Lecture 23

Wednesday, February 22, 2017 8:01 AM

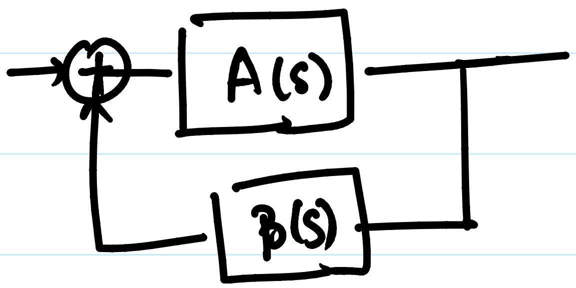
Oscillators.

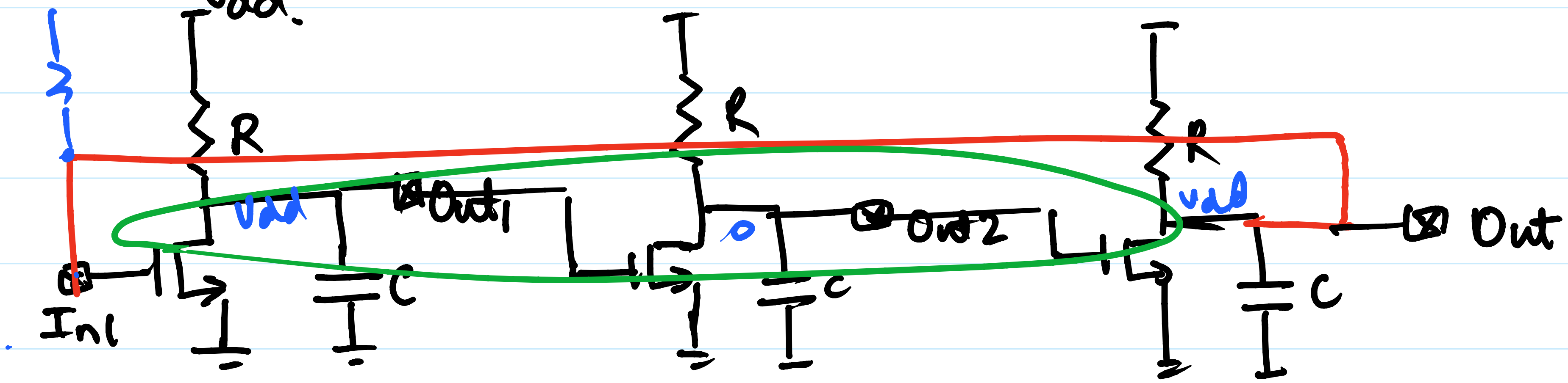
Feedback Analysis:

