Cubli: Dynamic Control of a Reaction Wheel Inverted Pendulum

June 20, 2016

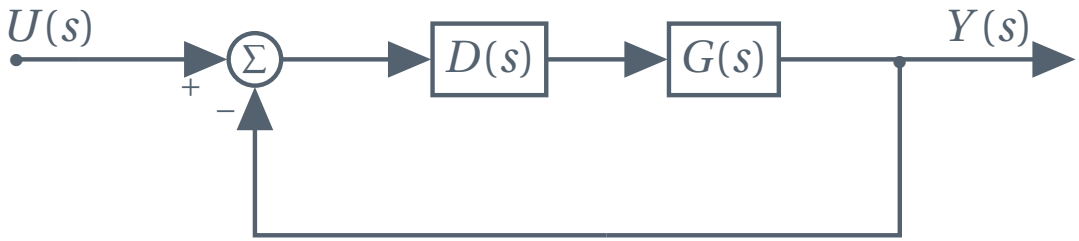
Bjørn Kitz
Julien Bréhin
Noelia Villarmarzo Arruñada
Niels Skov Vestergaard
Mikael Sander

SICT
Aalborg University
Denmark

AALBORG UNIVERSITY
DENMARK

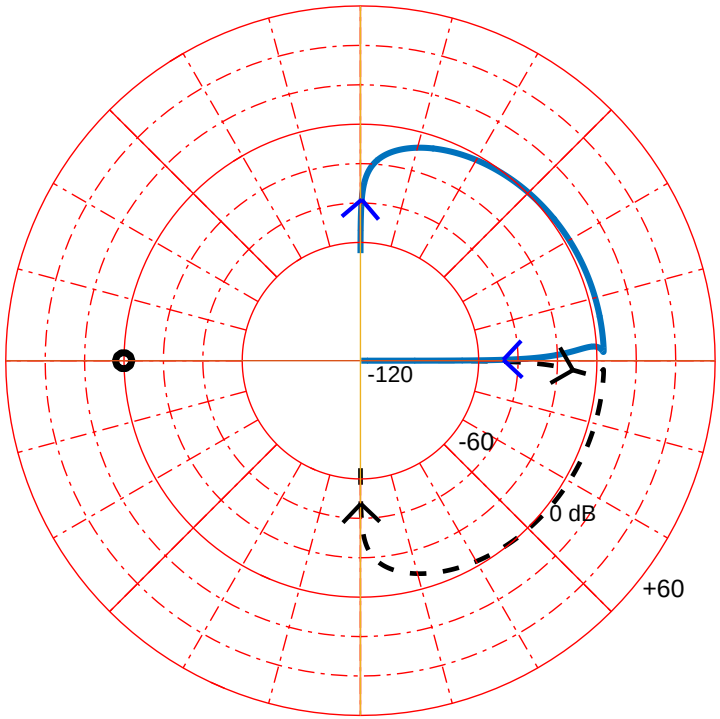
Agenda

Classical Controller Design



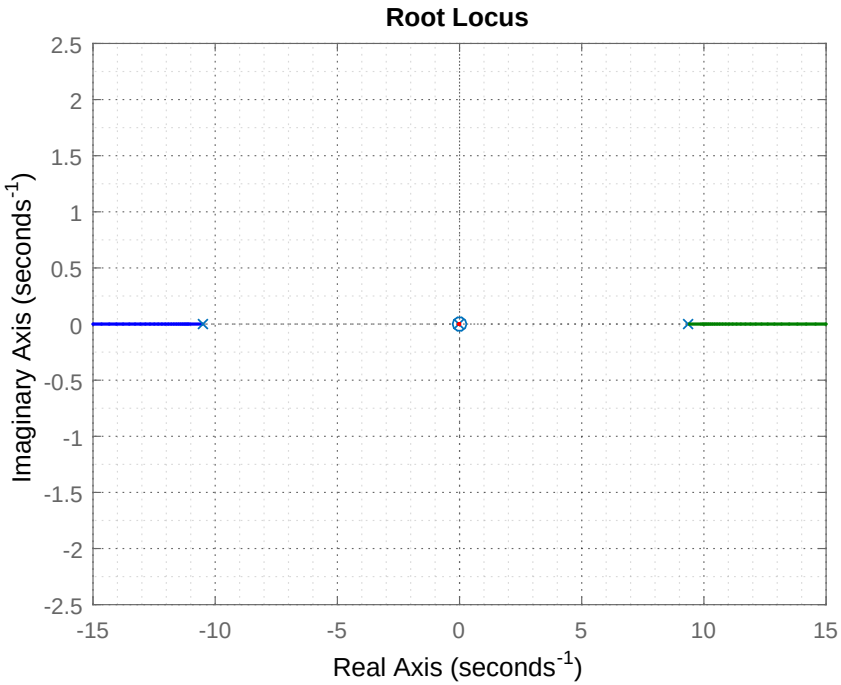
- U(s) refers to the desired angular position of the frame
- Y(s) is the actual angular position of the frame

