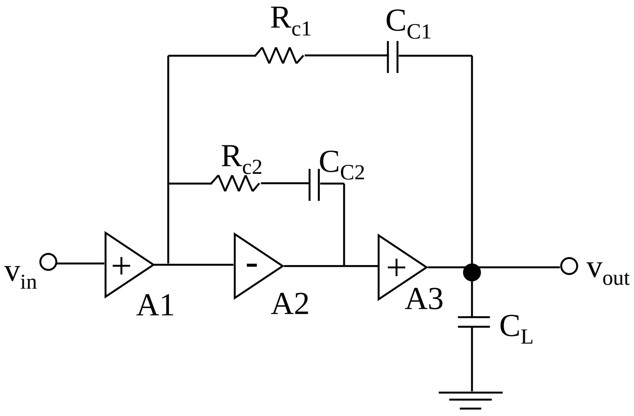
$$A(s) = A_o \frac{1}{\left(1+\frac{s}{\omega_{P1}}\right)\left[1+\frac{C_{C2}(C_{C1}+C_L)}{g_{m3}C_{C1}}s\right]}$$

$$A(s) = A_o \frac{1}{\left(1+\frac{s}{\omega_{P1}}\right)\left(1+\frac{C_{C2}C_L}{g_{m3}C_{C1}}s\right)}$$

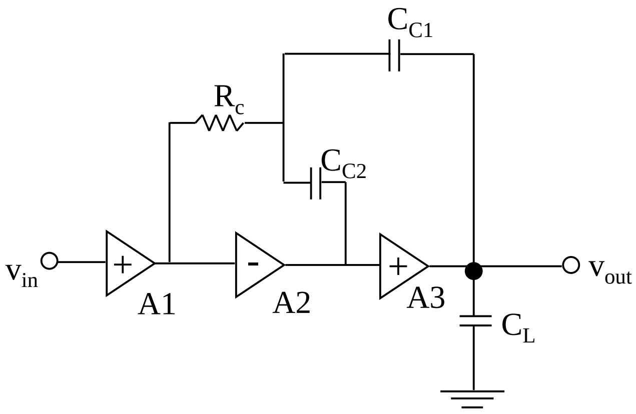
$$\tan m_\varphi = \frac{g_{m3}}{g_{m1}}\frac{C_{C1}^2}{C_{C2}C_L}$$

$$\tan m_\varphi = \frac{g_{m3}}{g_{m1}}\frac{C_{C1}^2}{(C_{C1}+C_L)}$$

Where m_φ is the phase margin



Conventional scheme for the RHP-zero elimination with two nulling resistors.



Technique for the RHP-zero elimination with one nulling resistor.

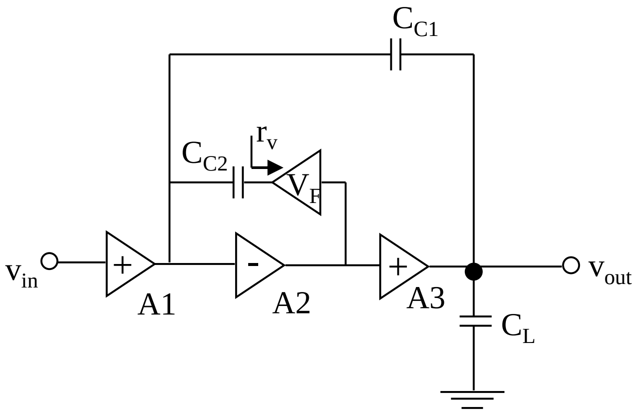
$$g_{m2} = g_{m3}$$

$$C_{C2} C_L > 4 C_{C1}^2$$

$$A(s) = A_o \frac{1}{\left(1 + \frac{s}{\omega_{P1}}\right)\left(1 + \frac{C_{C2} C_L}{g_{m3} C_{C1}} s\right)}$$

$$C_{C2} = \frac{{C_{C1}}^2 g_{m3}}{\tan m_\varphi C_L g_{m1}}$$

$$\frac{g_{m2,3}}{g_{m1}} > 4 \tan m_\varphi$$



$$r_v = \frac{\gamma}{g_{m3}}$$

Technique for the RHP-zero elimination with one voltage follower.

