RMPC

Robust and Predictive Control for a Quarter Car System

Ceoca Ovidiu

Agenda

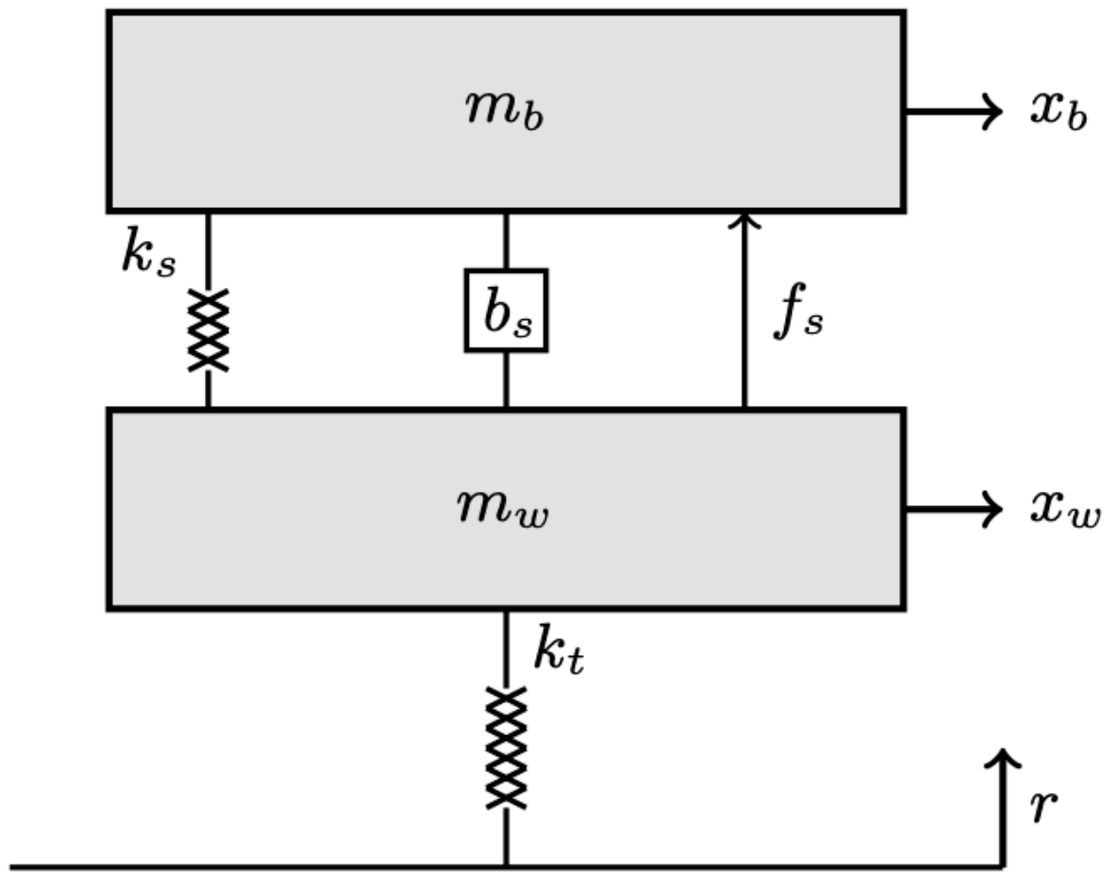
1. Creating the Robust Control for a Quarter Car Model
    1. Quarter Car Model
    2. The Controller
    3. The Uncertainties
    4. Model Responses with Uncertainties
2. Adding the MPC
    1. Controller Creation
    2. Robust Control and MPC Comparison
3. Conclusion

Quarter Car Model

Quarter Car Model

Parameters

- Chassis mass (mb): 300 [Kg]
- Wheel mass (mw): 60 [Kg]
- Suspension damping (bs): 1000 [N/(m*s)]
- Suspension stiffness (ks): 16000 [N/m]
- Tire stiffness (kt): 190000 [N/m]



Quarter Car Model

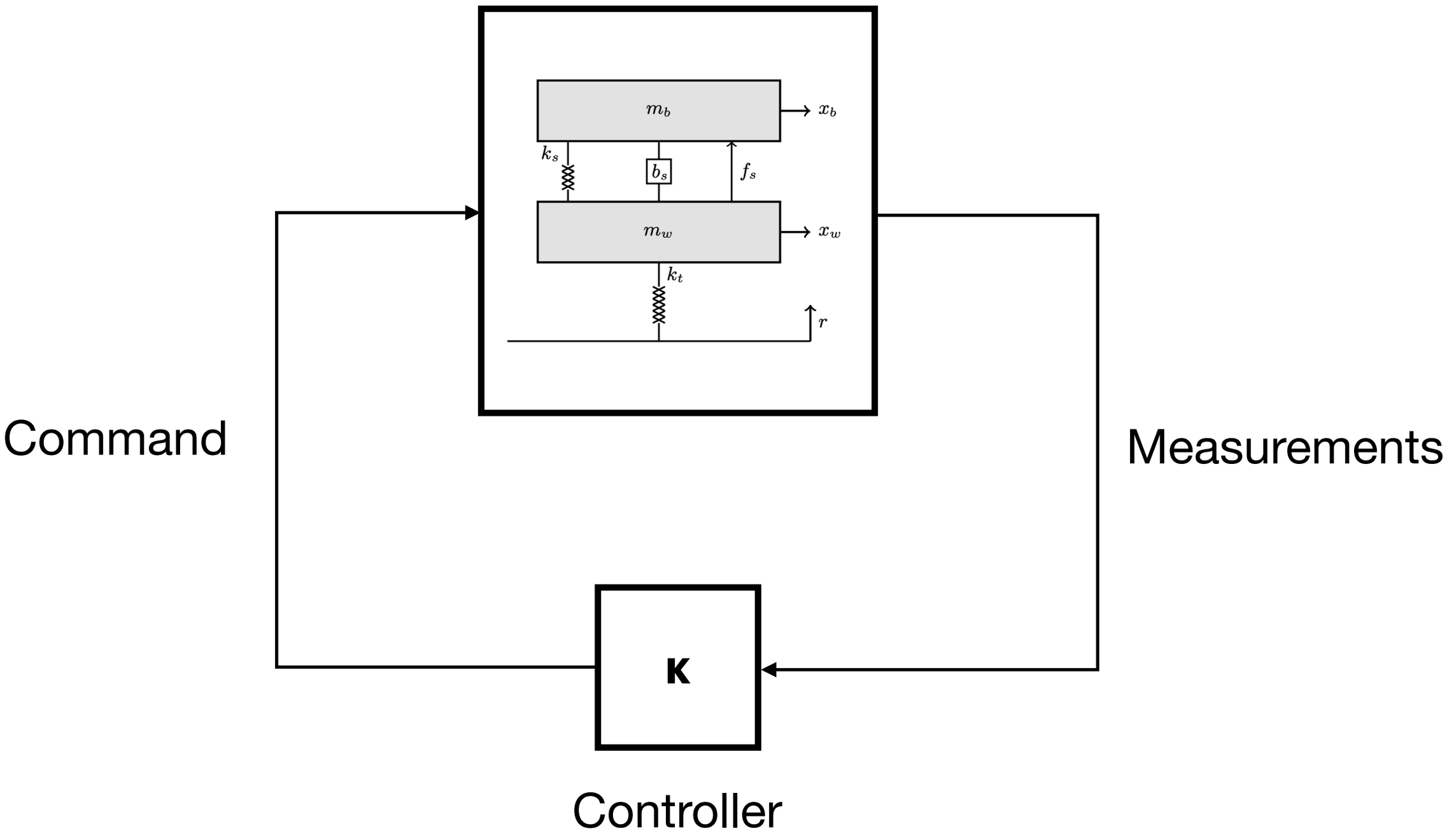
State-Space Model

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{-k_s}{m_b} & \frac{-b_s}{m_b} & \frac{k_s}{m_b} & \frac{b_s}{m_b} \\ 0 & 0 & 0 & 1 \\ \frac{k_s}{m_w} & \frac{b_s}{m_w} & \frac{-k_s - k_t}{m_w} & \frac{-b_s}{m_w} \end{bmatrix} \qquad B = \begin{bmatrix} 0 & 0 \\ 0 & \frac{1e3}{m_b} \\ 0 & 0 \\ \frac{k_t}{m_w} & \frac{-1e3}{m_w} \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ \frac{-k_s}{m_b} & \frac{-b_s}{m_b} & \frac{k_s}{m_b} & \frac{b_s}{m_b} \end{bmatrix} \qquad D = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

