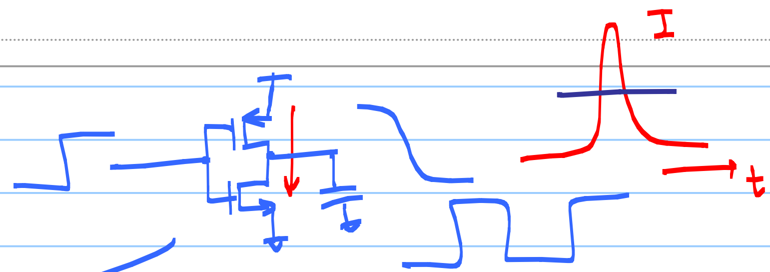
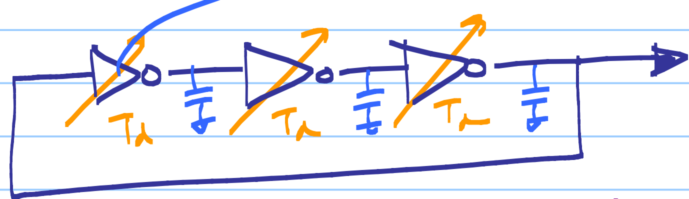
ECE 518 - Lecture 18

Note Title 3/21/2013



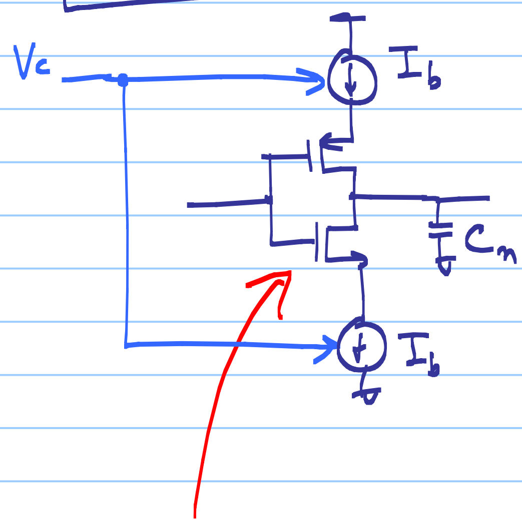
See Slides for VCO overview



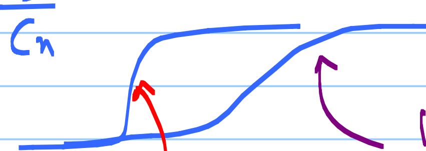
$f_{osc} \simeq \frac{1}{2N T_d}$