$$A(s) = \frac{A_o}{\left(1+\frac{s}{\omega_{P1}}\right)} \frac{\left(1+r_v C_{C2} s\right)\left(1-\frac{C_{C1}}{g_{m2} g_{m3} r_{o2}} s\right)}{\left[1+\frac{C_{C2}\left(C_L + C_{C1} + g_{m3} r_v C_{C1}\right)}{g_{m3} C_{C1}} s\right]\left[1+\frac{C_{C1} C_L r_v}{g_{m2} r_{o2}\left(C_L + C_{C1} + g_{m3} r_v C_{C1}\right)} s\right]}$$

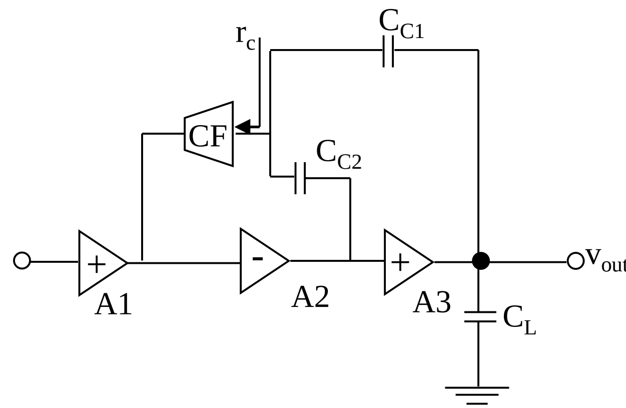
$$\omega_{P2} = \frac{g_{m3}}{C_{C2}\left(\frac{C_L}{C_{C1}} + 1 + \gamma\right)}$$

$$\omega_{Z1} = \frac{g_{m3}}{\gamma C_{C2}} = \frac{1}{\alpha}\omega_{P2}$$

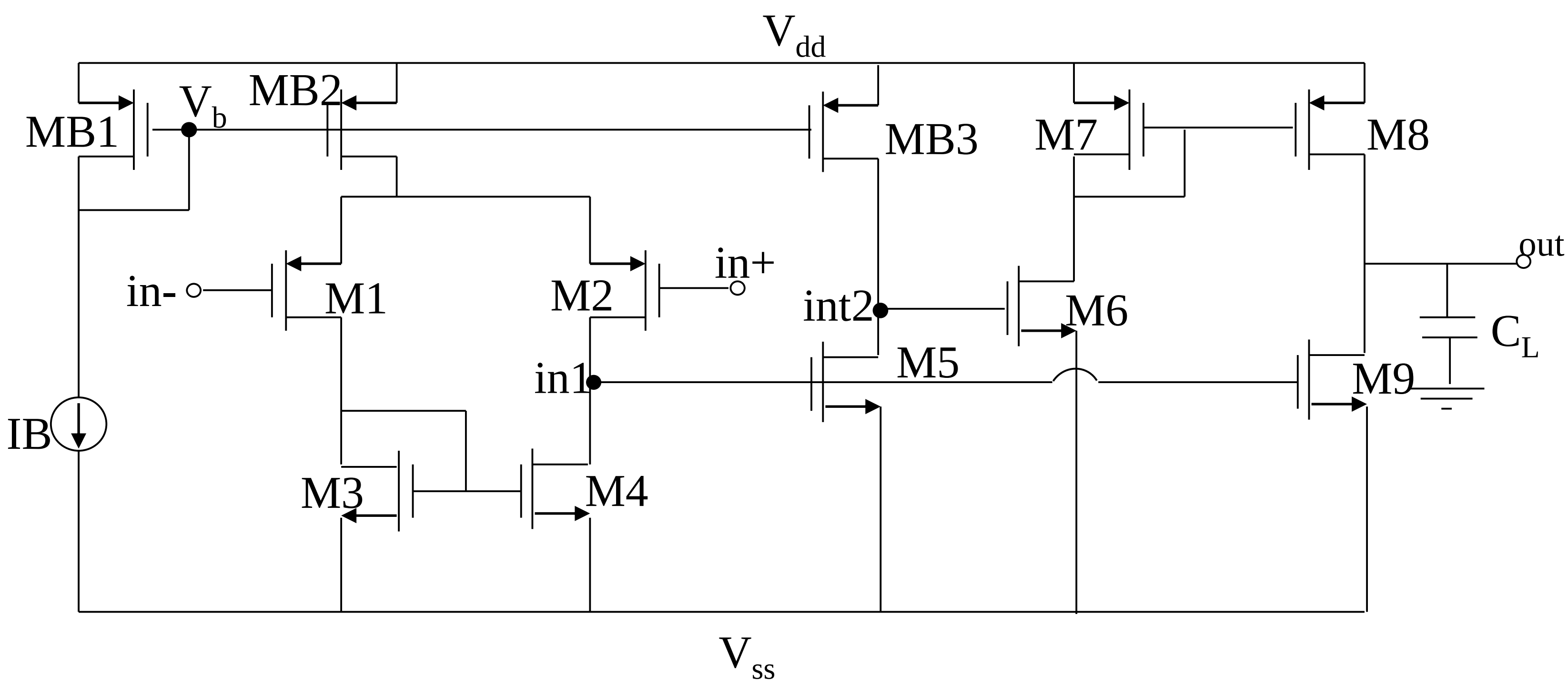
$$\omega_{Z2} = -\frac{g_{m3} g_{m2} r_{o2}}{C_{C1}}$$