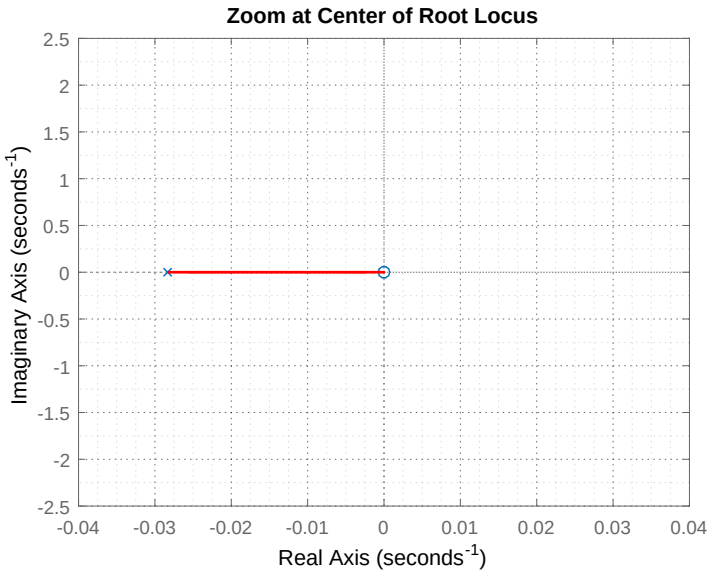
- Nyquist plot

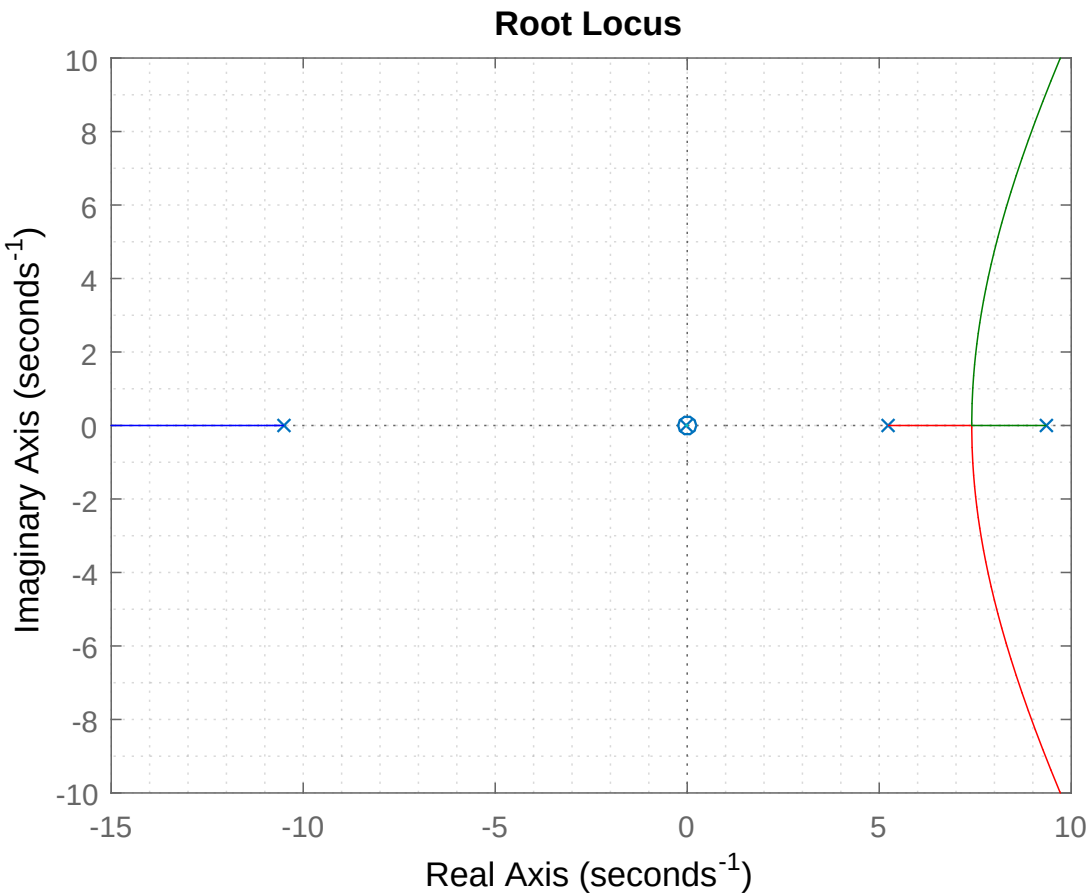


