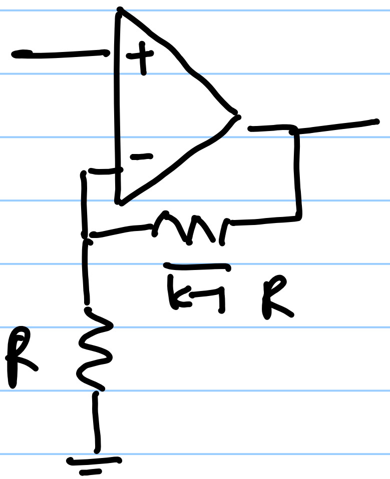
Note Title — 18-02-2022

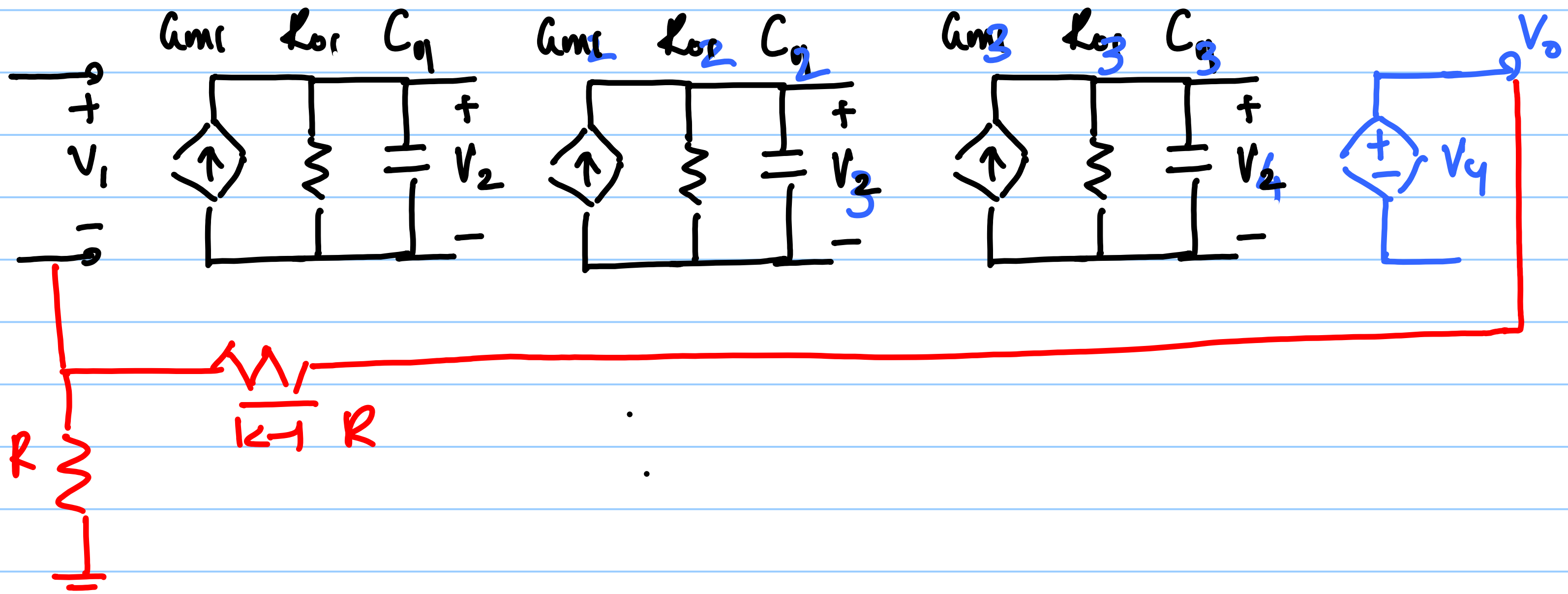
Lecture # 15

$$\measuredangle LG = -\tan^{-1}\left(\frac{\omega_n}{p_1}\right) \quad -\tan^{-1}\left(\frac{\omega_n}{p_2}\right)$$

$$LG = \frac{A_{oc} \checkmark}{\left(1+\frac{s}{p_1}\right)\left(1+s/p_2\right)}$$

