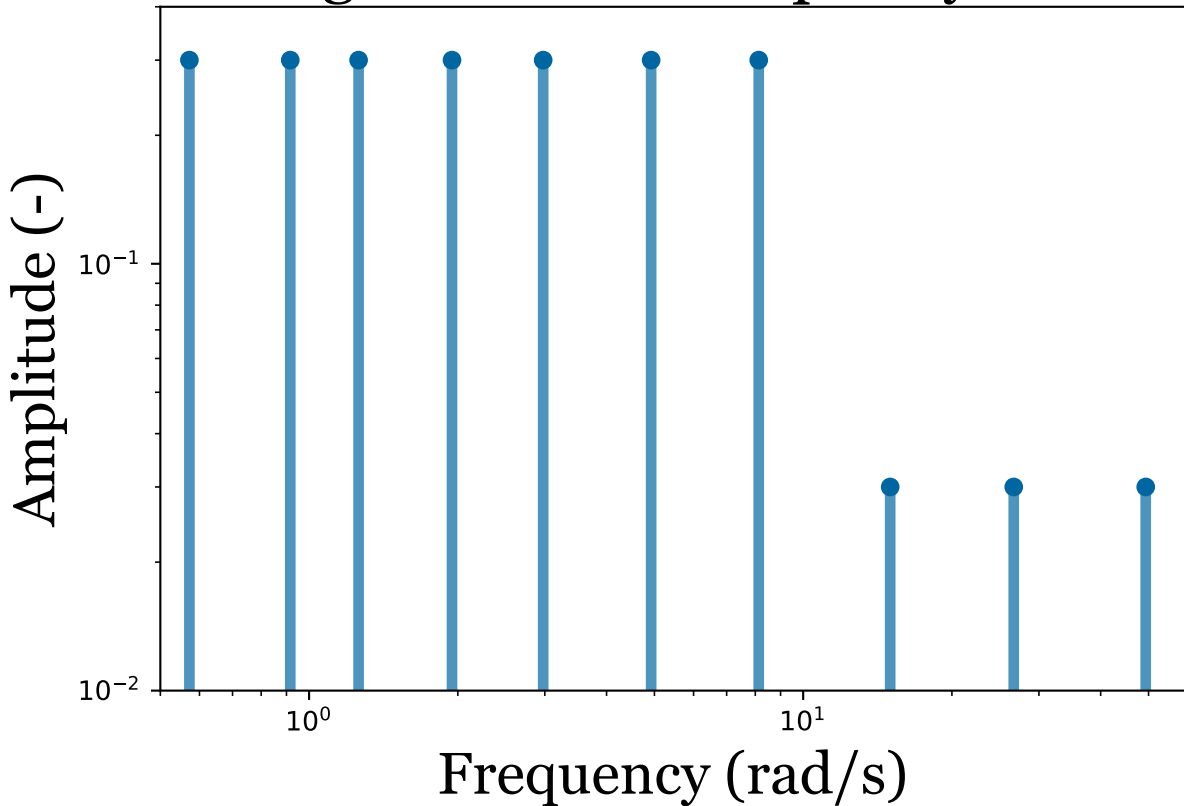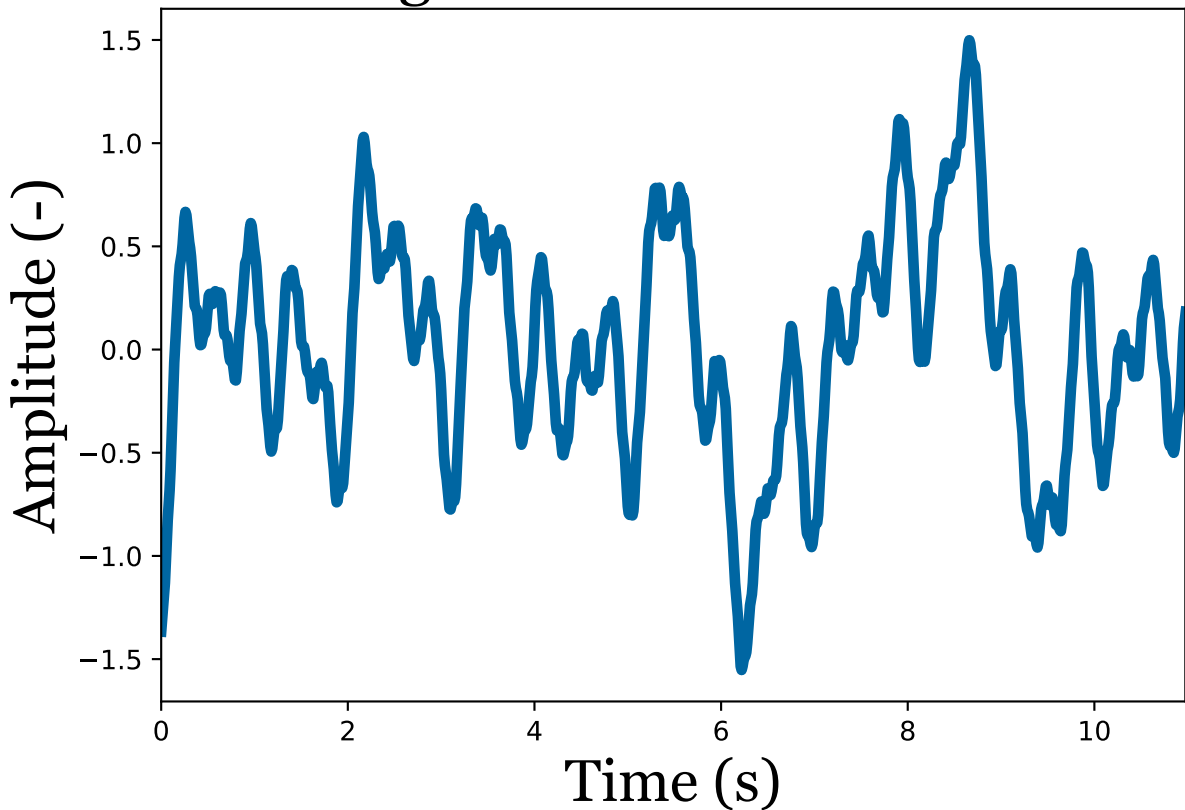