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Optimal Control for Motion Control of Four in-Wheel Motor Actuated Vehicles

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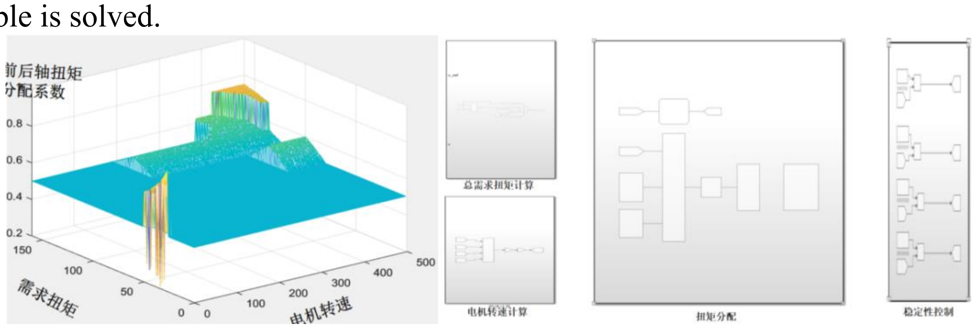
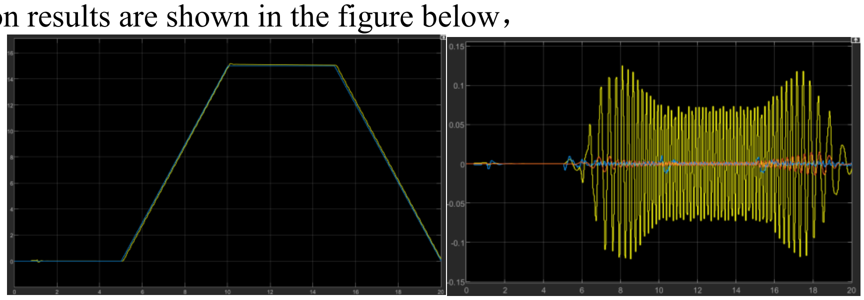
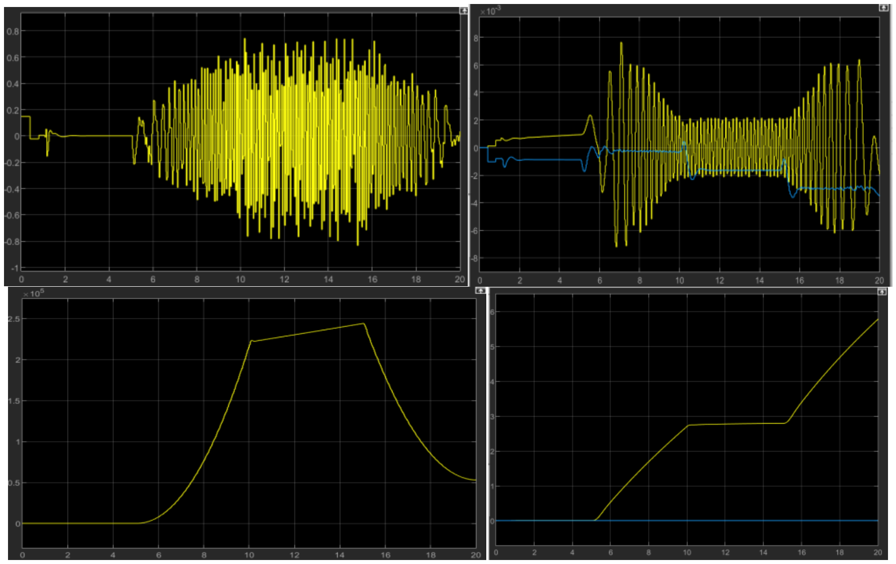
The Electric Vehicles (EVs) equipped with 4 In-Wheel Motor (IWM) , with its advantages of independently distributed torque, high power transmission efficiency, has shown great potential in reducing vehicle energy consumption, improving vehicle stability, and safety. Torque optimization distribution algorithm, as the core content of research on four in-wheel motor (IWM) actuated electric vehicles (EV), is a challenging problem to achieve torque optimization distribution for both economy and safety under unknown testing conditions. To address these issues, this paper aims to explore solutions to benchmark problems in electric vehicle motion control based on the four in-wheel motor (IWM) actuated electric vehicles (EV) model constructed using Modelon. It establishes a torque optimization distribution algorithm that considers both vehicle economy and stability.Under straight-line driving conditions, the paper focuses on improving economy by optimizing the longitudinal driving force distribution. Then, through real-time drivetrain slip control under dynamic conditions, it ensures that the wheels are in the optimum slip state to maintain vehicle stability. Under trajectory tracking conditions, the paper establishes separate objective functions for economy and stability, and investigates the switching logic of the two distribution algorithms from the perspective of balancing economy and stability. Ultimately, it achieves optimized longitudinal driving force distribution considering both economy and stability. Finally, the effectiveness of the algorithm is verified through joint simulation using Modelon and MATLAB.

In question 1, the total torque value required for current driving is calculated by using the MPC algorithm according to the actual speed, actual acceleration and reference speed of the vehicle. Then, combined with the speed, torque and efficiency relationship curves of each motor during operation, the torque distribution of the four wheels is carried out. In order to achieve the best economy during driving, the efficiency optimization control objective function of four-wheel drive electric vehicle with the minimum input power as the goal is established, and the offline front and rear axle distribution coefficient table is solved.



The simulation results are shown in the figure below，





In the second problem, the optimization objective function of economy and stability is established respectively. Construct trajectory tracking and direct sideways moment coordination control strategies. Firstly, a model prediction controller is established based on the 3-degree-of-freedom vehicle dynamics model, and the front wheel rotation angle and additional yaw moment are optimized and solved according to the reference trajectory and reference speed. Due to the torque distribution of the front and rear axles of the vehicle, the lateral acceleration is greatly affected by the torque distribution of the front and rear axles of the vehicle, while the torque distribution of the internal and external wheels of the vehicle has a great influence on the lateral acceleration. Therefore, this paper considers correcting the torque of the front and rear axles and the inner and outer wheels according to the vehicle's yaw angular velocity and lateral acceleration.