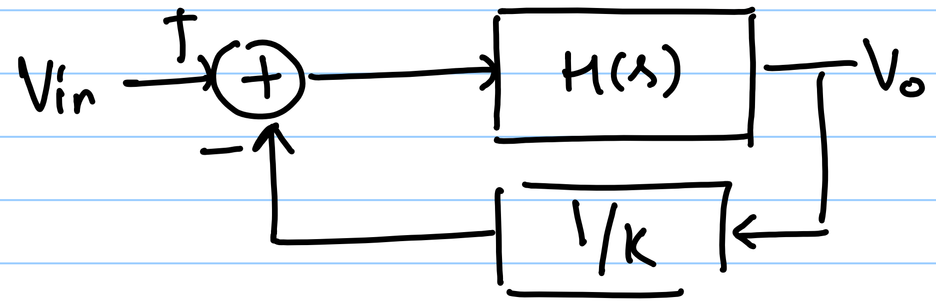
$$a+jb \xrightarrow{\angle} \tan^{-1}\left(\frac{b}{a}\right)$$





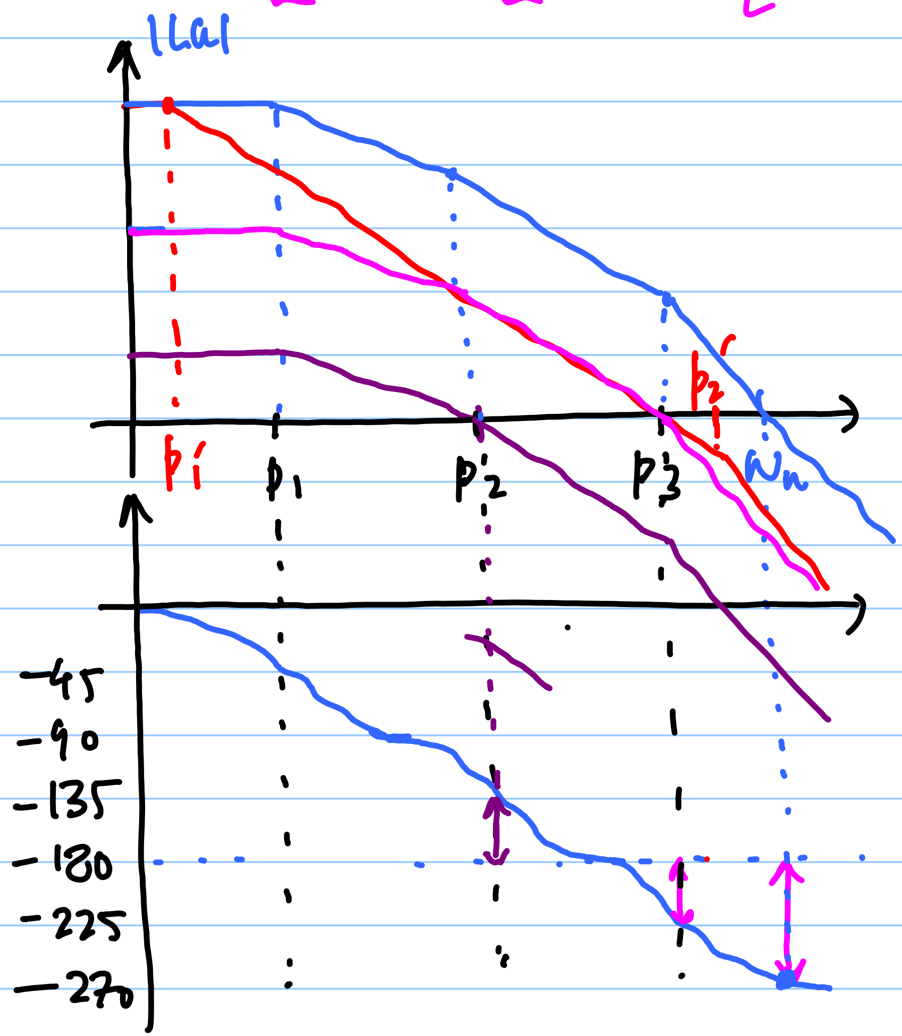
$$LG(s) = \frac{G_{m1}R_{o1}}{1+sR_{o1}C_{o1}} \, \frac{G_{m2}R_{o2}}{1+sR_{o2}C_{o2}} \, \frac{G_{m3}R_{o3}}{1+sR_{o3}C_{o3}} \times \frac{1}{K}$$