RC

current starved oscillator

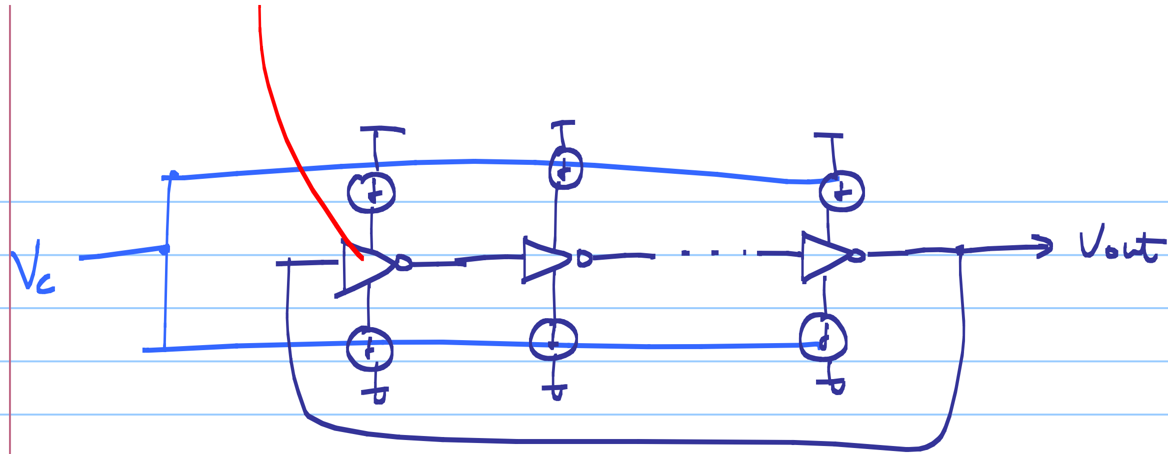


$\propto \frac{I_b}{C_n}$

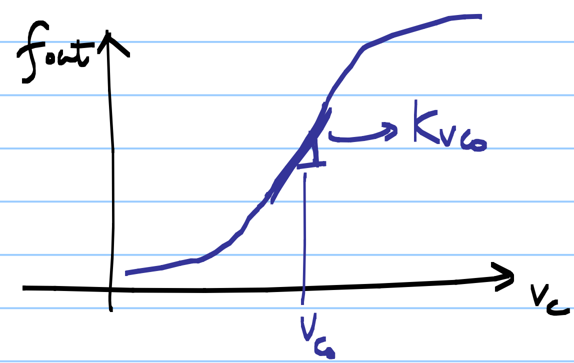


large bias current (less delay)

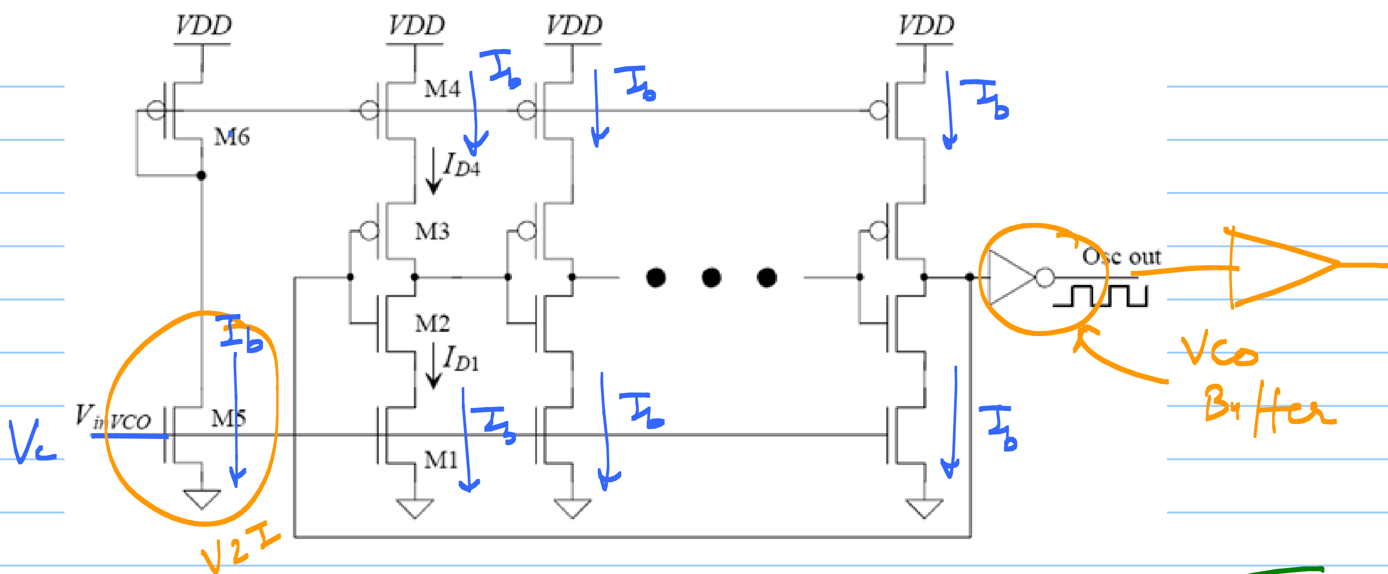
less current (more delay)



