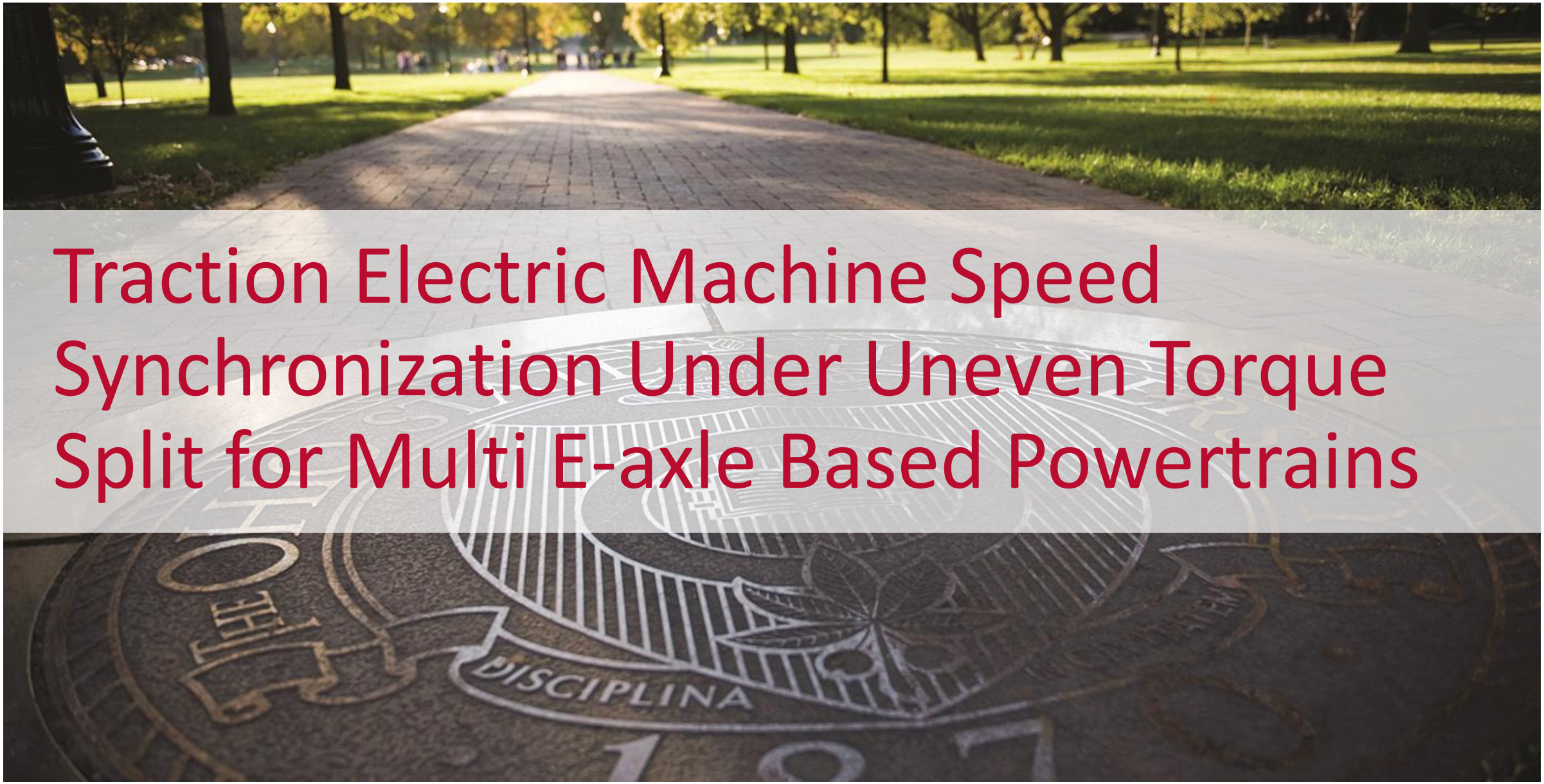
