

$$\theta =$$

$$I_{yy} \cdot \dot{\theta}_y = \tau_{dis} + \tau$$

$$\tau =$$

$$I_{yy} \dot{\theta}_y = \tau + \tau_{dis}$$

~~$$\tau = F_3 l_3 - F_1 l_1$$~~

~~$$= F_{C_3} \times r_{C_3} - F_{C_1} \times r_{C_1}$$~~

$$\tau = \sum_{j=1}^4 r_{C_1, j} \times F_{r_1, j}$$

$$F_1 = F_2 = F_3 = F_4 = \frac{F}{4}$$

Bo

$$r_{C_1, 1} = l + \Delta x$$

$$r_{C_1, 2} = -l + \Delta x$$

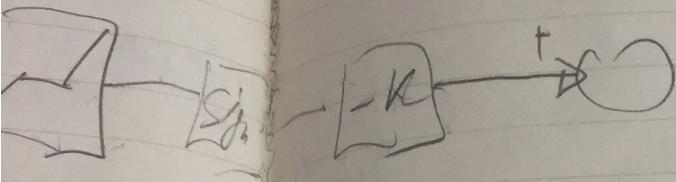
$$r_{C_1, 3} = \Delta x$$

$$r_{C_1, 4} = \Delta x$$

$\tau_{diff} =$

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 $\Delta b(q, \dot{q}) = b$
ctor $e(t, q)$ defines the difference between
 $q(t)$ and the reference vector $q_{ref}(t)$:

system (11). Thus, the switching gains of the additional control vector τ_v are only required to be greater than the magnitudes of the disturbance compensation error vector p , and disturbance vector



$$\Delta x = \mu \cdot x_2 \\ \mu(x_1 + x_3)$$

$$T = F_g \cdot \Delta x$$

$$T = \frac{F_g}{\mu} \cdot (l \cdot x_2) + F_g \left(\frac{l \cdot x_3}{\mu g} \right)$$

~~$$= \cancel{\mu \cdot \frac{F_g}{g}} \Delta x = F_g \cdot \Delta x$$~~

$$\Delta x = \mu \cdot (x_1 + x_3)$$

$$T = F_g \cdot \mu \cdot (x_1 + x_3)$$

$$T_{\text{diff}} \Rightarrow (x_1 + x_3) = \frac{T_{\text{ref}}}{F_g \cdot \mu} = \frac{T_{\text{ref}}}{\mu g \cdot \frac{m}{\mu}} =$$

$$= \frac{E_{\text{ref}}}{m g}$$

$$x_1 + x_3 = \frac{\tau_{ref}}{mg}$$

$$x_1 = x_3 = x$$

$$2x = \frac{\tau_{ref}}{mg}$$

$$x_{ref} = \frac{\tau_{ref}}{2mg}$$

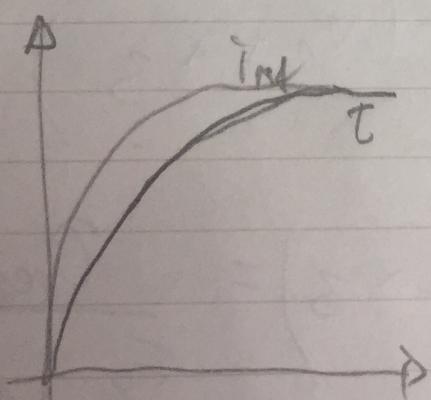
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$$e = y - y_{ref} = \theta_m - \theta_{ref}$$

$$\begin{aligned} a_n &= J_{yy} g \\ b_n &= 0 \end{aligned}$$

$$\tau_{ref} = -K_2 \operatorname{sign}(e) + I_{yy} \ddot{\theta}_{ref} - \dot{I}_{yy} \cdot \ddot{\theta}_{ref}$$

$$\sigma = e + \lambda_1 e + (\lambda_2 \int e(t) dt)$$



$$\lambda_1 = a_n^{-1} b_n = 0$$

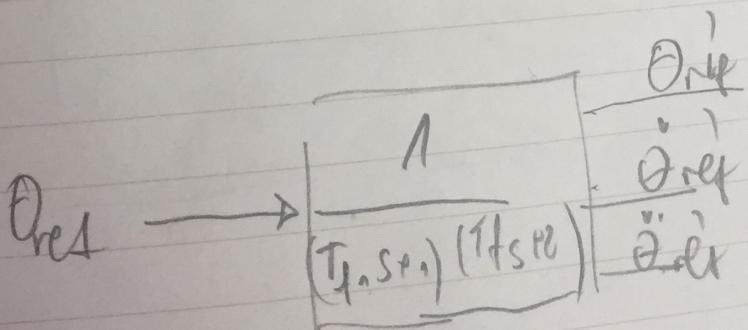
$$\theta_{\text{ref}} = I_{yy} \theta_{\text{ref}} - I_{yy} \alpha \cdot \text{el}(t) \\ - n_2 \text{sign}(\sigma)$$

$$\sigma = \underline{\dot{e}} + \overbrace{\lambda_1 e}^0 + \lambda \int \text{el}(t) dt$$