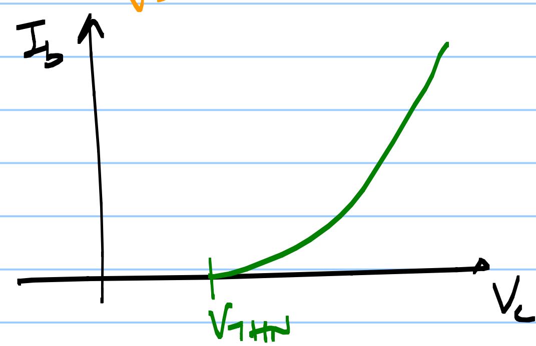
V_c
V_{out}



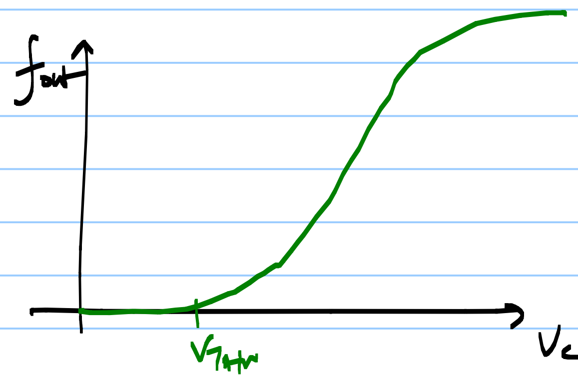
f_{out}
K_{vco}
v_c
V_{co}



VDD
VDD
VDD
VDD
M6
M4
M3
M2
M1
M5
I_{D4}
I_{D1}
$V_{in\,VCO}$
V_c
I_b
V2I
Osc out
VCO
Buffer



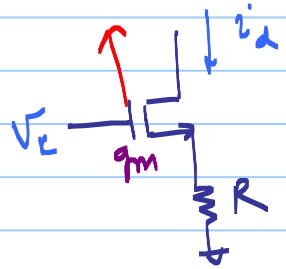
I_b
V_c
V_{THN}



f_{out}
V_c
V_{THN}

Spectre RF $\longrightarrow$ PSS $\longleftarrow$ periodic steady-state Analysis

Large device



Source degenerated CS stage

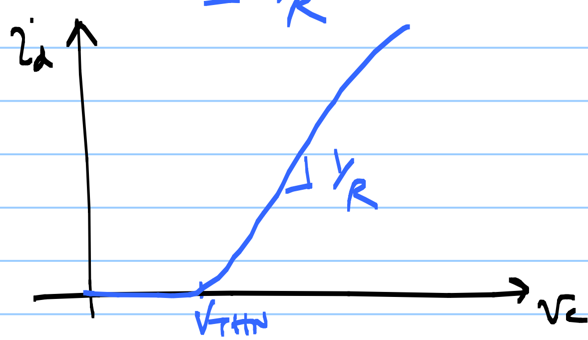
$$G = \frac{g_m}{1+g_m R} = \frac{1}{\frac{1}{g_m} + R} \cong \frac{1}{R}$$

