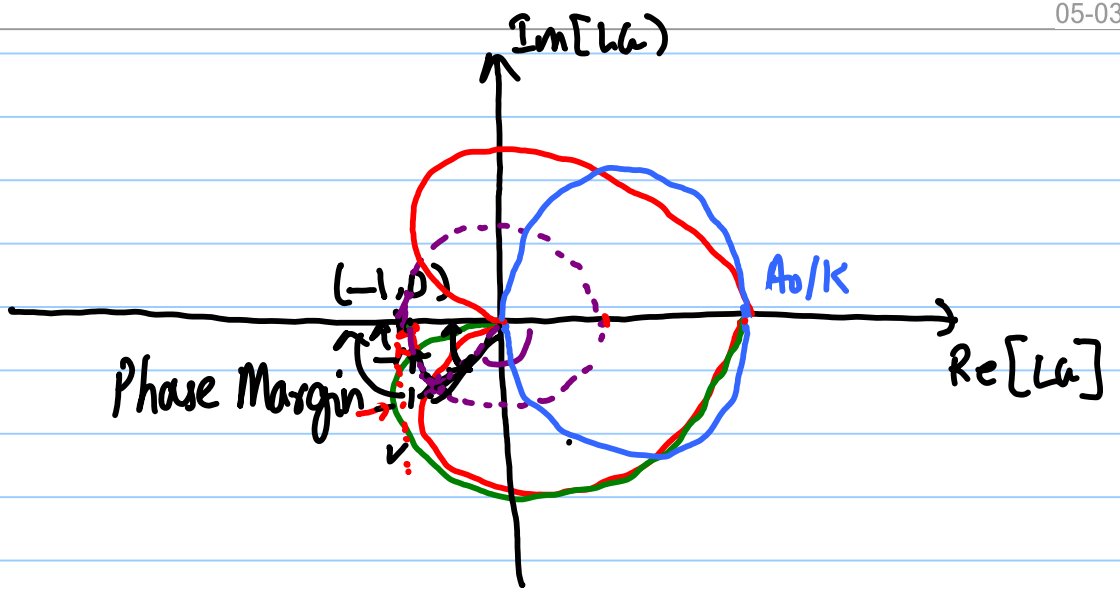
Lecture # 18

Note Title 05-03-2021

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

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

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



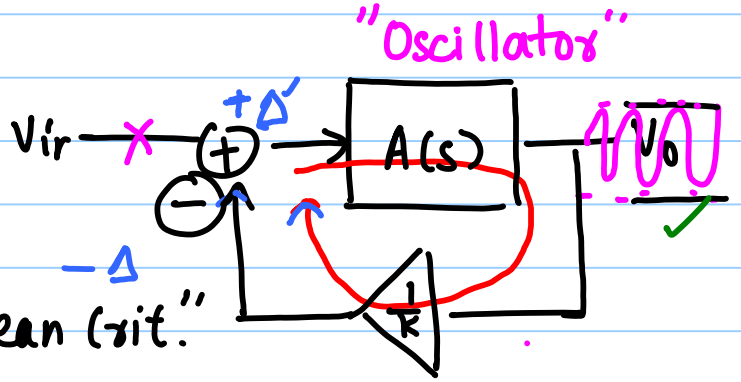
It doesn't encircle (-1,0). So, it is stable.

at ω_0, $|LG(j\omega_0)| \approx 1$ } "Barkhausean Criterion"

$\angle LG(j\omega_0) = -180^\circ$ }

$\angle LG(j\omega_0) = (2k+1)\pi$ for sustained oscillation.