$$= \frac{A_{DC}/K}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\left(1+\frac{s}{p_3}\right)}$$



$$\frac{V_{out}}{V_{in}} = \frac{LG}{1+LG} \times K$$

$$LG = \frac{A_{oc}/K}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\left(1+\frac{s}{p_3}\right)}$$



Ex. $LG = \frac{A_{oc}/K}{\left(1+\frac{s}{p_1}\right)^3}$

$$= \frac{A_0}{\left(1+\frac{s}{p_1}\right)^3}$$

$$\frac{V_o}{V_i} = K \cdot \frac{LG}{1+LG} = \frac{K}{1+\frac{1}{LG}}$$

$$= \frac{K}{1+\frac{\left(1+\frac{s}{p_1}\right)^3}{A_0}}$$

$$1+\frac{1}{A_0}\left(1+\frac{s}{p_1}\right)^3 = 0$$

$$\left(1+\frac{s}{p_1}\right)^3 = -1 \times A_0$$

$$= e^{j(2m+1)\pi} \cdot A_0$$

$$1+\frac{s}{p_1} = e^{j(2m+1)\pi/3} \cdot A_0^{1/3}$$

$$s = p_1\left(-1 + A_0^{1/3}\, e^{j(2m+1)\pi/3}\right)$$

$m = 0, 1, 2$

$$s_1 = p_1\left(-1 + A_0^{1/3} e^{j\pi/3}\right) = p_1\left(\underbrace{-1 + A_0^{1/3}\left(\tfrac{1}{2}\right.}\left.+ j\tfrac{\sqrt{3}}{2}\right)\right)$$

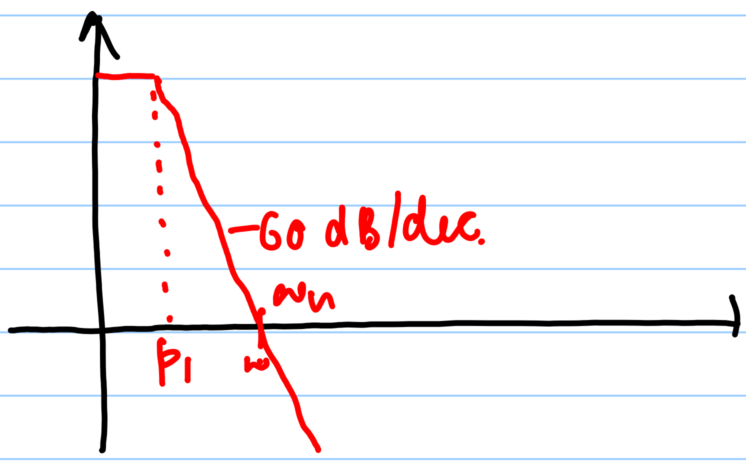
$$s_2 = p_1\left(-1 + A_0^{1/3} \cdot e^{j\pi}\right) = p_1\left(-1 - A_0^{1/3}\right) \checkmark \quad \text{L.H.P}$$

$$s_3 = p_1\left(-1 + A_0^{1/3} \cdot e^{j5\pi/3}\right) = p_1\left(\underbrace{-1 + A_0^{1/3}\left(\tfrac{+1}{2}\right.}\left.- j\tfrac{\sqrt{3}}{2}\right)\right)$$

