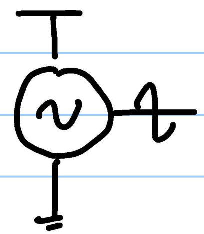
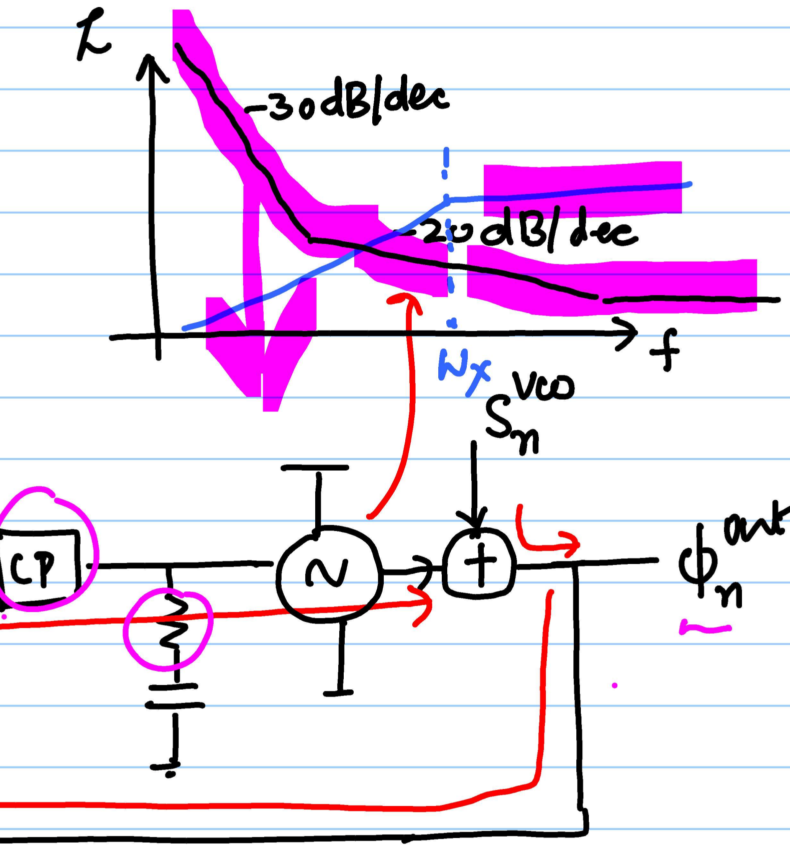
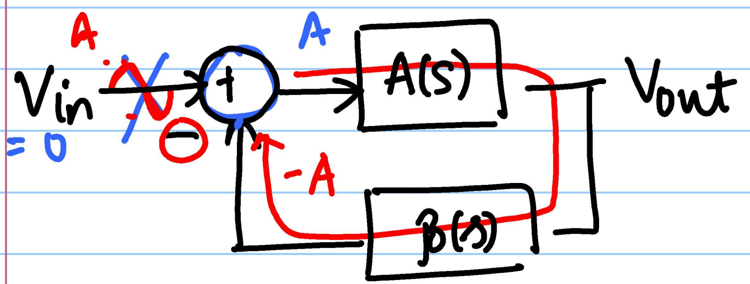
Lecture # 20

Oscillator





Feedback System



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

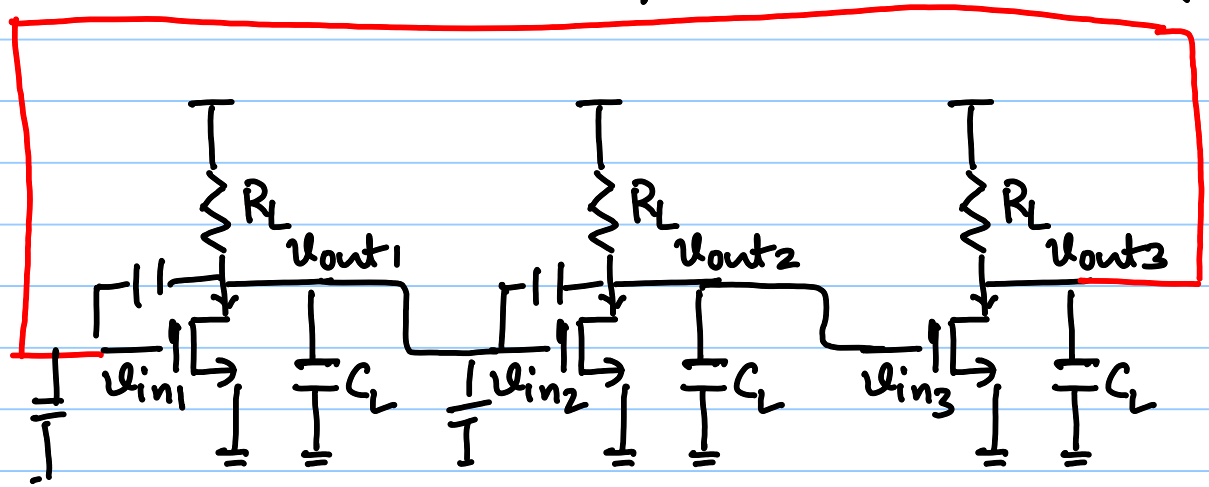
$$H(s) = \frac{V_{out}}{V_{in}} = \frac{A(s)}{1+\beta(s)A(s)} \rightarrow 0$$