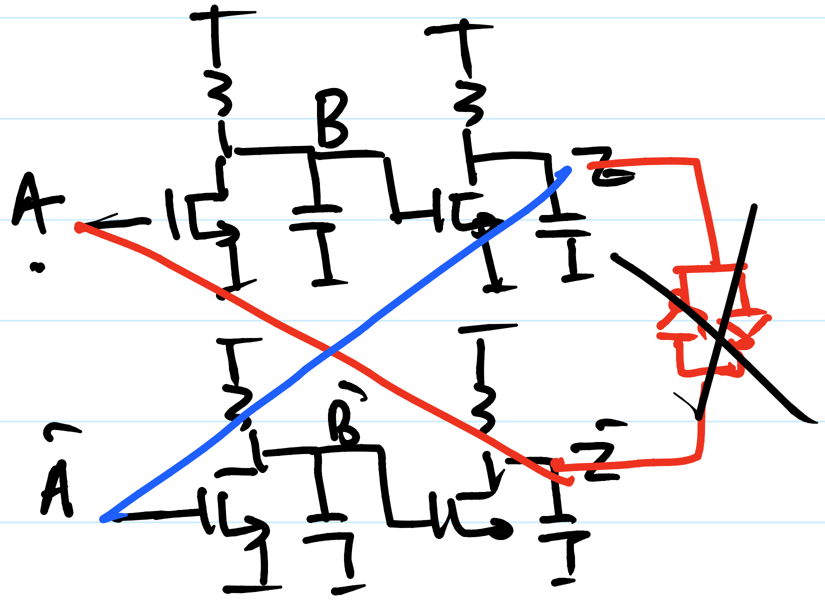
Barkhausen Criterion —

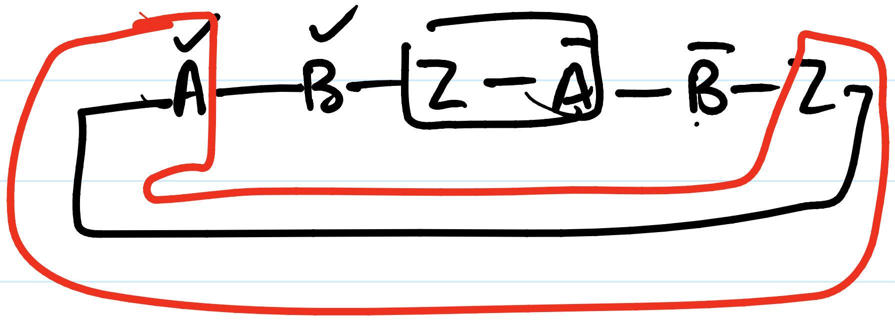
$$|A(j\omega_0)\beta(j\omega_0)| = 1$$

$$\angle(A(j\omega_0)\beta(j\omega_0)) = 2k\pi, \quad k = 0, \pm 1 \ldots$$







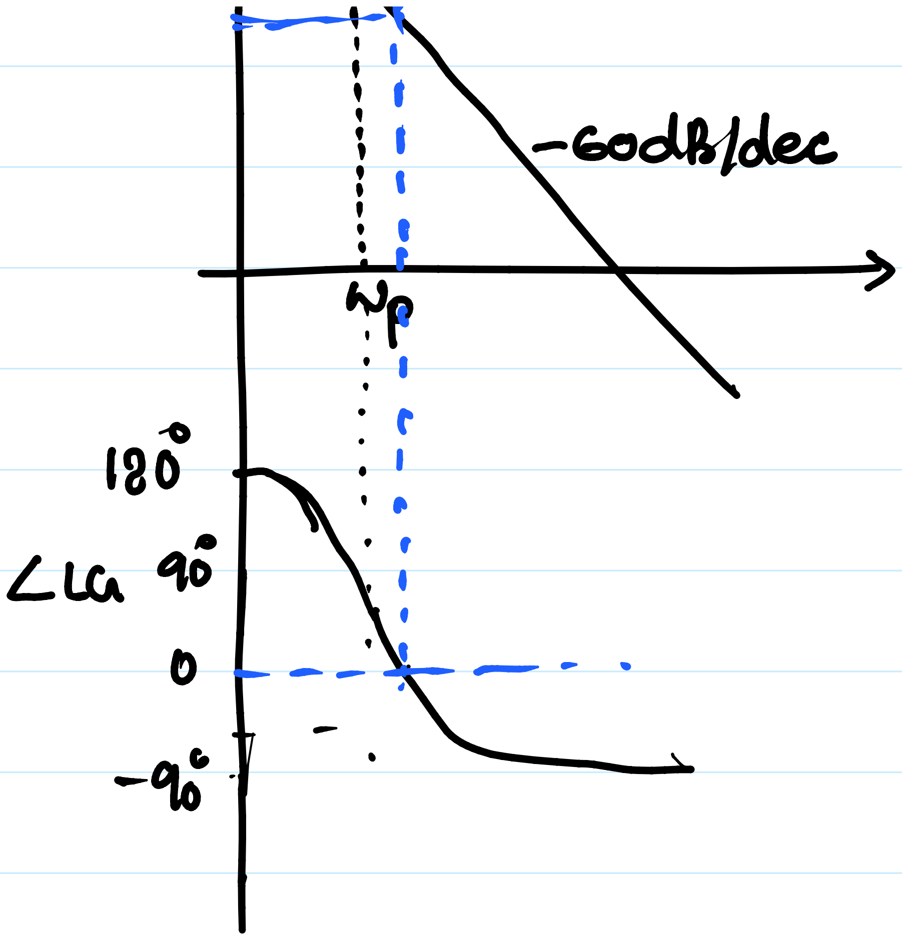


$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{-A_0}{1+s/\omega_p} \quad ; \quad A_0 \approx g_m R, \quad \omega_p = \frac{1}{RC}$$

