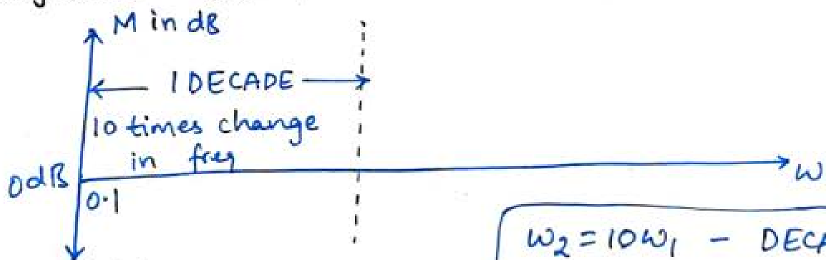
BODE PLOTS :

Purpose:

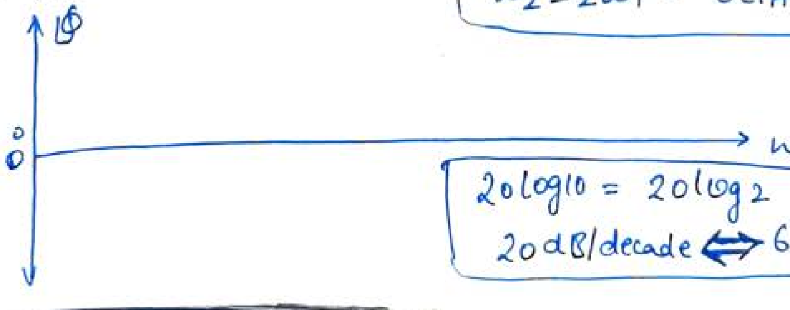
1. To draw the freq. response of OLTF
2. To find the closed loop system stability.
3. To find the gain margin and phase margin, gain cross-over frequency (ω_{gc}), phase cross over frequency (ω_{pc}).
4. To find the relative stability by using gain margin and phase margin.
5. If the gain margin & phase margin is very large then the system is more relatively stable but the system response become slow.
6. If the gain margin & phase margin is very small then the system is less relatively stable and more oscillatory.
7. The optimum range of gain margin is (5 dB - 10 dB)
8. The optimum range of phase margin is (30° - 40°)
9. The bode plot consists the two plots
   (i) Magnitude plot
   (ii) Phase plot

Magnitude plot:



$\omega_2 = 10\omega_1$ - DECADE
$\omega_2 = 2\omega_1$ - OCTAVE

Phase plot:



$20\log 10 = 20\log 2$
20 dB/decade $\Leftrightarrow$ 6 dB/octave

Procedure to draw bode plot :

1. Replace s by $j\omega$ to convert into freq. domain.

2. Write the magnitude and convert into decibels. The magnitude in dB is

$$M_{indB} = 20\log|GH(j\omega)|.$$

3. Write the phase angle by using $\tan^{-1}\left(\frac{\text{Img part}}{\text{Real part}}\right)$.

$$\phi = \tan^{-1}\left(\frac{I \cdot P}{R \cdot P}\right)$$

4. Vary the 'ω' from minimum to maximum and draw the approximated magnitude & phase plot.

Q) Draw the bode plot of $G(s)H(s) = K$.

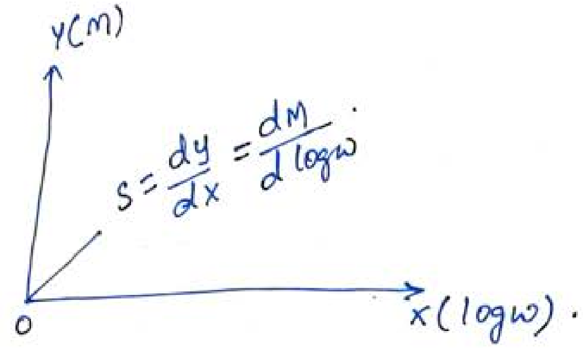
Sol. Procedure:

$s \to j\omega$.

$GH(j\omega) = K$.

$M = K$.

