

CMPE-242

Applied Feedback Control

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Questions?





$$F/X = \frac{1}{ms^2 + bs + k}$$

$$F/X = \frac{\frac{1}{m}}{s^2 + \frac{b}{m}s + \frac{k}{m}} \rightarrow \frac{\quad}{D(s) + N(s)}$$

$$F/X = \frac{\frac{1}{m}}{(s^2 + \frac{k}{m}) + \frac{b}{m}s} \quad \Delta(s) = \phi$$

$$(s^2 + \frac{k}{m}) + \frac{b}{m}s = \phi \rightarrow 1 + \frac{b}{m} \frac{s}{(s^2 + \frac{k}{m})} = \phi$$

$$\frac{\frac{b}{m}s}{(s^2 + \frac{k}{m})} = -1 \quad \leftarrow \text{Stern's Form}$$

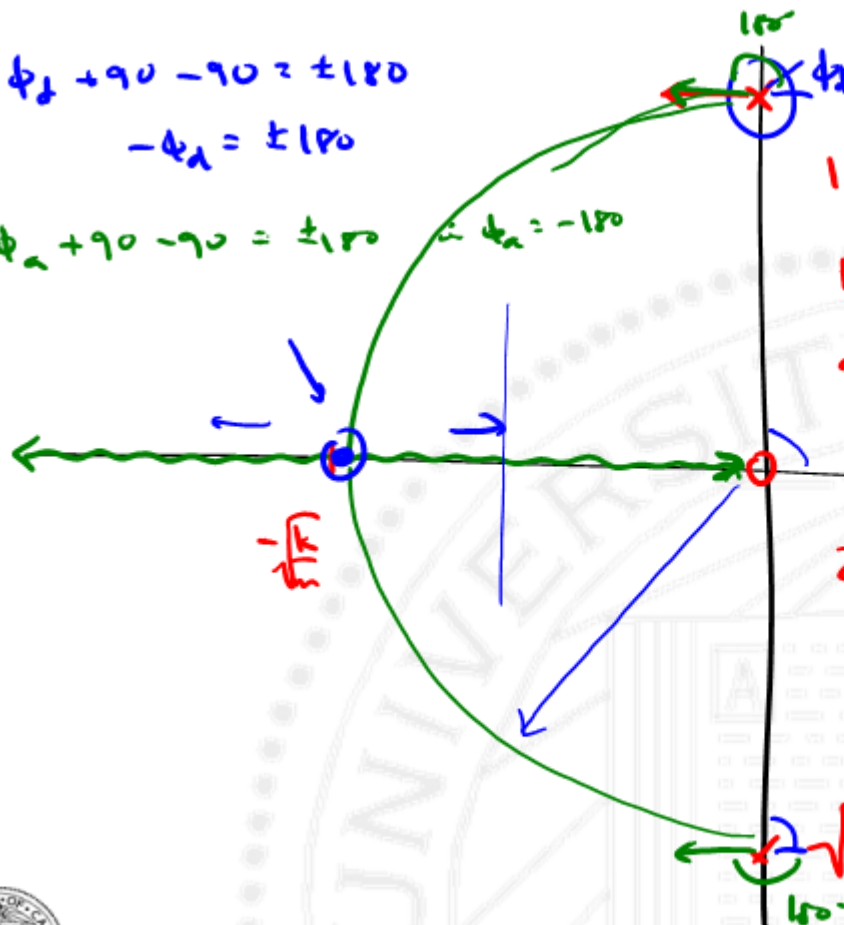


$$-\phi_d + 90 - 90 = \pm 180$$

$$-\phi_d = \pm 180$$

$$\phi_a + 90 - 90 = \pm 180$$

$$\phi_a = -180$$



$$F(s) = \frac{b}{m} \frac{1}{(s^2 + k/m)}$$

$$1 + k \frac{b(s)}{c(s)}$$

$$b(s) = s$$

$$c(s) = s^2 + \frac{k}{m}$$

$$b(s) \frac{dc}{ds} - c(s) \frac{db}{ds} = \phi$$

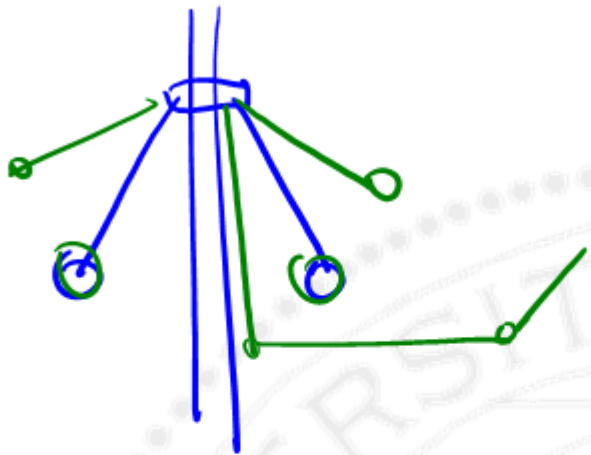
$$2s^2 - (s^2 + \frac{k}{m})1 = \phi$$

$$s^2 - \frac{k}{m} = \phi$$

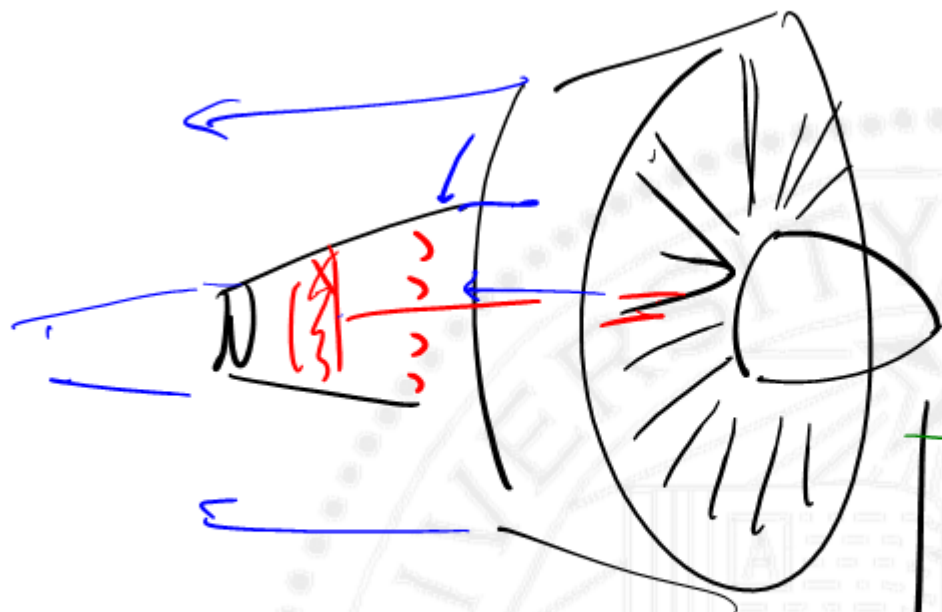
$$s = \pm \sqrt{\frac{k}{m}}$$

$$\sqrt{\frac{k}{m}} j$$





Turbine Inlet Temp
(TIT)