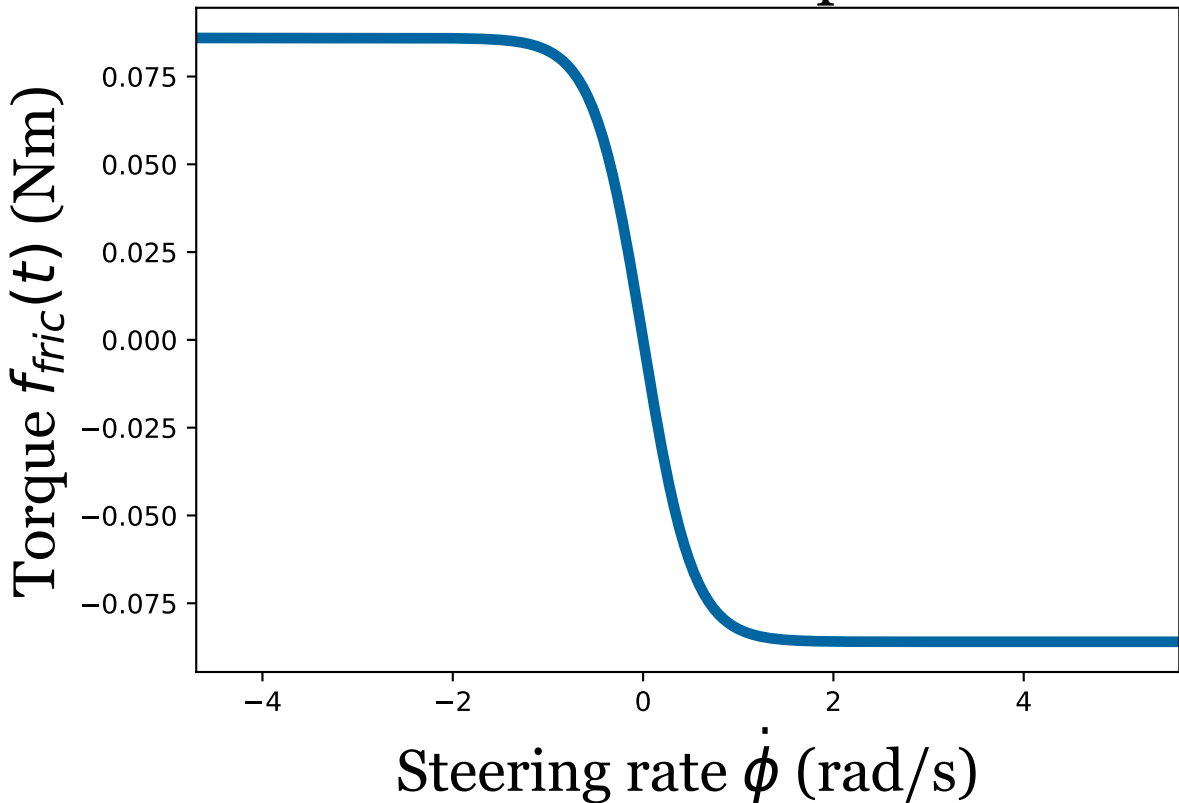Forcing function in frequency domain