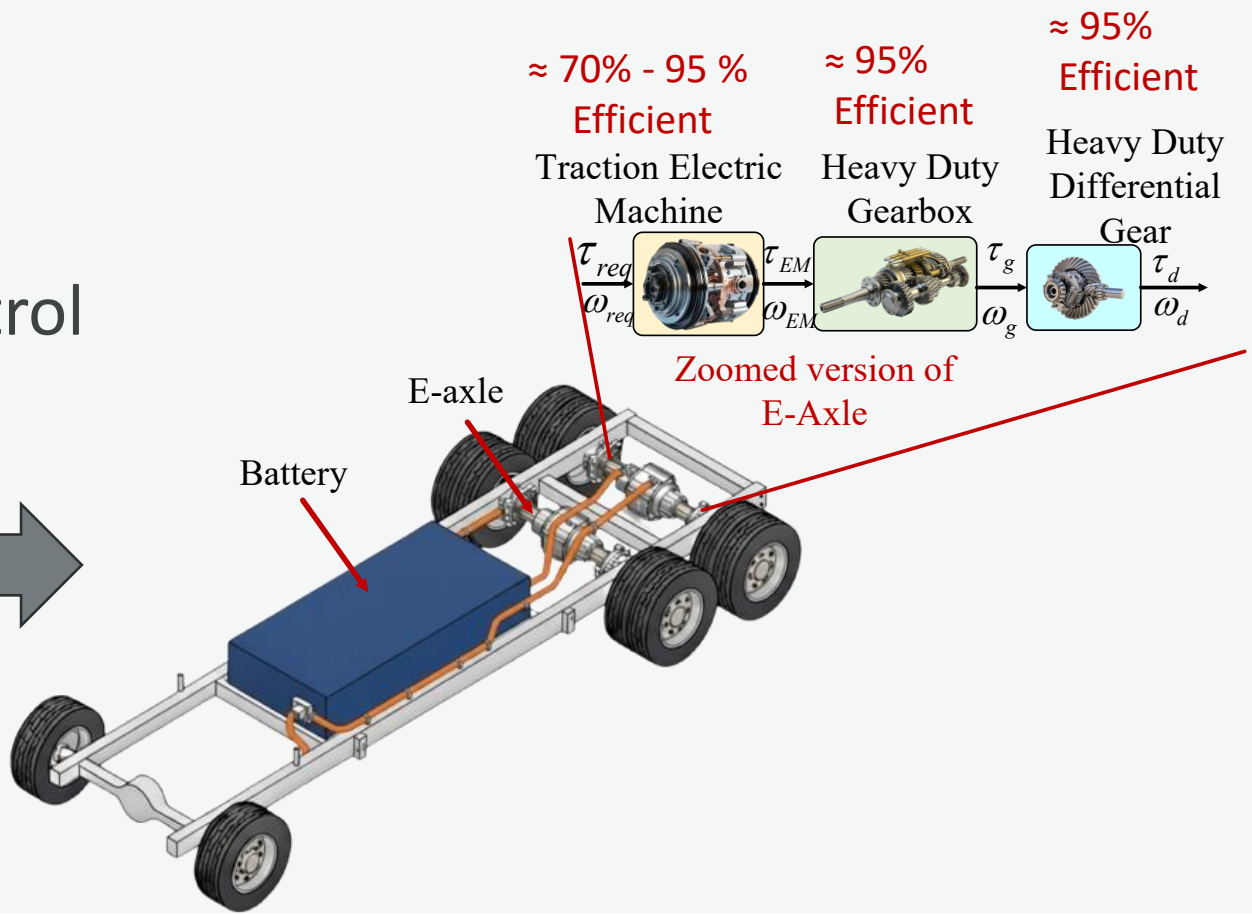