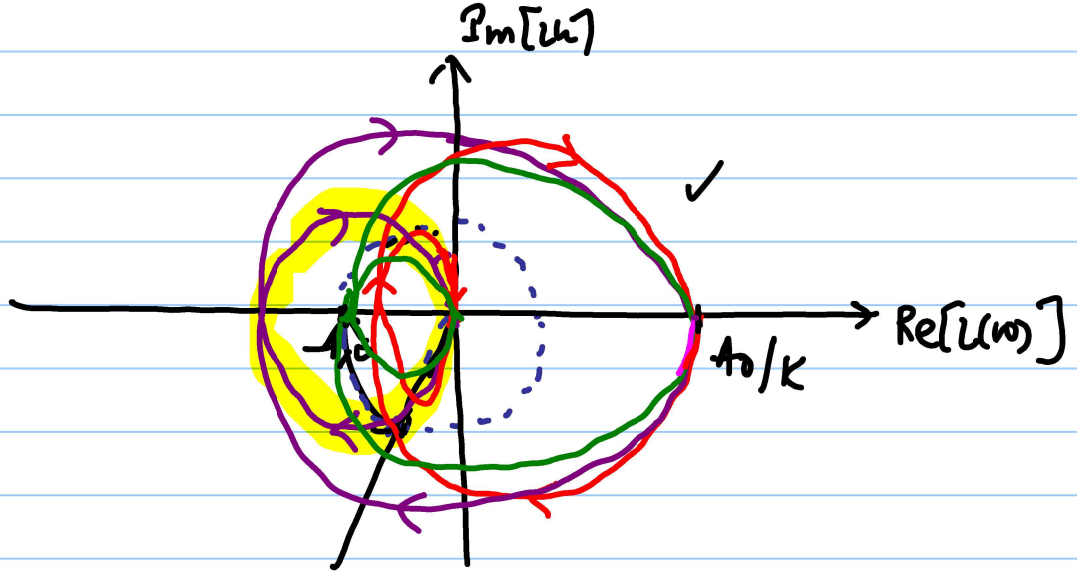
ω_0: unity gain frequency



$$LG = \frac{A(s)}{K} = \frac{1}{K}\frac{A_0}{(1+\frac{s}{p_1})(1+\frac{s}{p_2})}$$

$$L_h = \frac{A_0}{K\sqrt{1+\frac{\omega^2}{p_1^2}}\sqrt{1+\frac{\omega^2}{p_2^2}}\sqrt{1+\frac{\omega^2}{p_3^2}}} \times e^{-j\tan^{-1}\left(\frac{\omega}{p_1}\right)} \cdot e^{-j\tan^{-1}\left(\frac{\omega}{p_2}\right)} e^{-j\tan^{-1}\left(\frac{\omega}{p_3}\right)}$$