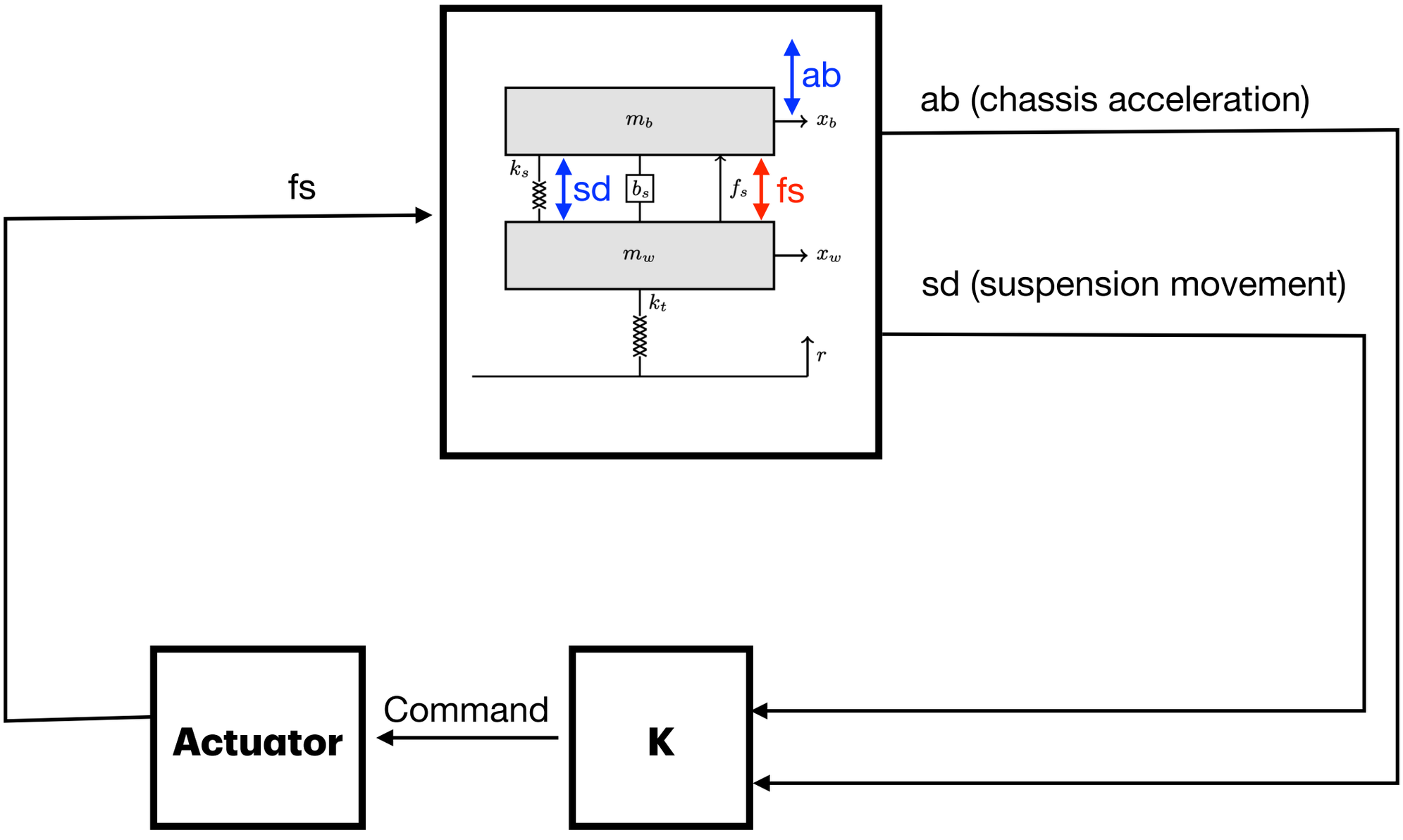
Quarter Car Model

Control Loop



Quarter Car Model

Control Loop



Quarter Car Model

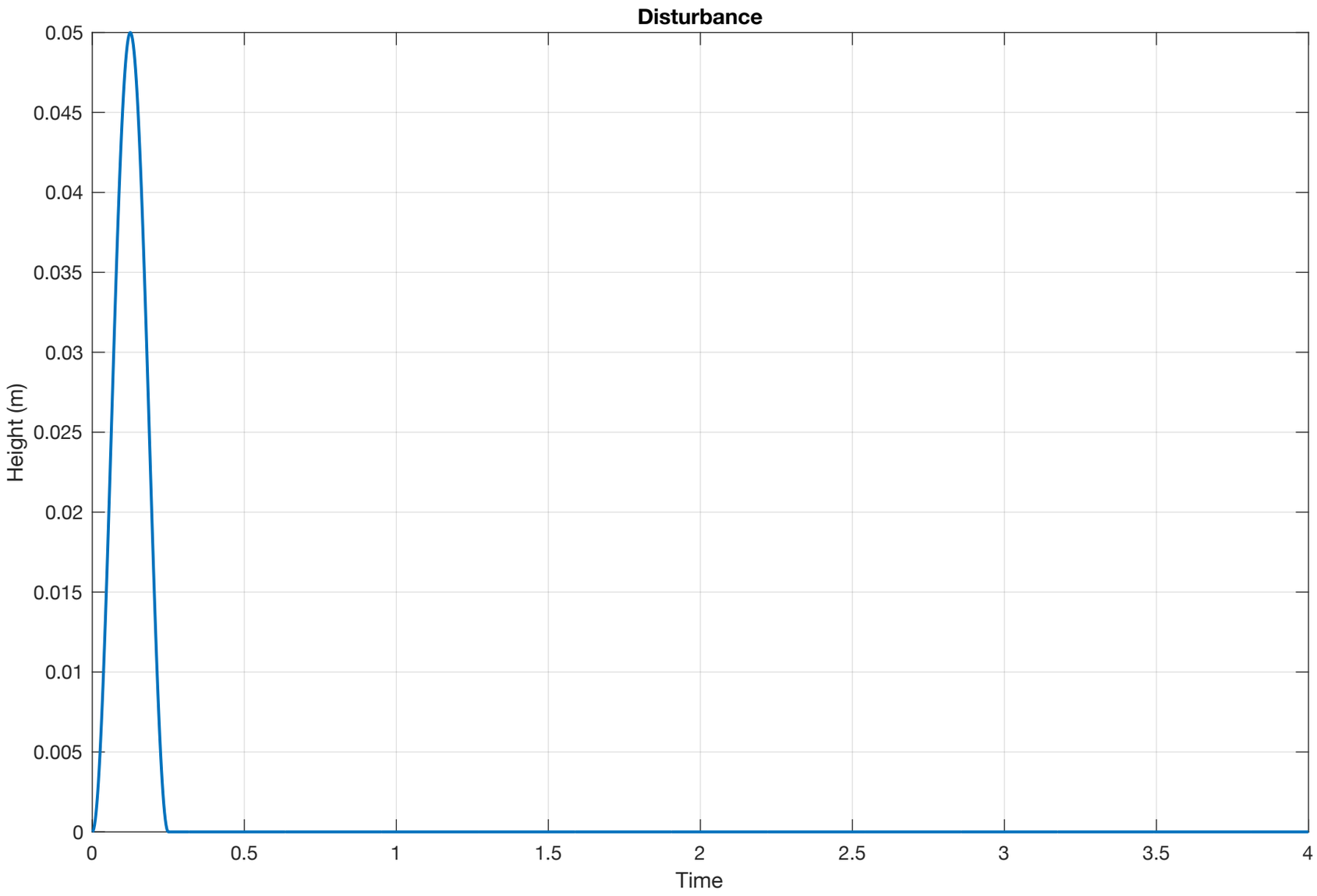
Actuator Transfer Function

$$H_{act} = \frac{1}{0.01667s + 1}$$

The Controller