for $g_m \gg \frac{1}{R}$

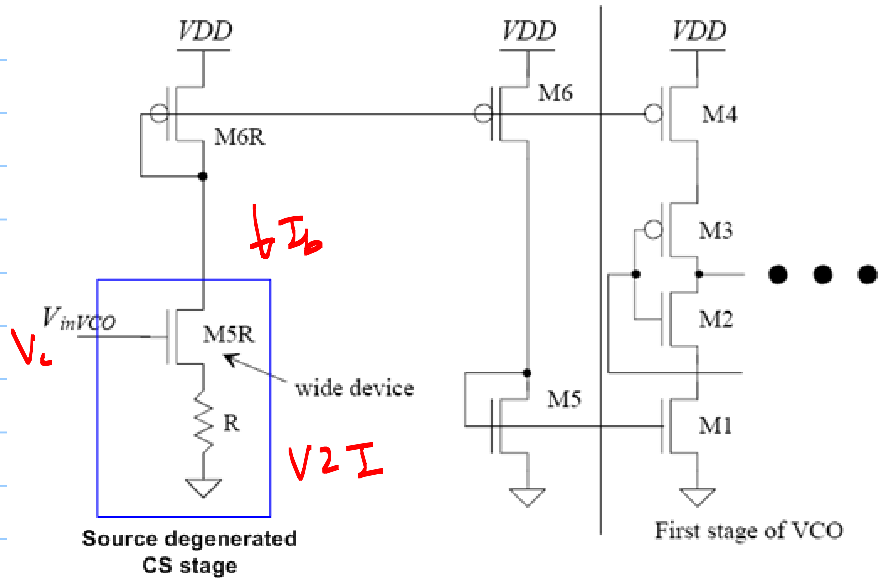
$\frac{1}{g_m} \ll R$

$i_d = G v_c$

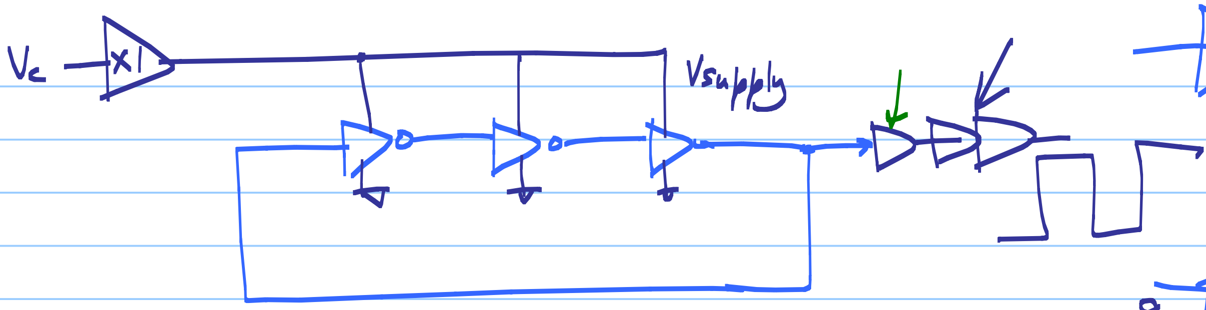
$$\boxed{i_d \cong \frac{v_c}{R}}$$

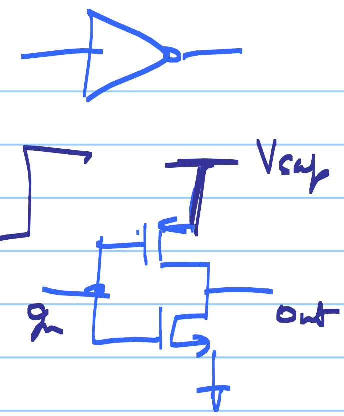


$\boxed{\text{CCO}}$



Supply regulated tuning



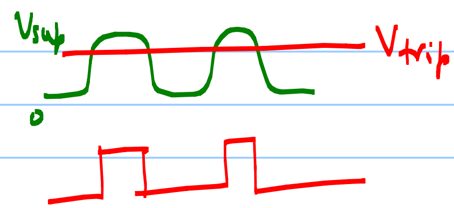


$V_{sup} \downarrow$

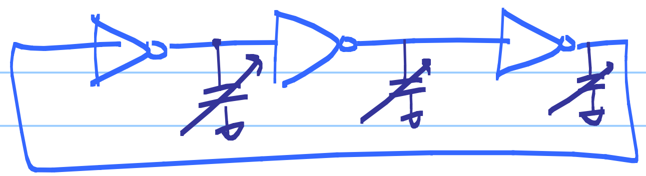
V_{DS} & V_{SD} $\downarrow$

$I_D \downarrow$

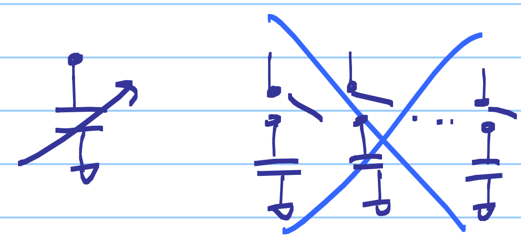
$T_d \uparrow$



* Duty cycle correction circuit

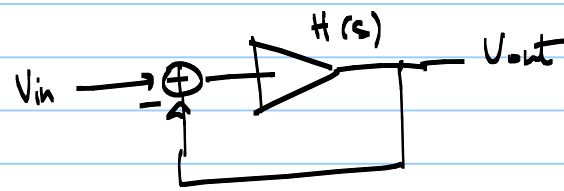


$$T_d = \sqrt{RC}$$



Oscillators Basics

$L(s) = H(s)$



$\Rightarrow$

$$|L(j\omega_{osc})| \geq 1$$

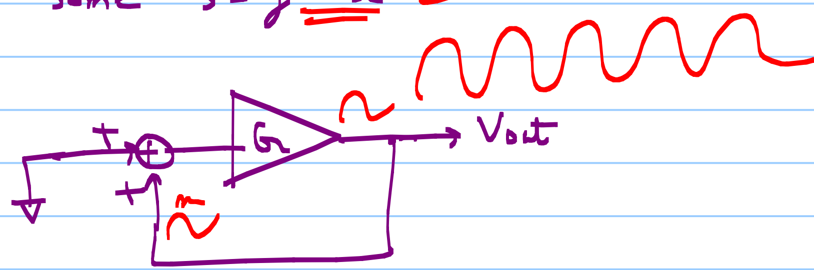