$$H(s) = \frac{A(s)}{1+\beta(s)\cdot A(s)}$$

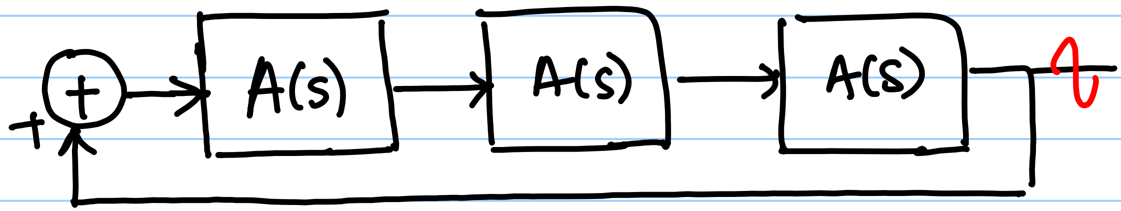
Barkhausen Crit: $\left|\beta(s)\,A(s)\right|_{\underline{s=j\omega_{osc}}} = 1$

$$\measuredangle\, \beta(s)\,A(s)\Big|_{s=j\omega_{osc}} = (2k+1)\pi$$

System will have sustained osc. at ω_{osc}.



$$A(s) = \frac{v_{out}}{v_{in}} = \frac{-1}{1+sC_LR_L} \times g_mR_L = \frac{-A_0}{1+s/\omega_p}$$



$$LG = (A(s))^3 = \frac{-A_0^3}{(1+s/\omega_p)^3}$$

$$|LG(j\omega_{osc})| = 1 \quad \checkmark \quad \Rightarrow \frac{A_0^3}{\left(\sqrt{1+\left(\frac{\omega_{osc}}{\omega_p}\right)^2}\right)^3} = 1$$