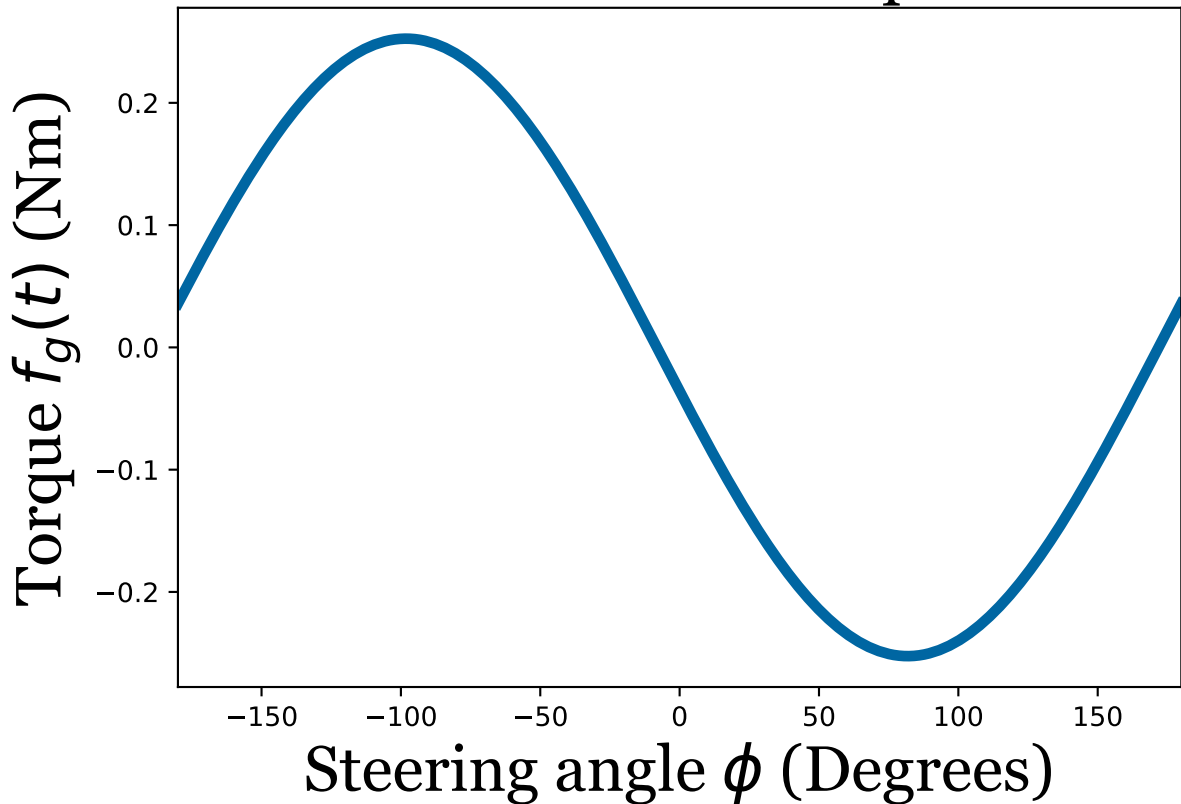Forcing function in time domain

