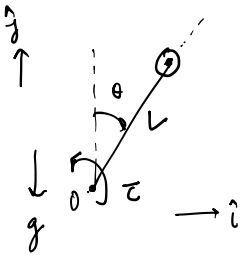
Tuesday, April 22, 2025 8:56 AM



Ref $\ddot{\theta}_R + K_1\theta_R = 0 \longrightarrow u_R$

$\dot{h} \simeq \tau_{total}$

$L\ddot{\theta} - g\sin\theta = \tau$

$\ddot{\theta} = \frac{g}{L}\sin\theta + \frac{\tau}{L}$ ($\frac{g}{L} = \omega_n^2$, $\frac{\tau}{L} = u_R + \delta u$)

$\Rightarrow \ddot{\theta} = \omega_n^2 \sin\theta + u_R + \delta u$

Goal $\theta - \theta_R \to 0$ | $\dot{\theta} - \dot{\theta}_R \to 0$

$V(\delta\theta, \delta\dot{\theta}) = \frac{1}{2}\delta\dot{\theta}^2 + \frac{1}{2}K\delta\theta^2$

$\dot{V}(\delta\theta, \delta\dot{\theta}) = \delta\dot{\theta}(\delta\ddot{\theta} + K\delta\theta) = -C\delta\dot{\theta}^2 \le 0$

$\delta\dot{\theta}(\delta\ddot{\theta} + K\delta\theta + C\delta\dot{\theta}) = 0$

$\delta\ddot{\theta} + K\delta\theta + C\delta\dot{\theta} = 0$

$\ddot{\theta} - \ddot{\theta}_R + K\delta\theta + C\delta\dot{\theta} = 0$

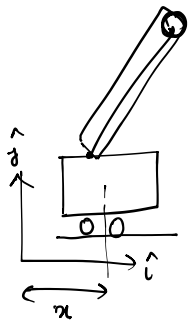
$\delta u + \omega_n^2\sin\theta + u_R - (-K_1\theta_R) + C\delta\dot{\theta} + K\delta\theta = 0$

$\delta u = -K_1\theta_R - \omega_n^2\sin\theta - u_R - C\delta\dot{\theta} - K\delta\theta$

$\dot{V}(\delta\theta, \delta\dot{\theta}) = -C\delta\dot{\theta}^2 \le 0 \longrightarrow \delta\dot{\theta} = 0 - \Omega$

$\ddot{V}(\delta\dot{\theta}=0, \delta\theta) = -2\delta\dot{\theta}\,\delta\ddot{\theta} = \not{0}\ 0$ ($\delta\dot{\theta} = 0$)

$\dddot{V}(\delta\dot{\theta}=0, \delta\theta) = (\delta\theta) \to < 0$



$Q_i = K_i\dot{q}_i$ Q_{max}

① $|K_i\dot{q}_i| \le Q_{max}$ · Controller performance

② $Q_i = -K\,sgn(\dot{q})\dot{q}$ → Optimal — Not optimal

③ $K_i\dot{q}_i$ $Q < Q_{max}$ Suboptimal

$Q_i = -Q_{max}\,sgn(\dot{q}_i)$ $Q \ge Q_{max}$