λ - Parameter

$$\lambda_1 = 0$$

$$\ddot{\theta}_{\text{ref}} = ?$$

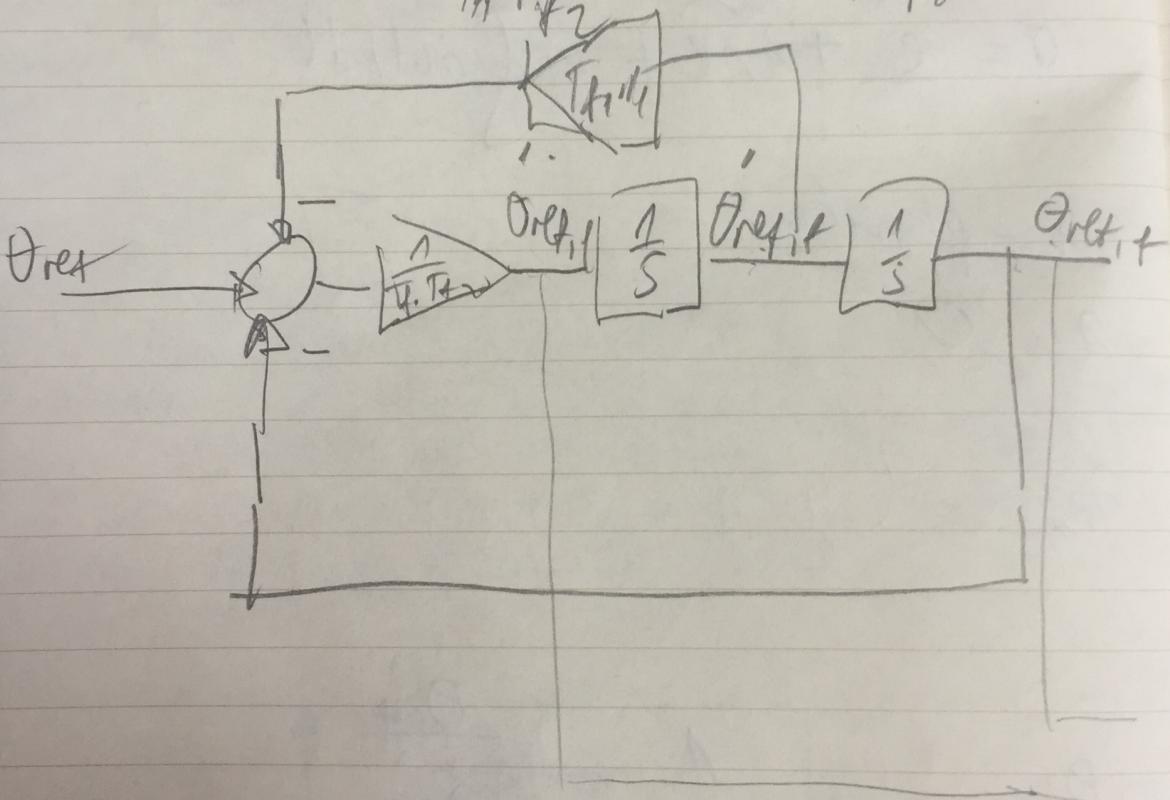


$$\frac{\theta_{\text{ref}, f}}{\theta_{\text{ref}, 0}} = \frac{1}{(T_{f1}, 1) (T_{f2}, s+1)}$$

$$(T_{f1} T_{f2} s^2 + (T_{f1} \cdot T_{f2} s) + 1) \dot{\theta}_{ref} = \dot{\theta}_{ref,f}$$

$$T_{f1} T_{f2} \ddot{\theta}_{ref,f} + (T_{f1} + T_{f2}) \dot{\theta}_{ref,f} + \dot{\theta}_{ref,f} \dot{\theta}_{ref,k}$$

$$\ddot{\theta}_{ref,f} = - \frac{(T_{f1} + T_{f2}) \dot{\theta}_{ref,f} - 1}{T_{f1} T_{f2}} \dot{\theta}_{ref,f} + \frac{1}{T_{f1} T_{f2}} \dot{\theta}_{ref,k}$$



the difference between treated as the system (11). Thus the switching gains of the additional