$$\angle L(j\omega_{osc}) = 180^\circ$$

Barkhausen Criterion

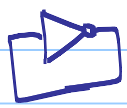
$$\frac{V_{out}}{V_{in}}(s) = \frac{H(s)}{1 + L(s)}$$

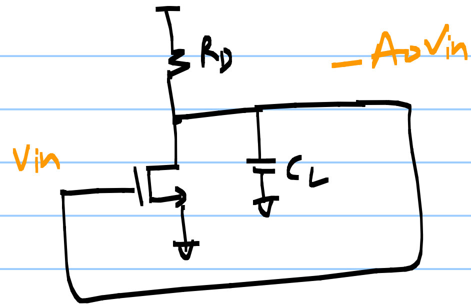
at some $s = j\omega_{osc}$

"necessary but not sufficient"



Ex. 1



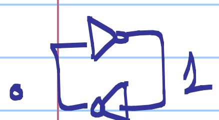


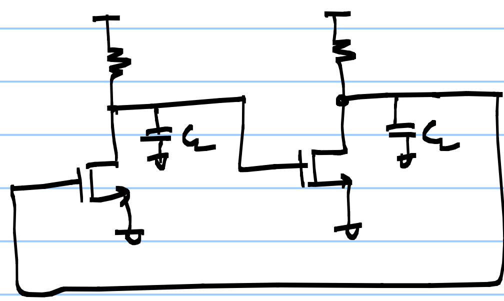
$$L(s) = \frac{-\overbrace{g_m R_D}^{A_0}}{(1 + s R_D C_L)}$$

excess phase $\Rightarrow$ 90° max

$$A_0 = g_m R_D$$
$$\omega_0 = \frac{1}{R_D C_L}$$

Ex. 2





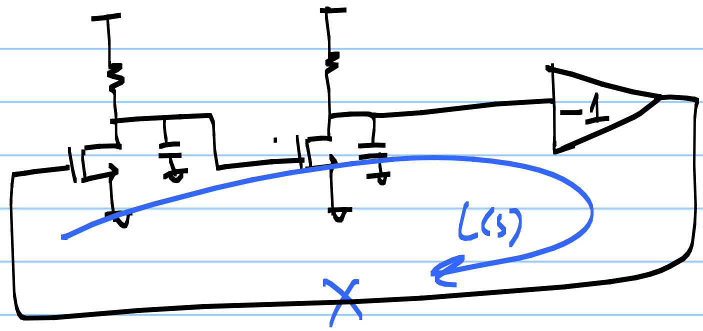
$$L(s) = \frac{A_0^2}{\left(1 + \frac{s}{\omega_0}\right)^2}$$

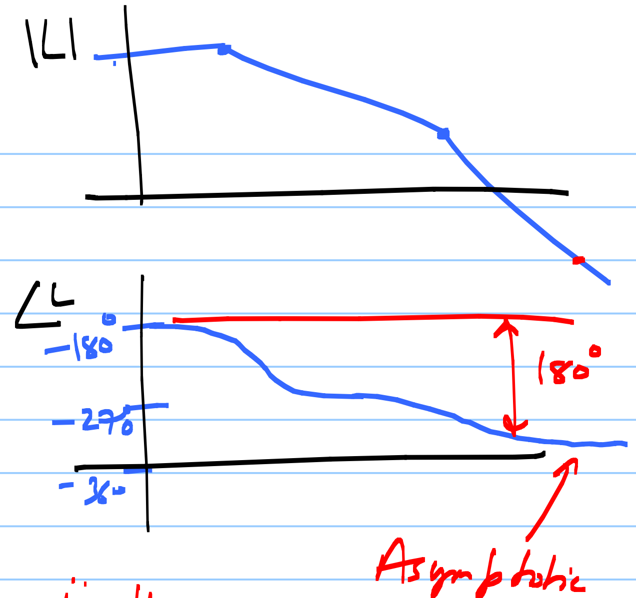
max phase shift $= 180^\circ$

+ve feedback at low frequencies.