s_1, s_3 will be in ~~the~~ R.H.P if $-1 + A_0^{1/3} \cdot \frac{1}{2} > 0$

$\Rightarrow A_0^{1/3} > 2$

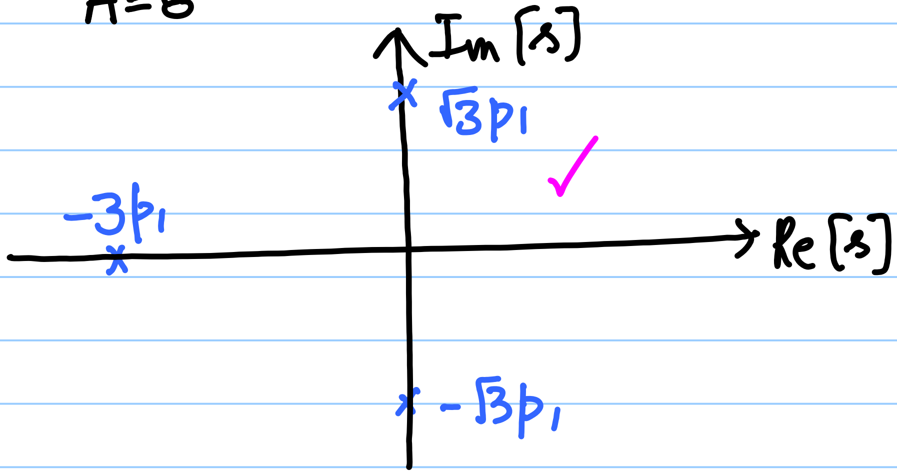
$$\boxed{\Rightarrow A_0 > 8}$$



$\measuredangle la$ -135°

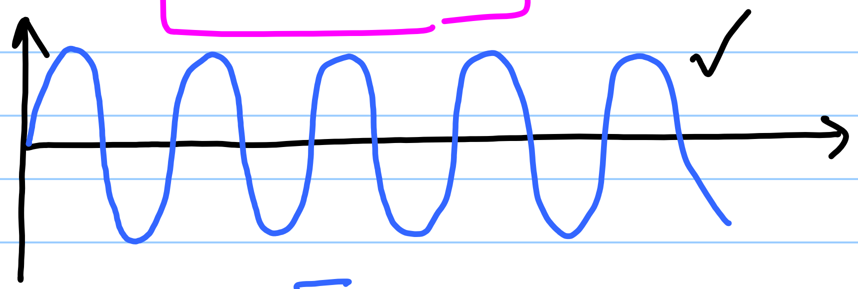
Third Order
- Can be stable
- Can be unstable.

$A = 8$

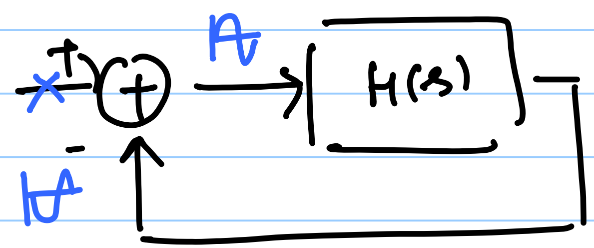


$$\frac{V_o}{V_i} = \frac{A_o}{\left(1+\frac{s}{3p_1}\right)\left(1+\frac{s}{j\sqrt{3}p_1}\right)\left(1+\frac{s}{-j\sqrt{3}p_1}\right)}$$

$\Rightarrow$ $\boxed{\text{Oscillator}}$



$\omega_{osc} = \sqrt{3}\,p_1$



Oscillator

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

$$\measuredangle LG(j\omega_{osc}) = 180^\circ$$

"Barkhausen Criterion"