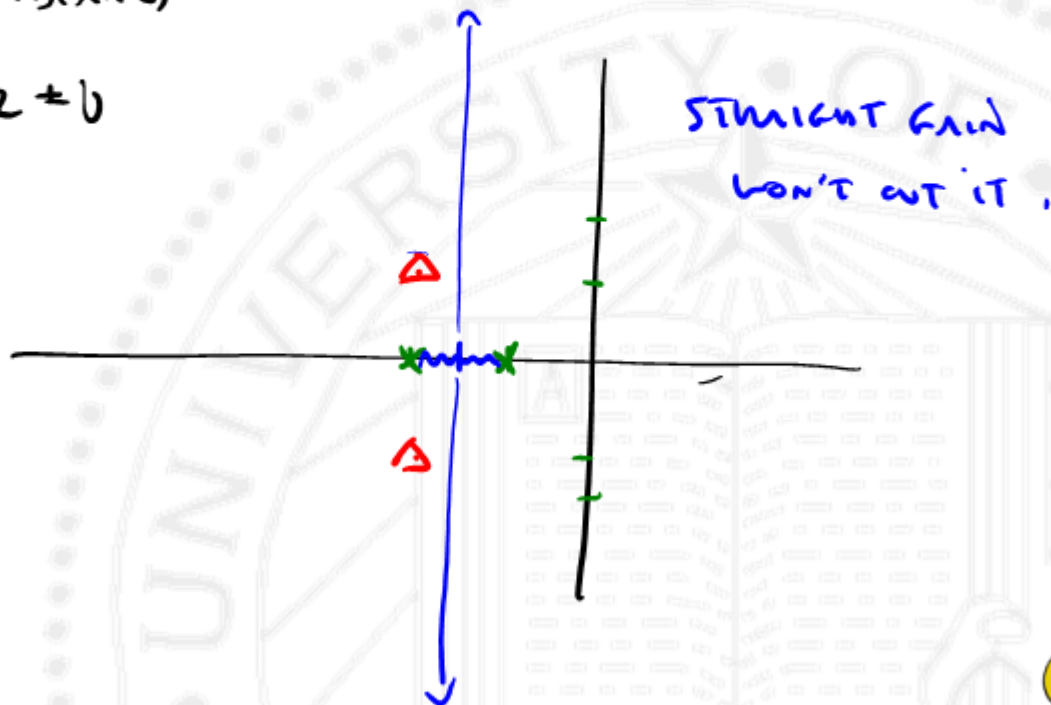


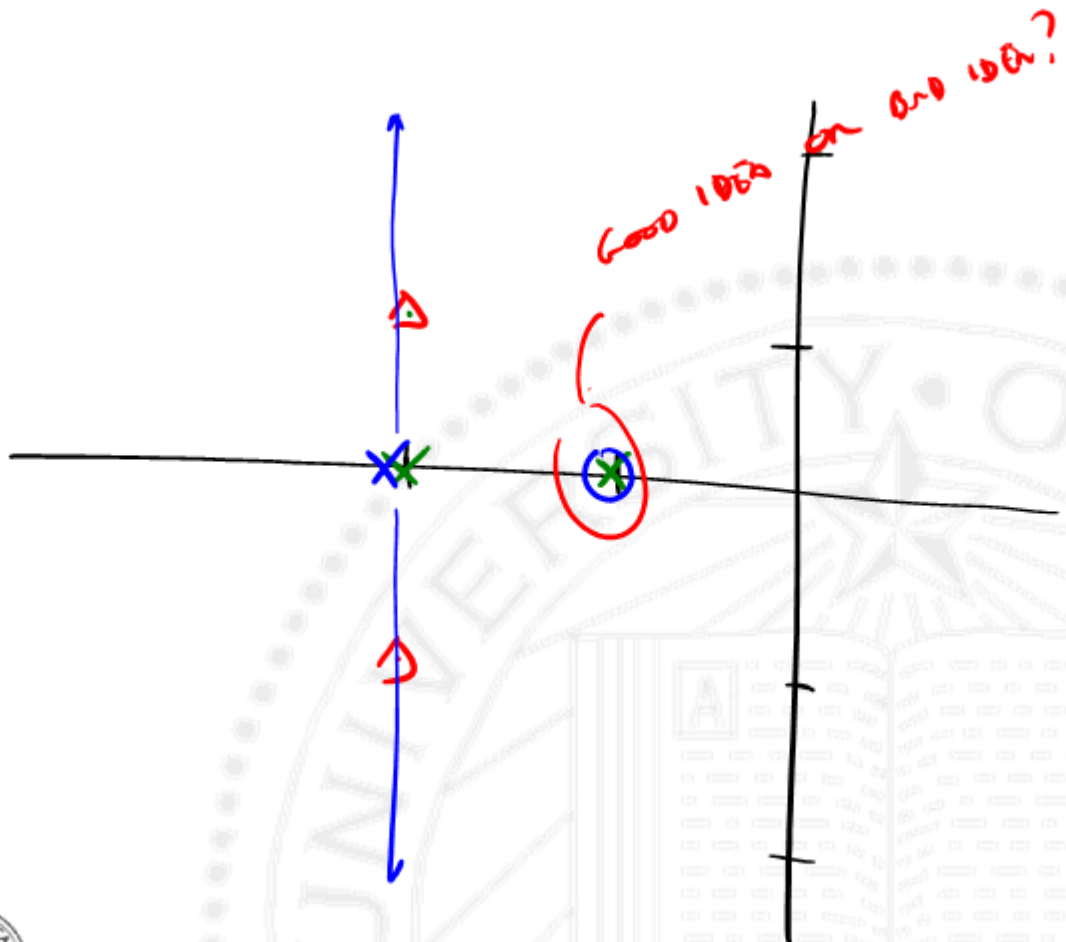
Analysis \rightarrow Synthesis

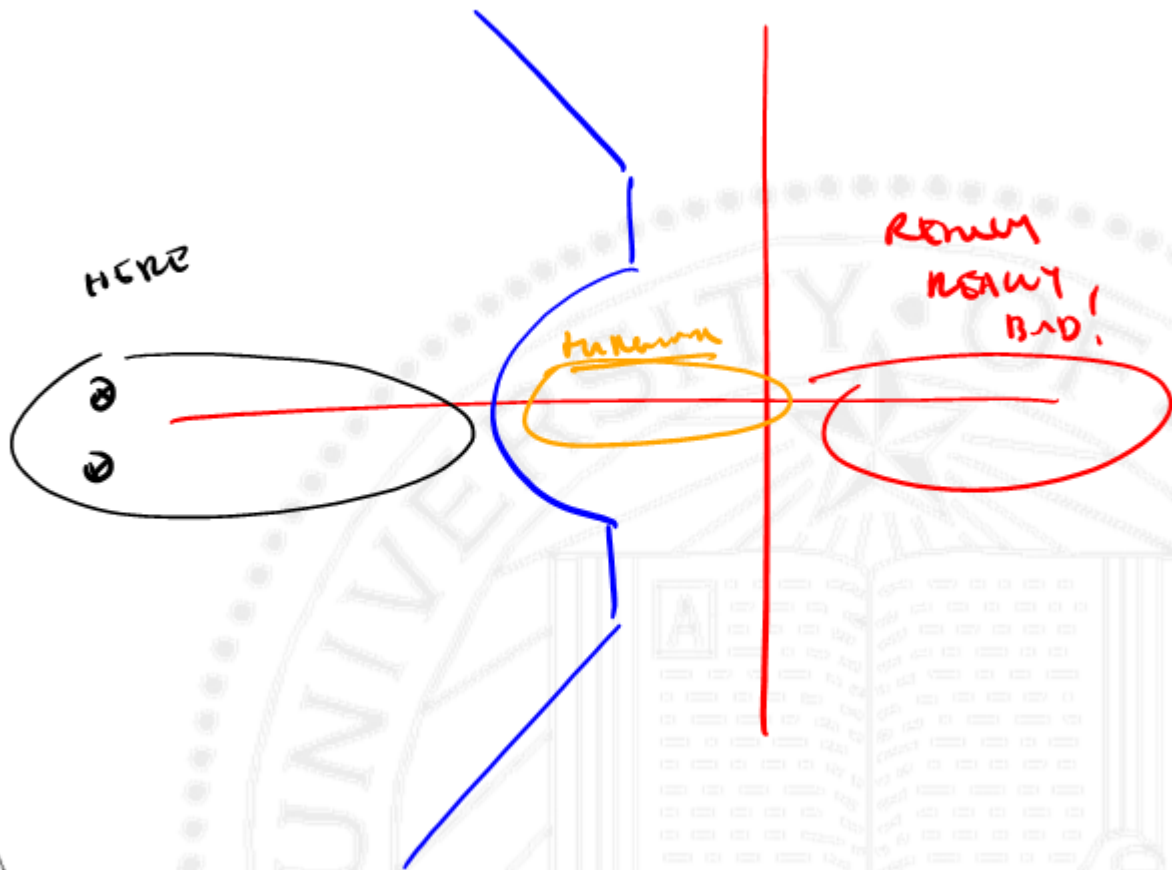
$$G(s) = \frac{8}{(s+1)(s+2)}$$

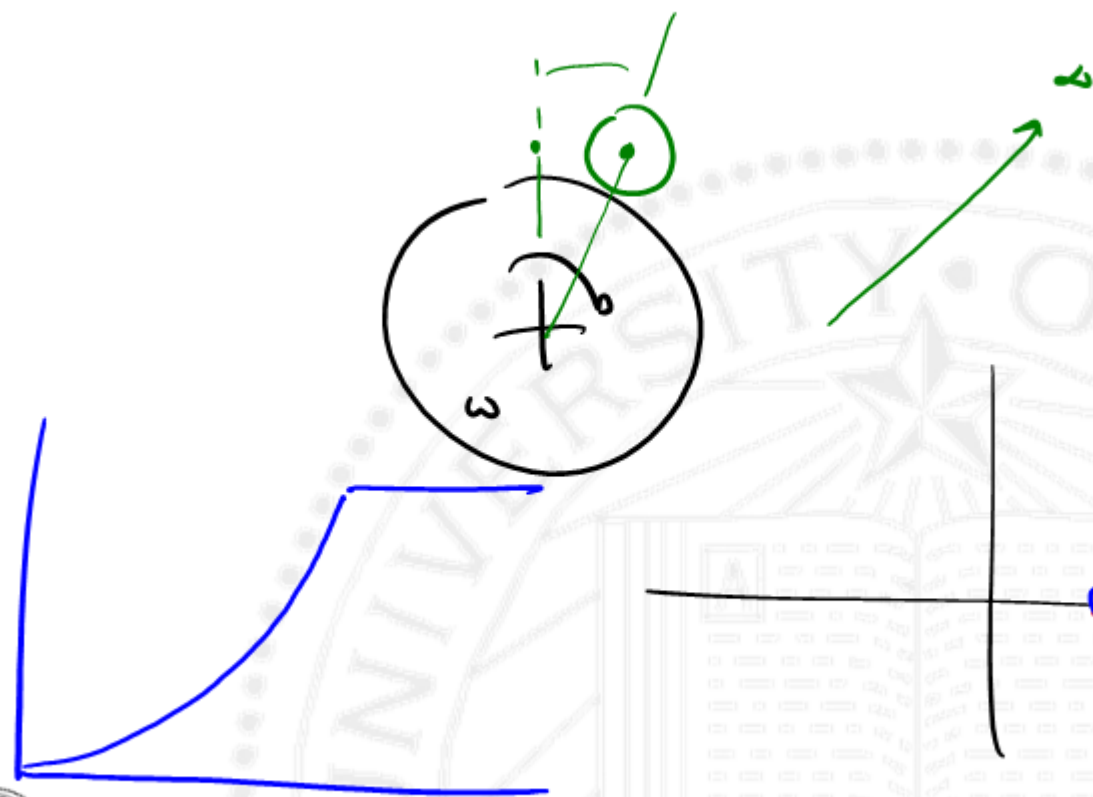
$$\Delta_{\text{des}} = -2 \pm j0$$

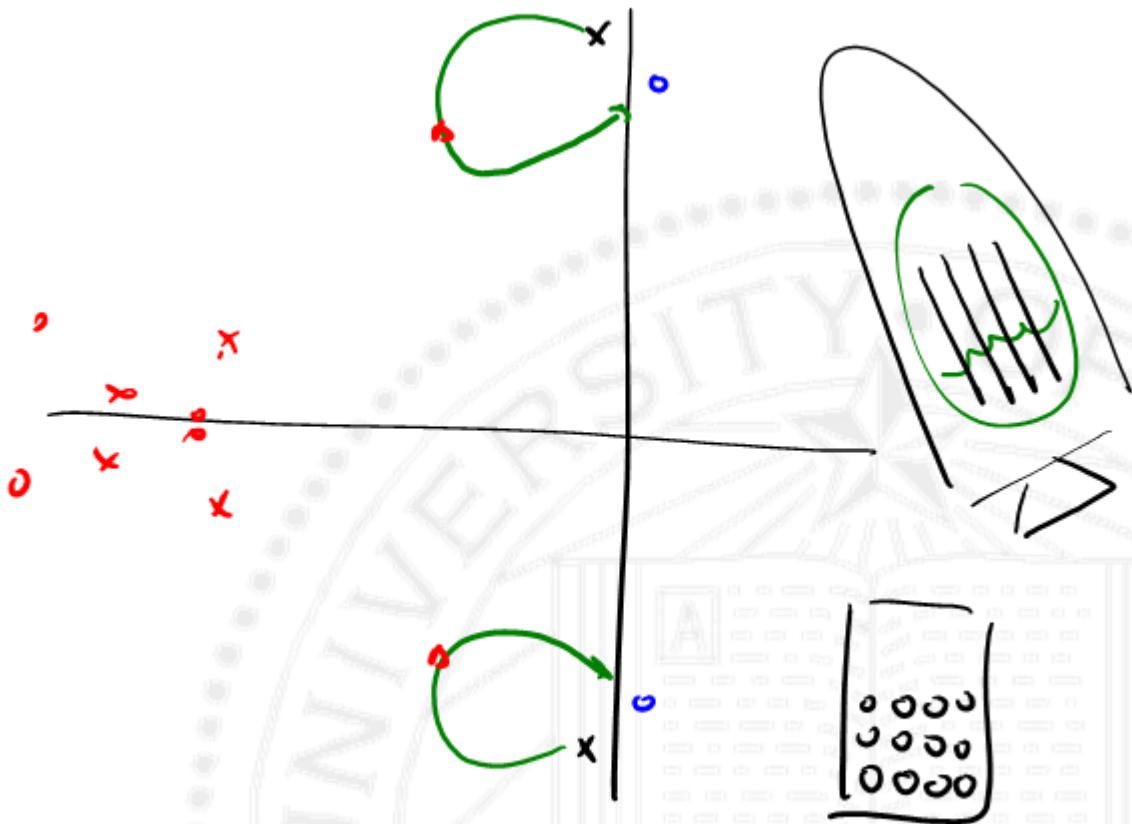
$K \frac{N_c}{D_c}$
 \uparrow
pick this





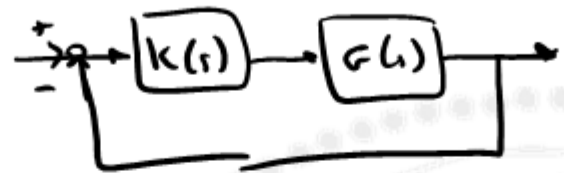






$$G(s) = \frac{8}{(s+1)(s+2)}$$

$$s_{dn} = -2 \pm j$$

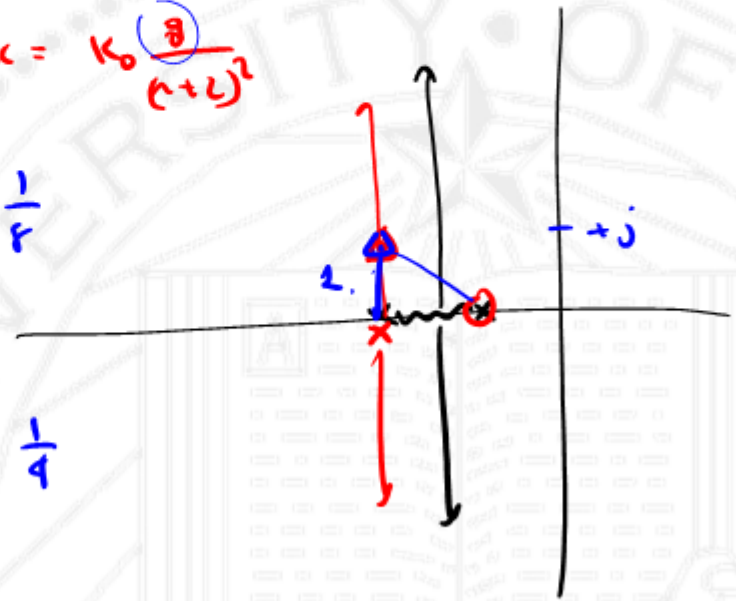


$$K(s) = K_0 \frac{s+1}{(s+2)}$$