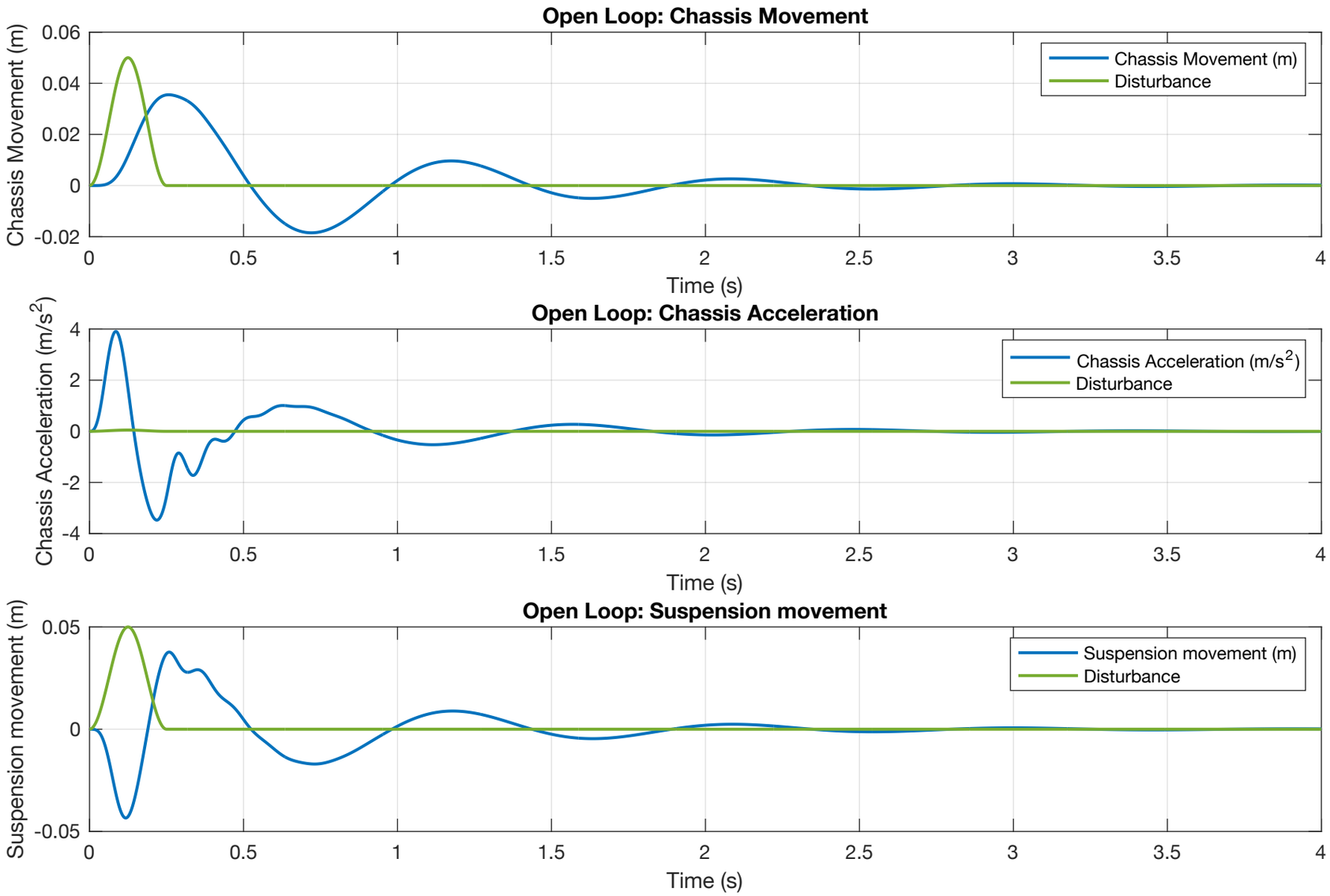
The Controller

Disturbance



The Controller

Model Response Without Controller



The Controller

Operational Modes

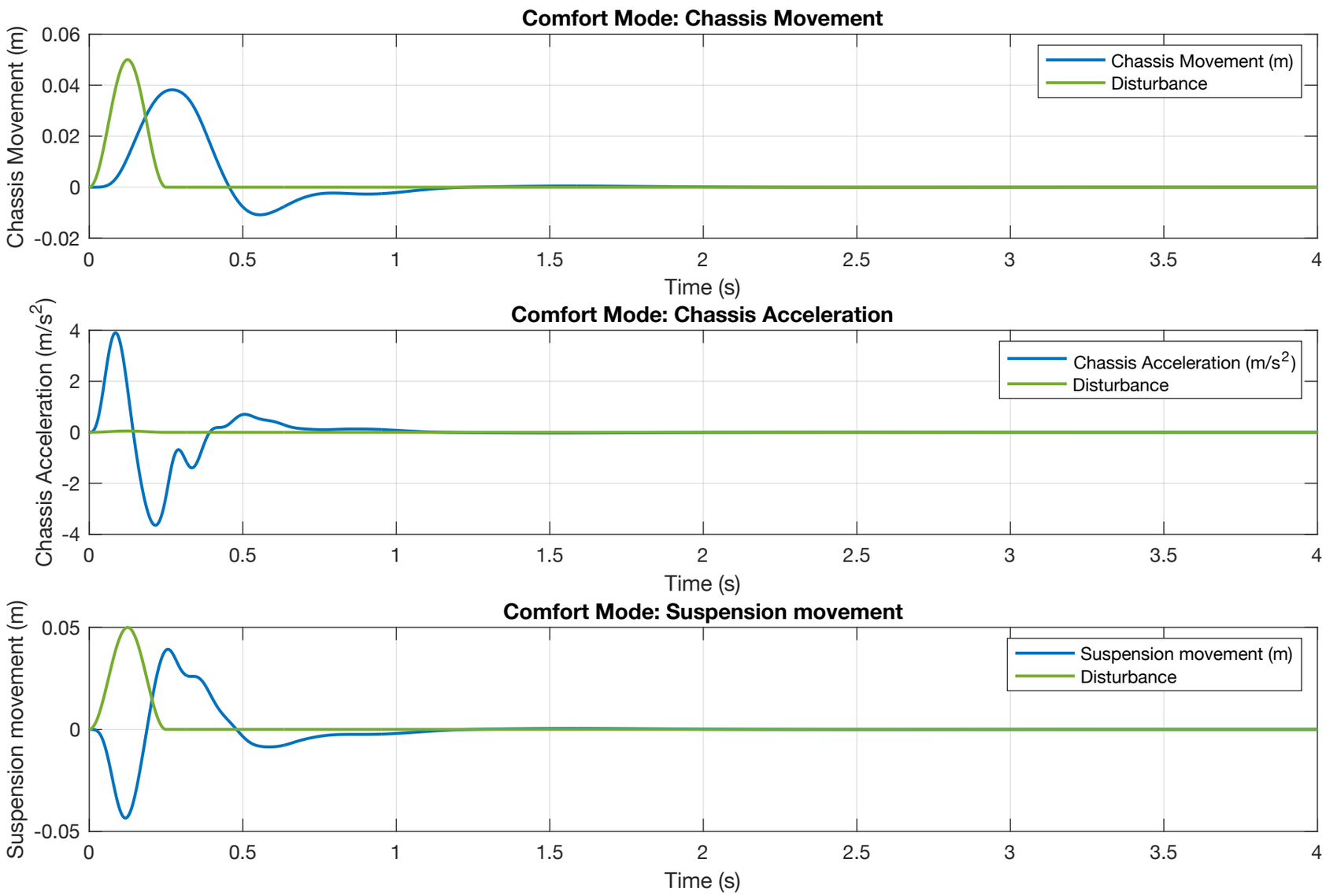
Comfort

Standard

Sport

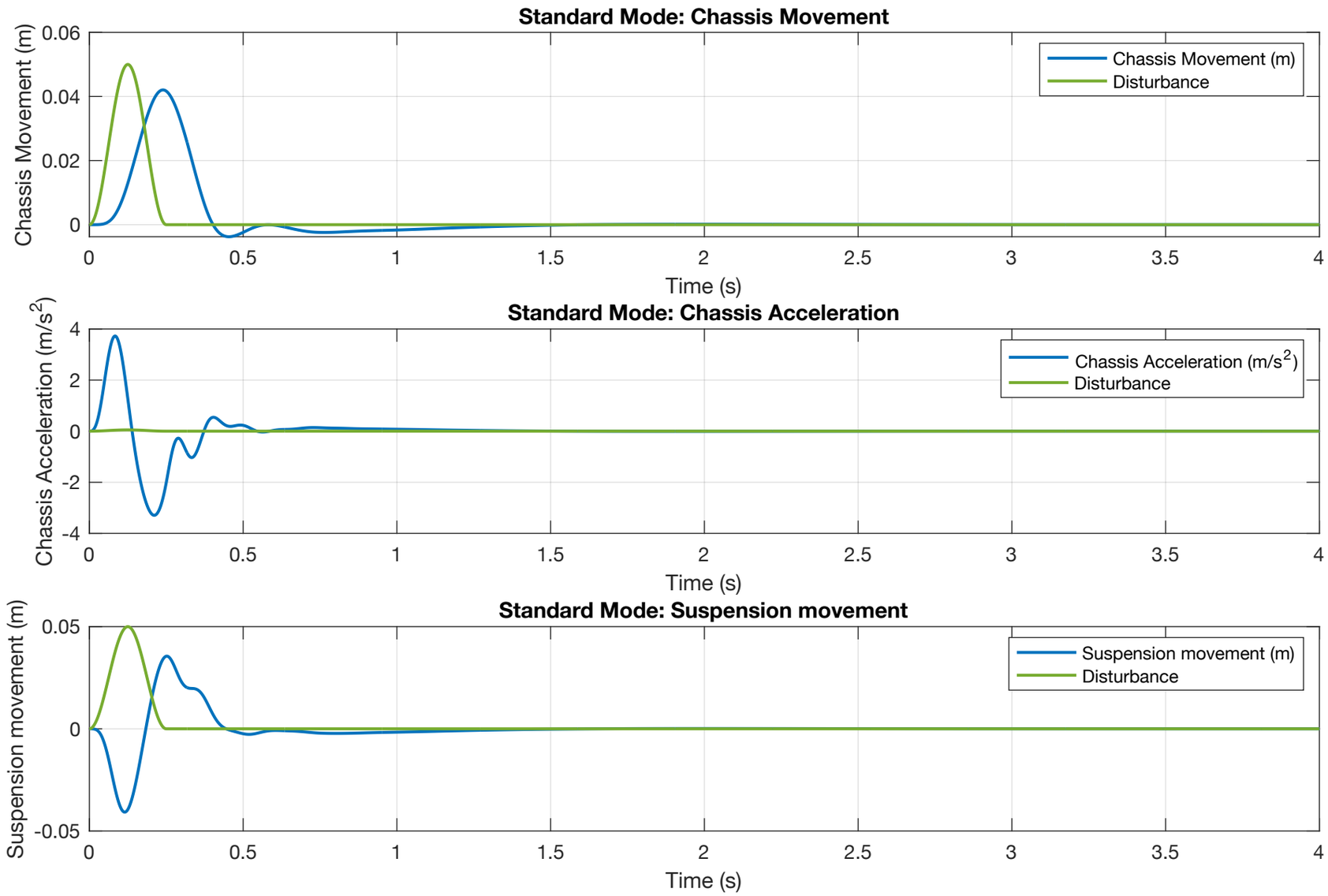
