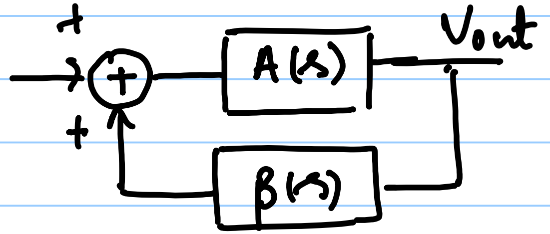
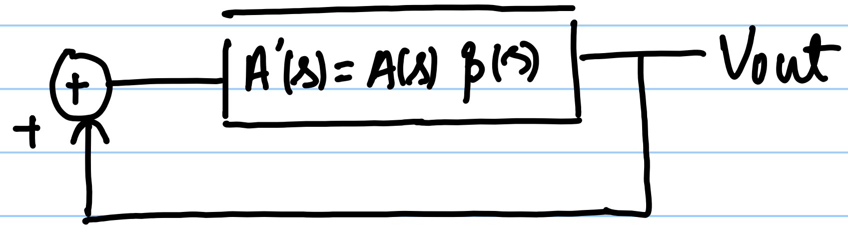
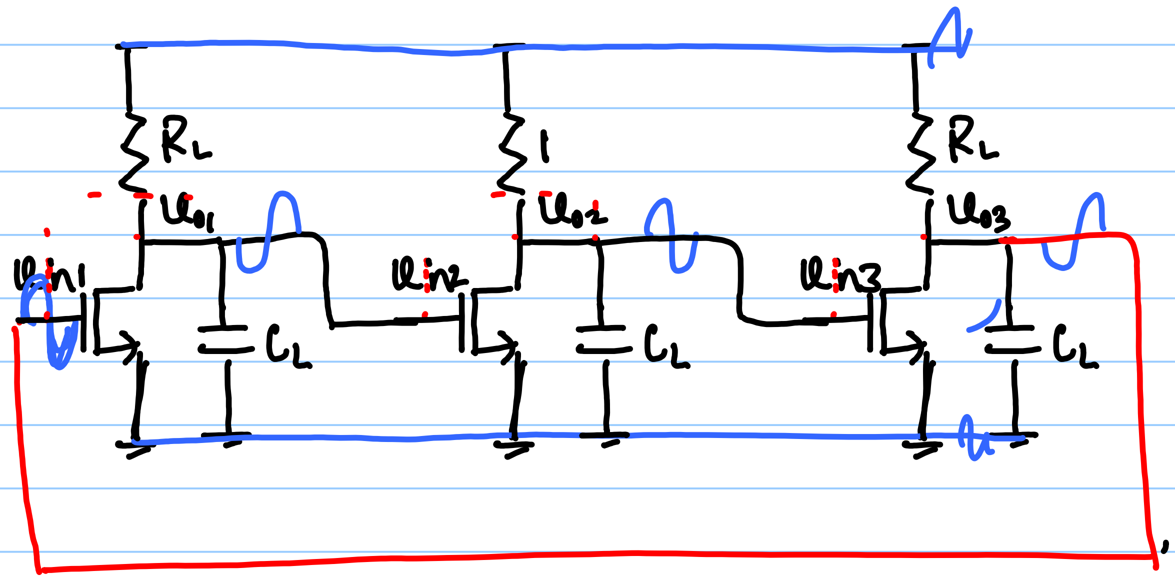
Lecture # 25



$$LG(s) = A(s)\ \beta(s)$$

$$|LG(\omega_{osc})| = 1 \quad , \quad \measuredangle LG(\omega_{osc}) = 2k\pi$$





$$\frac{V_o(s)}{v_{in}(s)} = -\frac{g_m R_o}{1 + s R_o C_L} \quad ; \quad R_o = \left(R_L \,||\, \frac{1}{g_{ds}}\right)$$

$$LG(s) = \frac{-A_o^3}{(1 + s/\omega_p)^3}$$

$$\measuredangle LG(\omega) = \underline{-180^\circ - 3\tan^{-1}\left(\frac{\omega}{\omega_p}\right)}$$

$$= \underline{k} \times 360^\circ$$

$$-180^\circ - 3\tan^{-1}\left(\frac{\omega_{osc}}{\omega_p}\right) = -360^\circ$$