$$\omega_{P3} = \frac{\frac{C_L}{C_{C1}} + 1 + \gamma}{C_L} \frac{g_{m3} g_{m2} r_{o2}}{\gamma}$$

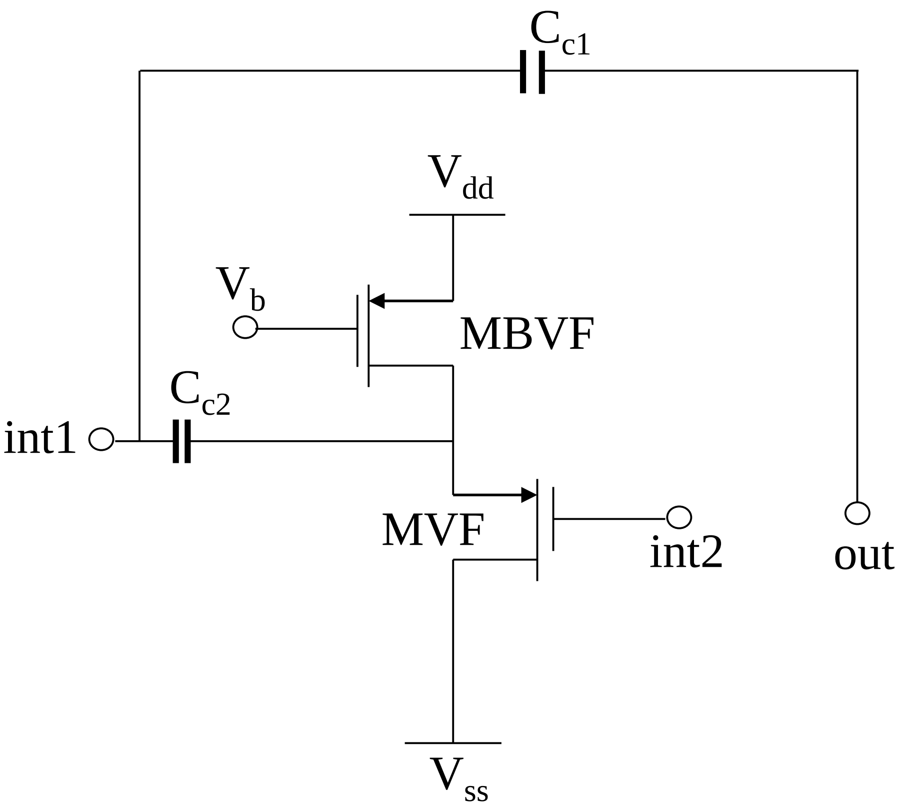
$$\alpha = \frac{\gamma C_{C1}}{C_L + (1+\gamma) C_{C1}}$$