$$\measuredangle LG(j\omega_{osc}) = 2k\pi \quad \checkmark$$

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

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

$$\tan^{-1}\left(\frac{\omega_{osc}}{\omega_p}\right) = 60^\circ$$

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

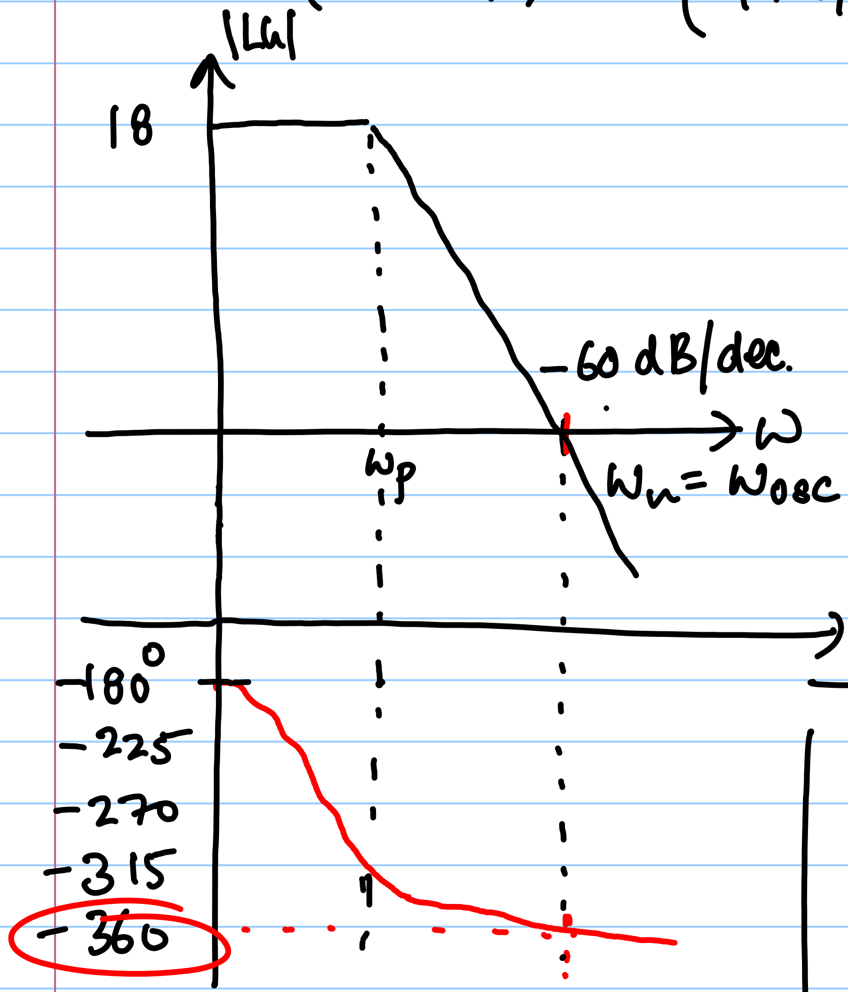
$$\boxed{A_0 = 2}$$

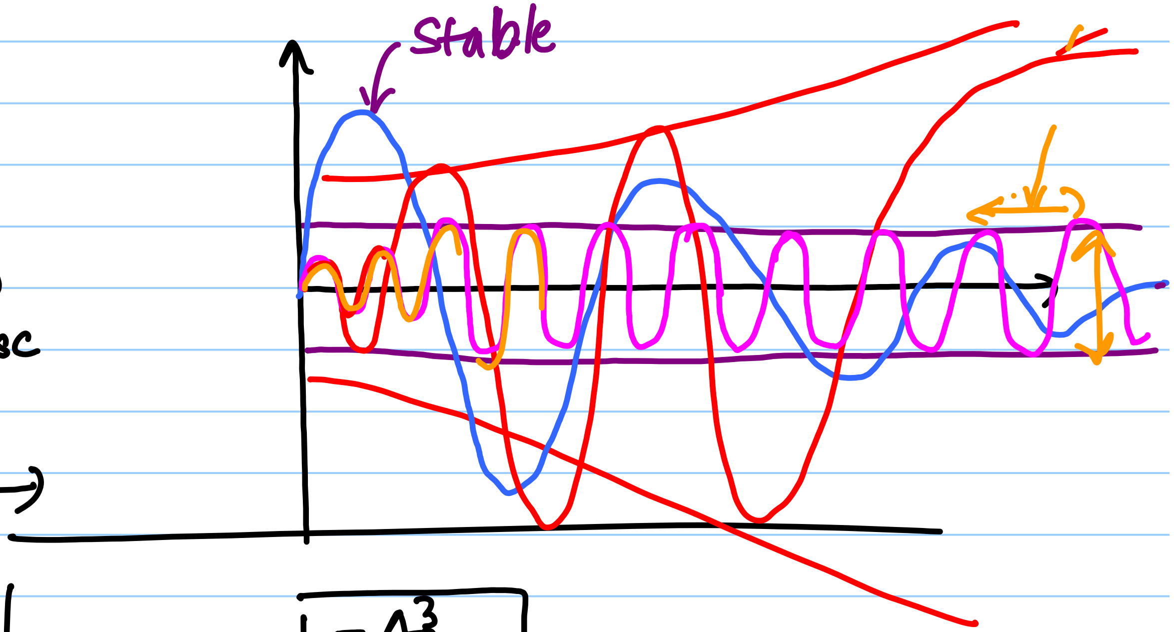
$$\frac{\omega_{osc}}{\omega_p} = \sqrt{3}$$