$L_h + 1 = 0 \longrightarrow$ R.H.P zero



$|L_h(j\omega_n)| = 1$

$\angle L_h(j\omega_n) = -180^\circ$

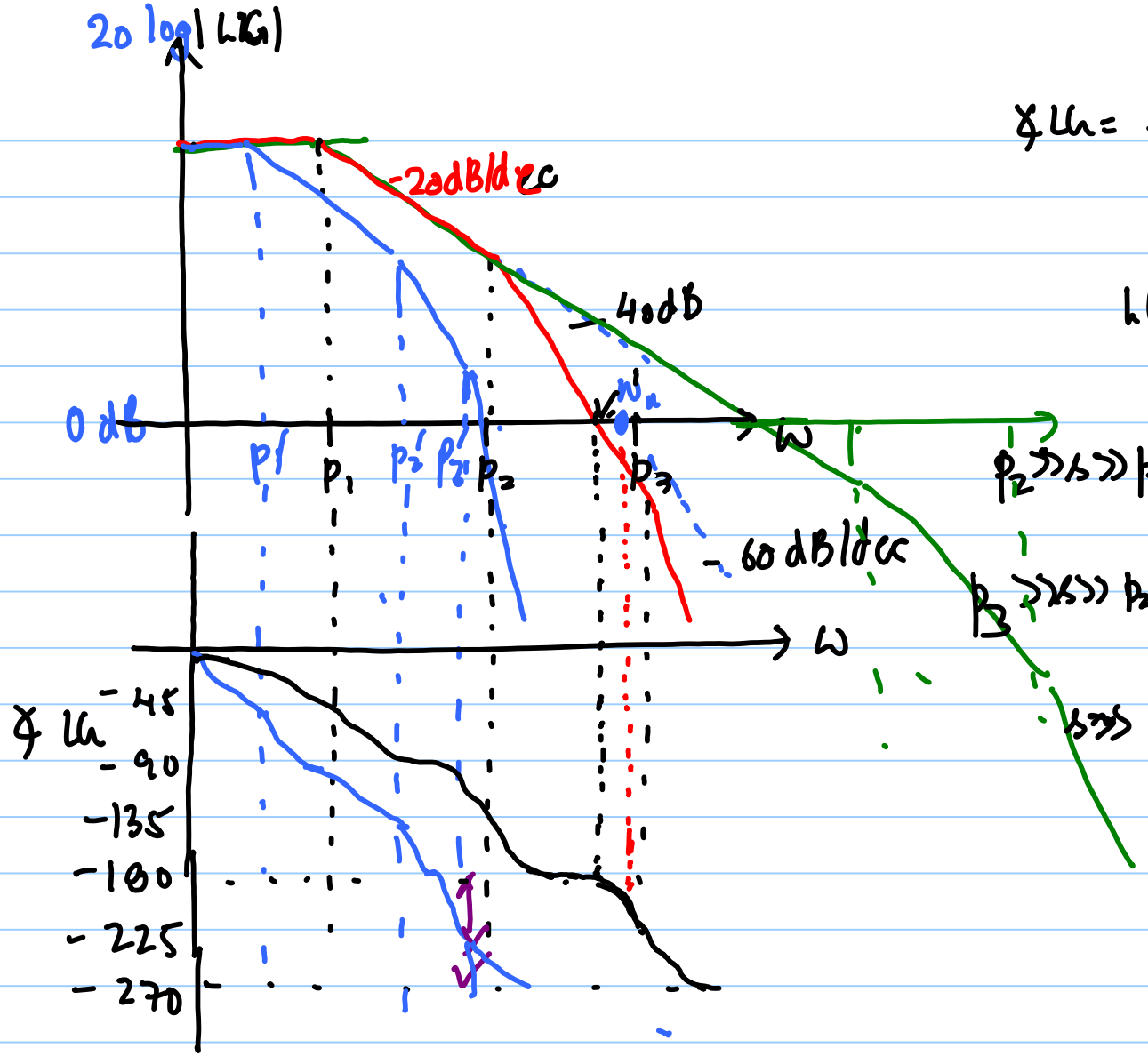
Bode plots

1. All pole system and evaluate L_h at $j\omega$ axis.

Plot $|L_h(j\omega)|$ vs. ω

find $|L_h(j\omega_n)| = 1$

$\angle L_h(j\omega_n) = \longrightarrow \phi_m = -180^\circ - \angle L_h(j\omega_n)$



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

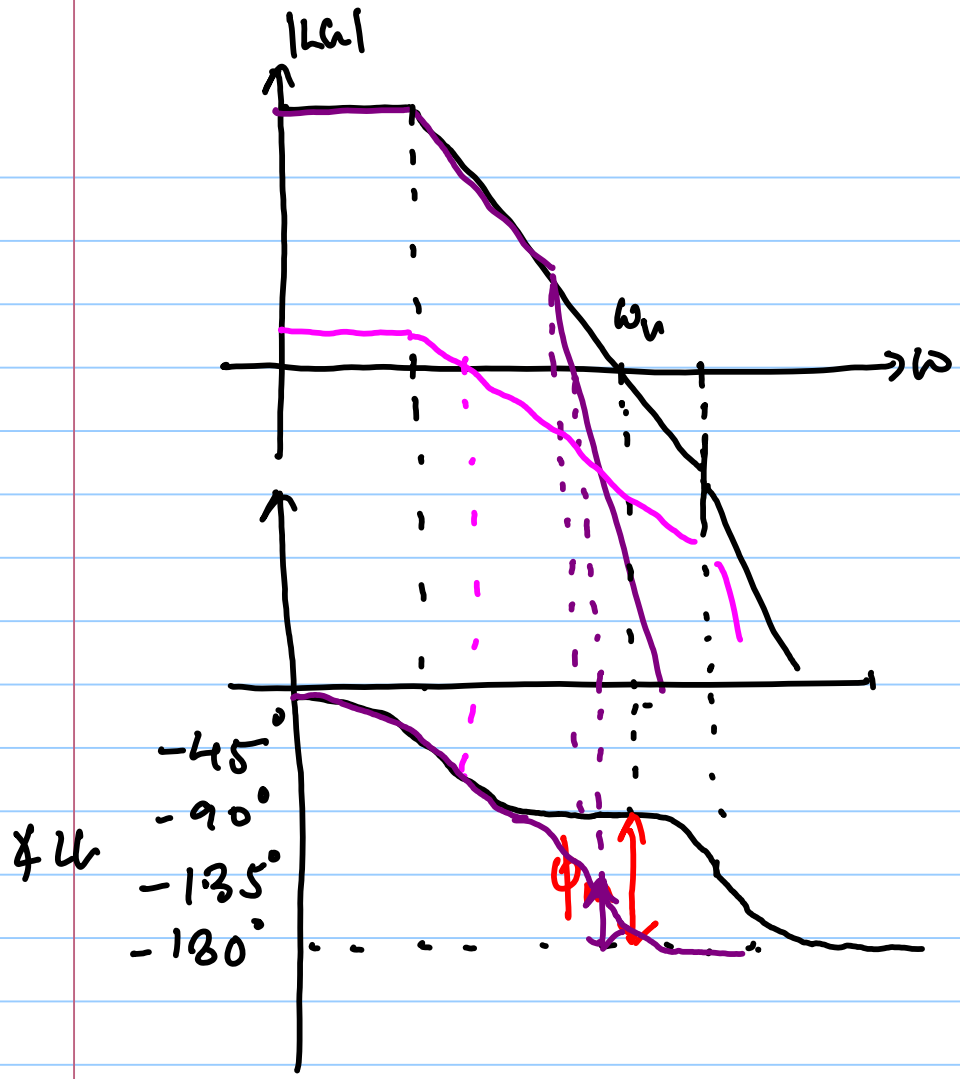
$$Lh = \frac{A_0/k}{\left(1+\frac{s}{p_1}\right)\left(1+\frac{s}{p_2}\right)\left(1+s/p_3\right)}$$