The Controller

Model Response Using H_∞ Controller (Comfort)



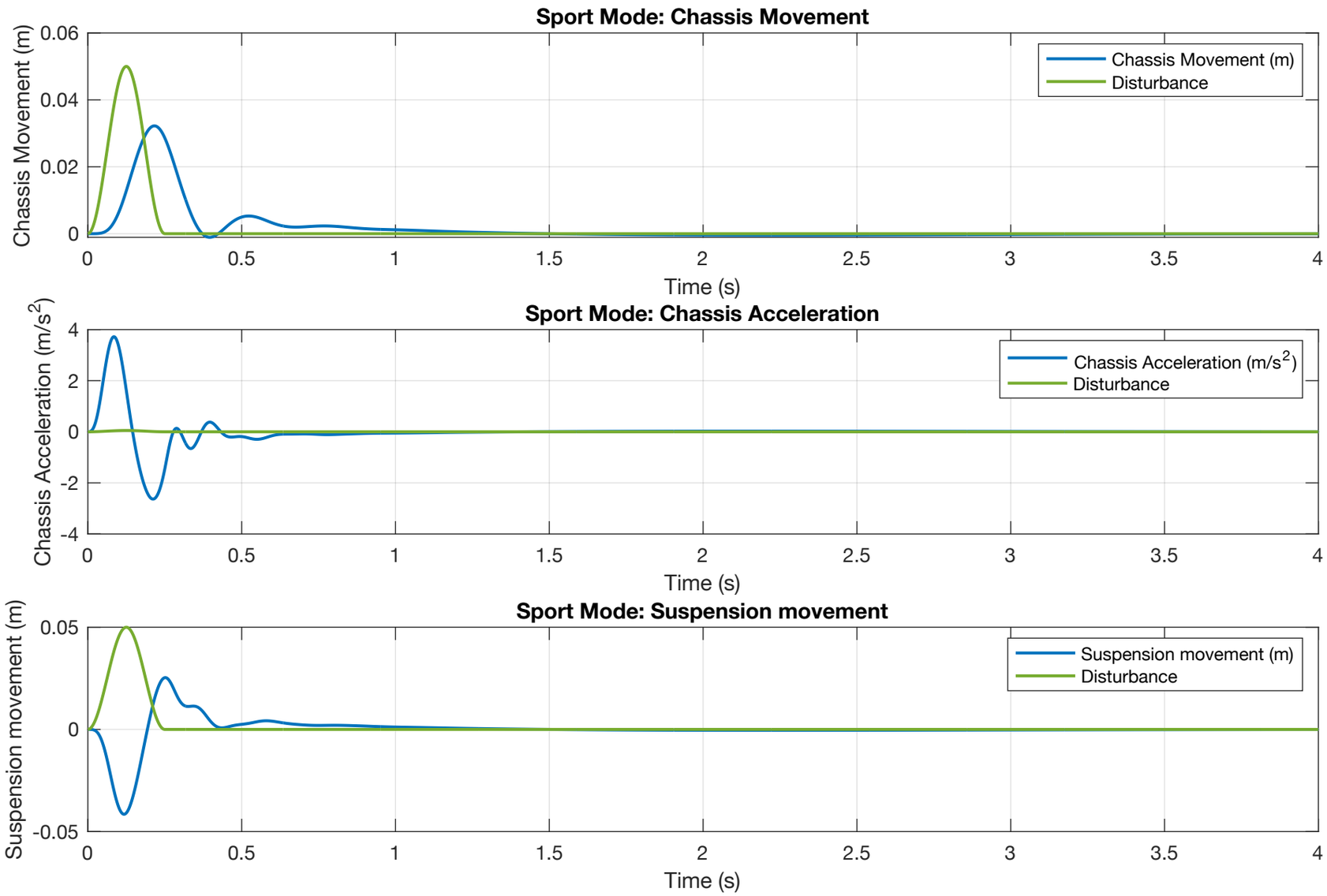
The Controller

Model Response Using H_∞ Controller (Standard)



The Controller

Model Response Using H_∞ Controller (Sport)