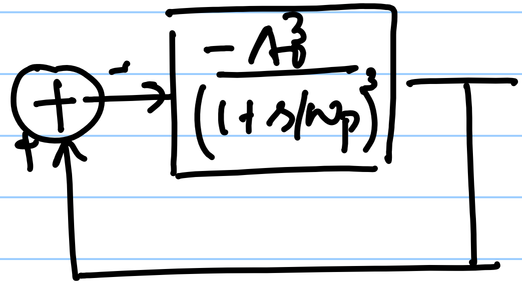
$$\omega_{osc} = \underline{\sqrt{3}\,\omega_p}$$

$$LG = \frac{-A_0^3}{(1+s/\omega_p)^3} = \frac{-8}{(1+s/\omega_p)^3}$$

$$|LG| = \frac{-A_0^3}{\left|1+j\frac{\omega_n}{\omega_p}\right|^3}$$







$$H(s) = \frac{A(s)}{1+A(s)}$$

$$H(s) = \frac{-A_0^3 / (1+s/\omega_p)^3}{1 - \dfrac{(-A_0^3)}{(1+s/\omega_p)^3}}$$

$$= \frac{-A_0^3}{A_0^3 + (1+s/\omega_p)^3}$$

Poles: $A_0^3 + (1+s/\omega_p)^3 = 0$

$$(1+s/\omega_p)^3 = (-1)\, A_0^3$$

$$(1+s/\omega_p) = (-1)^{1/3} A_0$$

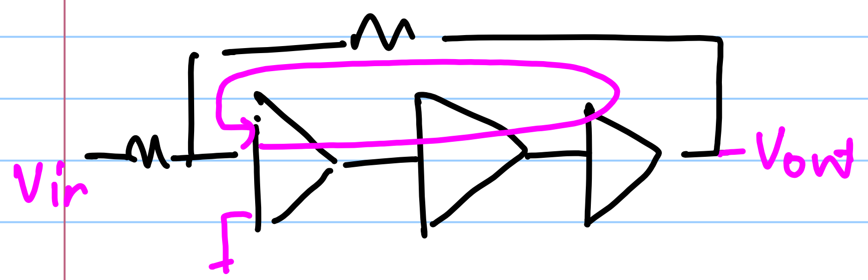
$$(-1)^{1/3} = \left(e^{jm\pi}\right)^{1/3}, m = 1,2,3$$

