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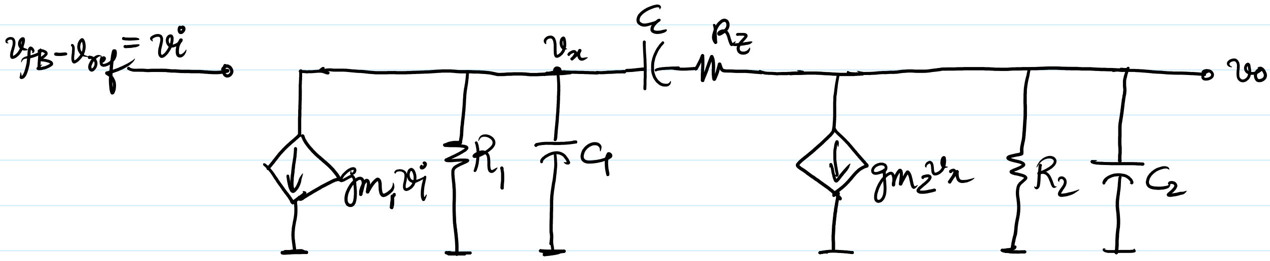
Stability Analysis



In the case of LDO [My LDO]

$R_1 = r_{o1} \| r_{o3}$, $C_1 = C_{gg\,pass}$, $R_2 = R_1 + R_2 \| r_{o\,pass} \| R_L$

$$\frac{v_o(s)}{v_i(s)} = \frac{g_{m1} R_1 g_{m2} R_2 \left(1 - sC_c/g_{m2}\right)}{1 + s\{R_1(C_1 + C_c[g_{m2}R_2 + 1]) + R_2(C_2 + C_c)\} + s^2 R_2 R_1 \{C_1C_2 + C_2C_c + C_2C_1\}}$$

$$\underset{\text{(dominant)}}{\omega_{p1}} = \frac{1}{R_1(C_1 + C_c(1 + g_{m2}R_2)) + R_2(C_2 + C_c)} \simeq \frac{1}{g_{m2} R_2 R_1 C_c}$$

$$\underset{\text{(Non-dom)}}{\omega_{p2}} = \frac{\cancel{R_1} C_c g_{m2} \cancel{R_2}}{\cancel{R_1 R_2}(C_1C_2 + C_1C_c + C_2C_c)} \simeq \frac{g_{m2} C_c}{C_1C_2 + C_1C_c + C_cC_2}$$

$$\simeq \frac{g_{m2}}{C_2} \text{ (bad approx for simplification)}$$

$$A_{DC} = g_{m1} R_1 g_{m2} R_2$$

$$\omega_{ugb} = A_{DC} \times \omega_{p1} = g_{m1} \cancel{R_1} \cancel{g_{m2}} \cancel{R_2} \times \frac{1}{\cancel{g_{m2}} \cancel{R_2} \cancel{R_1} C_c} = \frac{g_{m1}}{C_c}$$

$$\underset{\text{[Complete O.L.G]}}{A(s)} = \frac{A_{DC}\left(1 - s/\omega_z\right)}{\left(1 + s/\omega_{p1}\right)\left(1 + s/\omega_{p2}\right)}$$

for feedback factor = f

$$\text{Loop Gain}(L.G)(s) = A(s)f$$

$$\text{Closed } L.G(s) = \frac{1}{f}\,\frac{LG(s)}{1+LG(s)}$$

Calculating C_c

* Assuming $Z \geq 10 \cdot \omega_{ugb}$

$$\measuredangle \frac{V_o}{V_{in}} = -\tan^{-1}\left(\frac{\omega}{\omega_z}\right) - \tan^{-1}\left(\frac{\omega}{\omega_{p1}}\right) - \tan^{-1}\left(\frac{\omega}{\omega_{p2}}\right)$$

Check the P.M at ω_{ugb} to Evaluate the stability

After lot of simplification

$$\measuredangle \frac{V_o}{V_{in}} = -\tan^{-1}\left(\frac{\omega_{ugb}}{\omega_z}\right) - \tan^{-1}(A_{DC}) - \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right)$$

Considering zero has been nullified by adding LHP zero $R_z = 1/g_{m2}$

$$\measuredangle \frac{V_o}{V_{in}} = (\approx 0) - (\approx 90^\circ) - \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right)$$

$$P.M = 180^\circ - 90^\circ - \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right)$$

$$PM = 90^\circ - \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right)$$

For $P.M \geq 60^\circ$

$$60^\circ = 90^\circ - \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right)$$

$$30^\circ = \tan^{-1}\left(\frac{\omega_{ugb}}{\omega_{p2}}\right) \Rightarrow \tan(30^\circ) = \frac{\omega_{ugb}}{\omega_{p2}}$$

$$0.577 \approx \frac{\omega_{ugb}}{\omega_{p2}} \Rightarrow \omega_{p2} = \frac{\omega_{ugb}}{0.577} \Rightarrow \omega_{p2} = 1.73\,\omega_{ugb}$$

But ω_z will not be perfectly cancelled so, I'll keep a safe margin

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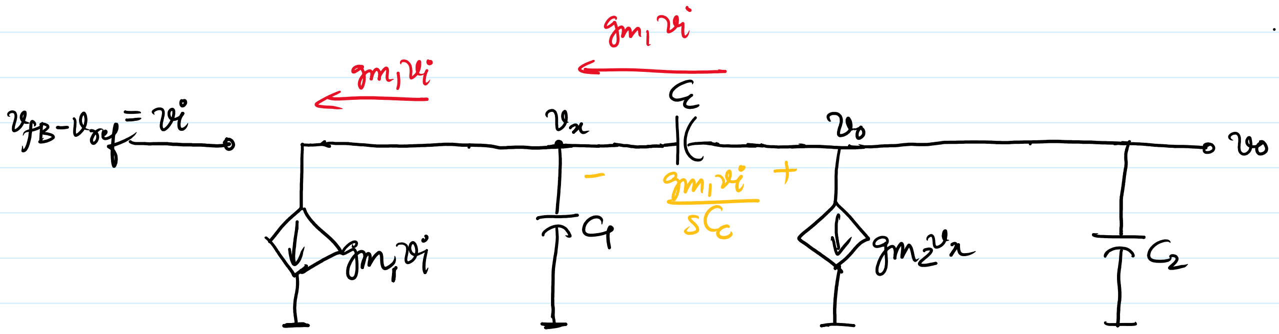
$$\omega_{p_2} \geq 2\,\omega_{ugb}$$

For this $\quad \underline{\underline{C_c \geq 0.2\,C_L}}$

Need of LHP zero to nullify RHP zero

- At higher freq curr flows through caps mostly



For large P.M $\quad g_{m2} \to$ large

Then $v_x \to 0$ for $g_{m2} \to \infty$

$$v_o = v_x + \frac{g_m v_i}{sC_c}$$

Ideally we donot want v_x $[v_x = 0]$

- LHP zero advances the signal
- RHP zero delays the signal [Make P.M Bad]

$$\Rightarrow \frac{g_{m1}}{sC_c} v_i - \frac{g_{m1}}{g_{m2}} v_i = \frac{g_{m1}}{sC_c}\left(1 - \frac{sC_c}{g_{m2}}\right)$$

$$v_x = -\frac{g_{m1}}{g_{m2}} v_i \quad \& \quad i_x = g_{m1} v_i$$

So from this If I add $1/g_{m2}$ Resistor we can nullify the effect of RHP zero.