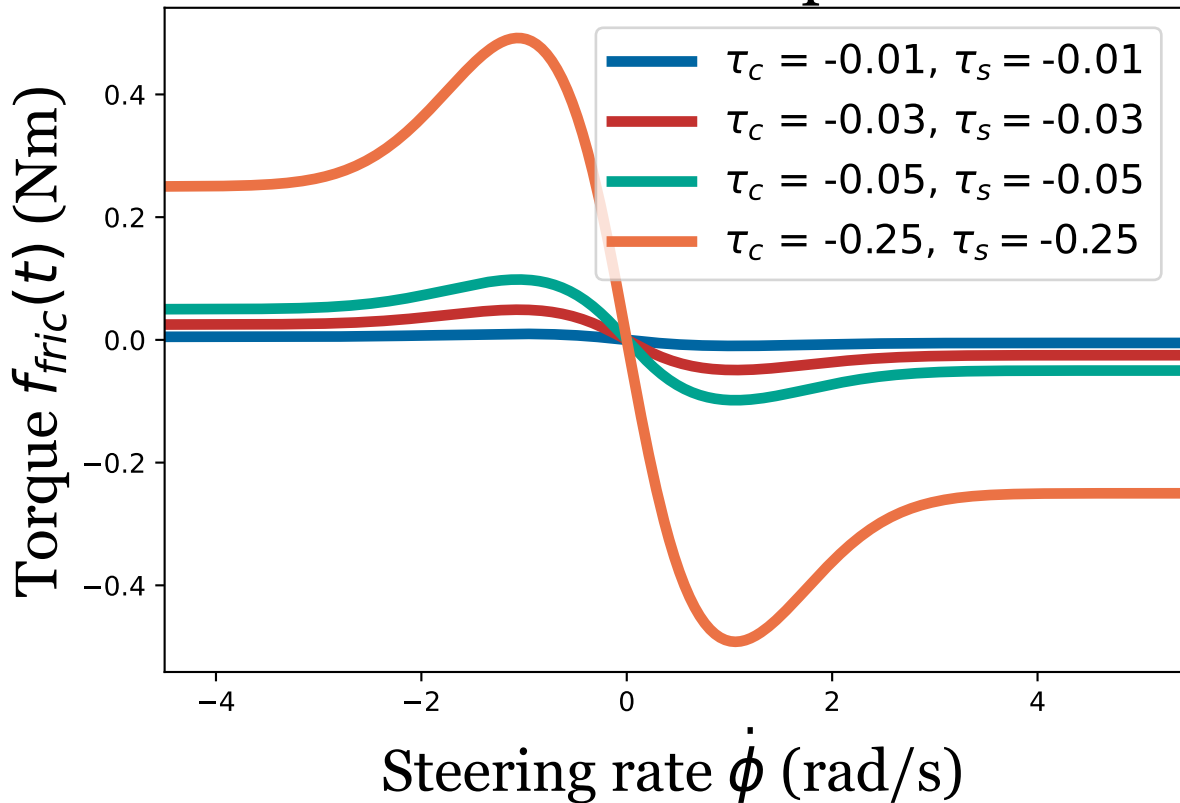**Friction torque**
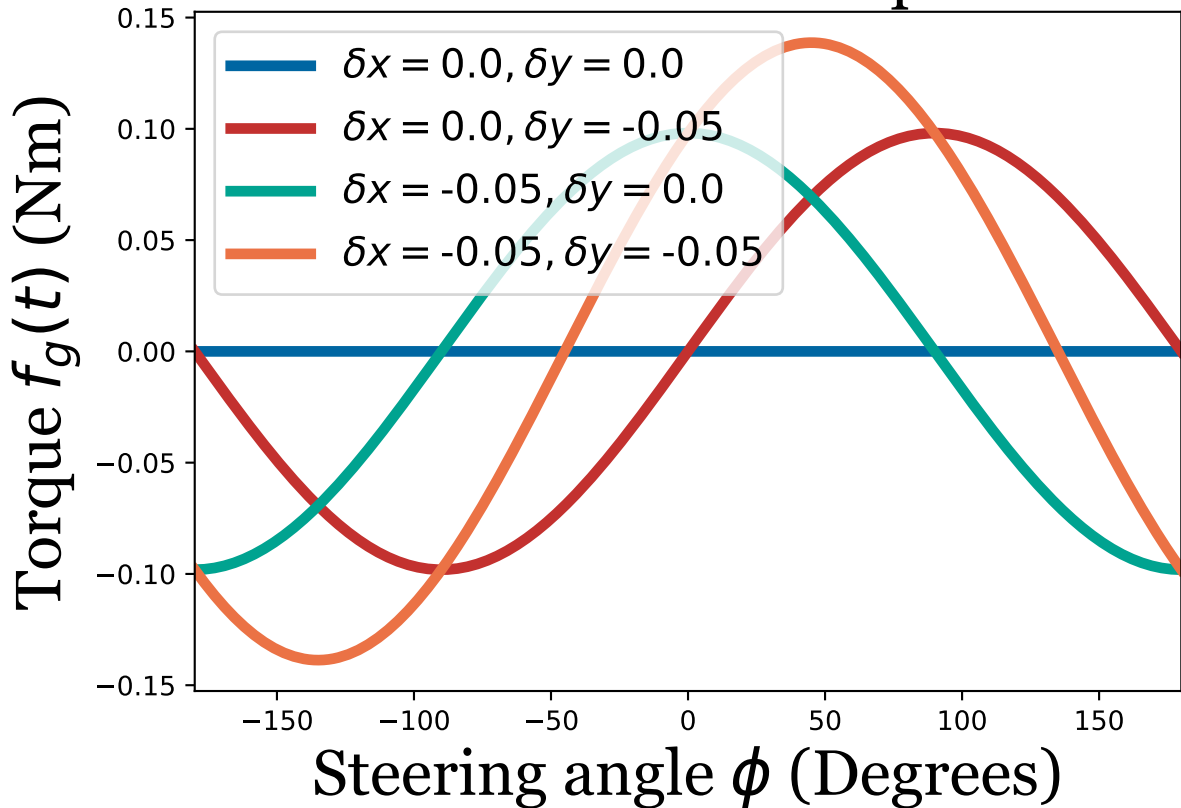