$$GK = K_0 \frac{8}{(s+2)^2}$$

$$|GK|_{s_{dn}} = 1 \rightarrow K_0 = \frac{1}{4}$$

$$DC \text{ gain } (GK) = \frac{1}{4}$$

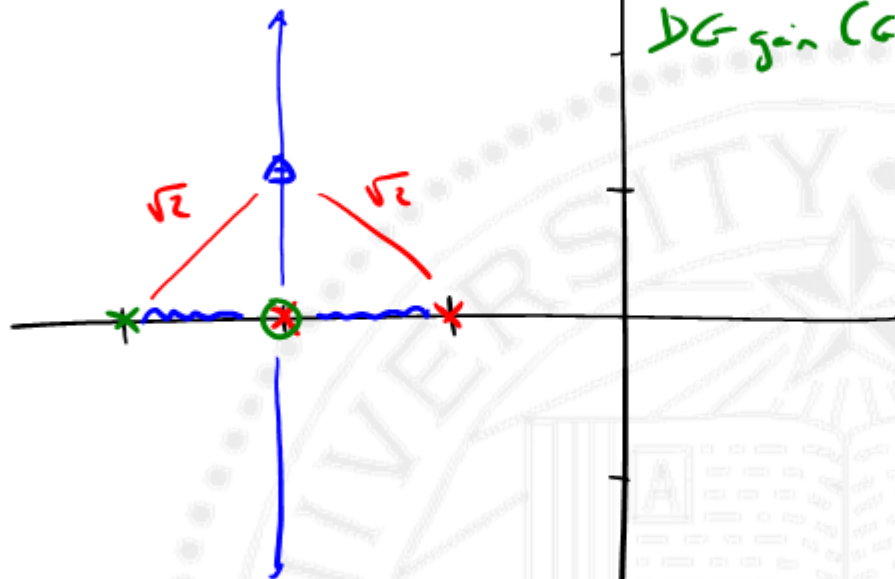


$$K(s) = k_0 \frac{(s+2)}{(s+3)}$$

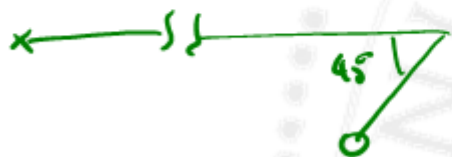
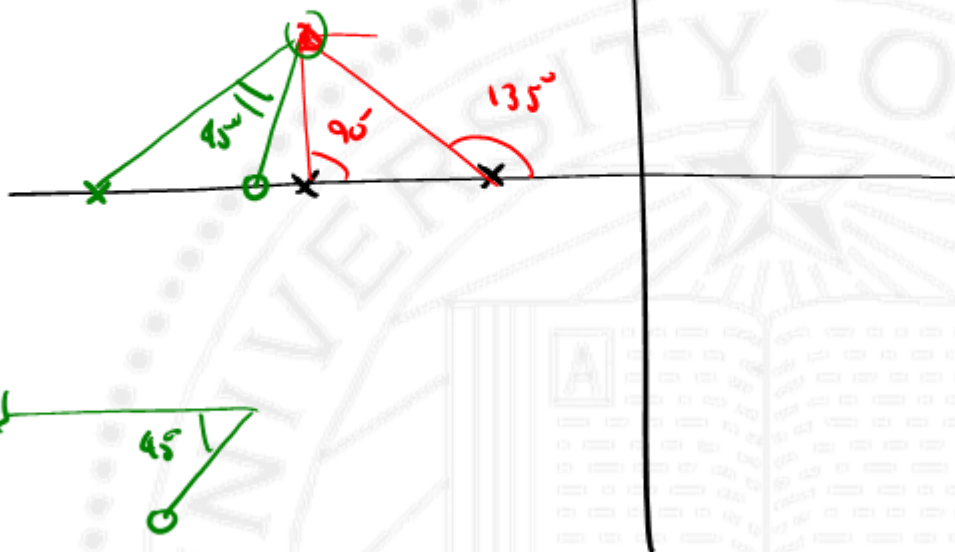
$$GK = \frac{8k_0}{(s+1)(s+3)}$$

$$\therefore k_0 = \frac{1}{4}$$

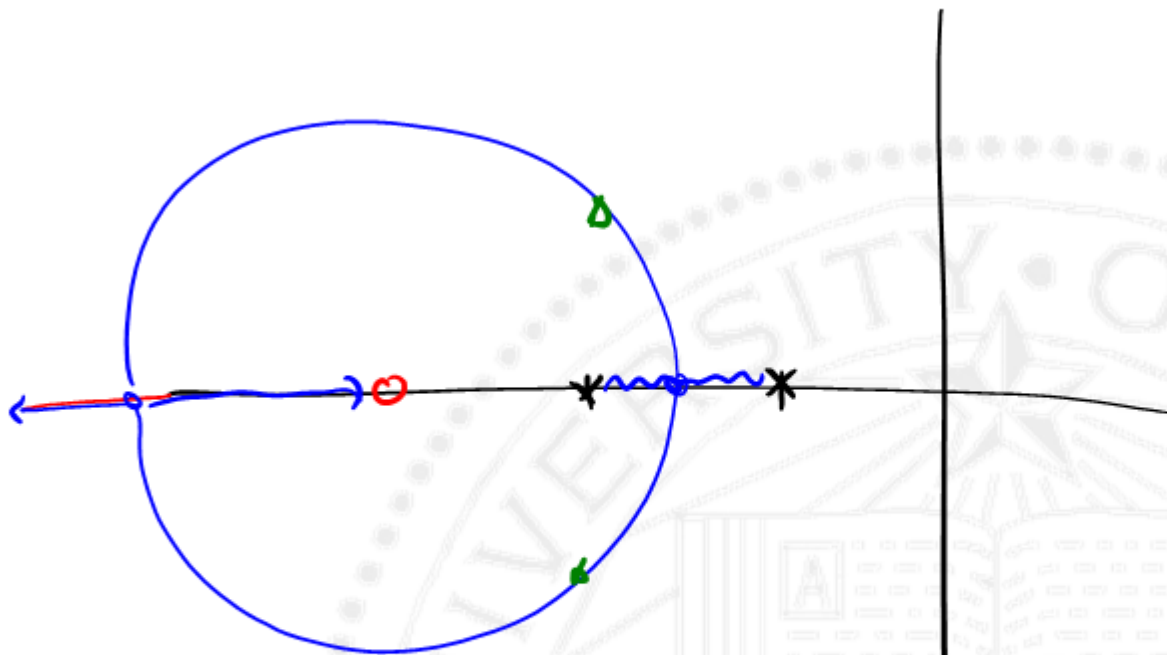
$$DG \text{ gain } (GK) = \frac{2}{3}$$



$$\angle G|_{\omega_m} = -225^\circ \quad \text{ADD } 45^\circ$$



$$K(s) = k(s+3)$$



