



PACCAR INC. POSITIVE / NEGATIVE TORQUE CONTROL MODEL FOR E-MOTOR SYSTEM (E-Truck Challenge)



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Motivation

Heavy-duty trucking represents one of the hardest sectors to decarbonize, and the PACCAR E-Truck Challenge tackles that head-on by converting a Class 7 Peterbilt combustion truck into a full Battery Electric Vehicle. This capstone project delivers the verified Simulink torque control model at the heart of that effort — precisely governing regenerative and drive torque to make the vehicle safe and operational.

Functional Requirements

1. Network & Safety

Standard Protocol: Uses industry-standard messaging to link vehicle computers.

Fail-Safe: Automatically cuts power to zero if the connection drops.

2. Signal Validation

Trust But Verify: Continuously cross-checks all pedal and gear sensors.

Error Response: Any invalid or conflicting sensor data instantly disables drive torque.

3. Brake Override

Brakes Always Win: Pressing both the gas and brake heavily prioritizes the brakes.

Instant Cutoff: Immediately cancels forward acceleration until the gas is released.

4. Power Delivery

Smooth Mapping: Calculates motor output dynamically based on pedal depth and current speed.

Reverse Limits: Automatically caps maximum torque and speed when backing up.

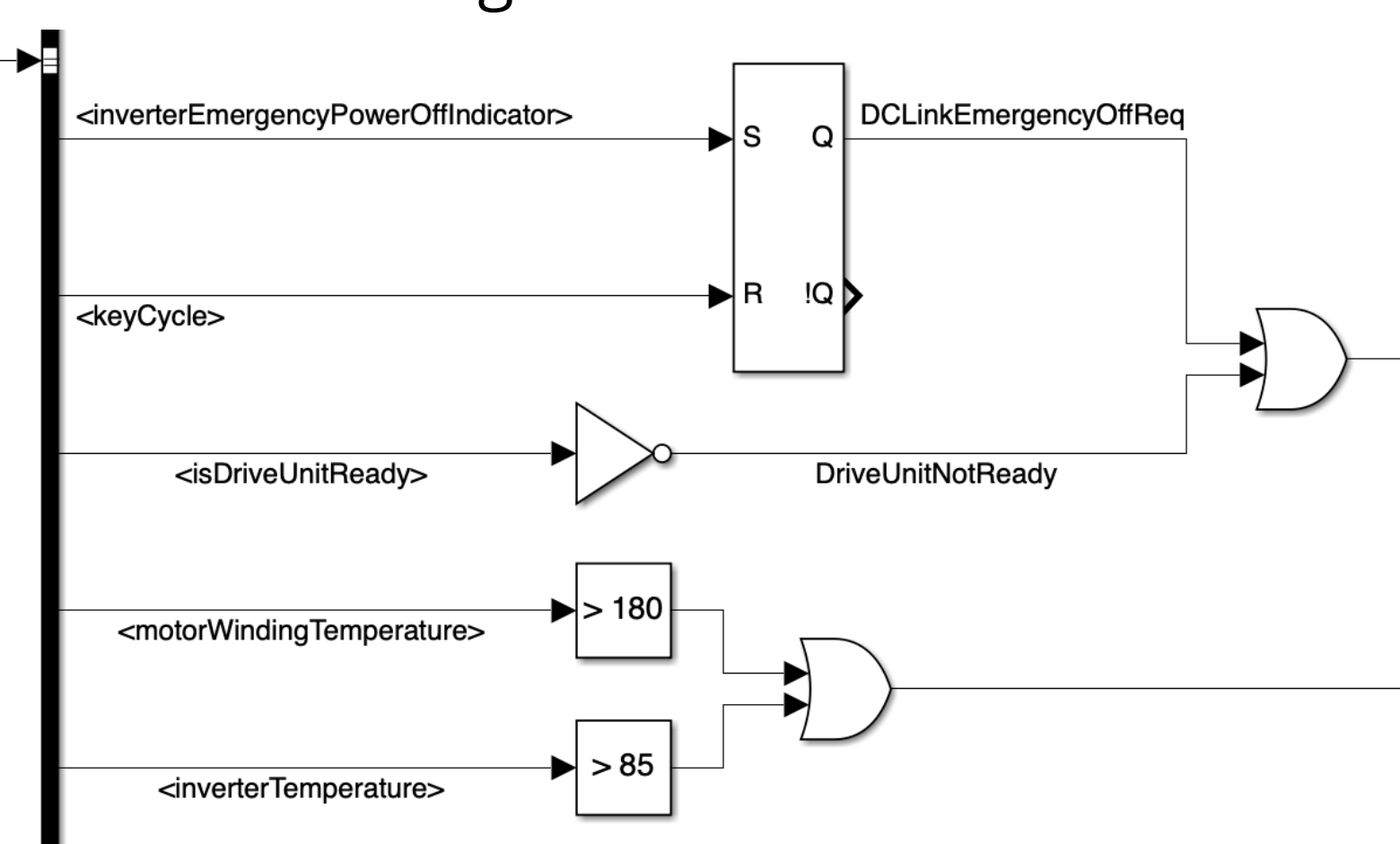
5. Regenerative Braking

Energy Capture: Uses the motor to slow the truck, recharging the battery.

Cargo Protection: Ramps braking force smoothly to prevent sudden jerking and maintain stability.

6. Hardware Protection

Thermal Limits: Gently dials back power if the motor or battery temperatures rise too high.