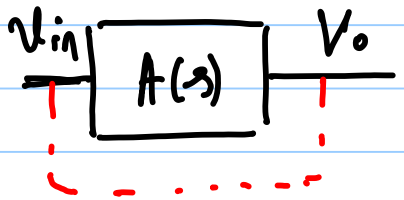
$$3\tan^{-1}\left(\frac{\omega_{osc}}{\omega_p}\right) = 180^\circ$$

$$\frac{\omega_{osc}}{\omega_p} = \tan(60^\circ)$$

$$\boxed{\omega_{osc} = \sqrt{3}\,\omega_p}$$

$$A(s) = \frac{V_o(s)}{V_{in}(s)} = \frac{-A_0}{1+s/\omega_p} \; ; \quad A_0 = g_m R_o$$

$$\omega_p = \frac{1}{R_o C_L}$$



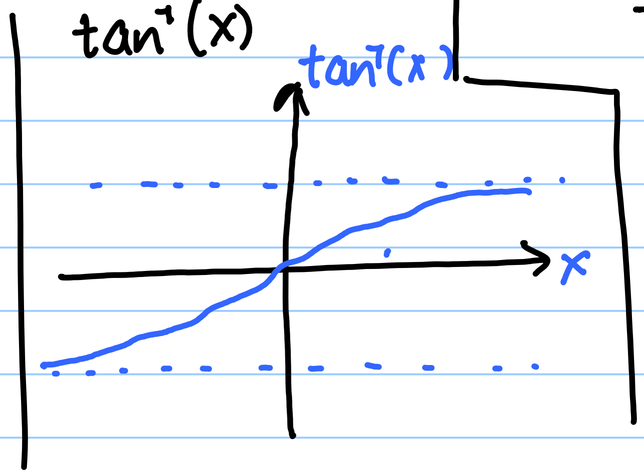
$$\measuredangle LG(\omega_{osc}) = 2k\pi = k \times 360^\circ$$

$$\measuredangle LG = -180^\circ - \tan^{-1}\left(\frac{\omega}{\omega_p}\right)$$

$$|LG(\omega)| = 1 = \frac{A_0}{\sqrt{1+(\omega/\omega_p)^2}}$$

$$LG(s) = \frac{A_0^2}{(1+s/\omega_p)^2}$$

$$\measuredangle LG = -2\tan^{-1}\left(\frac{\omega}{\omega_p}\right)$$

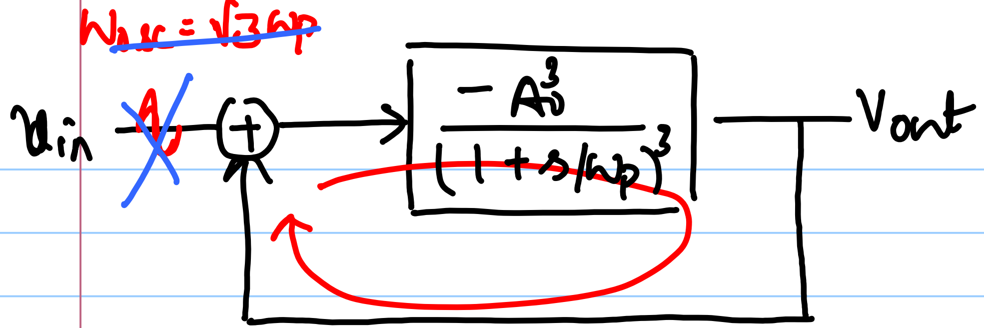


$$|LG(j\omega_{osc})| = 1$$

$$\frac{A_0^3}{\left|1+j\frac{\sqrt{3}\,\omega_p}{\omega_p}\right|^3} = 1$$

$$\frac{A_0^3}{2^3} = 1$$

$$\Rightarrow \boxed{A_0 = 2}$$



$$\frac{V_{out}}{V_{in}} = \frac{A(s)}{1 - A(s)} = \frac{-A_0^3 / \left((1+s/\omega_p)^3\right)}{1 + \frac{A_0^3}{(1+s/\omega_p)^3}}$$