$M_{indB} = 20\log K$ = Magnitude



$$\text{slope} = \frac{dM}{d\log\omega} = 0\,dB/\text{decade}.$$

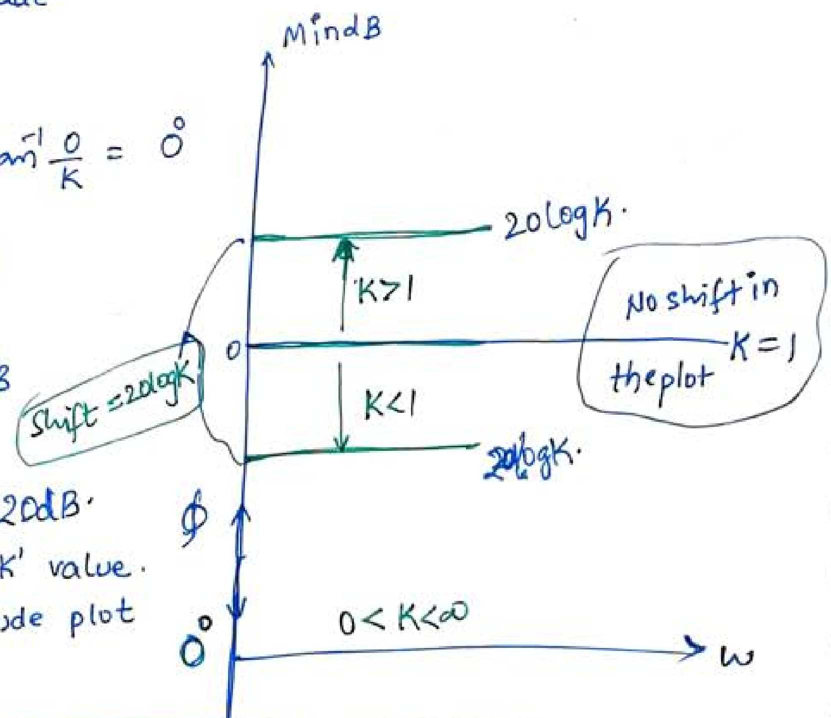
$$\text{Phase} = \angle\phi = \angle(K + j0) = \tan^{-1}\frac{0}{K} = 0^\circ$$

if $K = 1 \to M_{indB} = 0\,dB$

if $K = 10\,(>1) \to M_{indB} = 20\,dB$

if $K = 0.1\,(<1) \to M_{indB} = -20\,dB$.

→ The phaseplot is independent of 'K' value. Whereas the shift in the magnitude plot depends on 'K' value



'n' poles at origin: $\rightarrow S = -20n\,dB/dec$, $\phi = -90^\circ n$

$$G(s)H(s) = \frac{1}{s^n}$$

$s \rightarrow j\omega$

$$GH(j\omega) = \frac{1}{(j\omega)^n}$$

$$M = \frac{1}{\omega^n} \; ; \; \text{Slope } S = \frac{dM}{d\log\omega}$$

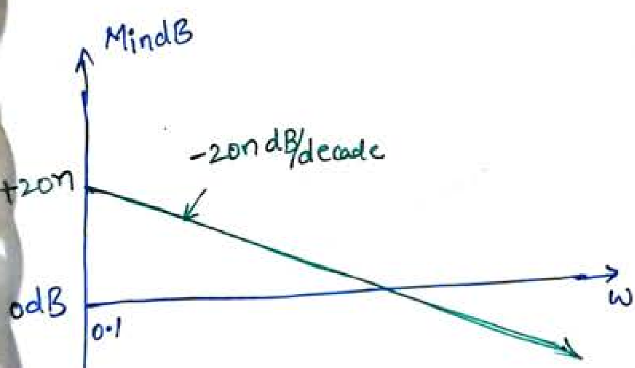
$$M_{in\,dB} = -20n \log\omega \; dB$$

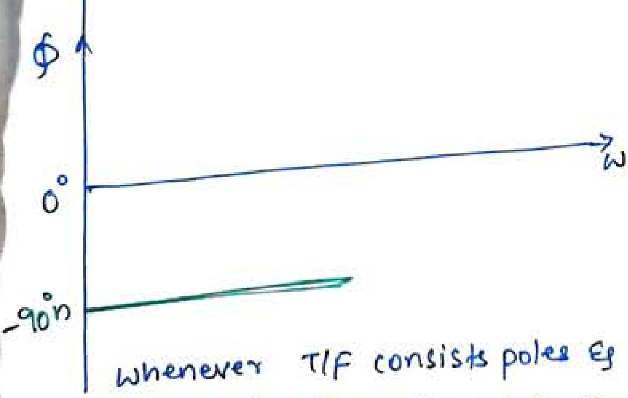
$$S = \frac{dM}{d\log\omega} = -20n \; dB/decade$$

