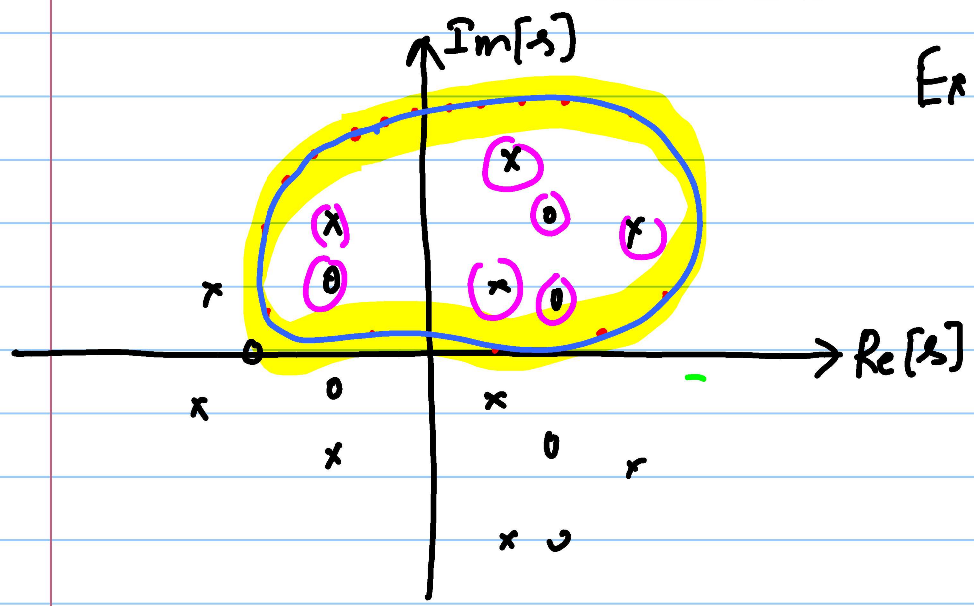
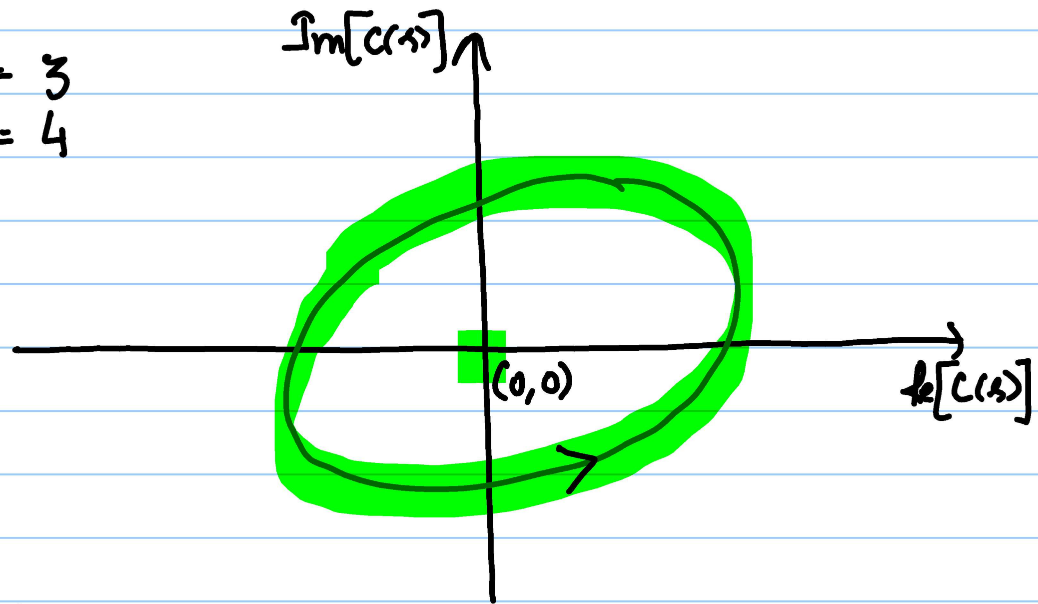
Note Title 22-02-2022

lecture # 16

Nyquist Stability Criterian.