Traction Electric Machine Speed Synchronization Under Uneven Torque Split for Multi E-axle Based Powertrains

THE OHIO STATE UNIVERSITY
CENTER FOR AUTOMOTIVE RESEARCH

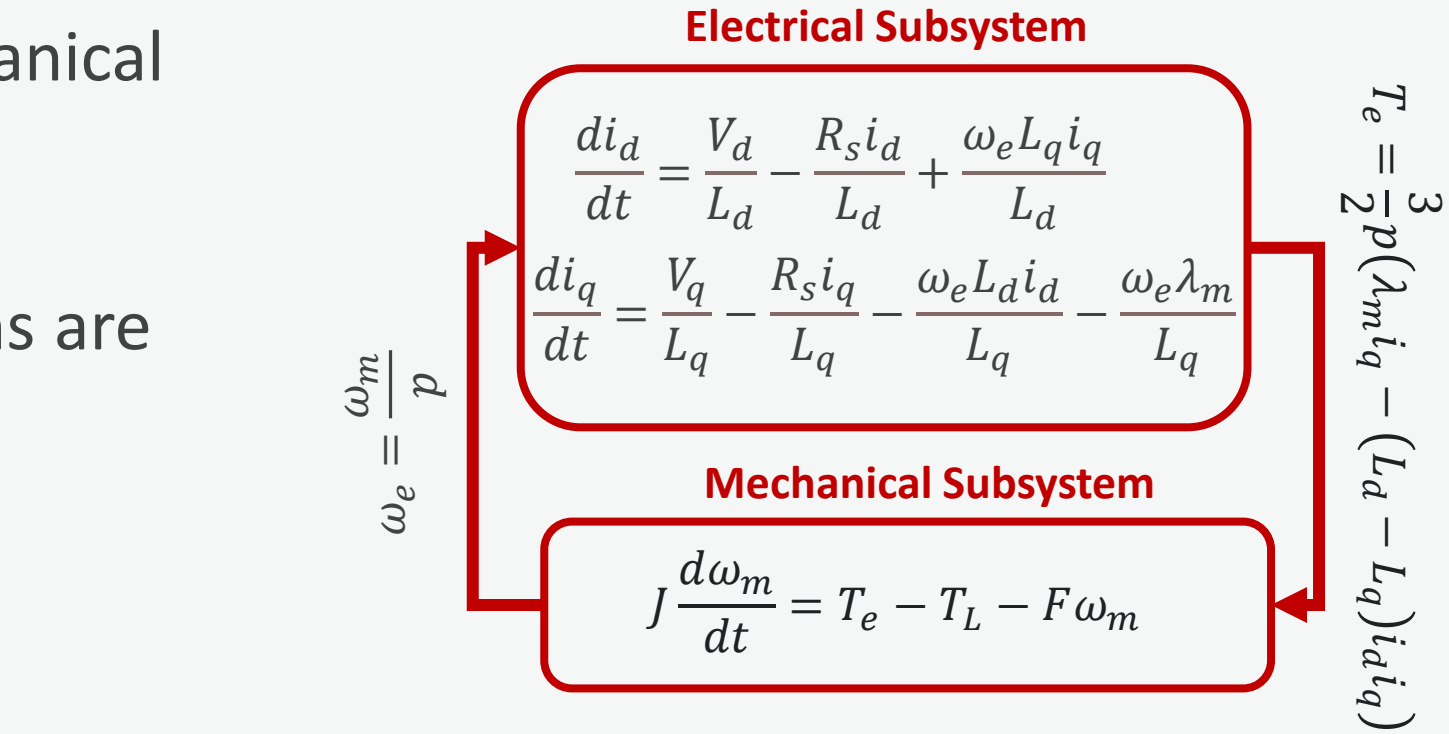
System Overview

- Electric trucks have simple powertrain
- E-axles needs optimal control to operate efficiently