$$\phi = \frac{\angle 1}{\angle j\omega \cdots n\text{times}} = \frac{0^\circ}{90^\circ n} = -90^\circ n$$

$$M|_{\omega=0.1} = -\text{slope}$$

$$M|_{\omega=1} = 0dB$$





'n' zeros at origin:

$$GH(s) = s^n$$

$s \rightarrow j\omega$

$$GH(j\omega) = (j\omega)^n$$

$$M = \omega^n \; ; \; \text{slope } S = \frac{dM}{d\log\omega}$$

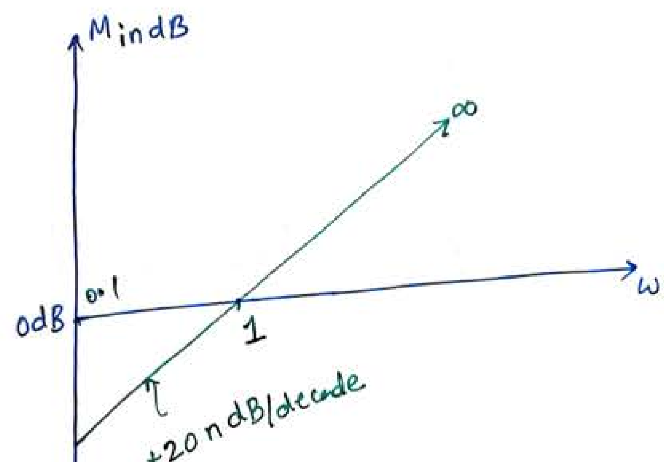
$$M_{in\,dB} = +20n\log\omega \; dB$$

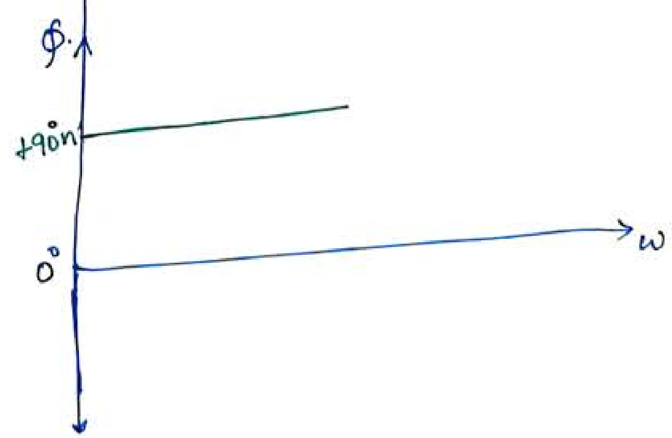
$$S = \frac{dM}{d\log\omega} = 20n$$

$$\phi = \angle j\omega \cdots n\text{times} = +90^\circ n$$

$$M|_{\omega=0.1} = -\text{slope}$$

$$M|_{\omega=1} = 0\,dB$$





whenever T/F consists poles & zeros at origin, then the plot should start with a magnitude of opposite sign of slope at a freq of 0.1 & should pass through 0dB line intersect 0dB at $\omega=1$ & extended upto ∞ if no corner frequency existed.

④ Draw the bode plot $GH(s) = \frac{100}{s^8}$.

Sol. $GH(s) = \frac{100}{s^8}$; $s \to j\omega$; $GH(j\omega) = \frac{100}{(j\omega)^8}$.

$M = \frac{100}{\omega^8}$; $M_{indB} = +20 \log \frac{100}{\omega^8} = +20 \log 100 - 20 \times 8 \log \omega$

Donot use the procedure even though you get answer. Use the analysis we have done already.

i.e, 8 poles at origin ; Slope $S = -20 \times n^{\nearrow 8} = -160$ dB/decade.

Phase $\phi = -90° \times n^{\nearrow 8} = -720°$

Shift $= 20 \log 100 = +40$dB.