The Uncertainties

The Uncertainties

Full Car Model

The Uncertainties

Full Car Model

Material Fatigue

The Uncertainties

Full Car Model

Material Fatigue

Sensors Noise or Delay

The Uncertainties

Full Car Model

Material Fatigue

Sensors Noise or Delay

Temperature Variations

The Uncertainties

Full Car Model

Wind Forces

Material Fatigue

Tire Stiffness

Vibrations

Road Disturbance

Sensors Noise or Delay

Tire Pressure

Body Mass

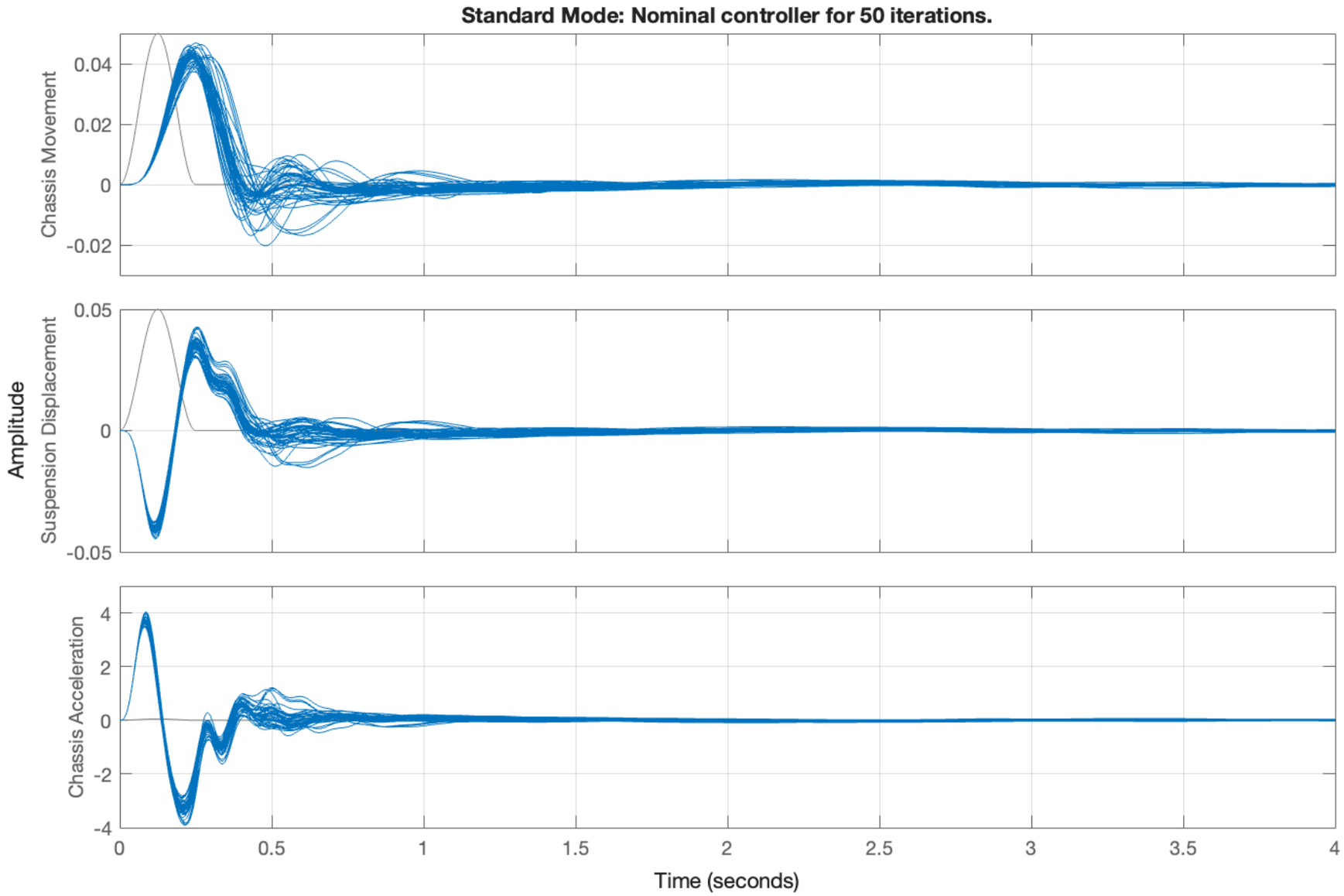
Temperature Variations

Actuators Fatigue

Model Responses

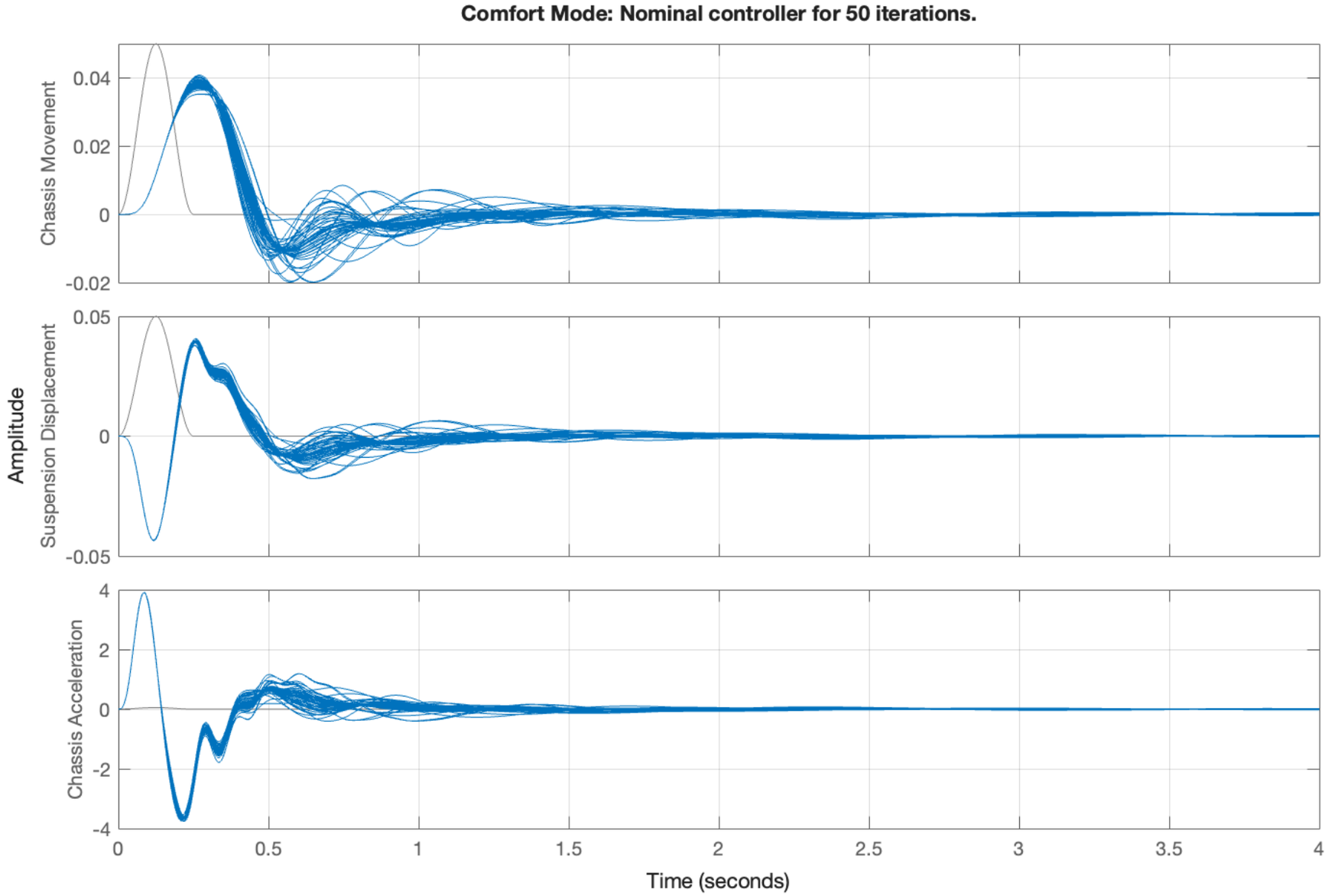
Model Responses

Model Responses using H_∞ Controller (Standard)