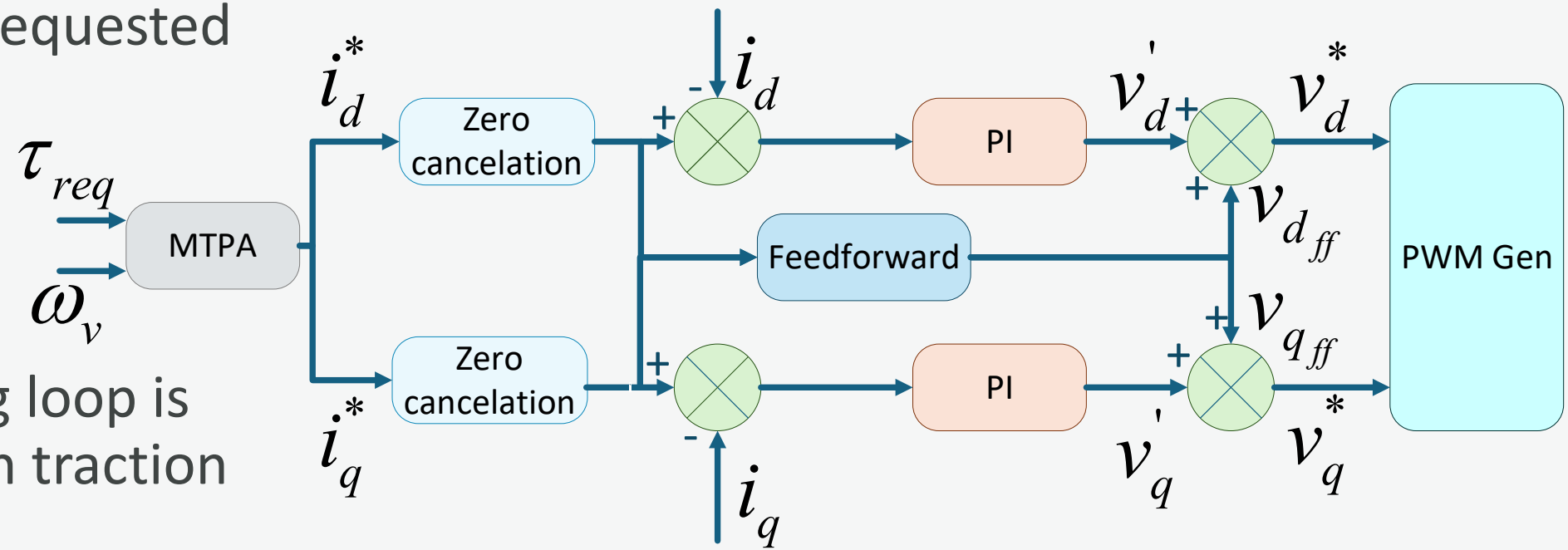
Traction Electric Machine Dynamics

- An EM is electromechanical system
- The electrical and mechanical subsystems are linked together



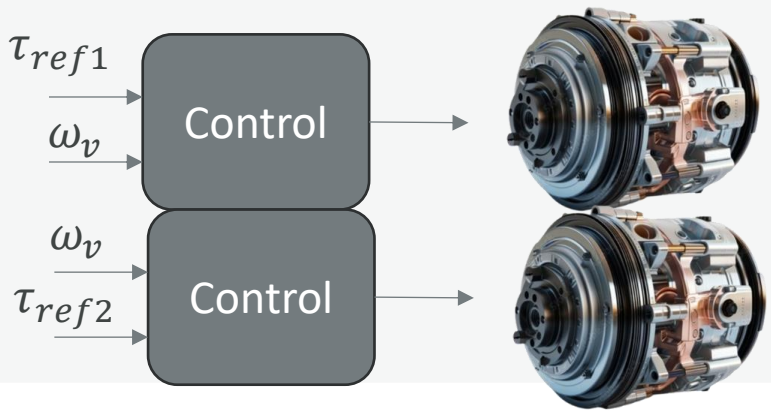
EM Control for Traction Applications

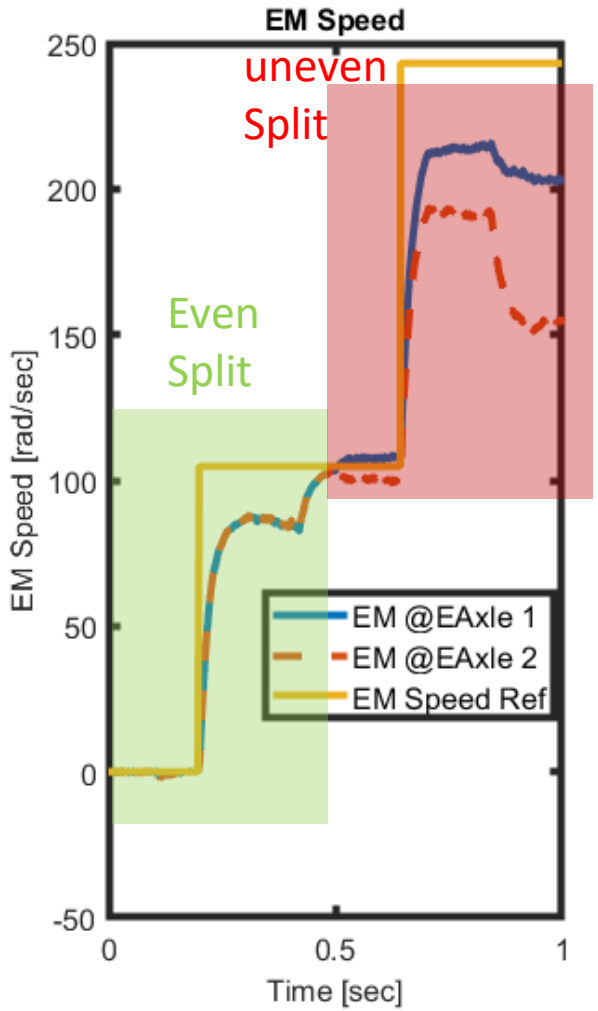
- EM control loop needs to track the requested torque
- Speed tracking loop is not required in traction applications