Limitations

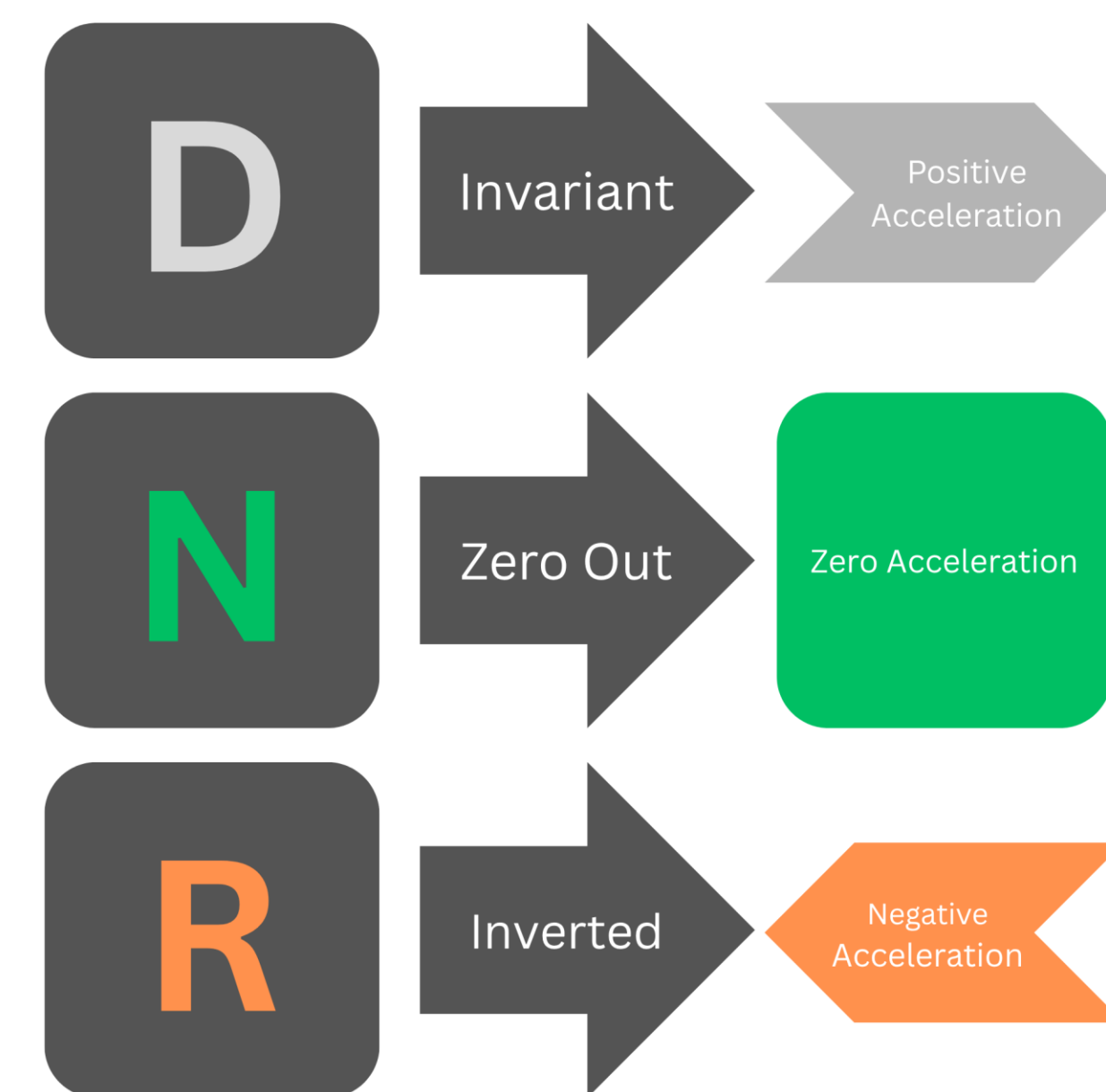
Limited testing

- Hardware-In-the-Loop testing was significantly impacted and delayed due to incompatible motor configuration.

Communication Integrity

- The system relies on protocol-level CAN/J1939 integrity checks and internal safety