문제은 stability 만족하는 K 값은?

1. Routh - Hurwitz

$$T_{CL} = \frac{K / s(s+1)(2s+1)}{1 + \frac{K}{s(s+1)(2s+1)}} = \frac{K}{s(s+1)(2s+1) + K}$$

$$CE = s^3 + 3s^2 + s + K$$

s^3	1	1
s^2	3	K
s^1	a_1	a_2
s^0	b_1	b_2

$$a_1 = -\frac{\begin{vmatrix} 1 & 1 \\ 3 & K \end{vmatrix}}{3} = -\frac{K-3}{3}$$

$$a_2 = 0$$

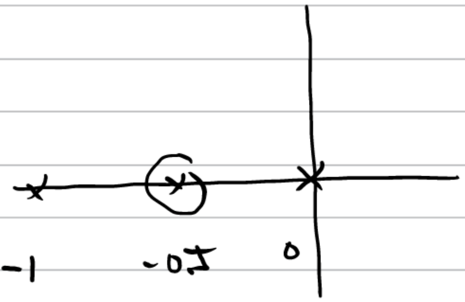
$$b_1 = -\frac{\begin{vmatrix} 3 & K \\ a_1 & 0 \end{vmatrix}}{a_1}$$

$$= \frac{- -a_1 K}{a_1} = K$$

① $K > 0$ $\qquad -\frac{K-3}{3} > 0$ ② $K < 3$.

2. Root locus.

$$1 + KL(s) = 0 \qquad L(s) = T_{OL} = \frac{1}{s(s+1)(2s+1)}$$

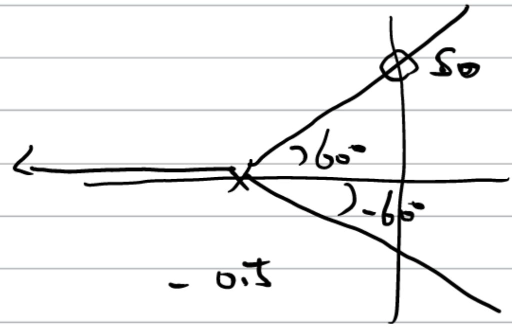


점근선의 Center

$$= \frac{\Sigma \cancel{z_i} P_i - \Sigma z_i}{n-m}$$

$$= -1 \quad 0.5 / 2 = -0.5$$

$$\text{각도} = \frac{180° \pm 360k}{3} = 60°,\ 180°,\ -60°$$



$$\tan 60° = \frac{S_0}{0.5} = \sqrt{3} \qquad S_0 = \sqrt{3} \times 0.5 \times j$$

$$K = \left| -1/L(s) \right| = \left| 1/L(s) \right| = \left| s(s+1)(2s+1) \right|_{s=\sqrt{3}\times 0.5 j}$$

$$k = 2.64 \qquad 0 < K < 2.64$$

3. Nyquist $\quad Z = 0. \quad N = ? \quad P = 0$

$N = 0$ 이어야 stable

$$T_{open} = \frac{K}{s(s+1)(2s+1)} \qquad K=1\text{로 설정.}$$

$$s = j\omega. \qquad \angle \frac{1}{j\omega(j\omega+1)(2j\omega+1)} = 180° \qquad \omega = ?$$

$$j\omega(-2\omega^2 + j3\omega + 1) = -j2\omega^3 - 3\omega^2 + j\omega$$
$$= j\omega(1 - 2\omega^2) - 3\omega^2$$

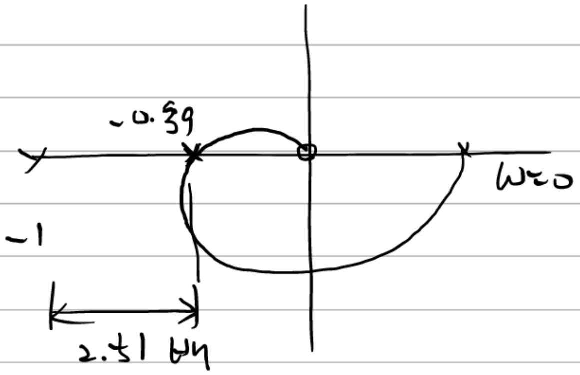
$$\frac{1}{jw(1-2w^2)-3w^2} = \frac{-jw(1-2w^2)-3w^2}{-w^2(1-2w^2)^2+9w^4}$$

$j=0$ $\quad w(1-2w^2)=0 \quad 1=2w^2 \quad w=\sqrt{1/2}$

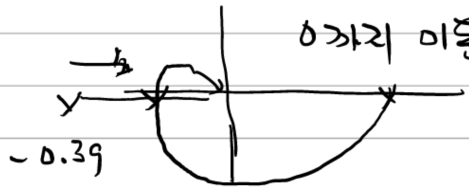
$= 0.709$

실수값 $= \dfrac{-3w^2}{-w^2(1-2w^2)^2+9w^4} = -0.661$

~~$1 < k < 1.5$~~



$K \approx 0 \rightarrow$



closed loop transfer 에서 negative gain

$\rightarrow$ $K > 0$ 이라는 전제!