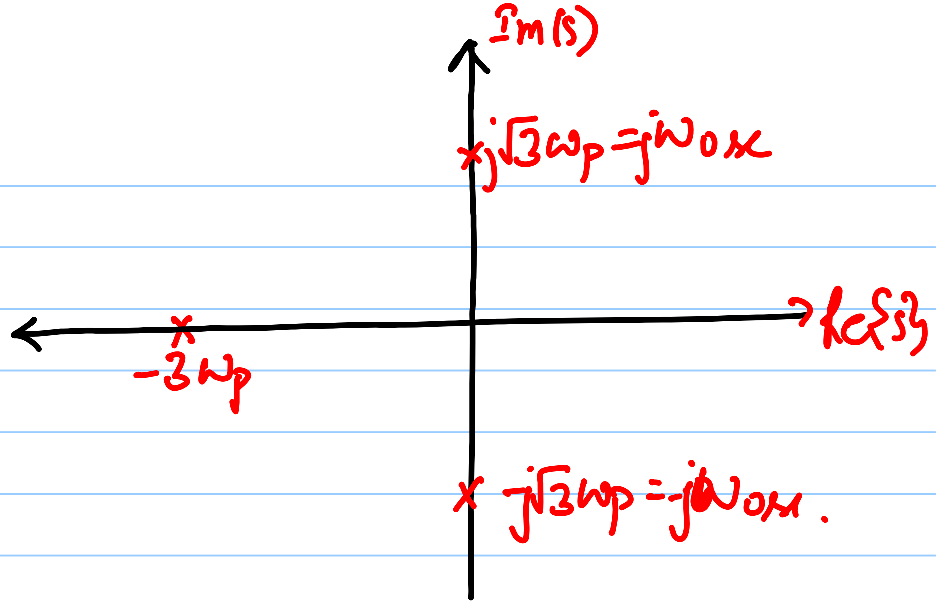
$$s_{1,2,3} = \omega_p(-1 - A_0)$$

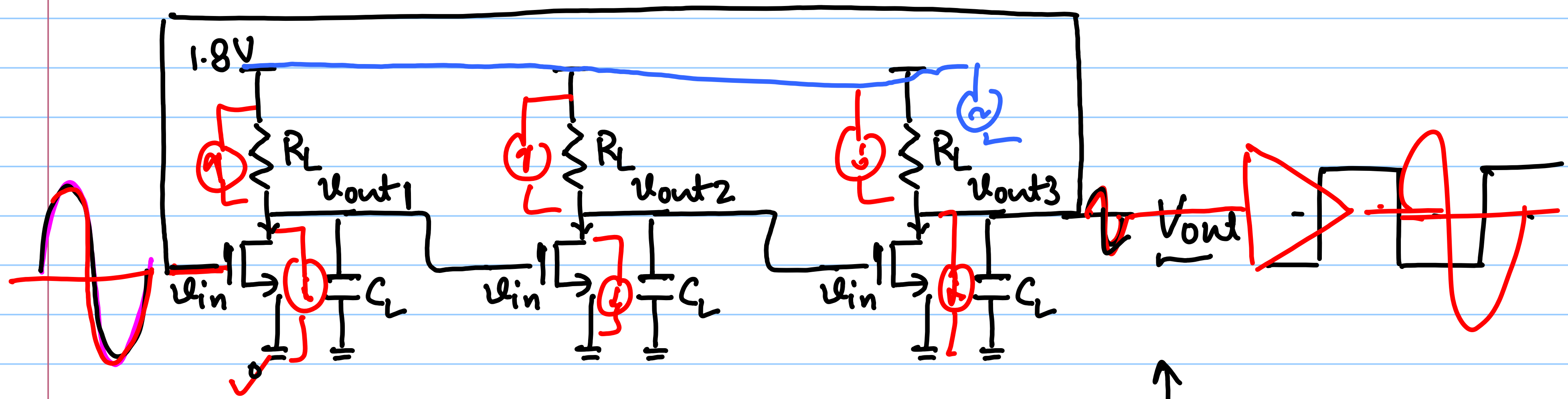
$$\omega_p\left(-1 + A_0 e^{\pm j60^\circ}\right)$$

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

$= -3\omega_p,\ j\omega_p(\pm\sqrt{3})$



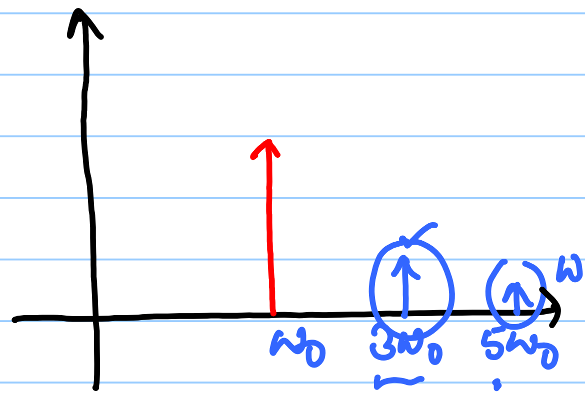




- Linearity : frequency
- Frequency stability / Spectrum.
- Amplitude of o/p freq.

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

$= \dfrac{\sqrt{3}}{R_L C_L}$



- Power supply/substrate noise.
- Phase Noise of oscillator.
- Controllability.