Ex: $N = 3$
$M = 4$

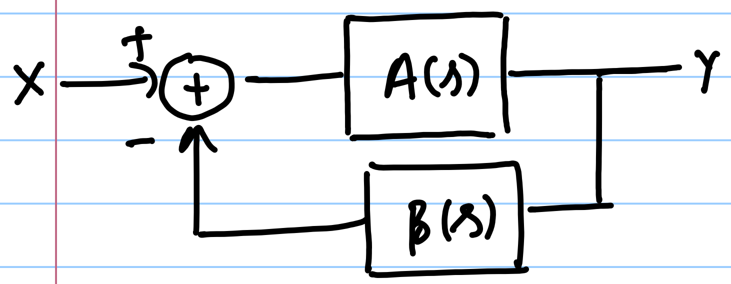


$$C(s) = \frac{(s-z_1)(s-z_2)\ \ldots\ (s-z_k)}{(s-p_1)(s-p_2)\ \ldots\ (s-p_L)}$$

K- zeroes
L- poles

I evaluate $C(s)$ at each point of the closeel contour.

- if N zeros and M poles inside the closed contour in s-plane then closed contour in $C(s)$-plane will encircle (0,0) N-M times.
- if $N > M$, it will encircle in clockwise, else anticlockwise for $N < M$



$$LG(s) = A(s)\,\beta(s) = \frac{N(s)}{D(s)}$$

$$\frac{Y}{X} = \frac{A(s)}{1+\beta(s)A(s)}$$ shouldn't have R.H.P poles

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

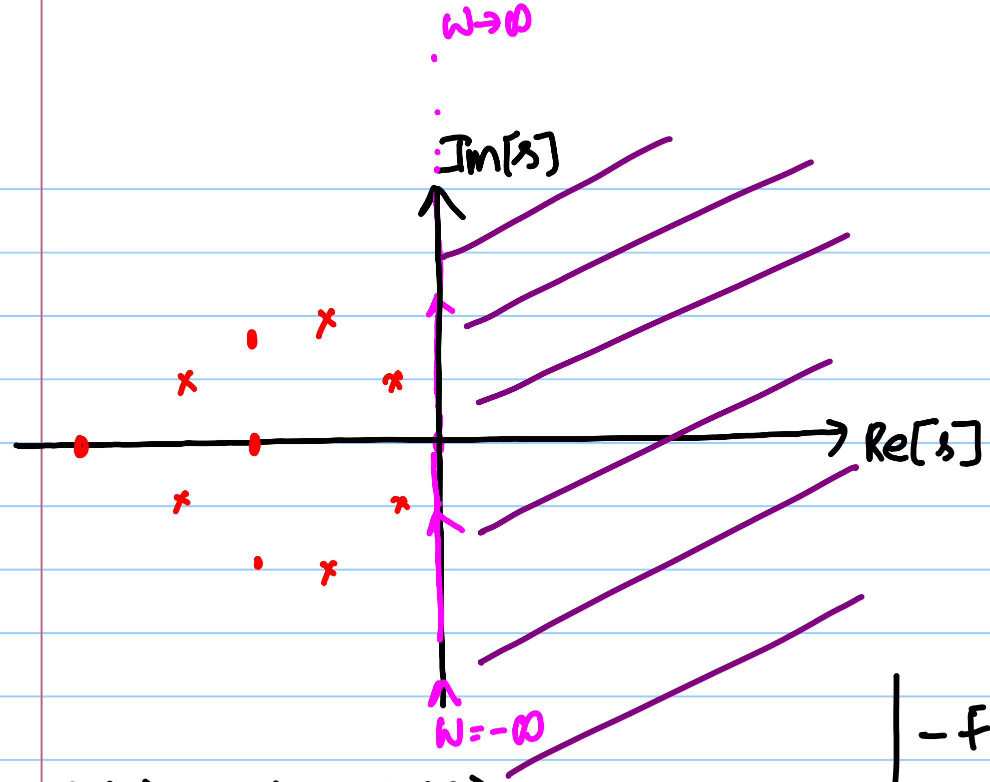
$$= \frac{1}{\beta(s)} \frac{LG}{\underline{1+LG}}$$

$\underline{1+LG} = 0$ ✓

$$\Rightarrow 1 + \frac{N(s)}{D(s)} = 0 \Rightarrow \underline{D(s) + N(s)} = 0$$

- if $\frac{Y}{X}$ has R.H.P poles then $N(s) + D(s)$ must have R.H.P zeros.