constraints but does not include additional end-to-end data validation (checksum/counter) for enhanced communication robustness.

Torque Arbitration/Calculation

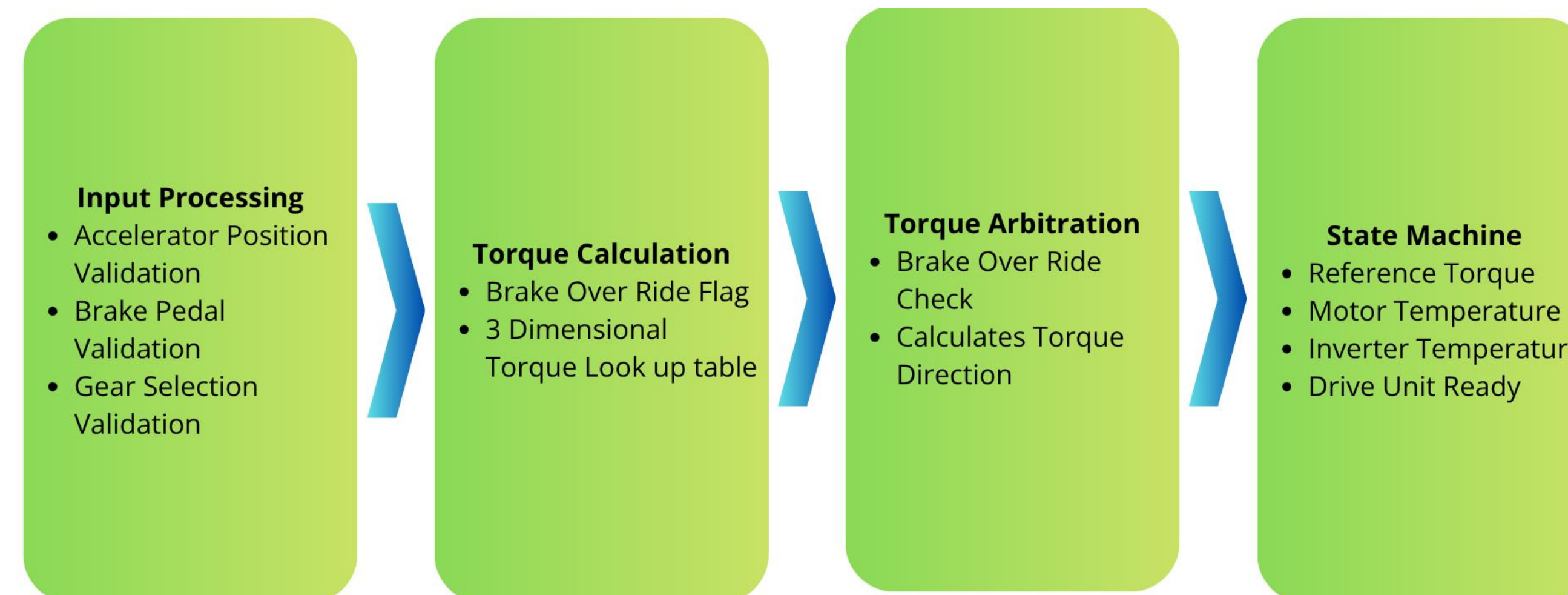


Safety Considerations

Brake Flag- The brake pedal overrides any torque request.