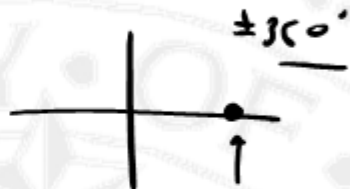
Zero Denom Root Locus



$$\Delta_{cl} = 1 + GK = 0$$

$$1 - GK = 0 \rightarrow GK = \pm 1$$

if $K < 0$, 0° or



Search s -plane for $\angle P(s) = \pm \underline{360^\circ}$



0° Root Locus

(1) $x \rightarrow 0$'s UNCHANGED

(2) REAL AXIS: NOT A 180° RL.

(3) Asymptotes: $\alpha = \frac{\sum p_i - \sum z_i}{n - m}$



(4) $\phi_d, \phi_n \leftarrow$ start point $0^\circ/180^\circ$.

(5) jw crossing: unchanged

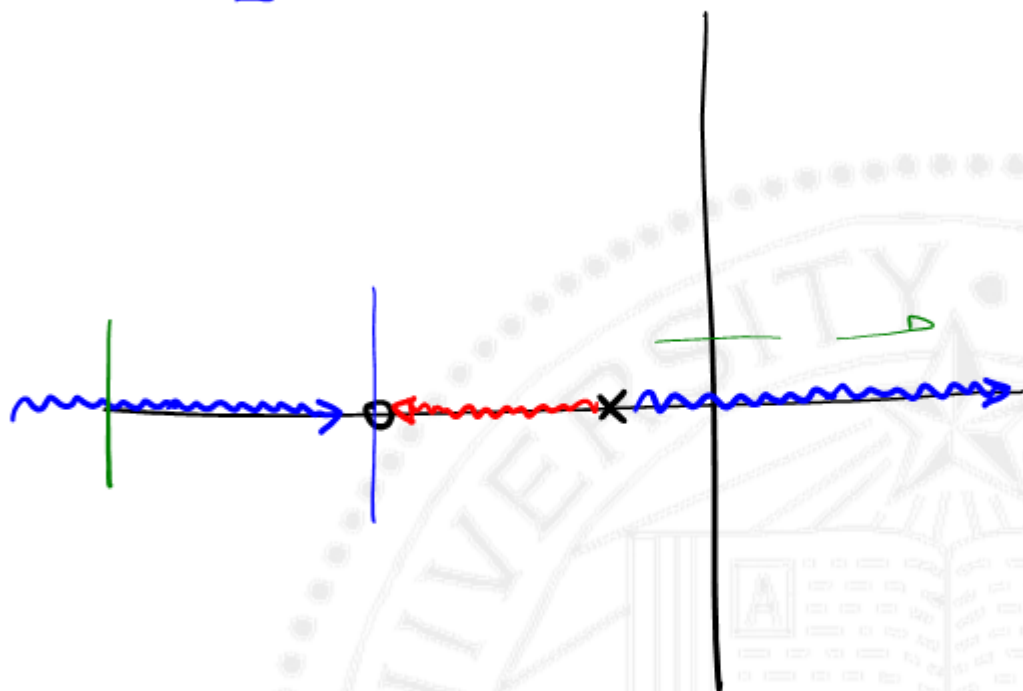
(6) Break-in / Breakout - unchanged.