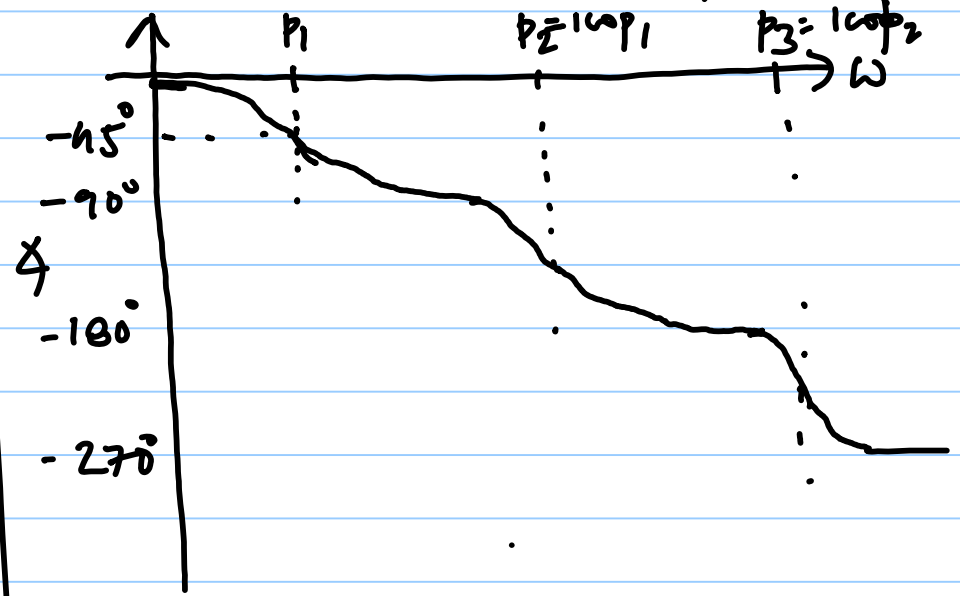
$p_2 \gg s \gg p_1$	$\approx \frac{s}{p_1}$	1	1
$p_3 \gg s \gg p_2$	$\approx \frac{s^1}{p_1}$	$\frac{s^1}{p_2}$	1
$s \gg p_3$	$\approx \frac{s}{p_1}$	$\frac{s}{p_2}$	$\frac{s}{p_3}$

$\Rightarrow 20\log_{10}[\,|Lh(\omega)|\,]$

find ω_u : unity gain freq.

$\angle Lh(\omega_u)$. $\longrightarrow$ $\phi_m = \angle Lh(\omega_u) - (-180^\circ)$



$-90^\circ - (-180^\circ) = 90^\circ$.

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