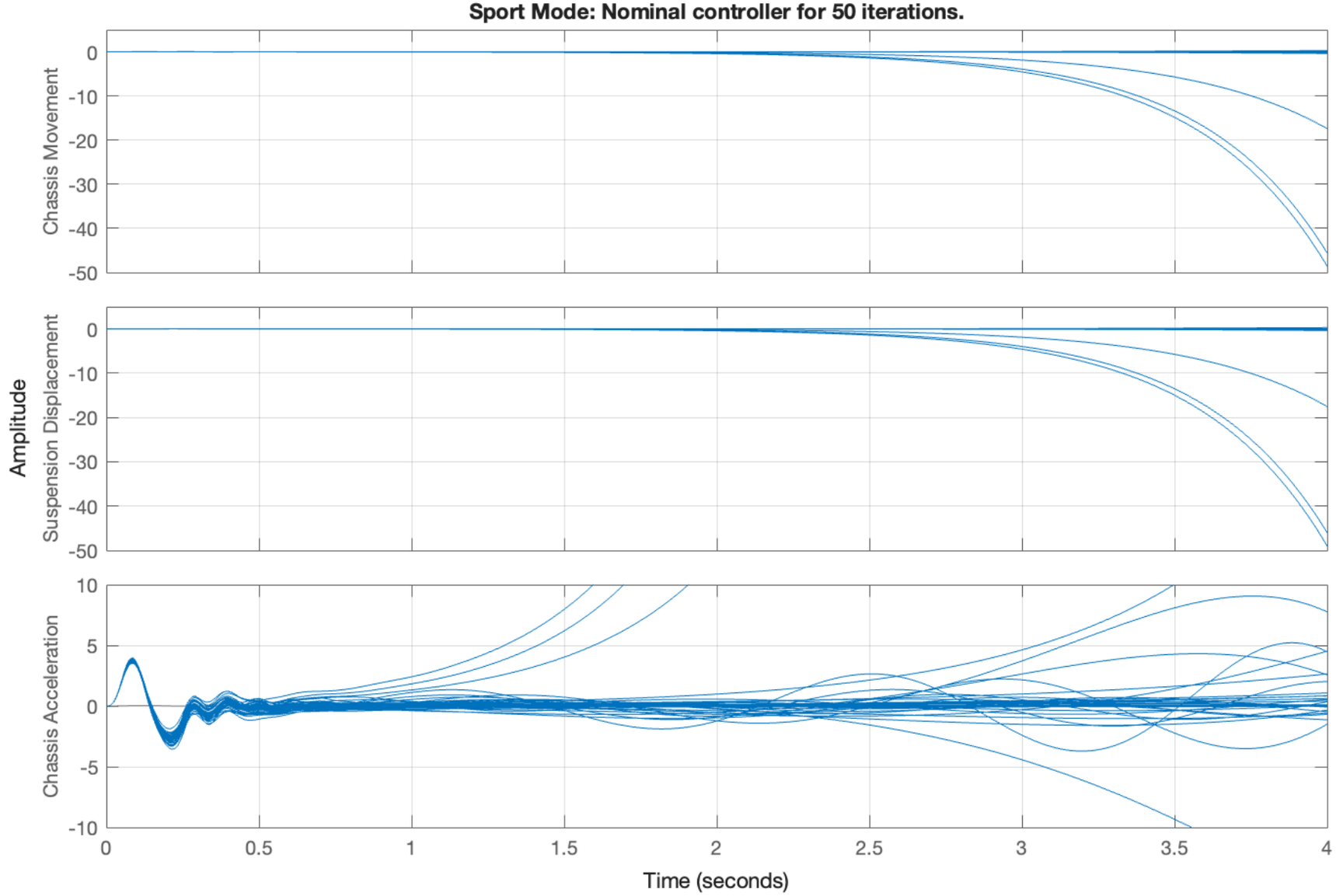
Model Responses

Model Responses using H_∞ Controller (Comfort)



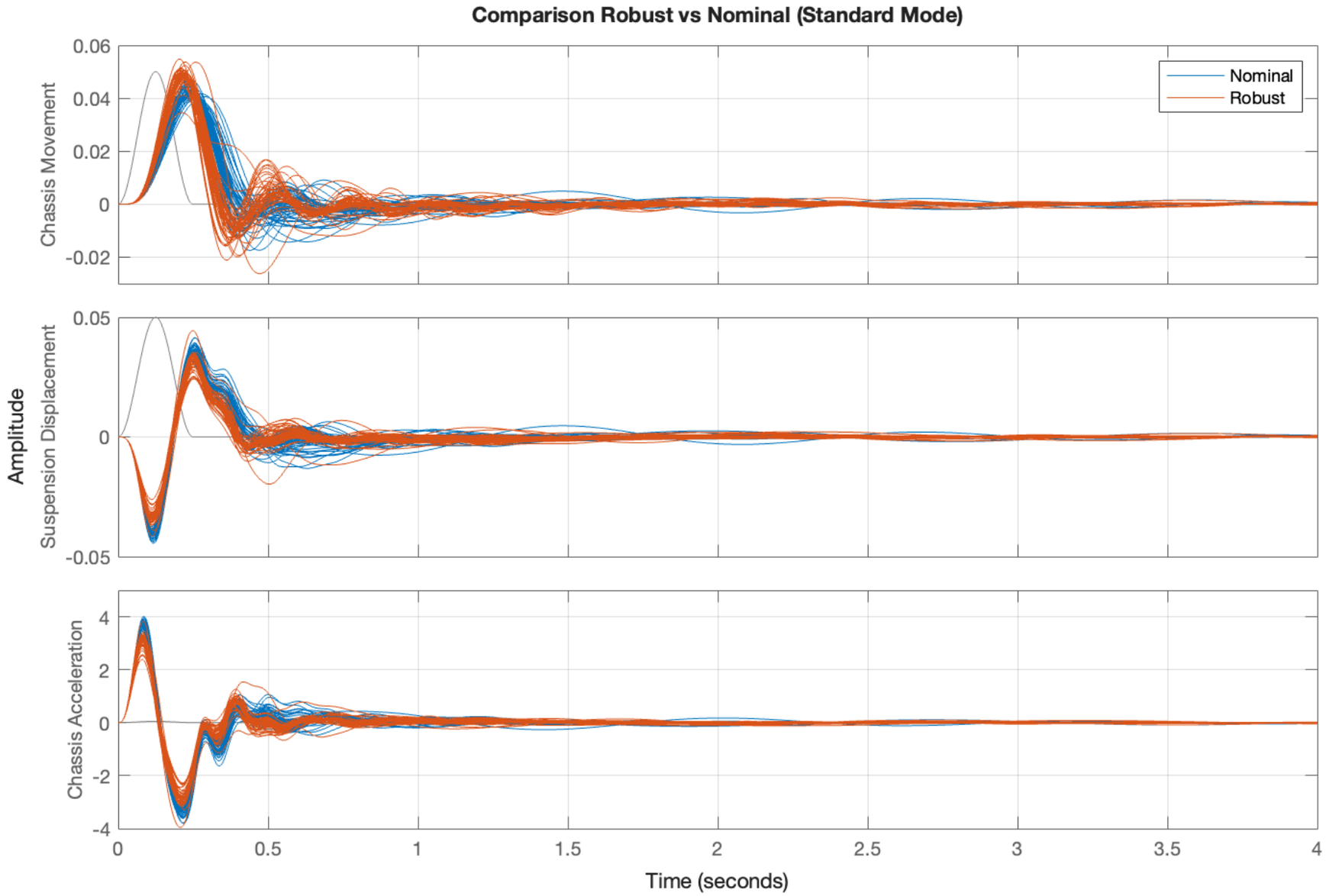
Model Responses

Model Responses using H_∞ Controller (Sport)



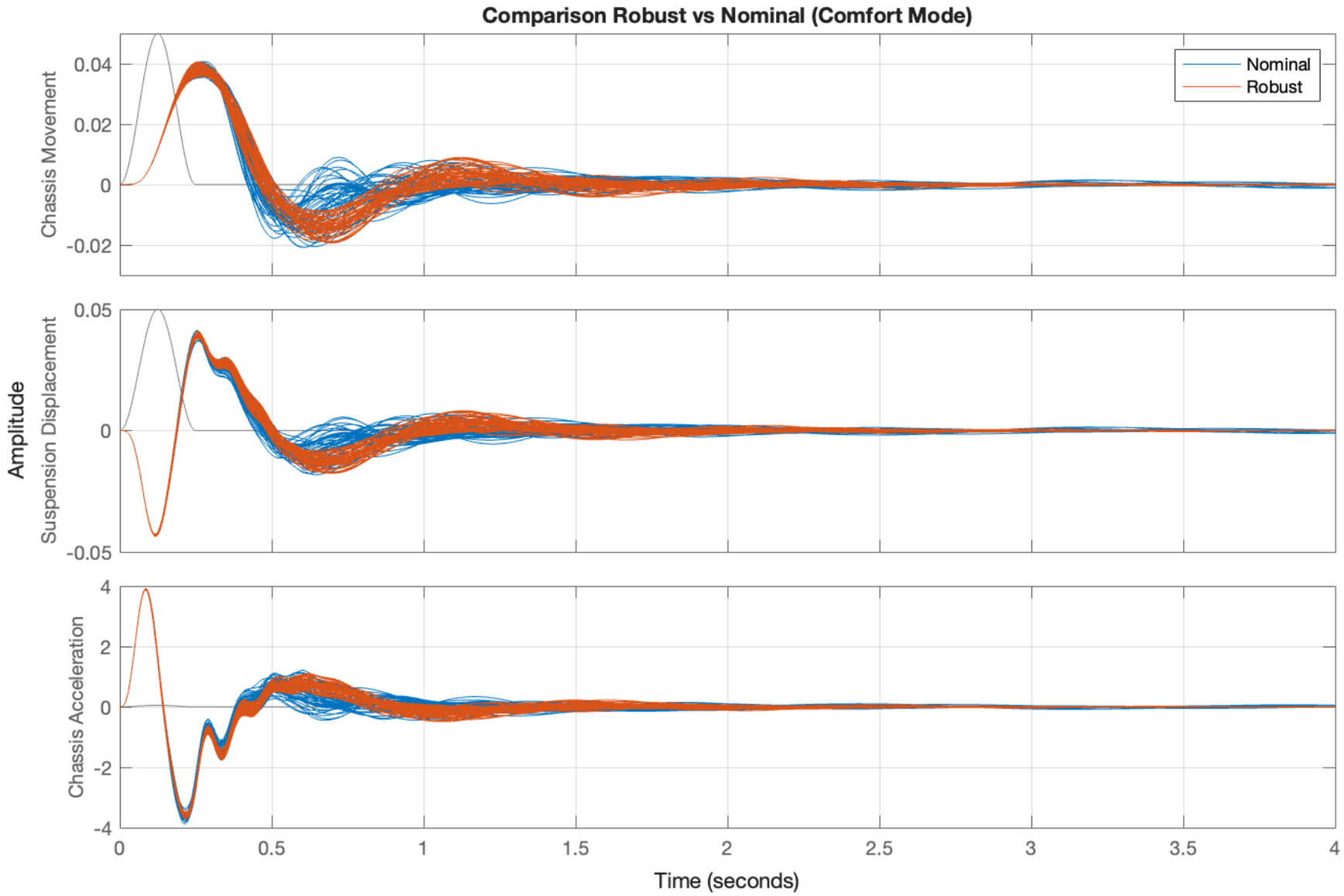
Model Responses

μ-Synthesis and H_∞ Controllers Comparison (Standard)