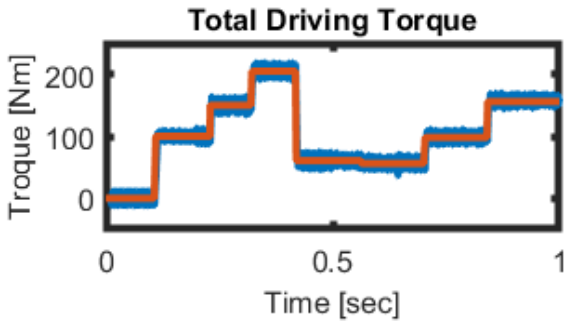


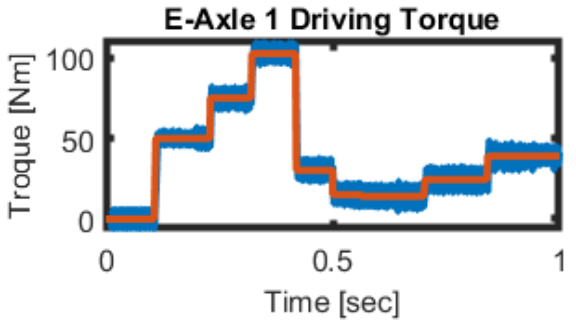
Impact of Uneven Torque Allocation (Not Connected to Vehicle Chassis)

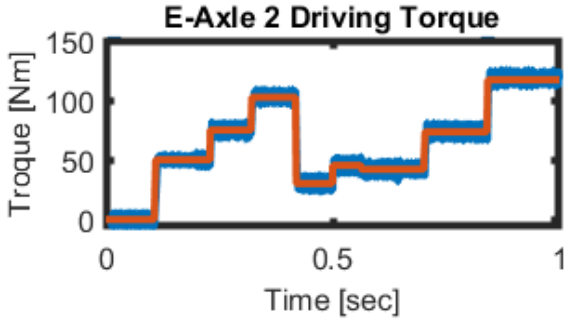
- Uneven torque allocation provides the EM loss minimization [1]
- Uneven torque allocation leads to unsynchronized operation of EMs
- Unsynchronized EMs speed can lead to unsafe vehicle operation.