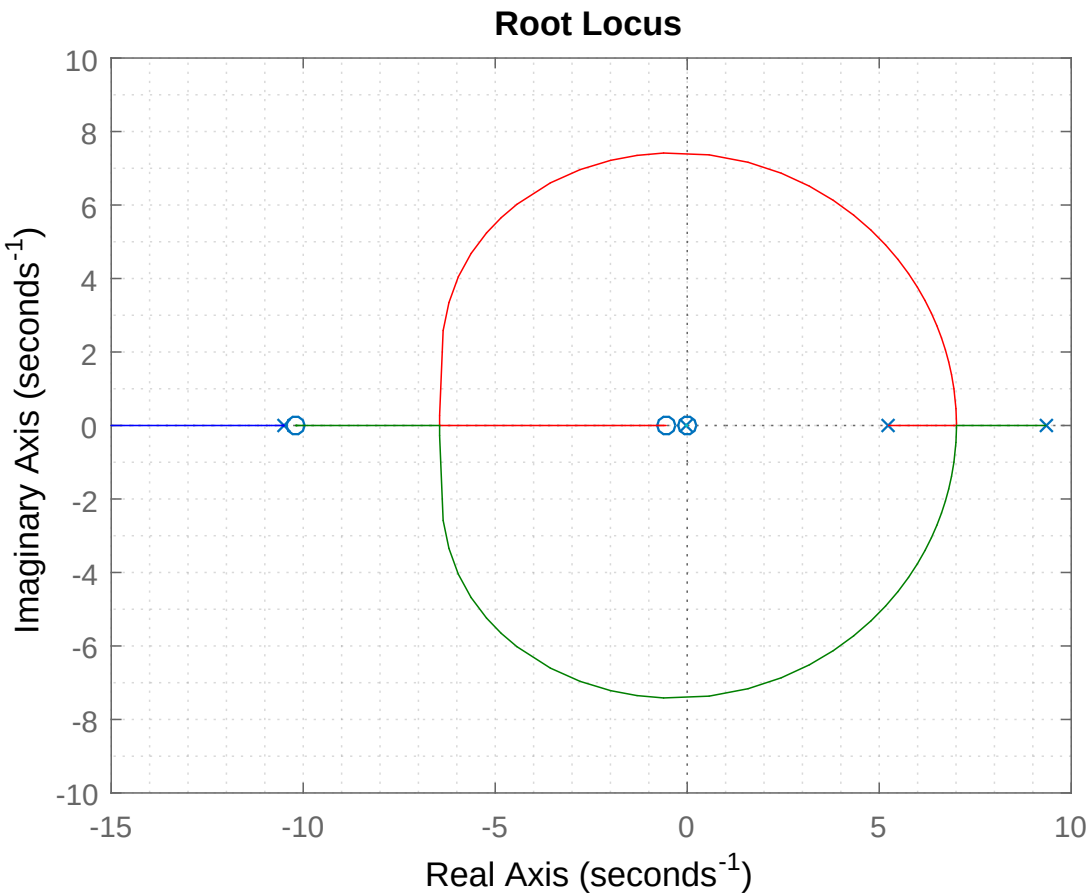
$$Z_{RHP} = N + P_{RHP}$$

