Enhancing the Driving Experience of Electric Vehicles through Drivetrain Feedback Control

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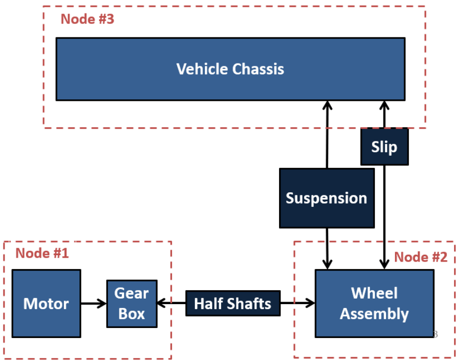
The average American spends an hour commuting daily. Electric vehicles (EV) are a green initiative rapidly increasing in popularity and will soon become the mode. If EVs are incorrectly damped, the vibrations from their powerful motors can lead to immediate mechanical failure, severe passenger discomfort, reduced drivability, and poor sales. This project focuses on vibrations exhibited by drivetrain components in the direction of motion and controlled by altering the motor torque using feedback control strategies.

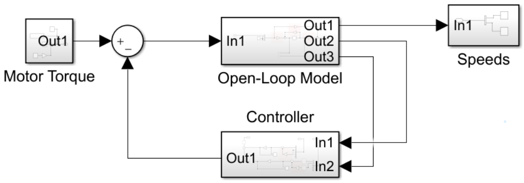


Creating the Physical Representation

A simplified driveline schematic illustrates the driveline of General Motor's Chevrolet Bolt. A mass-based nodal analysis produced equations describing the dynamics of the driveline model shown on the left. Viscous slip, a non-linear component, was linearized using first-order Taylor expansion around the equilibrium points. The state-space representation of the model in MATLAB utilized these equations, completing our physical representation of the driveline. This derived system served as the open-loop plant model for this project.

Simulation Model Correlation with Chevrolet Bolt Vehicle Data

To attain an accurate simulation model, we correlated it with the actual vehicle data. The team visited the 'General Motors Proving Ground' facility at Milford, Michigan, to perform frequency sweep tests and collect uncontrolled vehicle data at increasing frequencies. Bode plots through Fast Fourier Transformation of this data represented the vehicle's characteristics. Through minor corrections to our simulation model, we matched it to the real car and now serves as our corrected open-loop plant model.



Feedback Control Strategies

The scope of damping the vehicle in this project falls in the low-frequency domain. Passengers experience severe vibrations at resonant conditions, hampering drivability. Utilizing classical (PID, Lead-Lag, and Pole Placement) and modern (Optimal Control and Model Predictive Control) feedback control strategies allows for assessing damping performance and tuning drivability to suit customer needs. For example, comfort settings may require aggressive damping when compared to sportier settings.

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