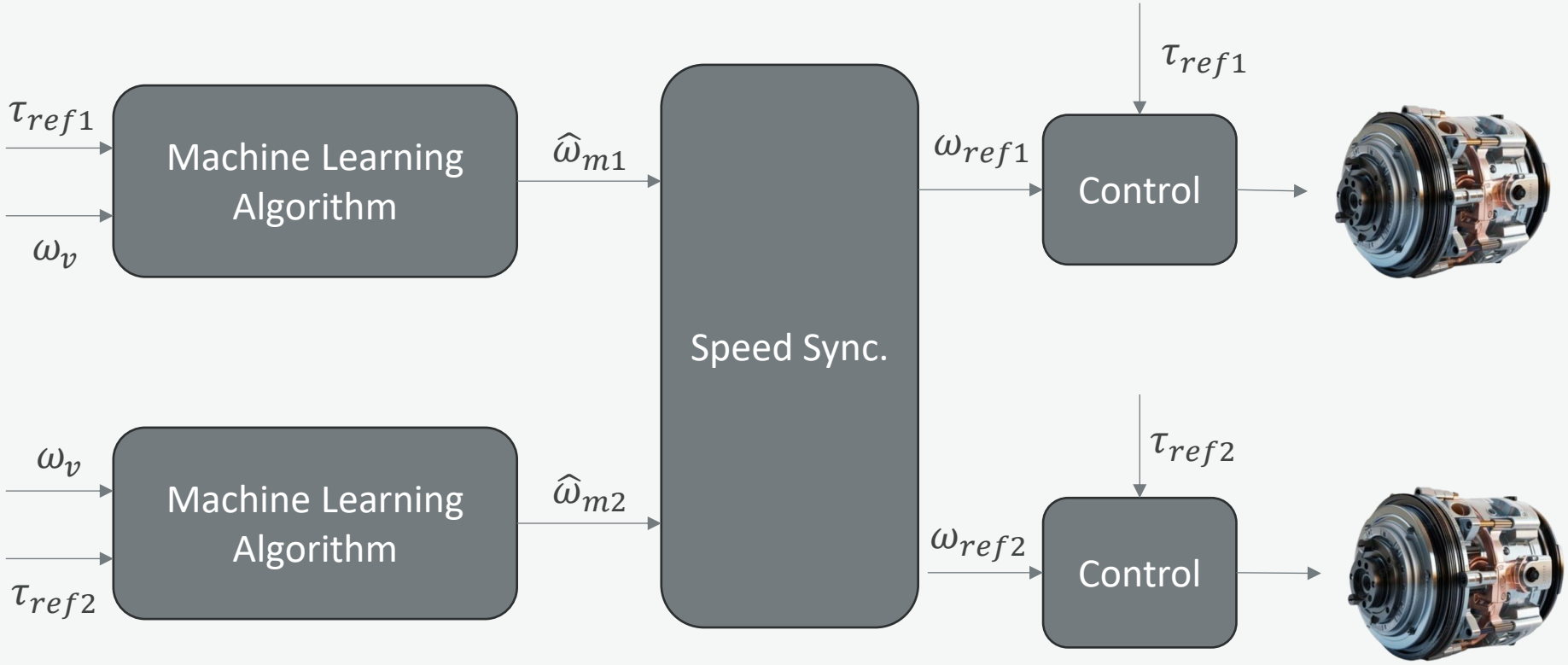




A. H. Safder, A. Hanif and Q. Ahmed, "Optimal Torque Allocation for Energy Efficient Operation of Dual E-Axle Based Powertrain for Heavy Duty Electric Vehicles," *2025 IEEE/AIAA Transportation Electrification Conference and Electric Aircraft Technologies Symposium (ITEC+EATS)*, Anaheim, CA, USA, 2025, pp. 1-6, doi: 10.1109/ITEC63604.2025.11098060.

Updated Block Diagram

- The trained ML model will predict the EM speed
- Speed sync will generate the references for EM control loop based on the predict speed values



Comparison

Features	Vehicle Enforced Synchronization	My Approach
Control Philosophy	Reactive: Physics corrects imbalances after they occur.	Proactive: Predicts and prevents imbalances before they occur.
Drivetrain Stress	High: Mechanical components absorb synchronization forces.	Low: Electronic adjustment minimizes mechanical stress.
Energy Efficiency	Sub-optimal: Energy wasted as heat and vibration during transients.	Optimized: Maintains both motors in their high-efficiency regions.
E-axle Life	Standard wear due to cyclic stress and oscillations.	Extended: Significantly reduced mechanical wear
Ride Quality	Potential for low-frequency shudder or vibrations.	Excellent: Smooth operation eliminates drivetrain oscillations.
Torque Accuracy	Optimal torque split can be distorted during transients.	High: Precisely delivers the intended optimal torque split.

Why This Approach

- **Intelligent Reference Adjustment:** predicted dynamics to provide references that naturally lead to synchronized operation.
- **Proactive & Predictive:** Moves from reacting to problems to preventing them.
- **Efficiency & Performance:** Maintains optimal operation, saving energy and improving drive quality.

Thank you

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