Roots (-Gh)

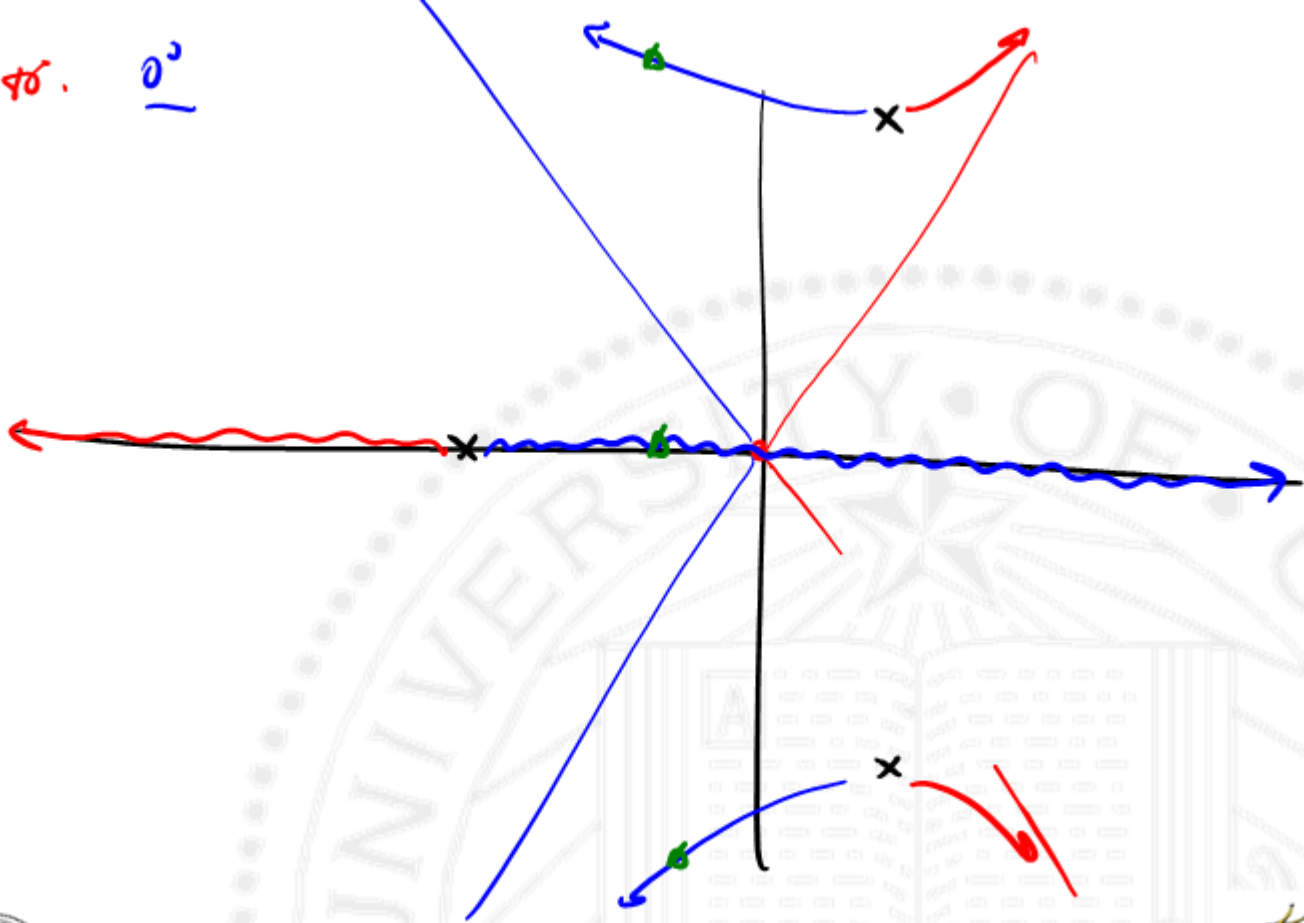


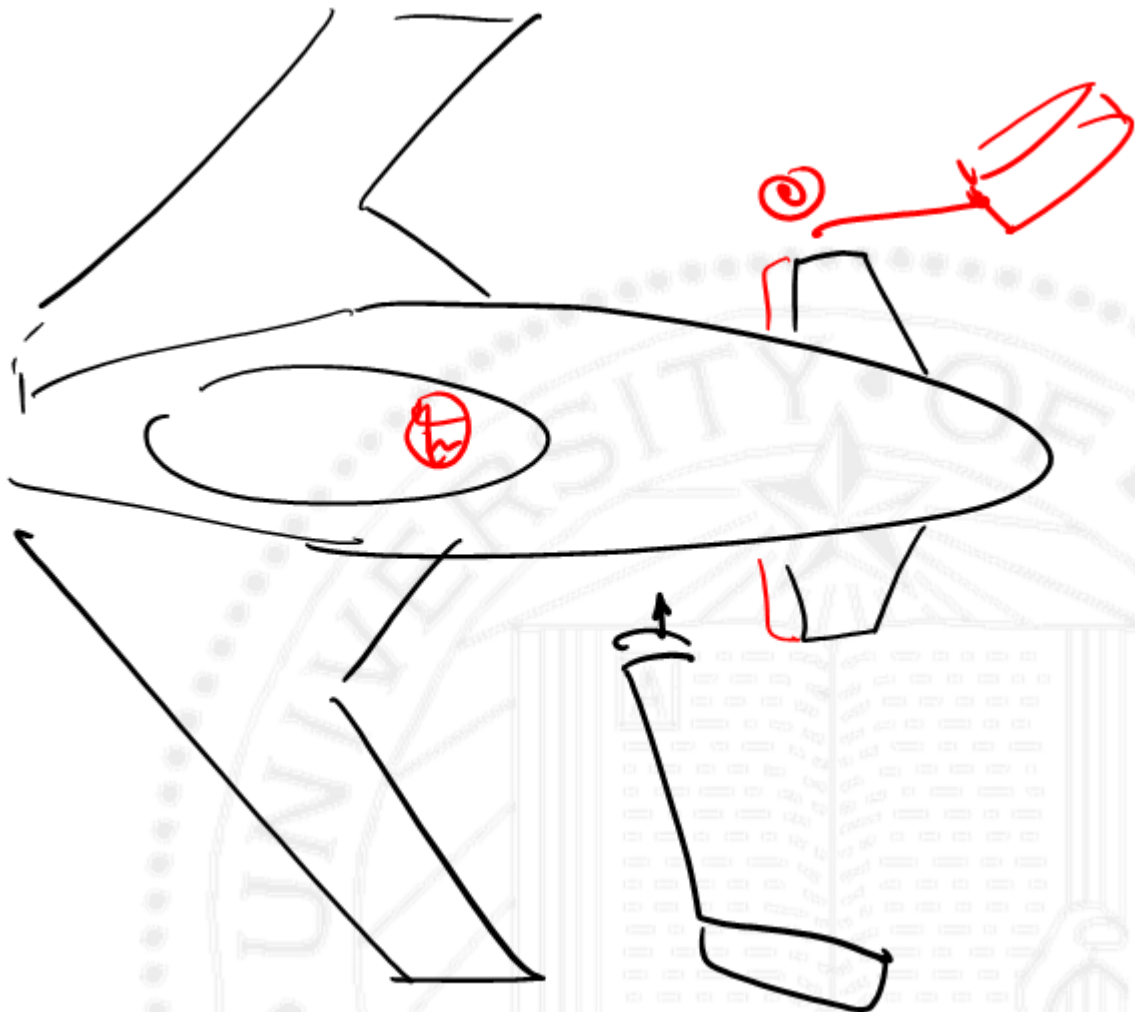
180°

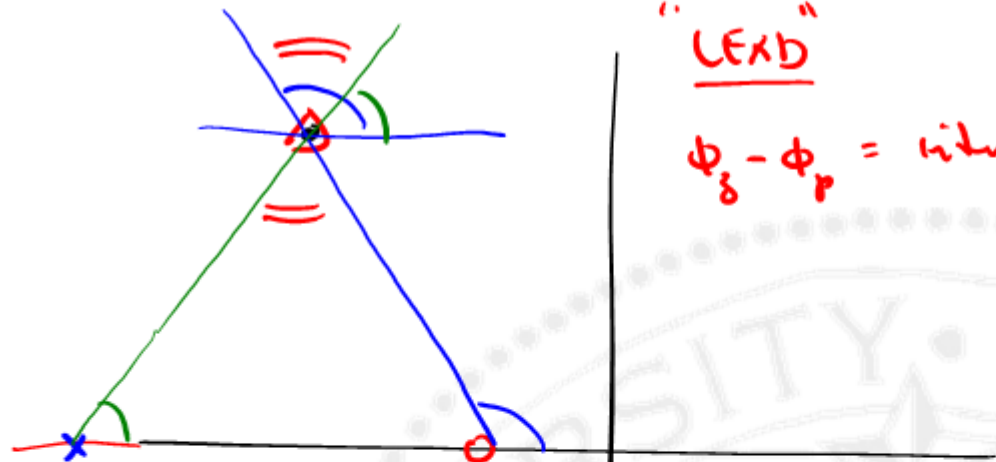
10°



180° 0°

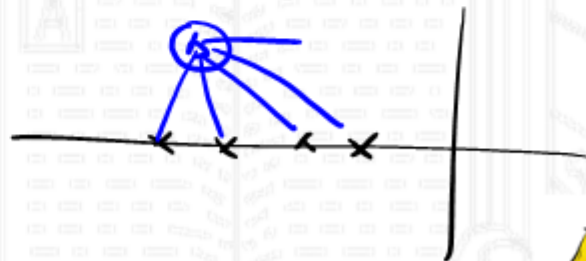






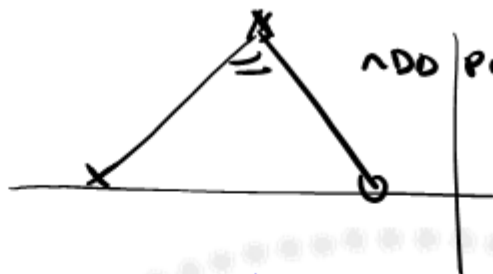
"LEAD"

$\phi_z - \phi_p = \text{introduction angle.}$



LEAD :

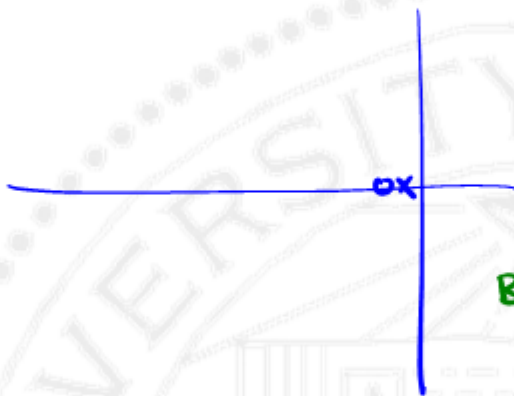
$$K_o \frac{s+3}{s+p}$$



ADD PHASE TO RL.

