CMPE-242
Applied Feedback Control

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Office Hours

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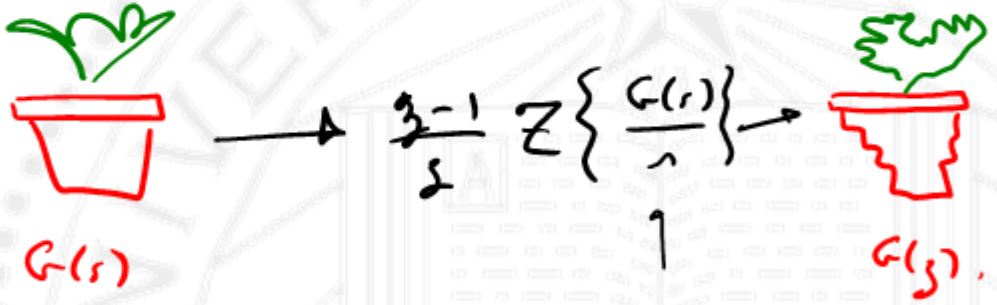
When to use TUSTIN, EXACT, ZOH.

ZOH: → convert plant from analog to digital



$G(s) \triangleq$ ∫1 response plant $G(z) =$ ∫1 response plant

c2d(G, 'zoh')

Exact $\quad \lambda = \frac{1}{T}\ln z \qquad z = e^{\lambda T}$

when I want to see equivalent poles / zeros

$$K(s) = k\frac{\prod(s - z_i)}{\prod(s - p_i)}$$

"zpk"

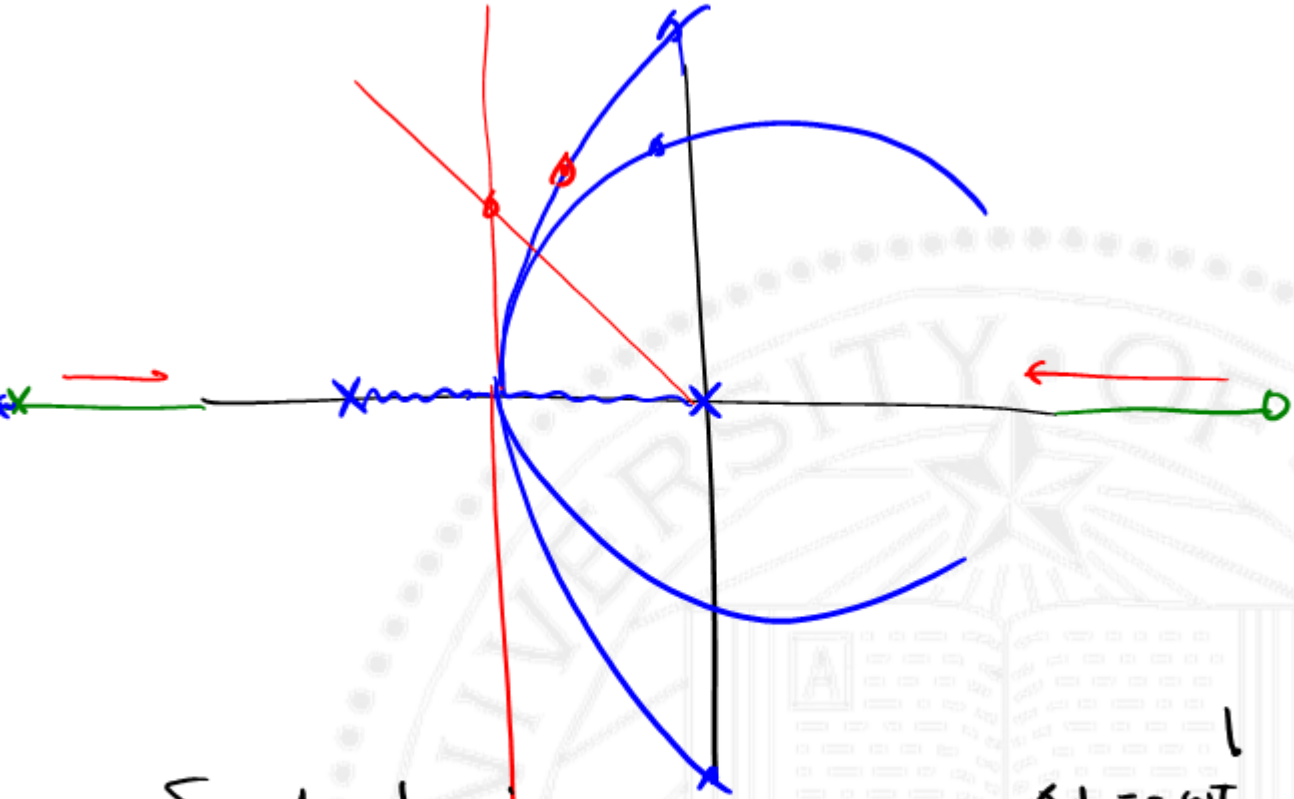
choose k_0 to get ideal DC gain.