$f_{VCO} = K_{VCO} \cdot (V_c)$

i_c

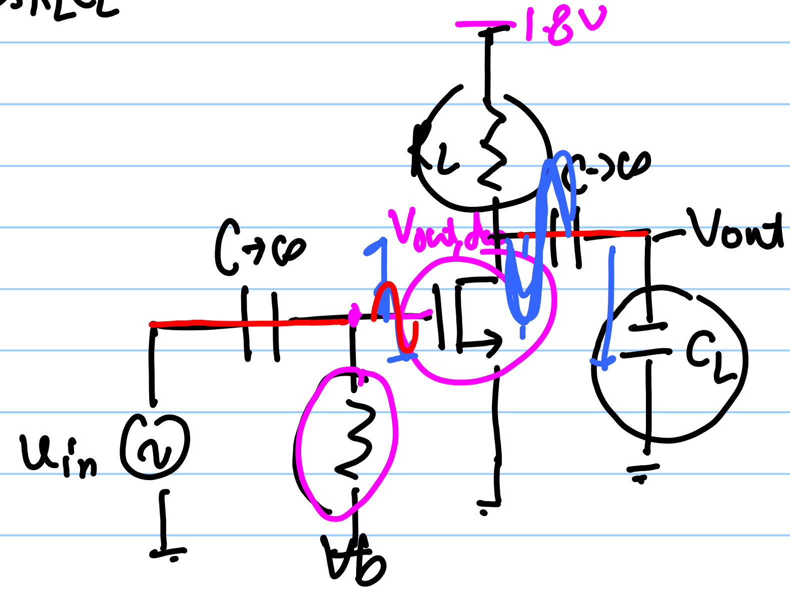
$f_{VCO} = K(R_L, C_L)$

Amplitude

For each stage. Gain $= \dfrac{-g_m R_L}{1 + sR_L C_L}$

frequency

$\omega_{osc} = \dfrac{\sqrt{3}}{R_L C_L} = \dfrac{\sqrt{3}}{(R_L \| R_o) C_L}$

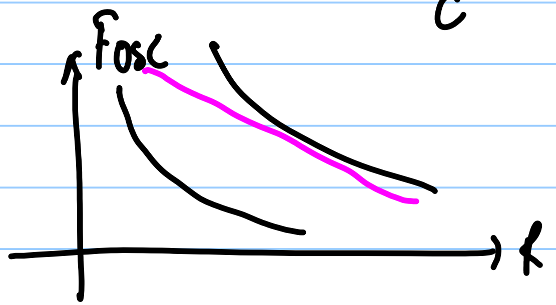


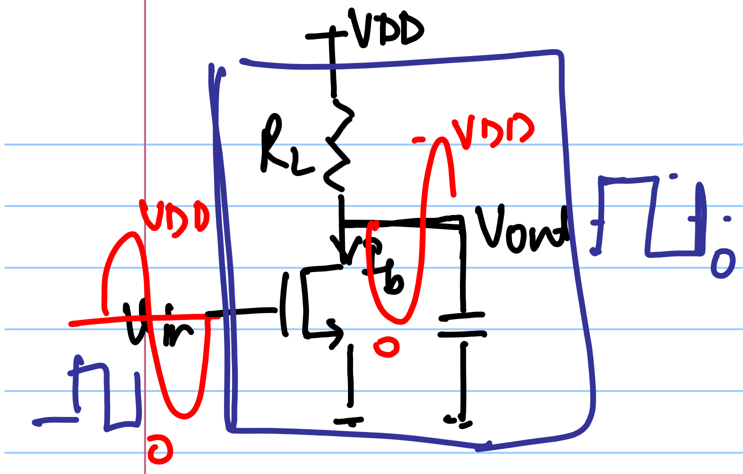
$V_{GS} - V_{th} \le V_{DS}$

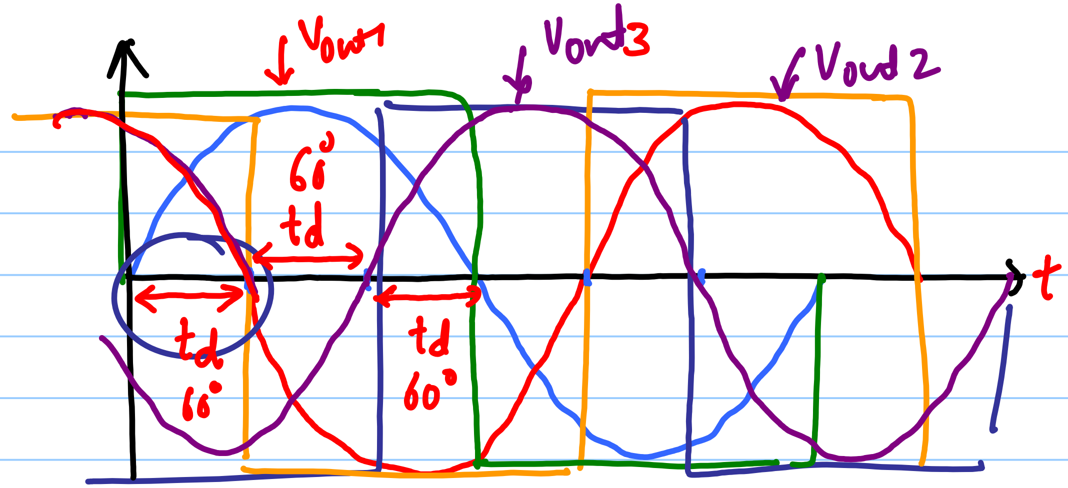
PVT variations $\begin{cases} R_L' : \\ C_L' : \\ R_o' : \end{cases}$

$\omega_{osc} \propto \dfrac{1}{R}$

$\propto \dfrac{1}{C}$







$0 \leq V_{out} \leq VDD$

$$\frac{-A_0}{1+s/\omega_p} = \frac{-2}{\left(1+j\frac{\sqrt{3}\omega_p}{\omega_p}\right)}$$

$$\left|\quad\right| = 1$$

$$\angle(\quad) = -180^\circ - 60^\circ$$