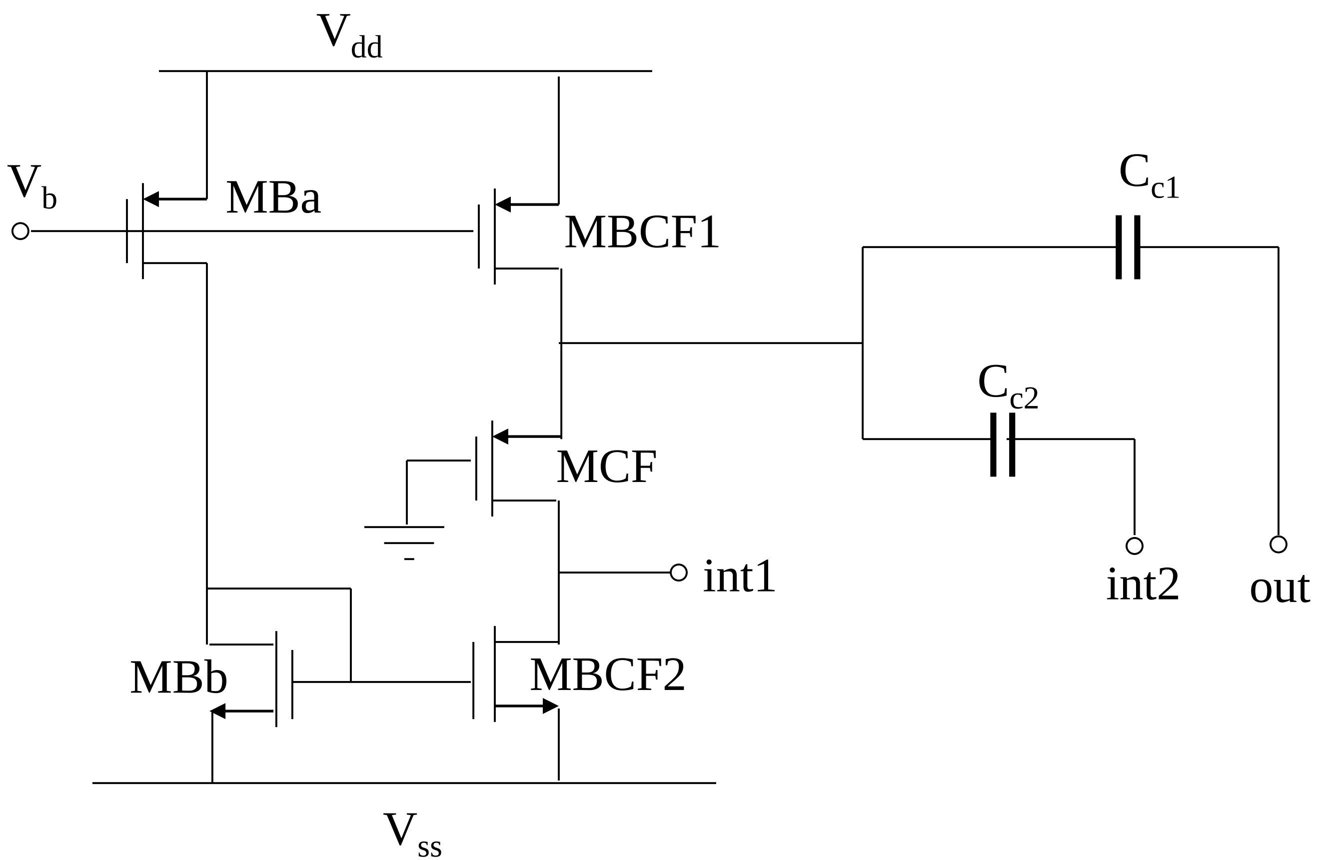
Technique for the RHP-zero elimination with one current follower.



Simplified schematic of the core amplifier used for the simulations.



Voltage-follower based compensation network.



Current-follower based compensation network.

REFERENCE: *R. .Mita, G. Palumbo and S. Pennisi, " Design Guidelines for Reversed Nested Miller Compensation in Three-Stage Amplifier", IEEE Trans. on Circuits and Systems II, vol. 50, n0.5, pp227-233, May 2003*