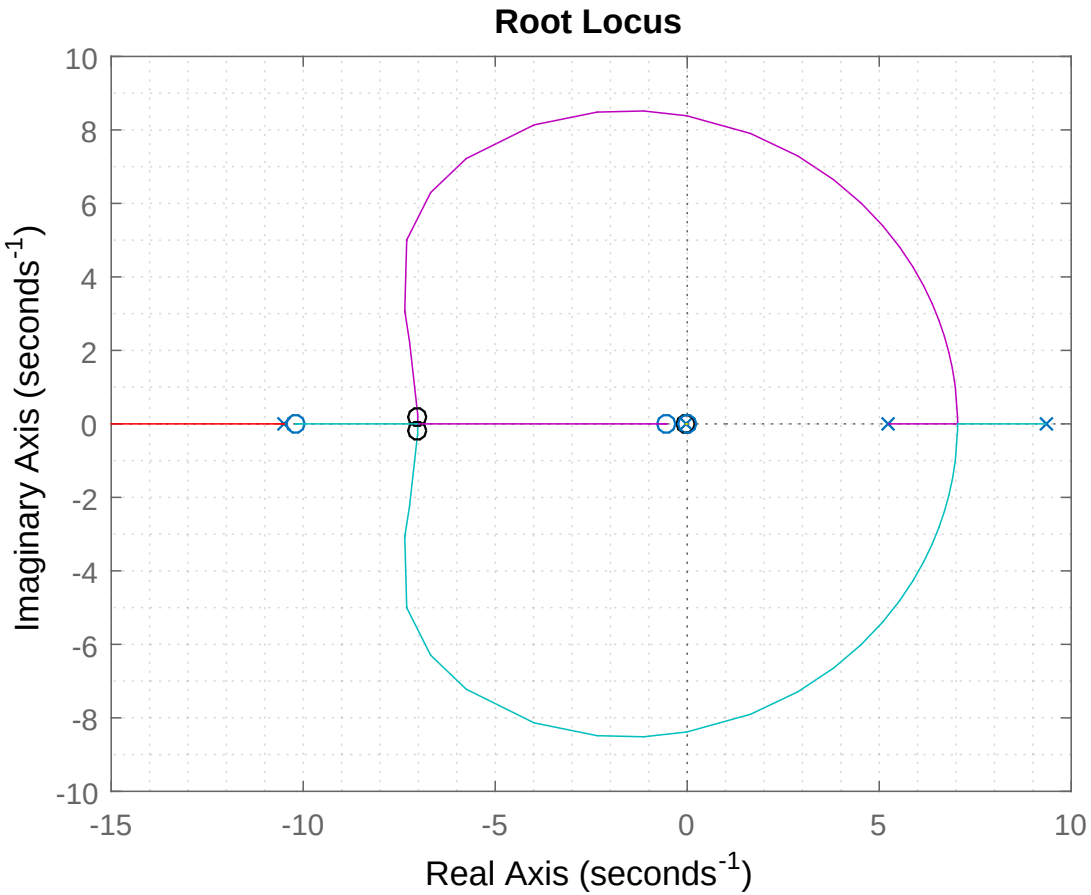
Root Locus

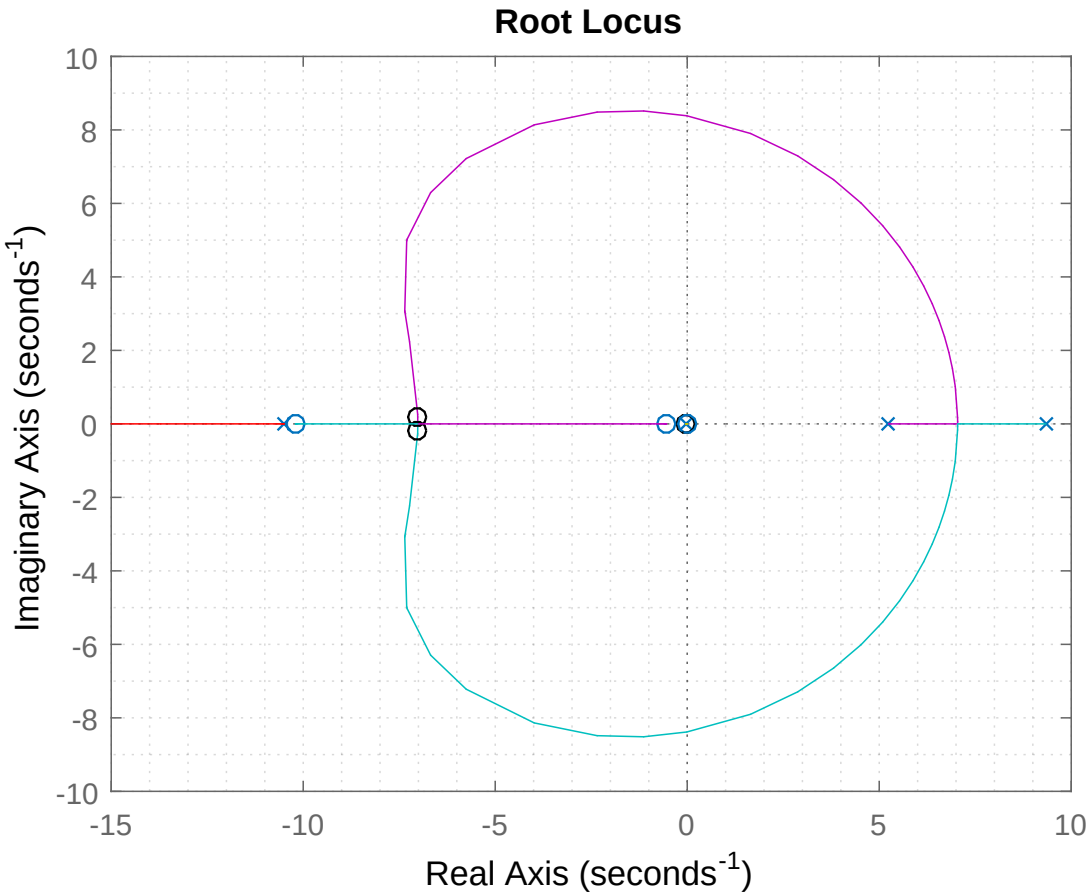