LAL

$$K_o \frac{s+2}{s+p}$$



$$x - 0.001$$

$$o - 0.01$$

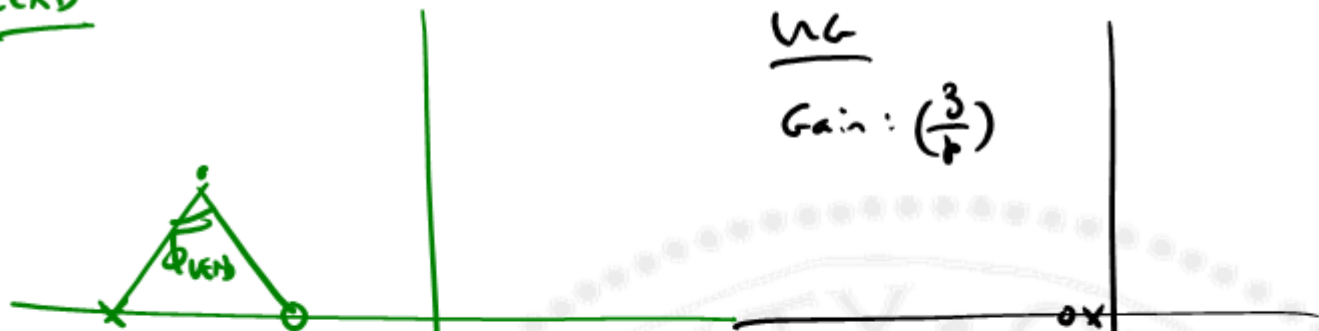
$$\sim \frac{10x}{1}$$

BOOST DC gain

DC gain: $\left(\frac{2}{p}\right)$

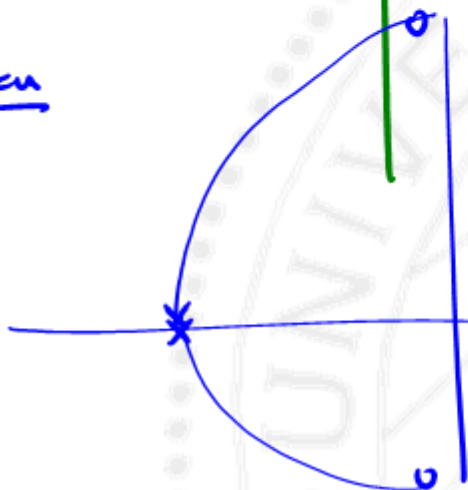


LEAD



$$\frac{w_c}{p}$$
$$\text{Gain: } \left(\frac{3}{p}\right)$$

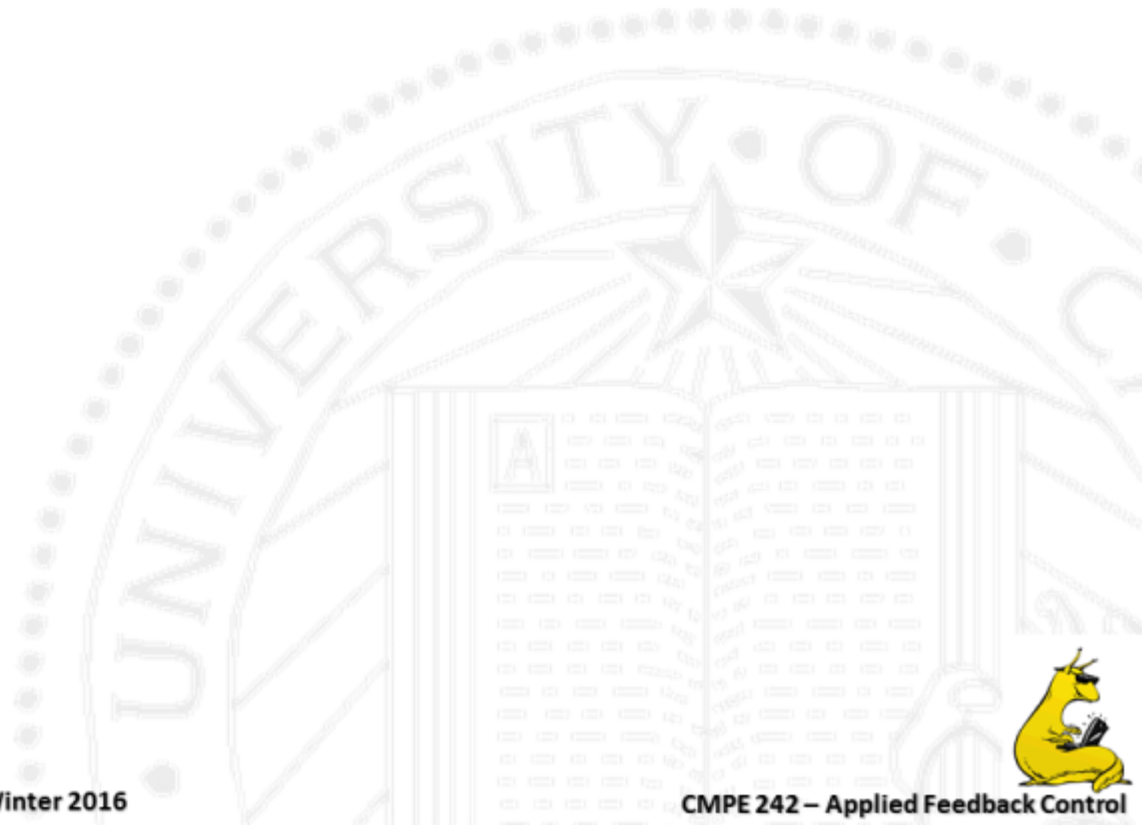