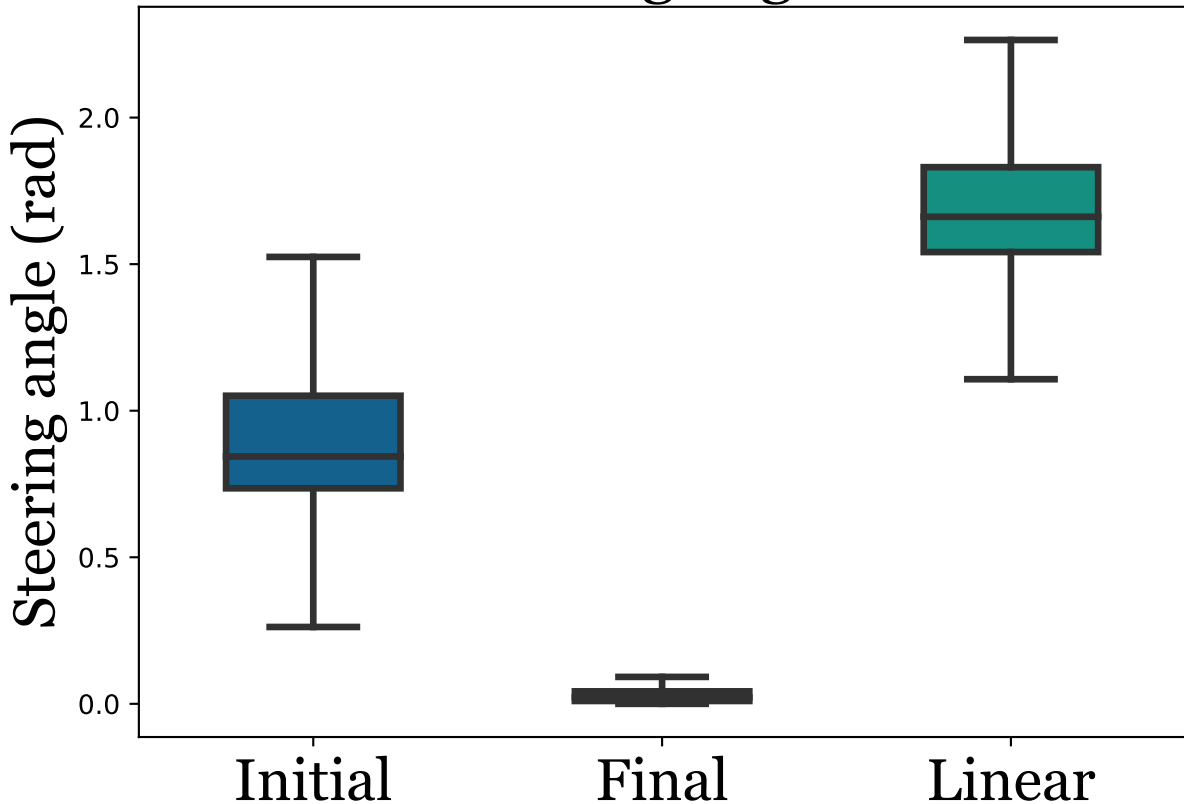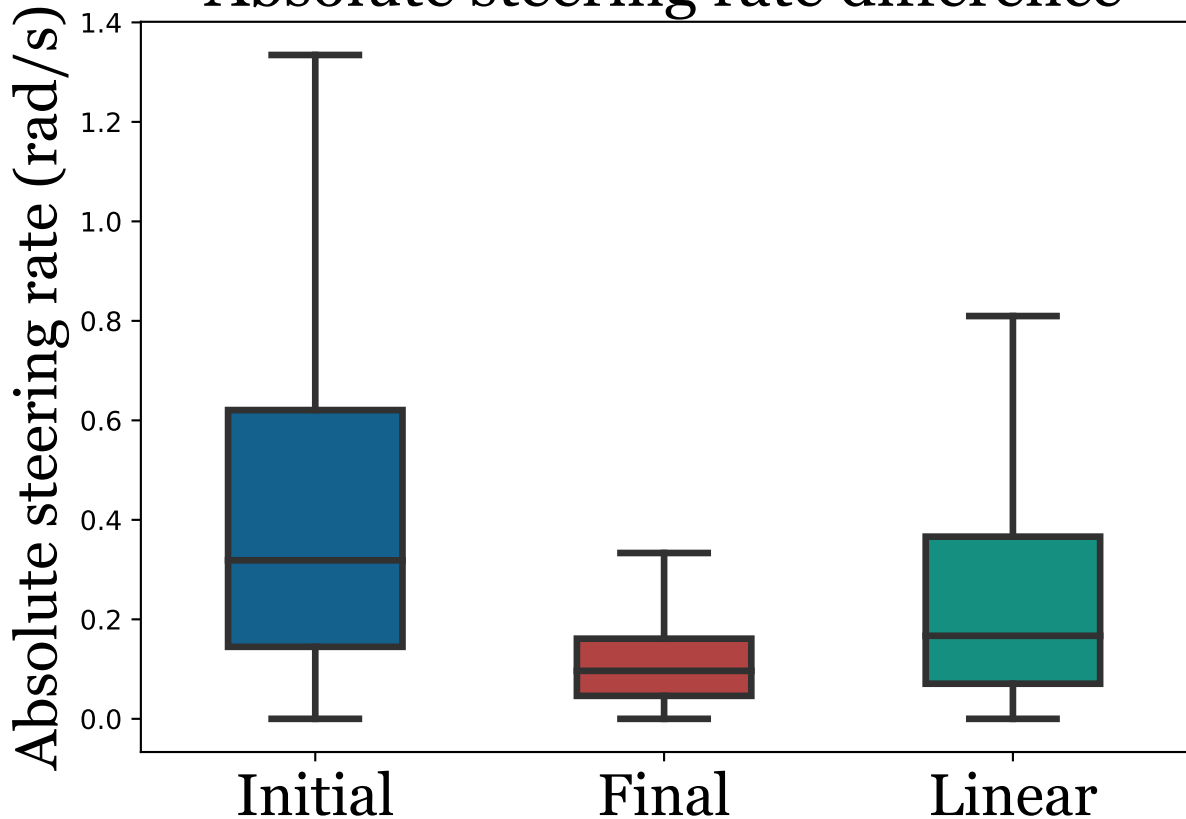
Gravitational torque