$\lambda_{des} \rightarrow M_p, T_r \longrightarrow z_{des}$

$K(s) \longrightarrow K(z) \Big|_{\text{TUSTIN}}$

$G^*(s) \simeq G(s)$ + PADÉ (ROOT LOCUS)

LINEAR PHASE (BODE)

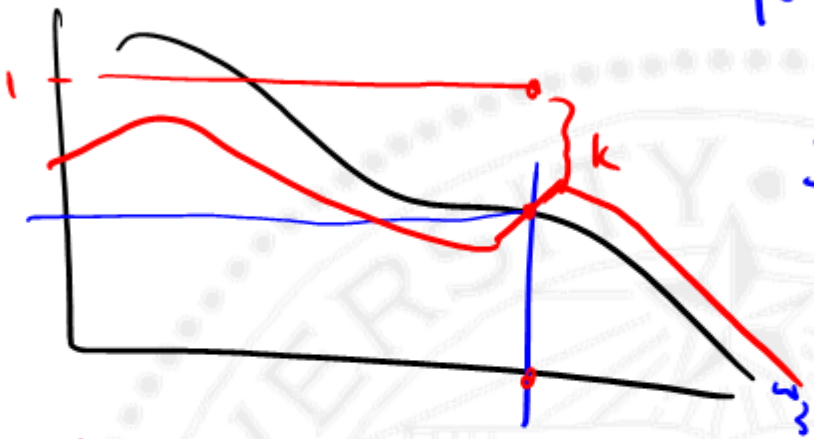


Sample time $\sim$ 20-30 ω_{x_0}

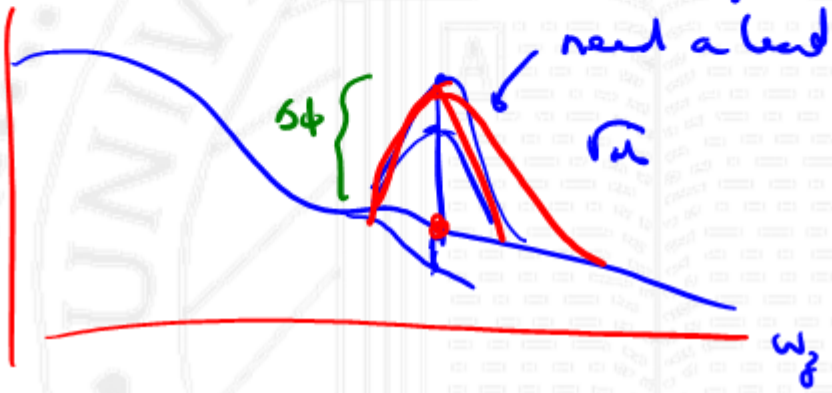
$$\delta\phi = -\frac{\omega T}{2}$$

Bode in Digital

$|GK(j\omega)|$

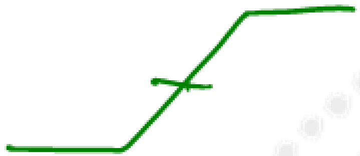


$\frac{GK}{1+GK}$

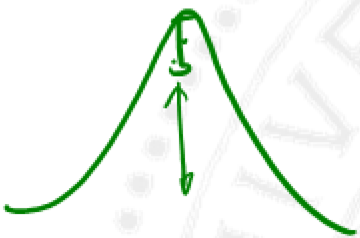


Design the lead in s.