$$LG = \left(\frac{-A_0}{1+s/\omega_p}\right)^3 \quad ;$$

$$\angle LG = 180^\circ - 3\tan^{-1}\left(\frac{\omega_0}{\omega_p}\right) = 2k\pi$$

$$0 = 180^\circ - 3\tan^{-1}\left(\frac{\omega_0}{\right.}$$



$$0 = 180^\circ - 3\tan^{-1}\left(\frac{\omega_o}{\omega_p}\right)$$

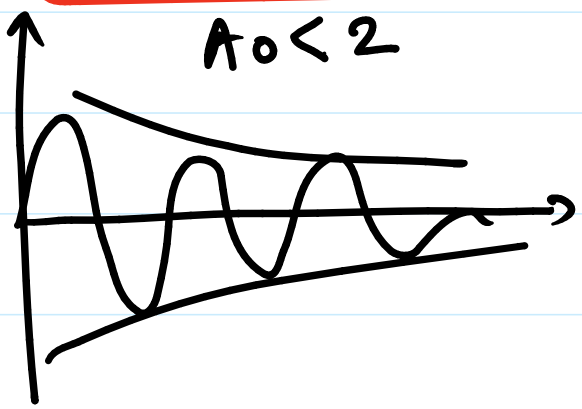
$$\omega_o = \omega_p \tan(60^\circ) = \sqrt{3}$$

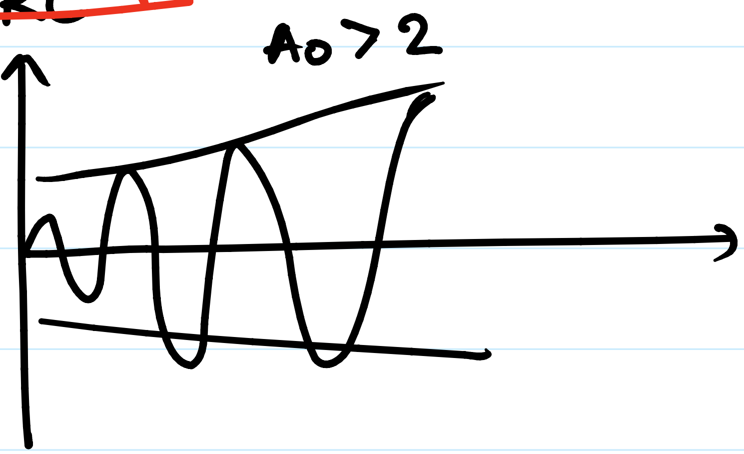
$$\boxed{\omega_o = \sqrt{3}\,\omega_p}$$

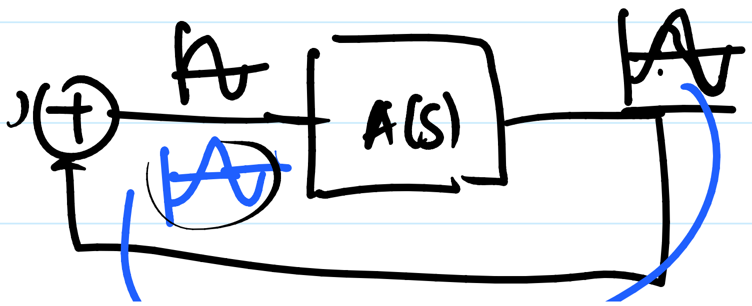
$$|LG(j\omega_o)| = \frac{A_o^3}{\left(\sqrt{1+\left(\frac{\omega_o}{\omega_p}\right)^2}\right)^3} = 1$$