Friction torque

Legend:
- $\tau_c = -0.01, \tau_s = -0.01$
- $\tau_c = -0.03, \tau_s = -0.03$
- $\tau_c = -0.05, \tau_s = -0.05$
- $\tau_c = -0.25, \tau_s = -0.25$

Torque $f_{fric}(t)$ (Nm)

Steering rate $\dot{\phi}$ (rad/s)

Gravitational torque

Legend:
- $\delta x = 0.0, \delta y = 0.0$
- $\delta x = 0.0, \delta y = -0.05$
- $\delta x = -0.05, \delta y = 0.0$
- $\delta x = -0.05, \delta y = -0.05$

Torque $f_g(t)$ (Nm) vs. Steering angle ϕ (Degrees)

Absolute steering angle difference

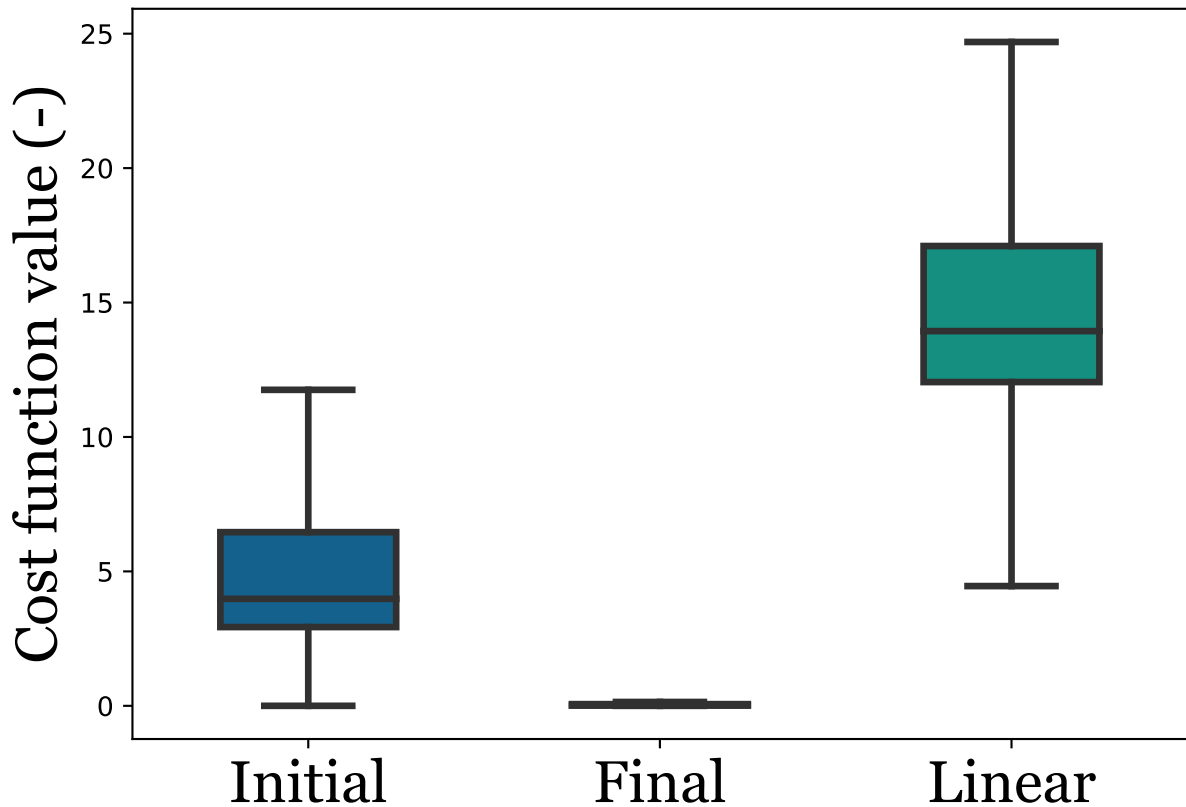**Absolute steering rate difference**

Cost function values

Steering angle comparison
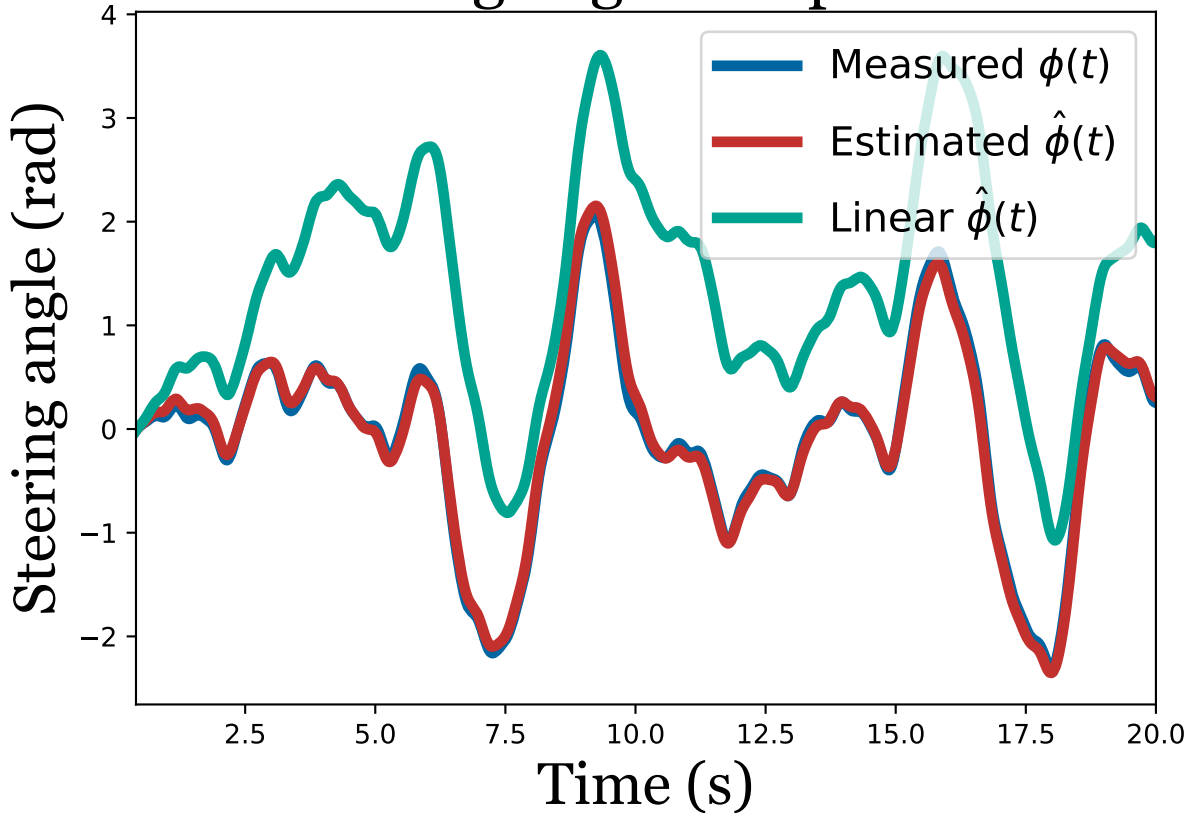
Steering rate comparison