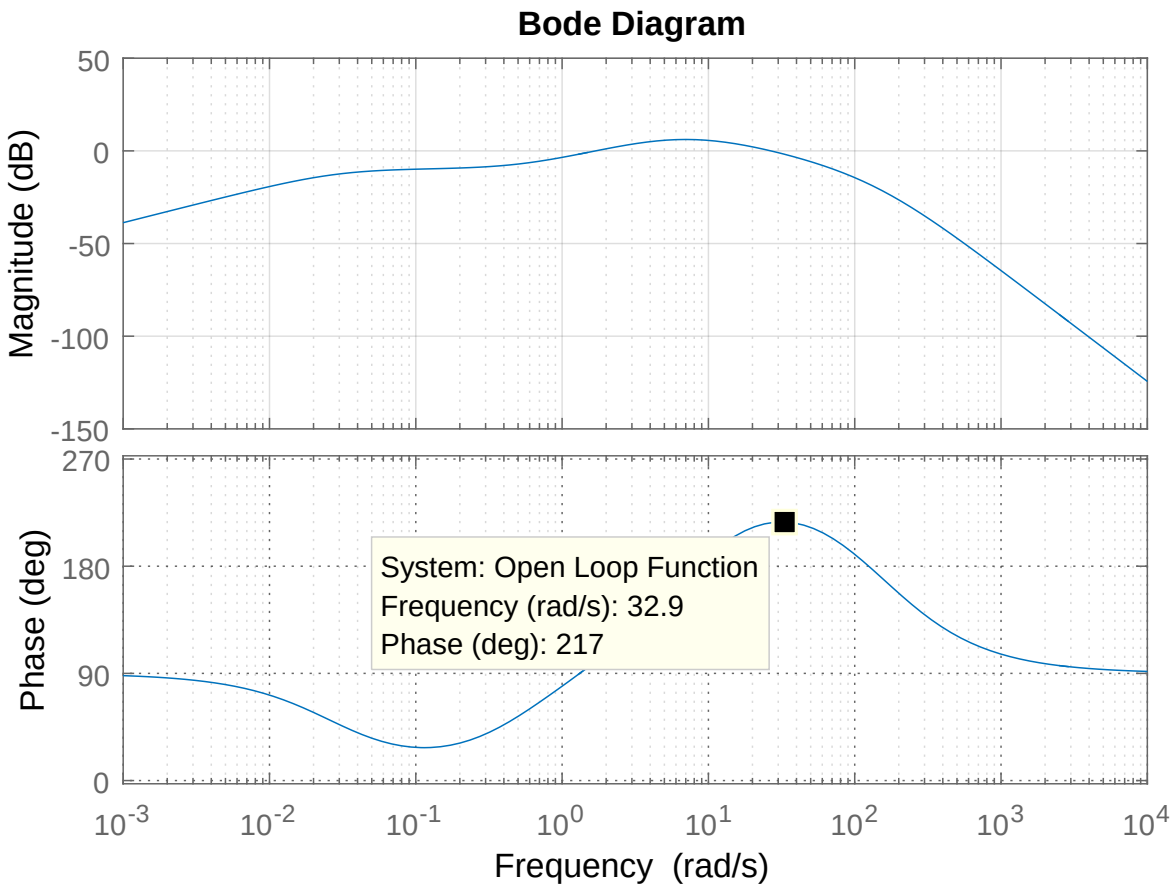






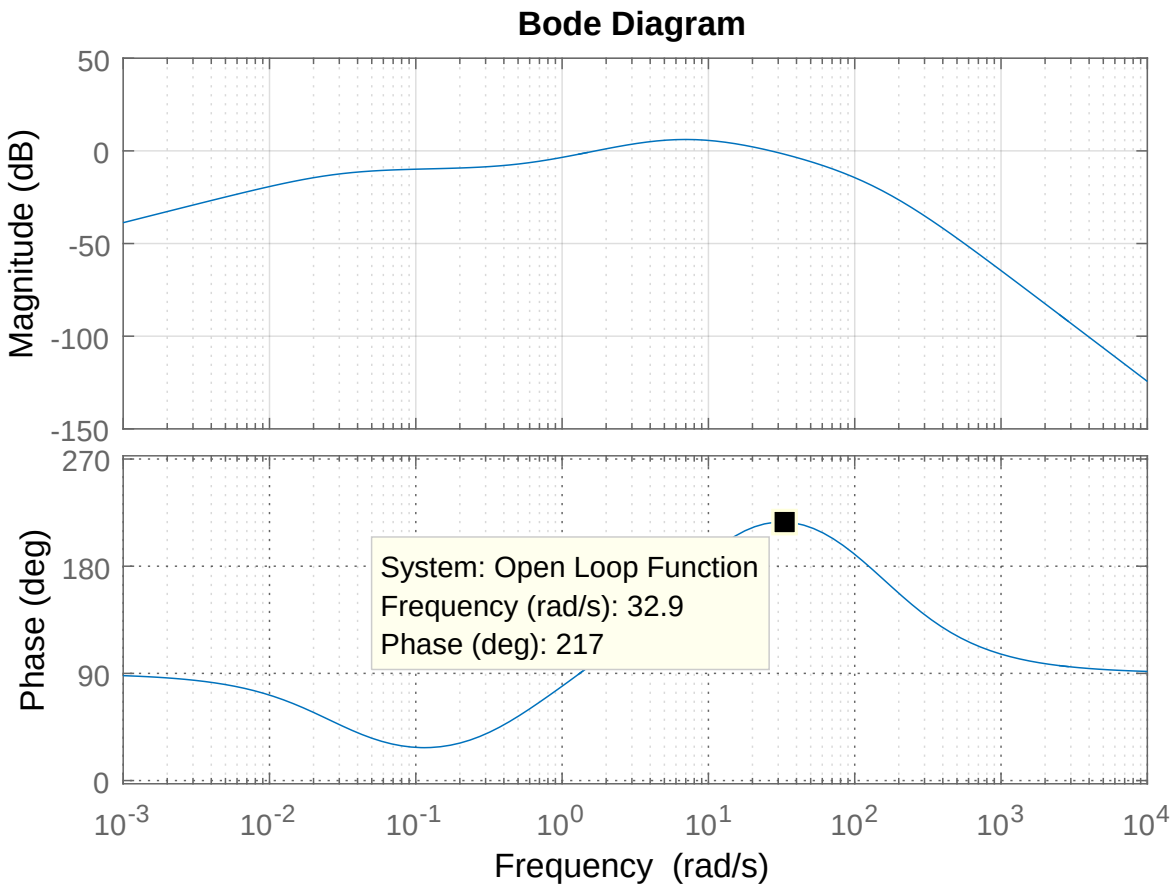


$$D(s) = -4059,8 \cdot \frac{(s+10,2)\cdot(s+0,546)}{(s-5,23)\cdot(s+100)\cdot(s+200)}$$