MOTEN

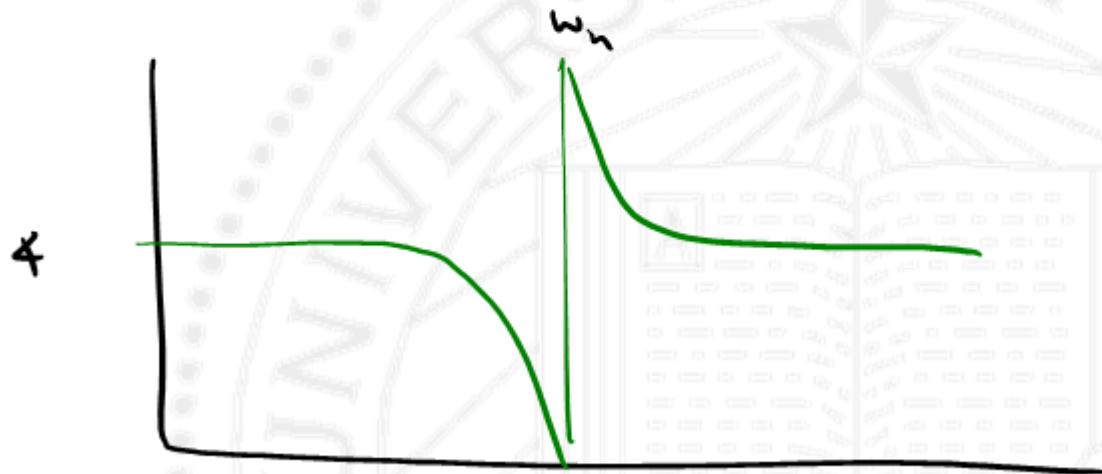
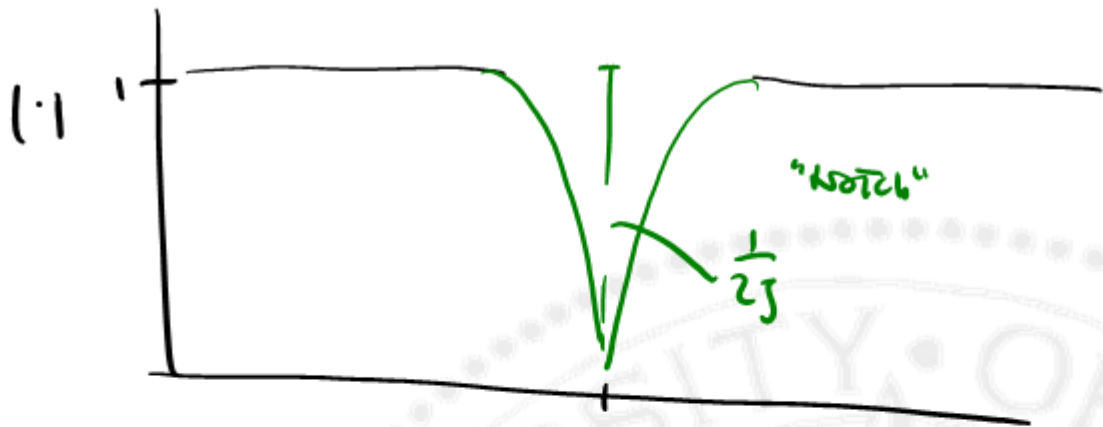


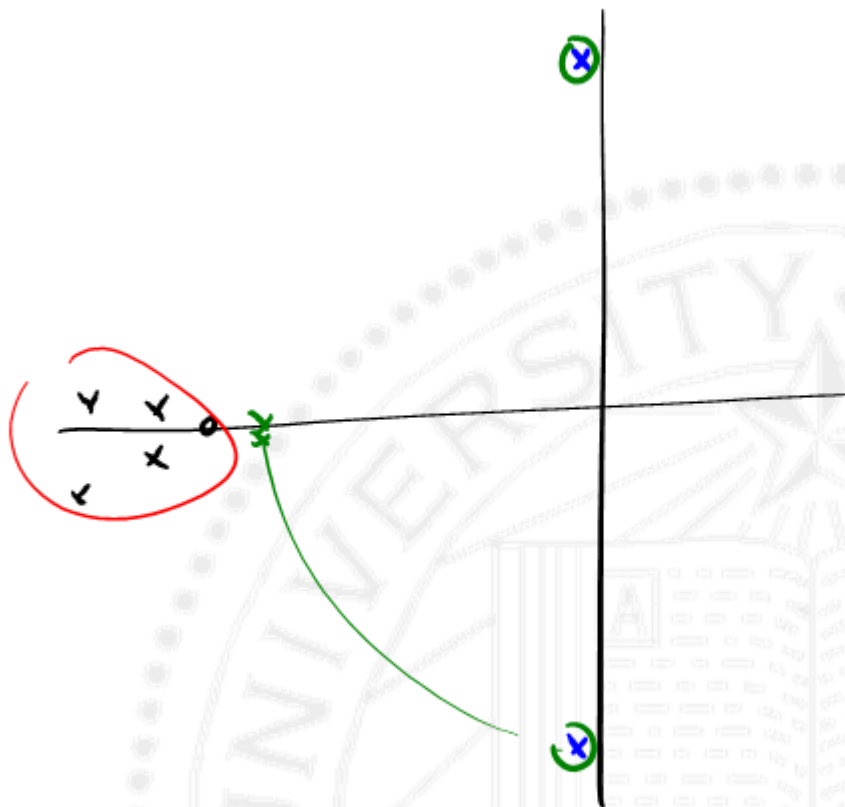
$$K_0 \frac{s^2 + 2\zeta_3 \omega_3 s + \omega_3^2}{s^2 + 2\zeta_r \omega_r s + \omega_r^2}$$

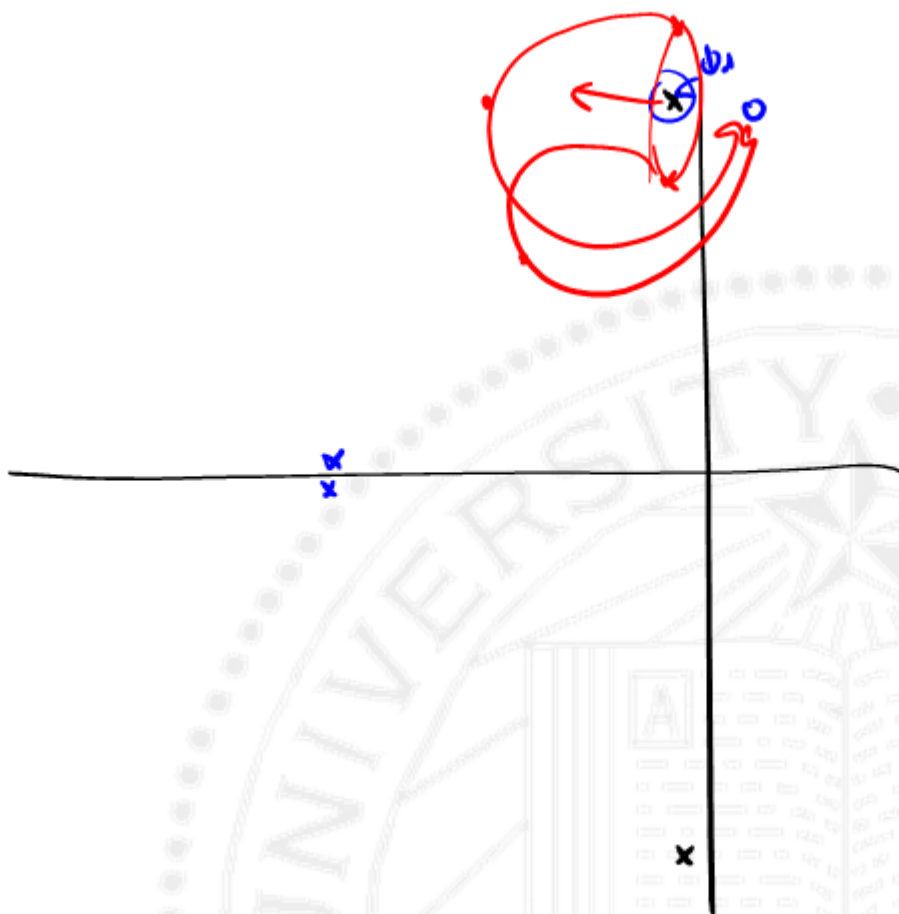
$$\frac{K_0 (s^2 + 2\zeta \omega_n s + \omega_n^2)}{(s + \omega)^2}$$