$\sqrt{ab} \rightarrow$

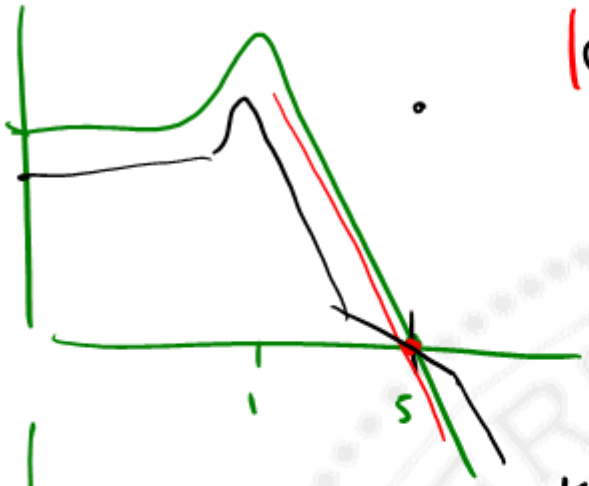


$K\sqrt{\frac{b}{a}}$

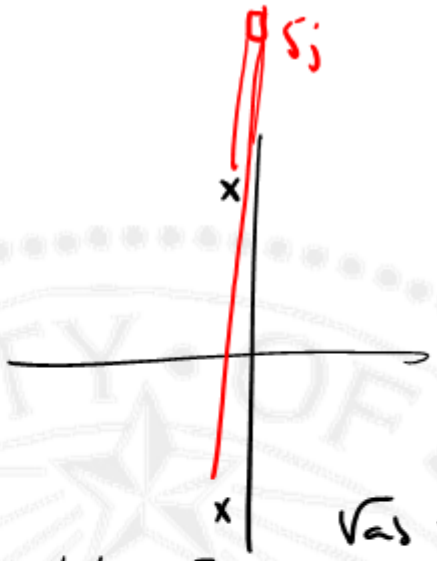


at $\sqrt{ab} \rightarrow \Delta\phi$ loss due to sampling $\frac{-\omega T}{2}$

LEAD(s) $\rightarrow$ LEAD(z) | Tustin, Prewarp @ $\sqrt{ab}$



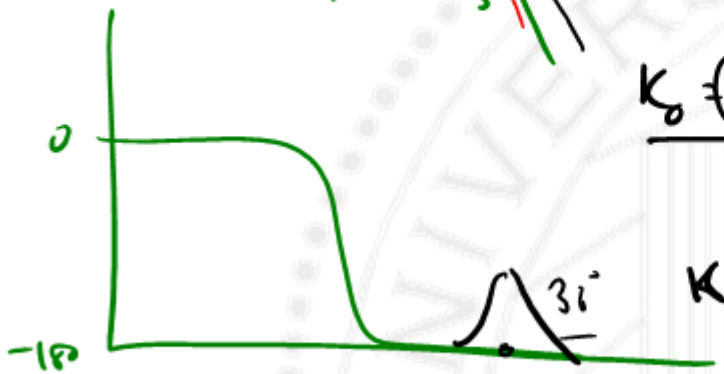
$|G(sj)|$



$K_0 = 10$ — $\omega_{x_0} = 1$

$\sqrt{ab} = 5$

$\frac{b}{a} = 9$.

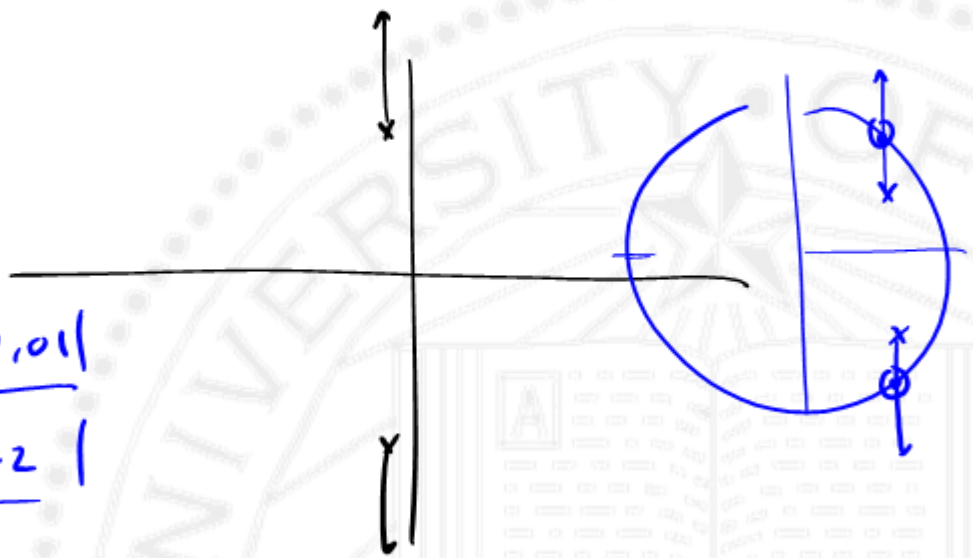


$K_{lead} = \sqrt{\frac{b}{a}} \frac{(s+a)}{(s+b)}$

Control plant to $G(s)$.

$\delta T = 0.2 \longrightarrow \omega_s = 5\pi$.

$K(s) = K_0$



$\delta T = 0.01$

$\delta T = 0.2$

$K_{lead}(s)$ → 36° phase $\omega_{x0} = 5$

$K_1(s) \leftarrow K_1(z) \rightarrow$ 36° phase margin $\omega_{x0} = 5$ $T_s = 0.01$

$K_2(s) \leftarrow K_2(z) \rightarrow$ 36° phase margin " ... $T_s = 0.2$

$\omega_{x0} = 5$ rad/s $= \frac{5}{2\pi}$ Hz. ~ 0.8 Hz.

$\lfloor$

120 x ω_{x0}.

$-38°$ ~ $\boxed{C_x \omega_{x0}}$ ← 5 Hz