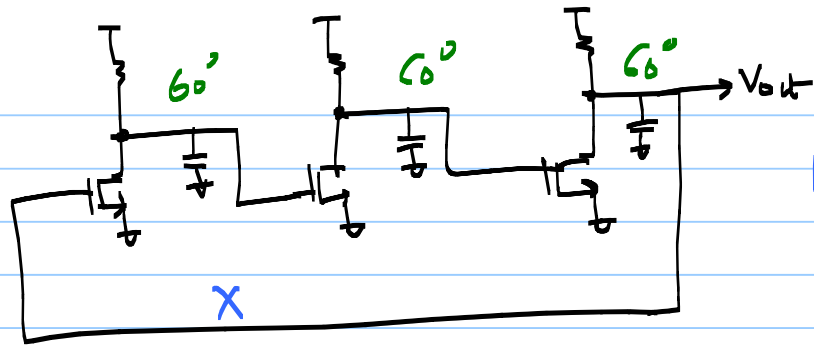
Latches in a state

Ex.:3

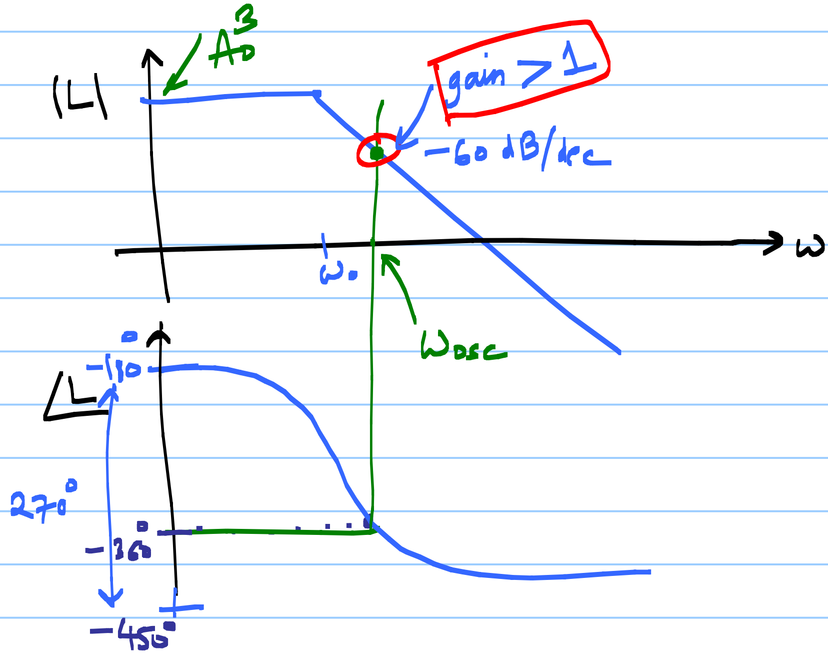




* doesn't meet the B.C.



$$L(s) = \frac{-A_0^3}{\left(1+\frac{s}{\omega_0}\right)^3}$$



excess phase shift

$\Delta\phi = 180°$ for 3 stages

→ 60° for each stage

$$\cancel{3}\tan^{-1}\left(\frac{\omega_{osc}}{\omega_o}\right) = 60^\circ \times \cancel{3}$$

$$\omega_{osc} = \omega_o \cdot \tan(60^\circ)$$

$$\boxed{\omega_{osc} = \omega_o\sqrt{3}}$$

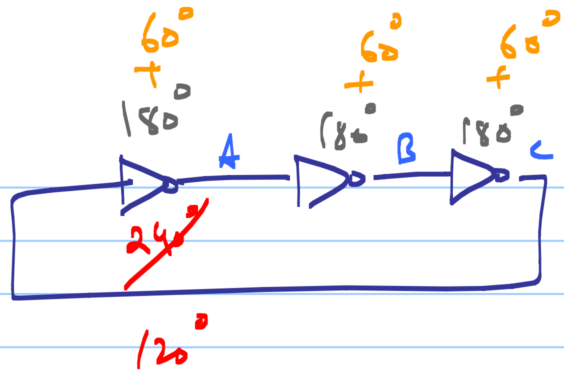
$$\Rightarrow \quad \left|L(j\omega)\right|_{\omega_{osc}} = 1$$