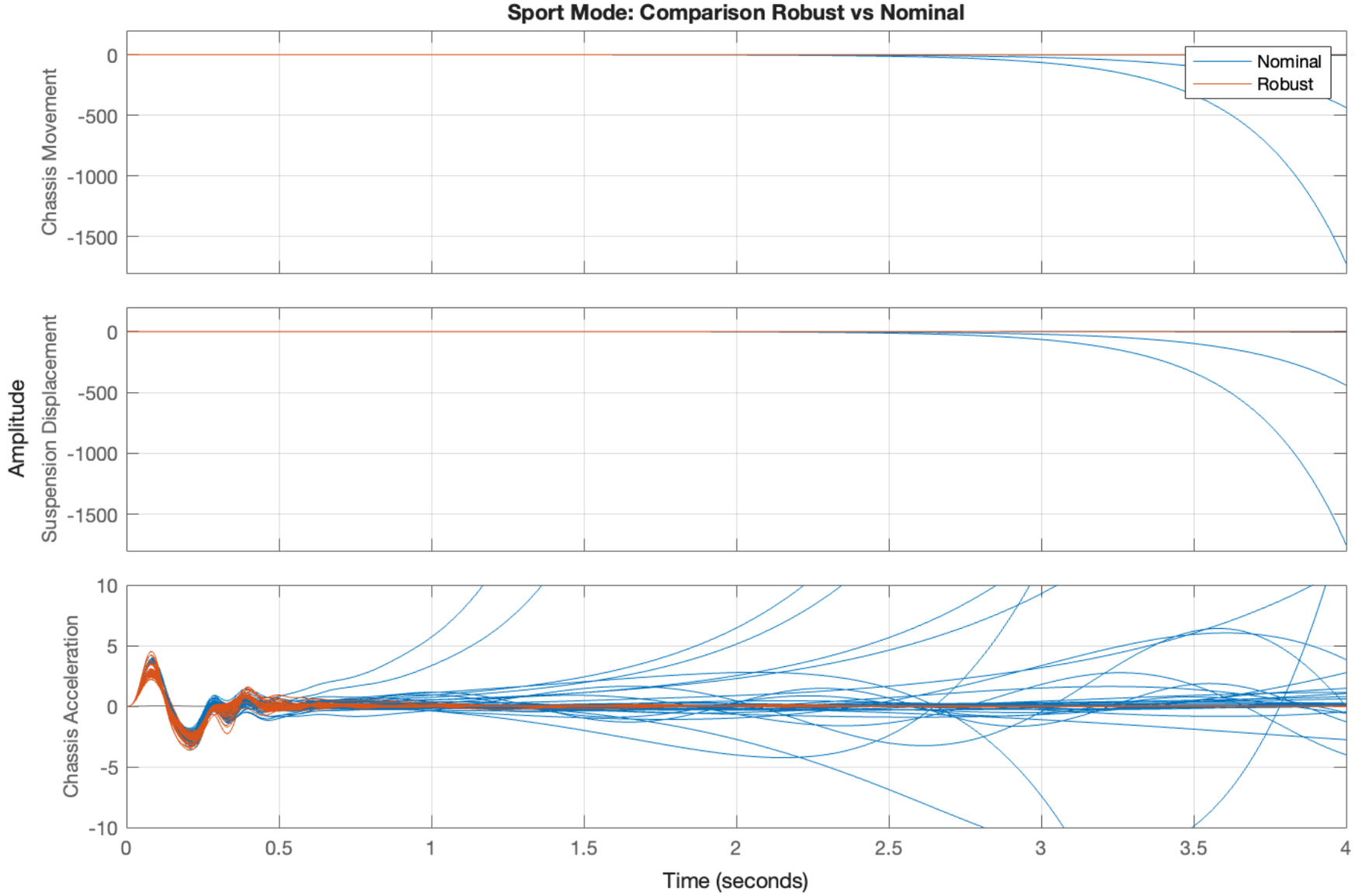
Model Responses

μ-Synthesis and H_∞ Controllers Comparison (Comfort)



Model Responses

μ-Synthesis and H_∞ Controllers Comparison (Sport)