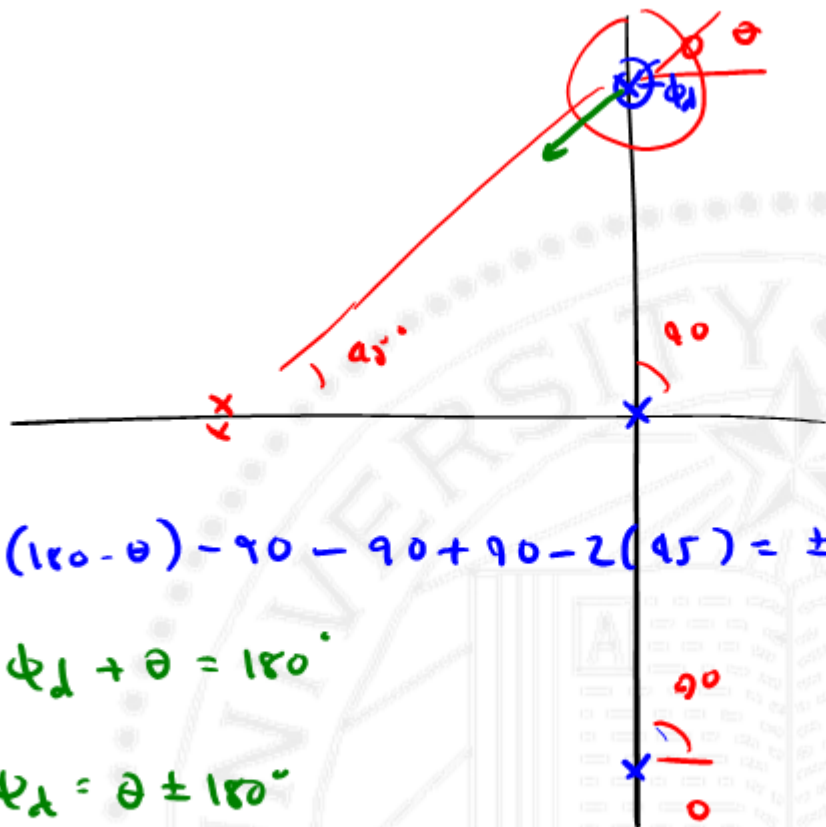










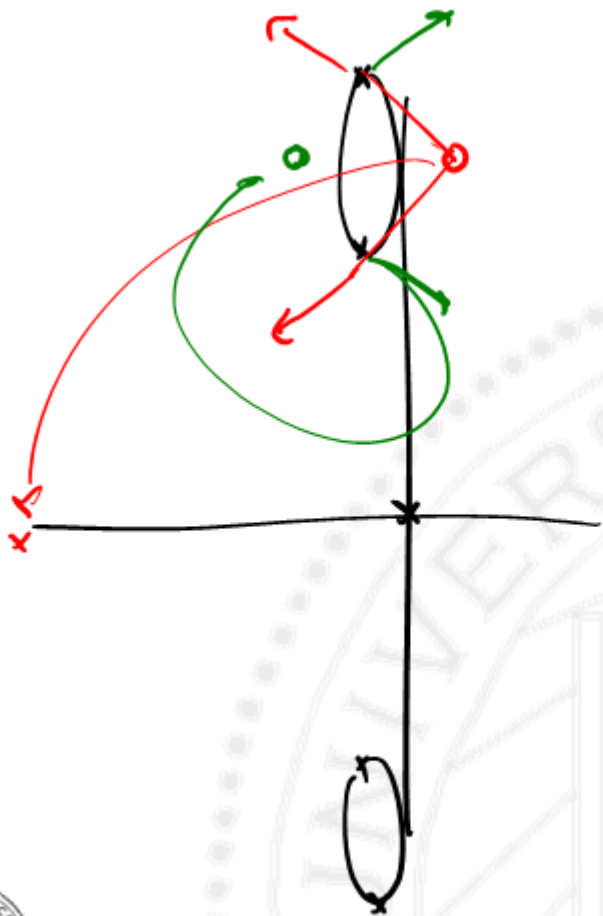


$$-\phi_d + (180 - \theta) - 90 - 90 + 90 - 2(45) = \pm 180$$

$$-\phi_d + \theta = 180$$

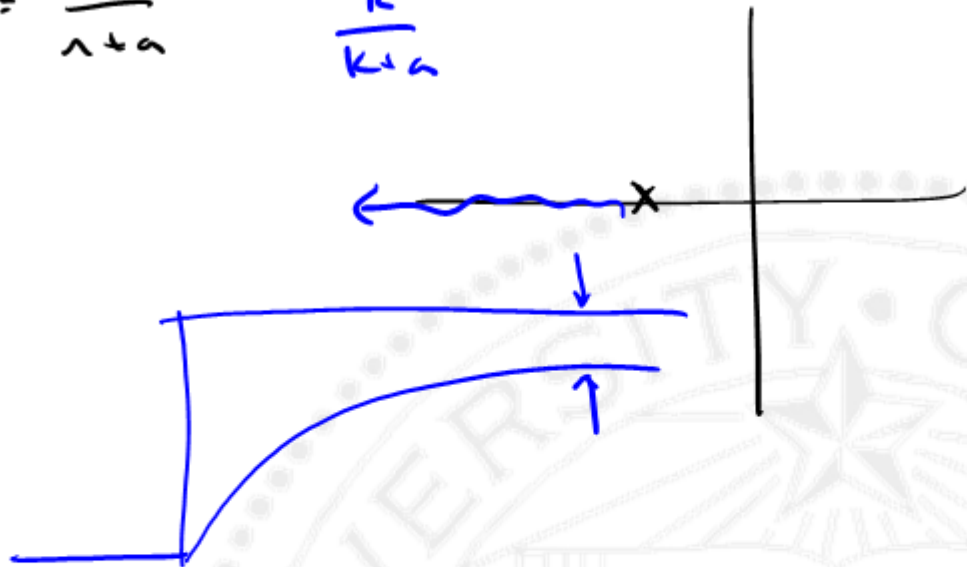
$$\phi_d = \theta \pm 180$$



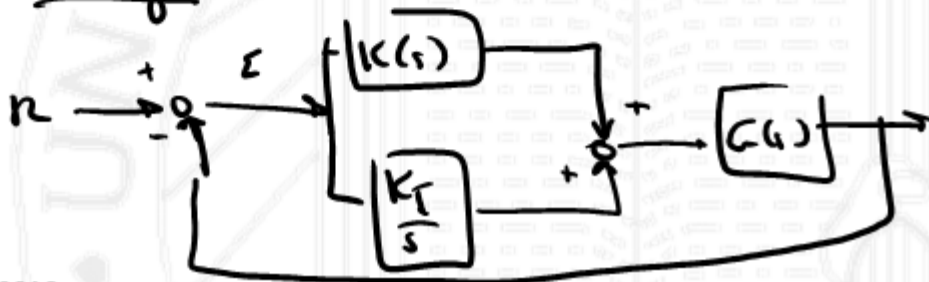


$$\text{Carrot} = \frac{1}{s+a}$$

$$\frac{k}{k+s}$$



Integral Control



Integral Control

- Anti-windup
- Reset