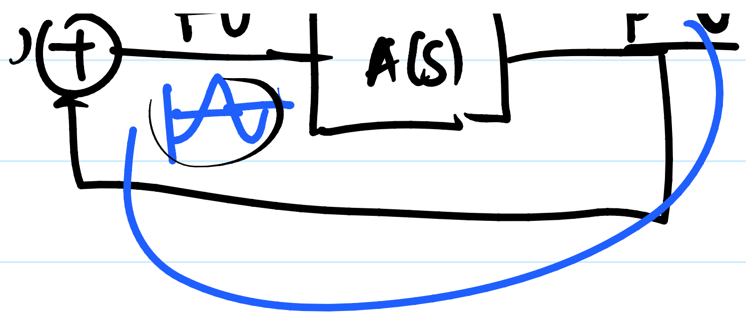
$$\frac{A_o^3}{2^3} = 1 \Rightarrow \boxed{A_o = 2}$$

$$\boxed{A_o = 2, \quad \omega_o = \sqrt{3}\,\omega_p = \frac{\sqrt{3}}{RC}}$$









$$LG = \left[\frac{-A_0^3}{(1+s/\omega_p)^3}\right]$$

closed loop gain, $$LG_{cl}(s) = \frac{(-A_0)^3/(1+s/\omega_p)^3}{1 - \dfrac{(-A_0)^3}{(1+s/\omega_p)^3}}$$

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

Closed loop poles :-

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

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

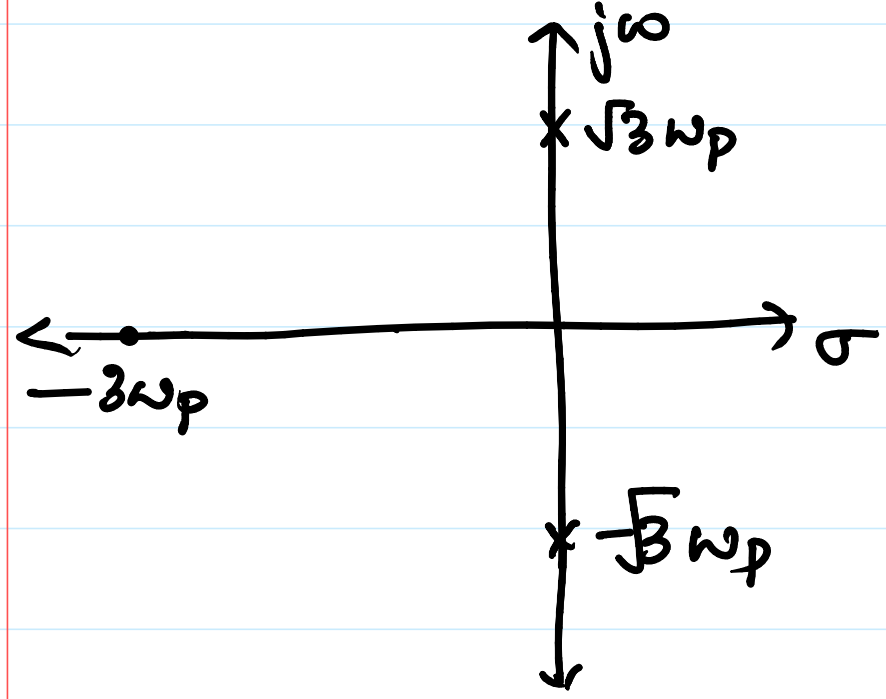
$$(s/\omega_p) = -1 + e^{j(\pi+2k\pi)/3}\cdot A_0 \quad ; \quad k = 0,1,2.$$

$$s = \left[-1 + 2\cdot e^{j(\pi/3 + 2k\pi/3)}\right]\omega_p$$

$$k=0, \quad \frac{s}{\omega_p} = -1 + 2 \cdot e^{j\pi/3} = -1 + 2\left(\frac{1}{2} + j\frac{\sqrt{3}}{2}\right)$$

$$-1 + 2\, e^{j\pi} \checkmark$$

$$-1 + 2 \cdot e^{-j\pi/3}$$



$$LG = \frac{A_0^4}{(1 + s/\omega_p)^4} \qquad \angle LG = -4\tan^{-1}\left(\frac{\omega}{\omega_p}\right)$$

Oscillators Parameters / Metrics.