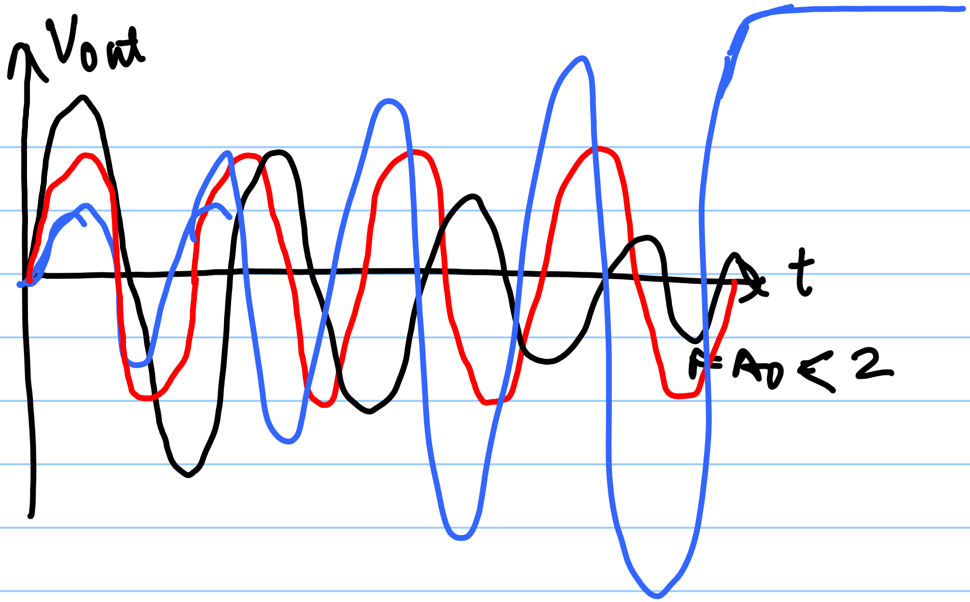
$$\left(1 + \frac{s}{\omega_p}\right)^3 + A_0^3 = 0$$

$$\left(1 + \frac{s}{\omega_p}\right)^3 = \underset{\sim}{(-1)}\, A_0^3 = \left(e^{j\pi k}\right) A_0^3$$

$$\frac{s}{\omega_p} = \left(e^{jk\pi/3} A_0 - 1\right)$$

$$s_{1,2,3} = \underbrace{\omega_p(-1 - A_0)}\ ;\ \omega_p \underbrace{\left(-1 + A_0 e^{\pm j60^\circ}\right)}$$

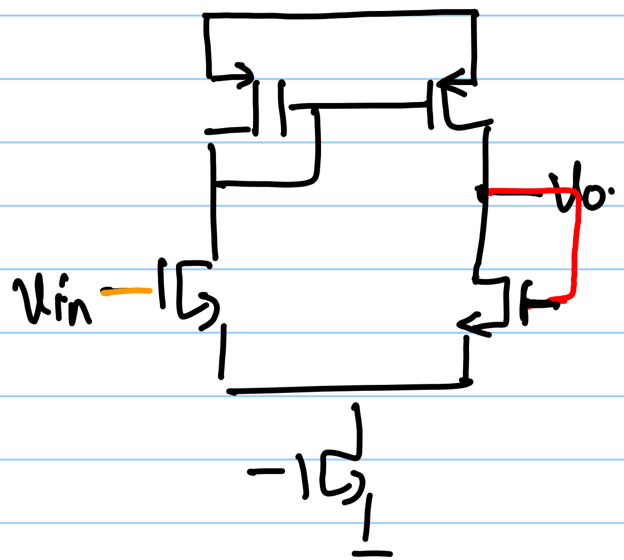
$$\Downarrow$$

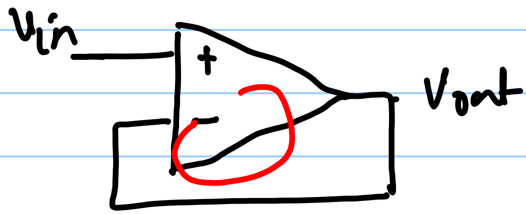


$$\omega_p\left(-1+2\left(\cos 60^\circ \pm j\sin 60^\circ\right)\right)$$

$$\omega_p\left(-1+2\left(\frac{1}{2} \pm j\frac{\sqrt{3}}{2}\right)\right)$$

$$\omega_p\left(\pm j\sqrt{3}\right)$$





Oscillator Parameters:

- Amplitude } - Stability.
- frequency }
- Noise ✓
- Power ✓
- Controllability
- PSRR

$$W_{osc} = \sqrt{3}\,\omega_p = \frac{\sqrt{3}}{R_0 C_L}$$

Performance Metrics

- ✓ Tuning range
  - Bring osc. back to single freq. during PVT variations.
  - Vary the freq. of osc. depending on appl.

$\Delta f = 5x$.

- ✓ Tuning Linearity. $\boxed{\frac{\Delta F}{\Delta Ctrl} = \text{linear}}$ ✓
- ✓ Lowest noise with minimum power.
- PSRR