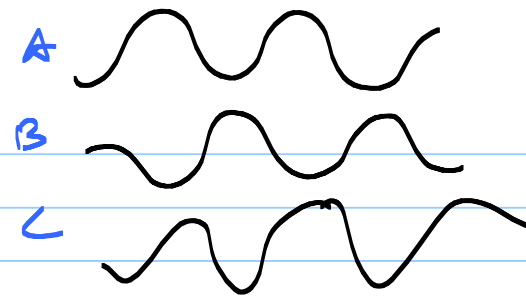
$$\Rightarrow \quad \frac{A_o^3}{\left(\sqrt{1+\left(\frac{\omega_{osc}}{\omega_o}\right)^2}\right)^3} = 1 \quad \Rightarrow \quad \boxed{A_o = 2}$$

$\omega_{osc} = \sqrt{3}\omega_o$

each stage gain $= 2$

total DC loop gain $= 8$





$$\left(\frac{360^\circ}{N}\right)$$

$$L(s) = \frac{-A_0^3}{\left(1+\frac{s}{\omega_0}\right)^3}$$

$$\frac{V_{out}}{V_{in}}(s) = \frac{H(s)}{1+L(s)}$$

closed-loop poles $\Rightarrow$ roots of $L(s)+1=0$

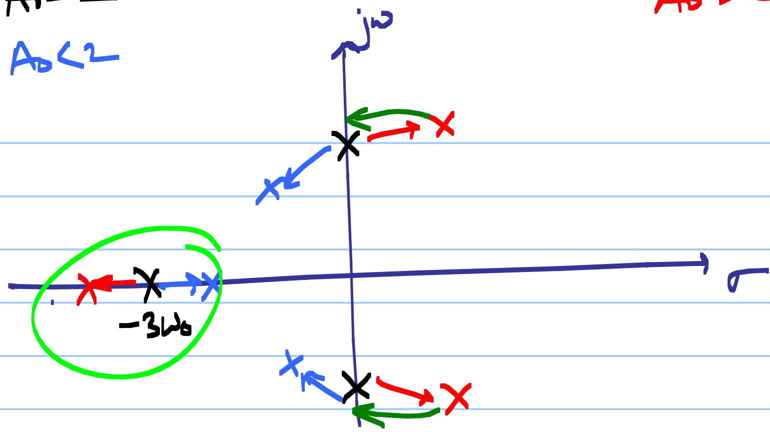
roots of $1 + \frac{A_0^3}{\left(1+\frac{s}{\omega_0}\right)^3} = 0$

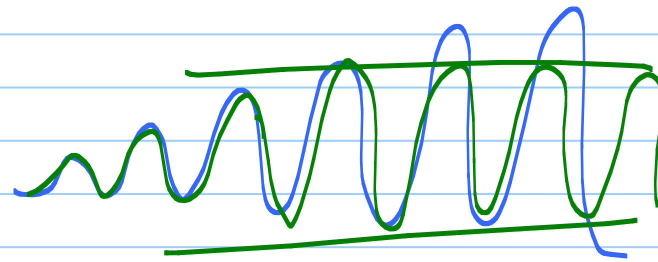
$$S_z = \begin{cases} -(A_0+1)\omega_0 \longrightarrow \underline{e^{-(A_0+1)\omega_0} \cdot u(t)} \text{ decays} \\ \left[\frac{A_0(1 \pm j\sqrt{3})}{2} - 1\right]\omega_0 \longrightarrow \text{conjugate poles for oscillation} \end{cases}$$

$A_0 = 2$

$A_0 < 2$

$A_0 > 2$





$$V_{out}(t) = a\, e^{\left(\frac{A_0 - 2}{2}\right)\omega_0 t} \cdot \cos\left(\frac{A_0\sqrt{3}}{2}\,\omega_0 t\right)$$