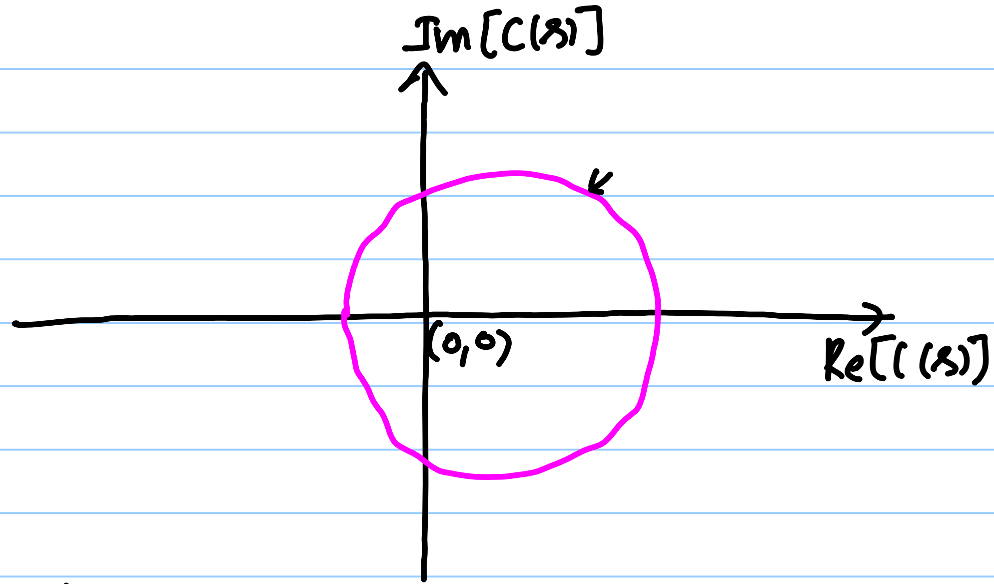
- $C(s) = 1 + LG(s)$ ✓



$$C(s) = 1 + LG(s)$$

$$1 + LG(s)$$

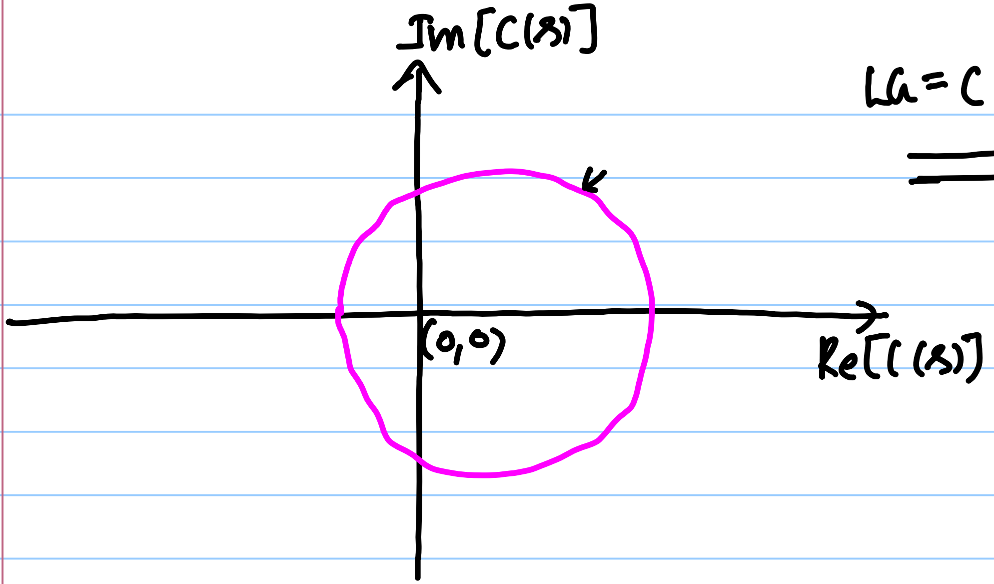
$$LG(s) = C(s) - 1$$



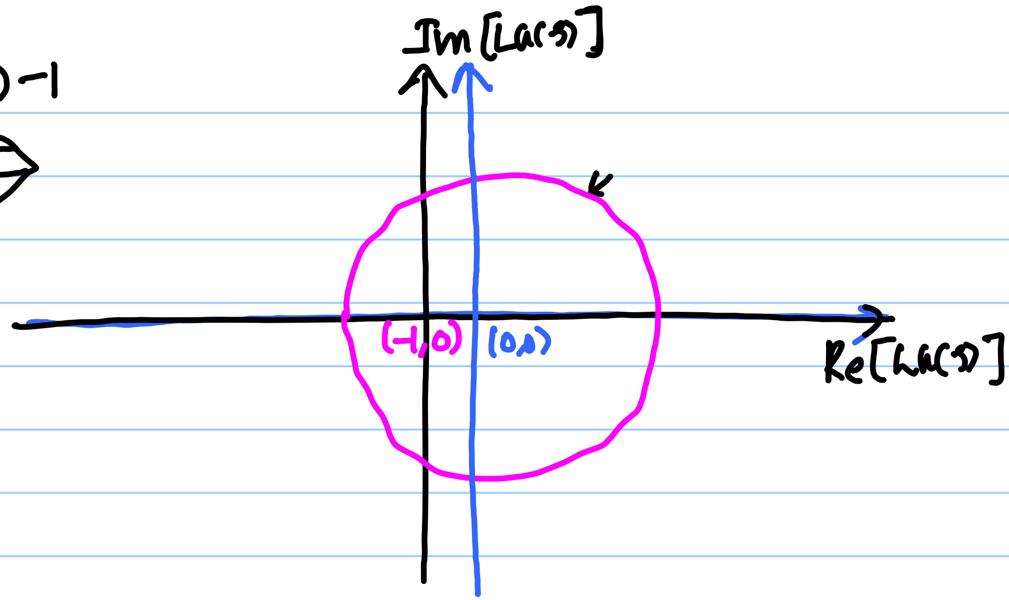
- First Order System

$$C(s) = 1 + \frac{A(s)}{K} = 1 + \frac{A_0/K}{1 + s/\omega_p}$$ ✓

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



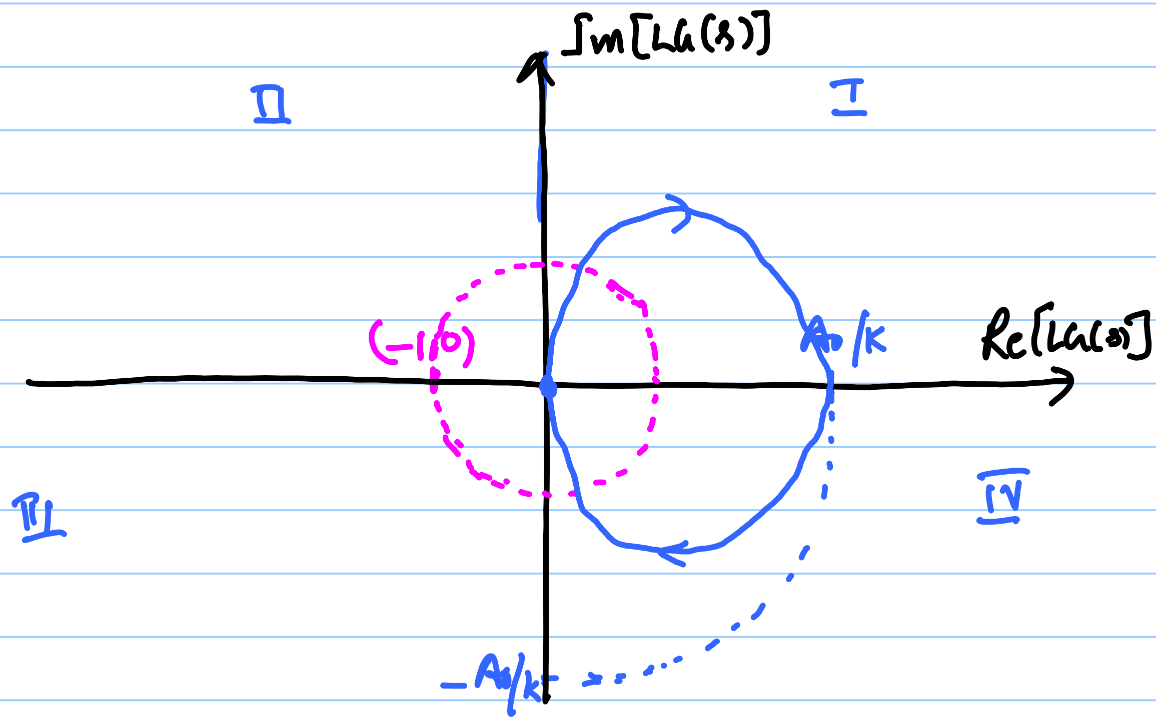
$$LG = C(s) - 1 \Longrightarrow$$



$$LG = \frac{A_0/K}{1 + s/\omega_p}$$