Oscillators Parameters / Metrics.

1. Amplitude — limited swing / full scale

$$A = f(I_0, V_{dd})$$

2. Frequency — $\omega_{osc} = \sqrt{3}\,\omega_p = \dfrac{\sqrt{3}}{RC}$

Vary R & C → Vary freq.

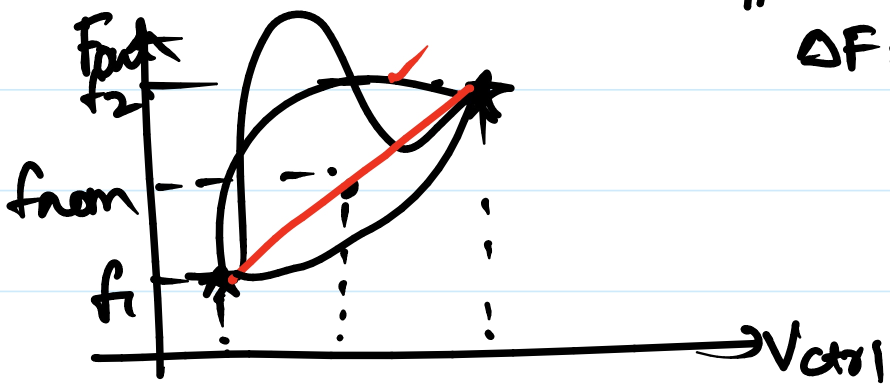
±20% ±30%

Frequency is susceptible to PVT variations

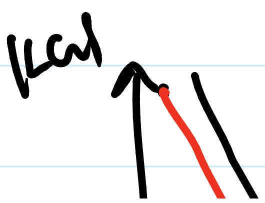
Tuning Range

- Variation in frequency around a nominal o/p freq. (ΔF)

$\Delta F = f_2 - f_1$

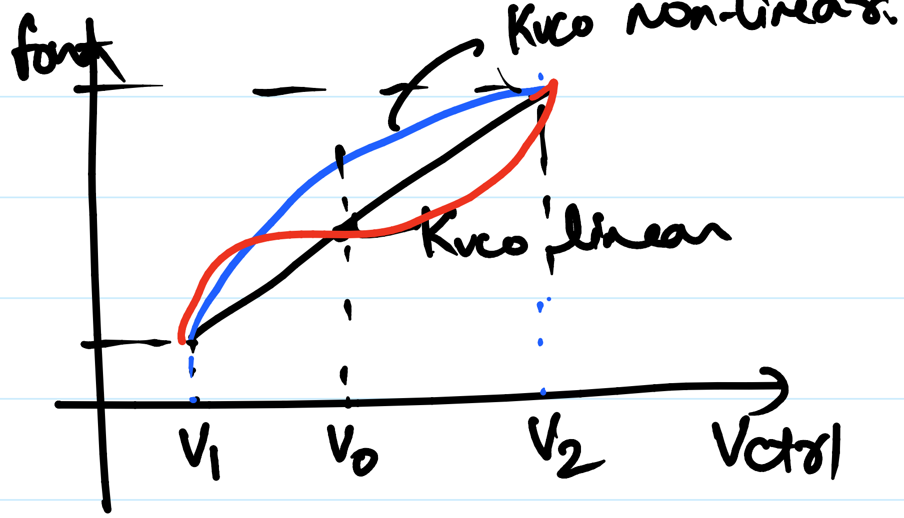


- Large tuning range



Tuning Linearity

- $\dfrac{\Delta F}{V_{ctrl}}$ = constant (ideal)



- $K_{vco} = \dfrac{\Delta F}{V_{ctrl}}$

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