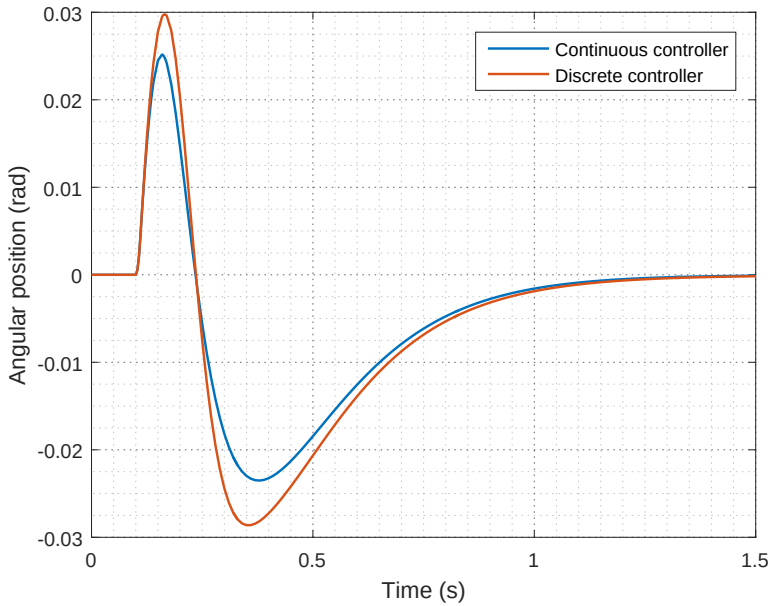
Root Locus Designed Controller

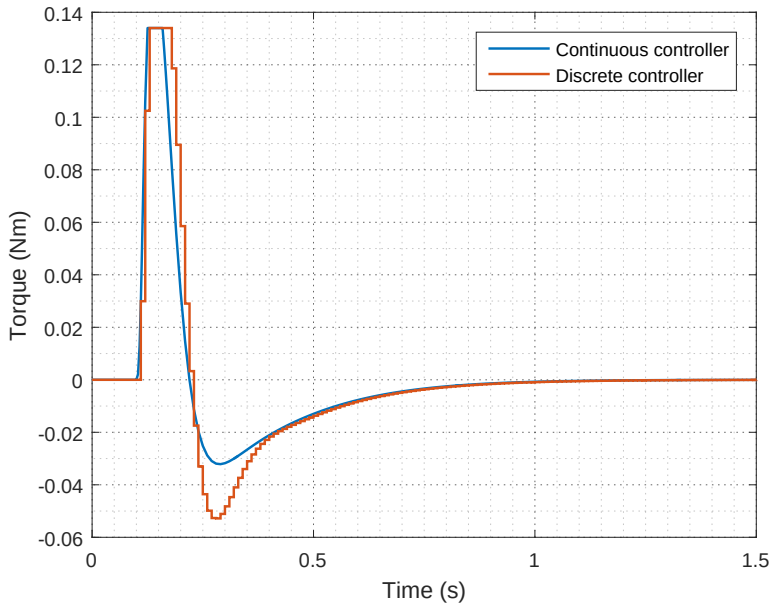
Discretization



$$D(z) = \frac{\tau_{m,w}(z)}{e_\theta(z)} = \frac{-7,338 + 6,58 \cdot z^{-1} + 7,335 \cdot z^{-2} - 6,584 \cdot z^{-3}}{1 - 1,3879 \cdot z^{-1} + 0,3409 \cdot z^{-2} + 0,001576 \cdot z^{-3}}$$

- Behavior of the continuous and the discrete controllers in simulation





- Difference equation

$$\begin{aligned}\tau_m[n] = &-8.314 \cdot e_\theta[n] + 7.422 \cdot e_\theta[n-1] + 8.3023 \cdot e_\theta[n-2] \\ &-7.434 \cdot e_\theta[n-3] + 1.382 \cdot \tau_m[n-1] - 0.3415 \cdot \tau_m[n-2] \\ &-0.001638 \cdot \tau_m[n-3]\end{aligned}$$

- Angular position of the frame and angular velocity of the wheel in the real Cubli