First order System: Unconditionally stable

Second order system: Stable but undesired settling

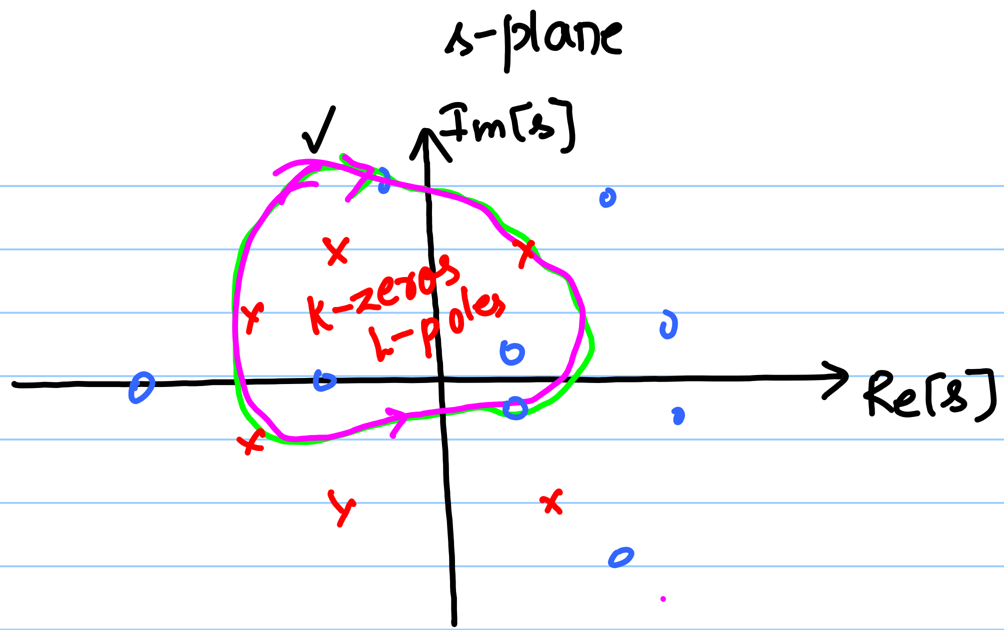
Third order system: Can be unstable.

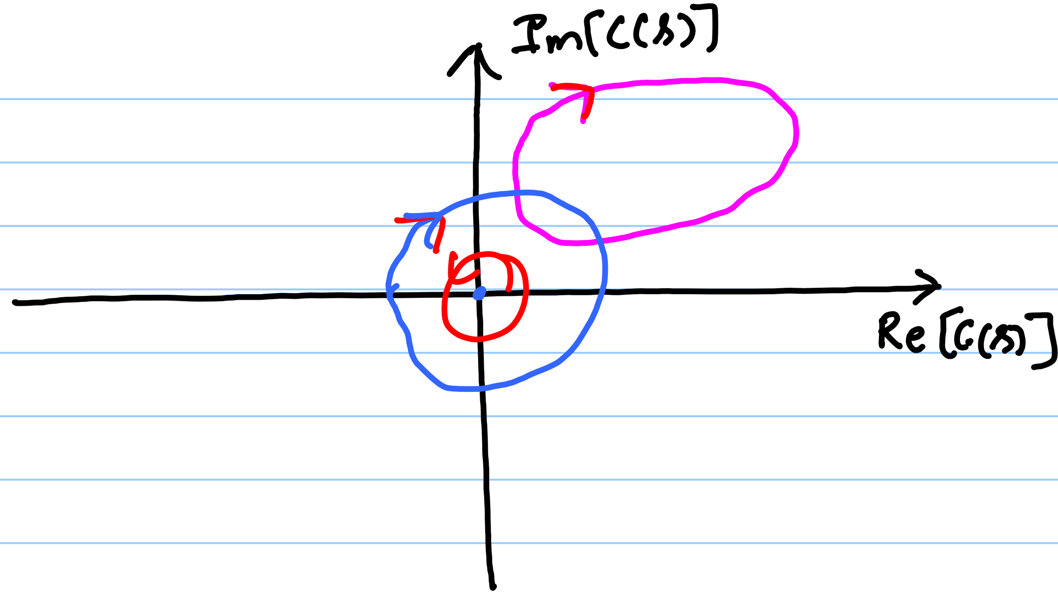
✓ $$LG(s) = \frac{(s-z_1)(s-z_2)\cdots(s-z_m)}{(s-p_1)(s-p_2)\cdots(s-p_n)}$$ ✓ $\boxed{n-m<2}$

1.) A system is unstable if it has poles in R.H.P. in closed-loop. ✓

$1 + LG(s) = 0$ finding roots is difficult.

"Nyquist Stability Criterian"





~~$C(s) = s+10$~~

$$C(s) = \frac{(s-z_1) \cdot \cdot (s-z_m)}{(s-p_1) \quad (s-p_n)}$$

- Contour in C(s) plane will encircle (0,0) K-L times.
- if K-L > 0, then encirclement is in clockwise direction
- if K-L < 0, anti-clockwise.