MPC

MPC

Model Predictive Control for Standard Mode

1. Model Discretisation

$$T_s = 0.01$$

2. Defining the horizons

$$N_p = 20$$

$$N_c = 10$$

3. Create the MPC Object

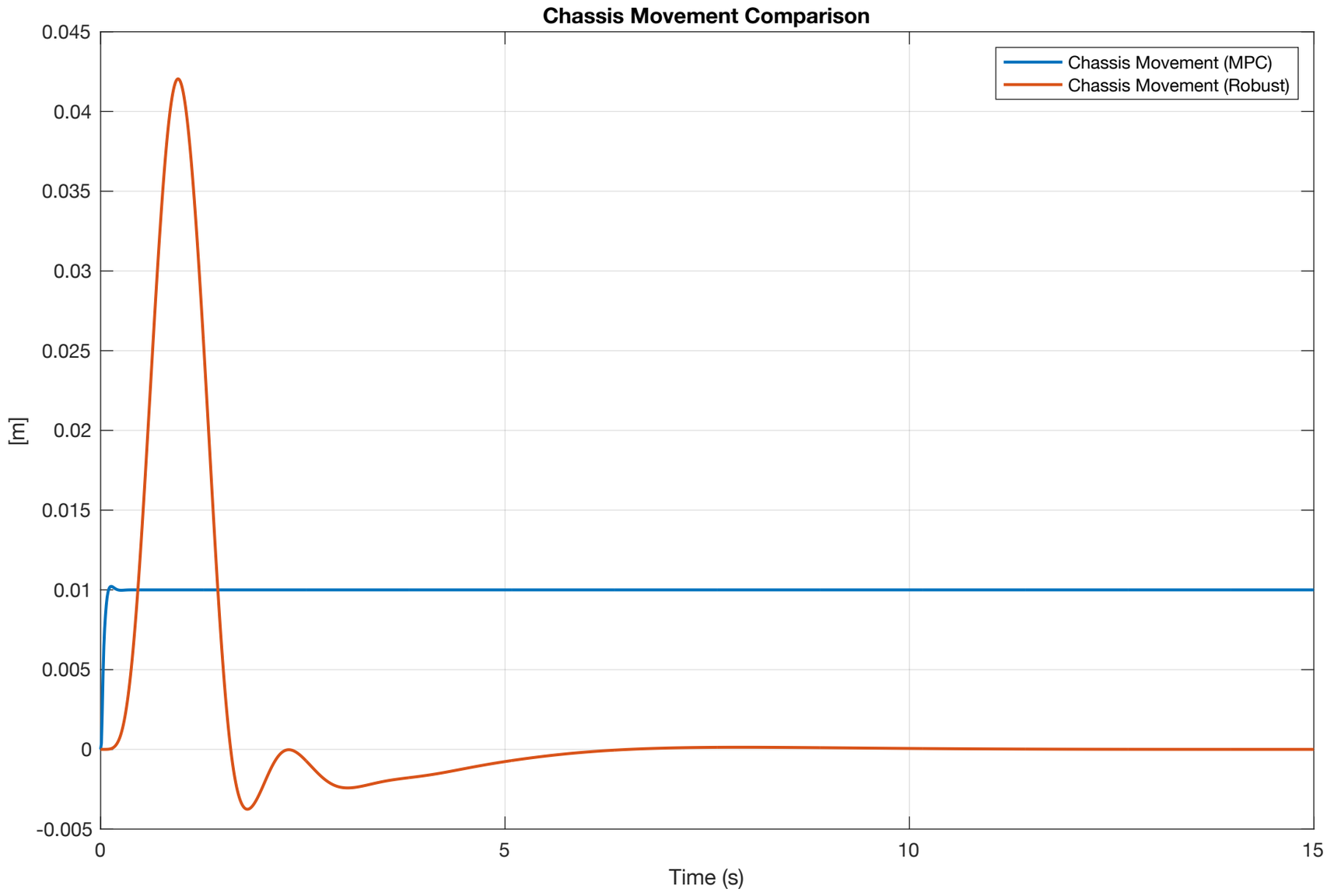
$$mpc(sysd, T_s, N_p, N_c)$$

4. Simulation

$$[y, t, u] = sim(args)$$

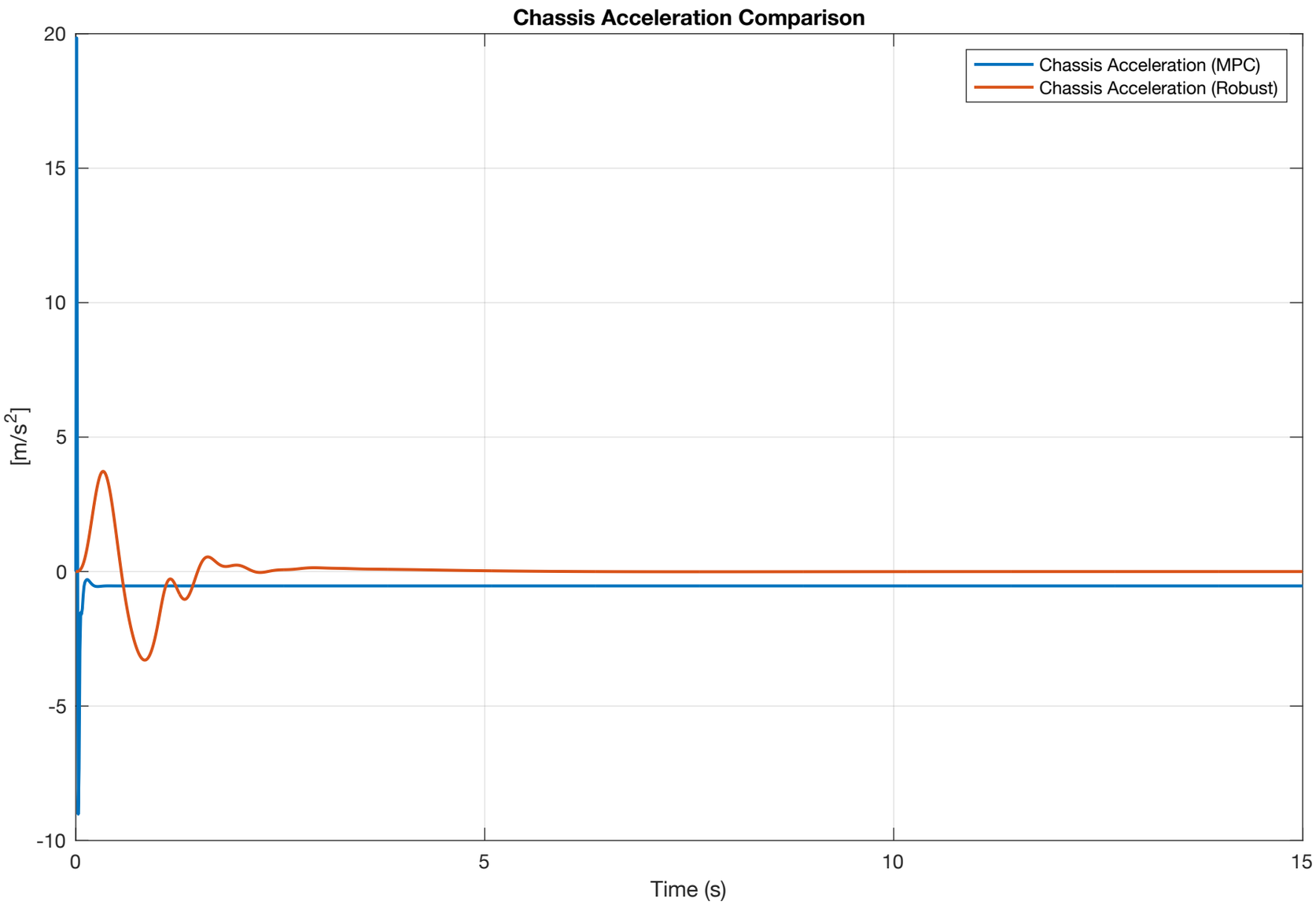
MPC

Chassis Movement



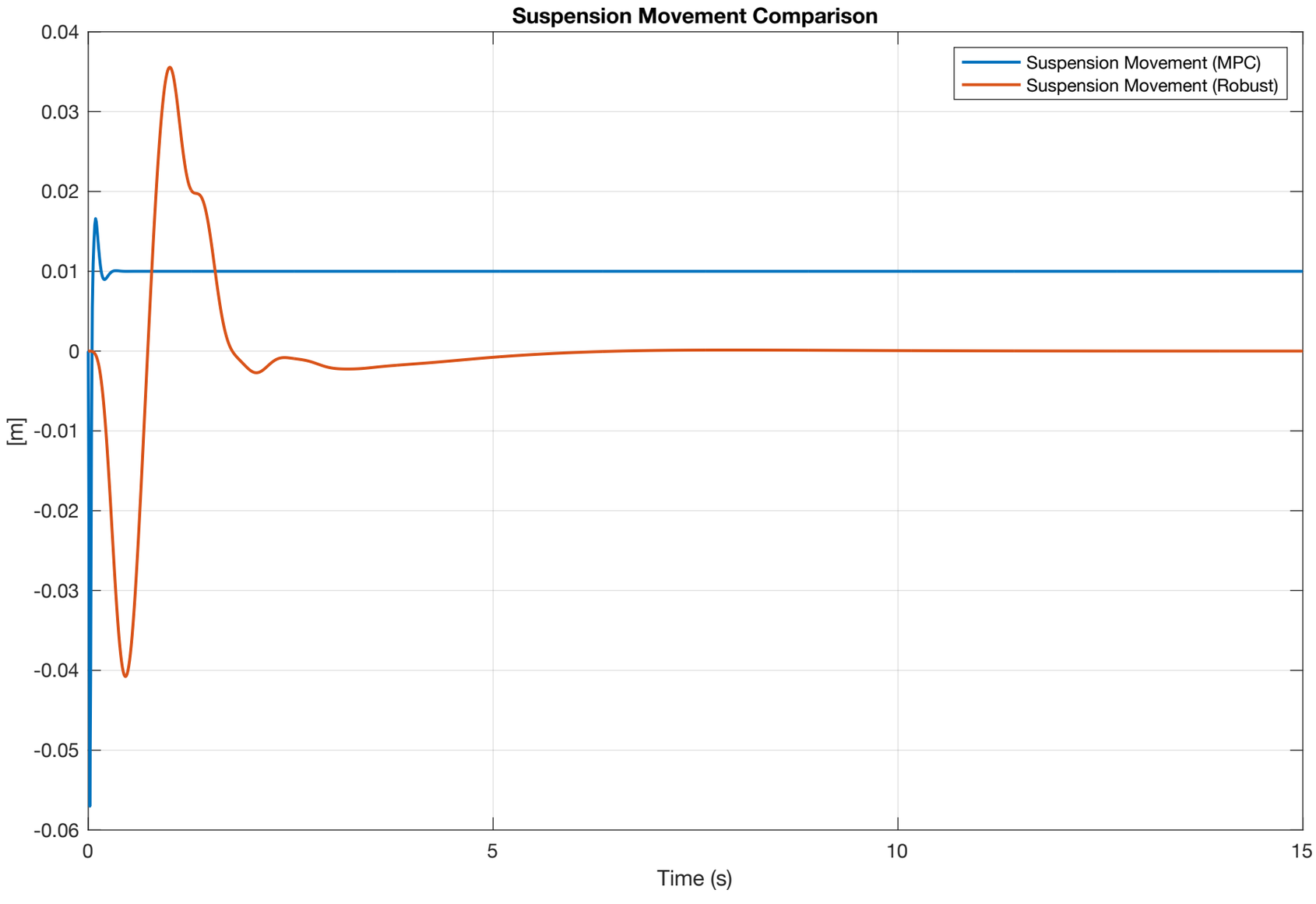
MPC

Chassis Acceleration



MPC

Suspension Movement



Conclusion

Thank you!

Questions?