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

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

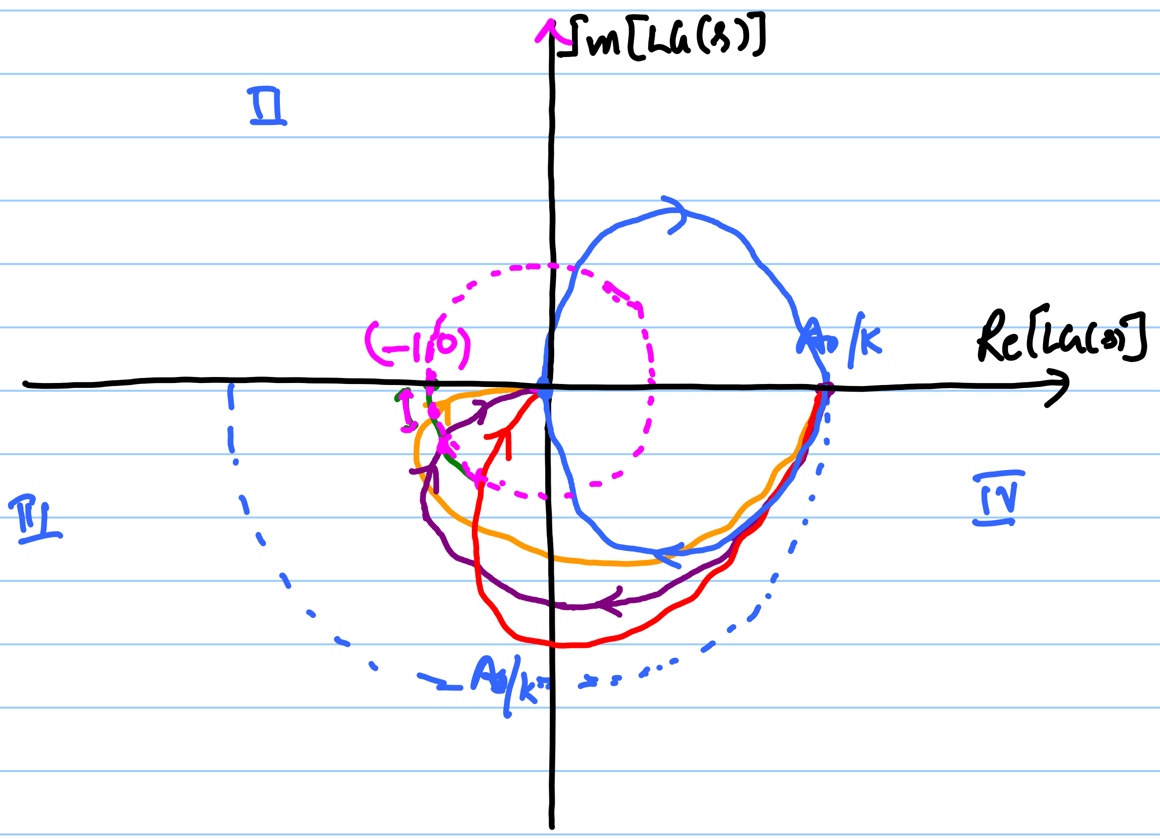


2nd Order

$$LG = \frac{A_0/K}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{p2}}\right)}$$

$$|LG| = \frac{A_0/K}{\sqrt{1+\left(\frac{\omega}{\omega_{p1}}\right)^2}\sqrt{1+\left(\frac{\omega}{\omega_{p2}}\right)^2}}$$

$$\measuredangle LG = -\tan^{-1}\left(\frac{\omega}{\omega_{p1}}\right) - \tan^{-1}\left(\frac{\omega}{\omega_{p2}}\right)$$



3^{rd} Order System

$$LG = \frac{A_0/K}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\left(1+\frac{s}{p_3}\right)}$$

$$|LG| = \frac{A_0/K}{\sqrt{\left(1+\frac{\omega^2}{p_1^2}\right)\left(1+\frac{\omega^2}{p_2^2}\right)\left(1+\frac{\omega^2}{p_3^2}\right)}}$$

$$\phi = -\tan^{-1}\left(\frac{\omega}{p_1}\right) - \tan^{-1}\left(\frac{\omega}{p_2}\right) - \tan^{-1}\left(\frac{\omega}{p_3}\right)$$