Legend:
- Measured $\dot{\phi}(t)$
- Estimated $\hat{\dot{\phi}}(t)$
- Linear $\dot{\hat{\phi}}(t)$

Y-axis: Steering rate (rad/s)
X-axis: Time (s)
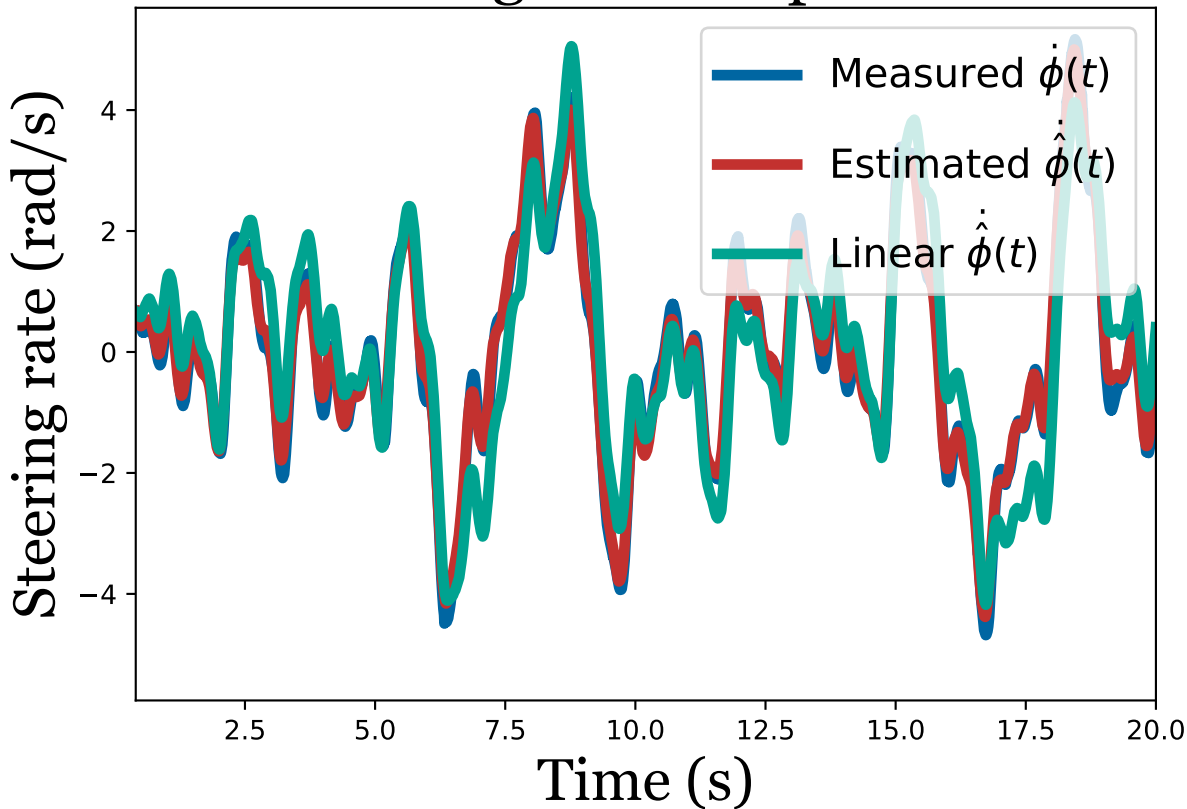
Difference measured and simulated state

Legend:
- input $u(t)$
- $\Delta\dot{\hat{\phi}}(t)$