Is Drive Unit Ready- If the drive unit does not have a valid gear state or crucial error codes are thrown, torque will not be delivered

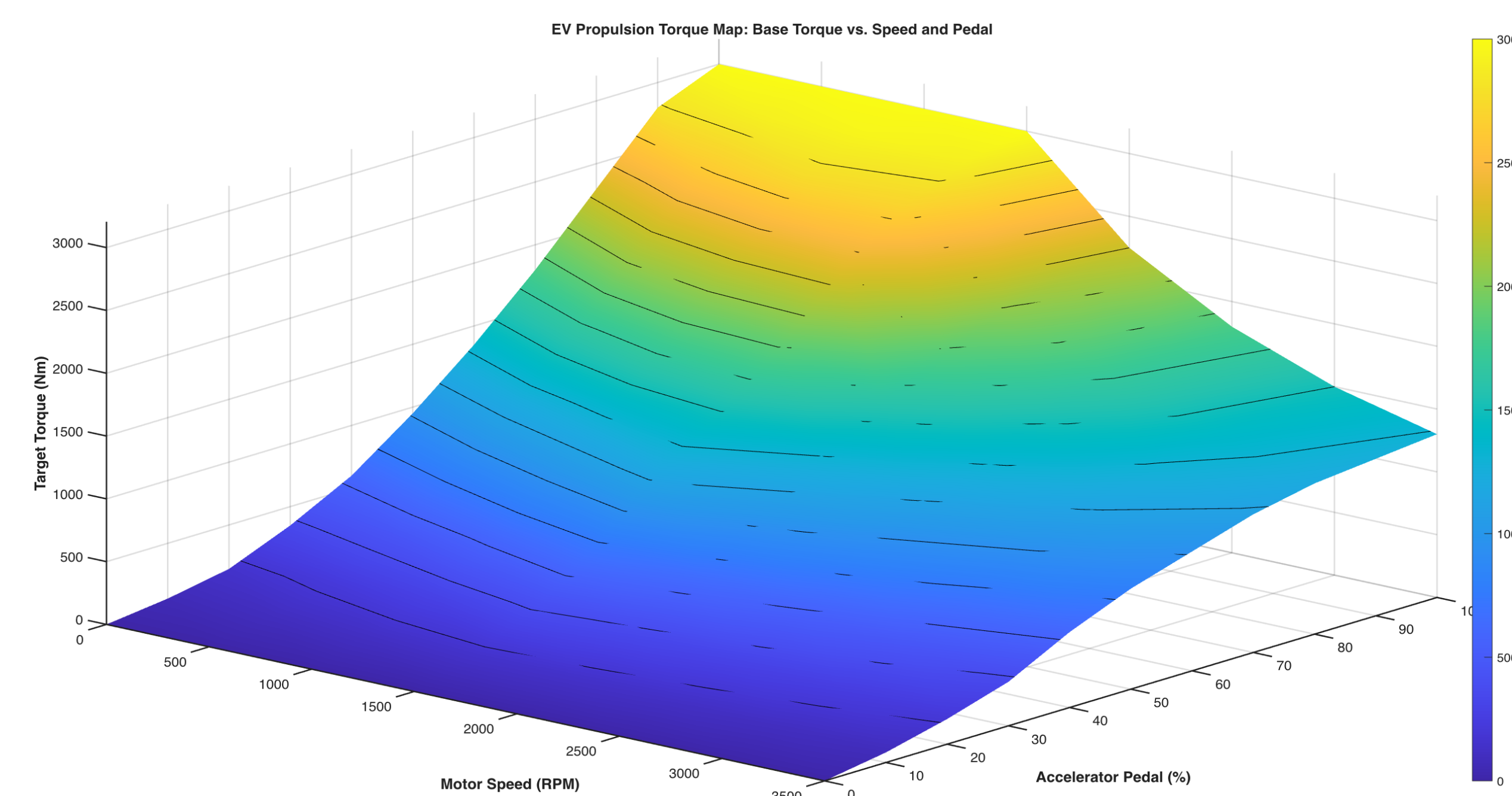
Hardware Limitations- All torque requests are scaled depending on hardware temperatures and conditions.



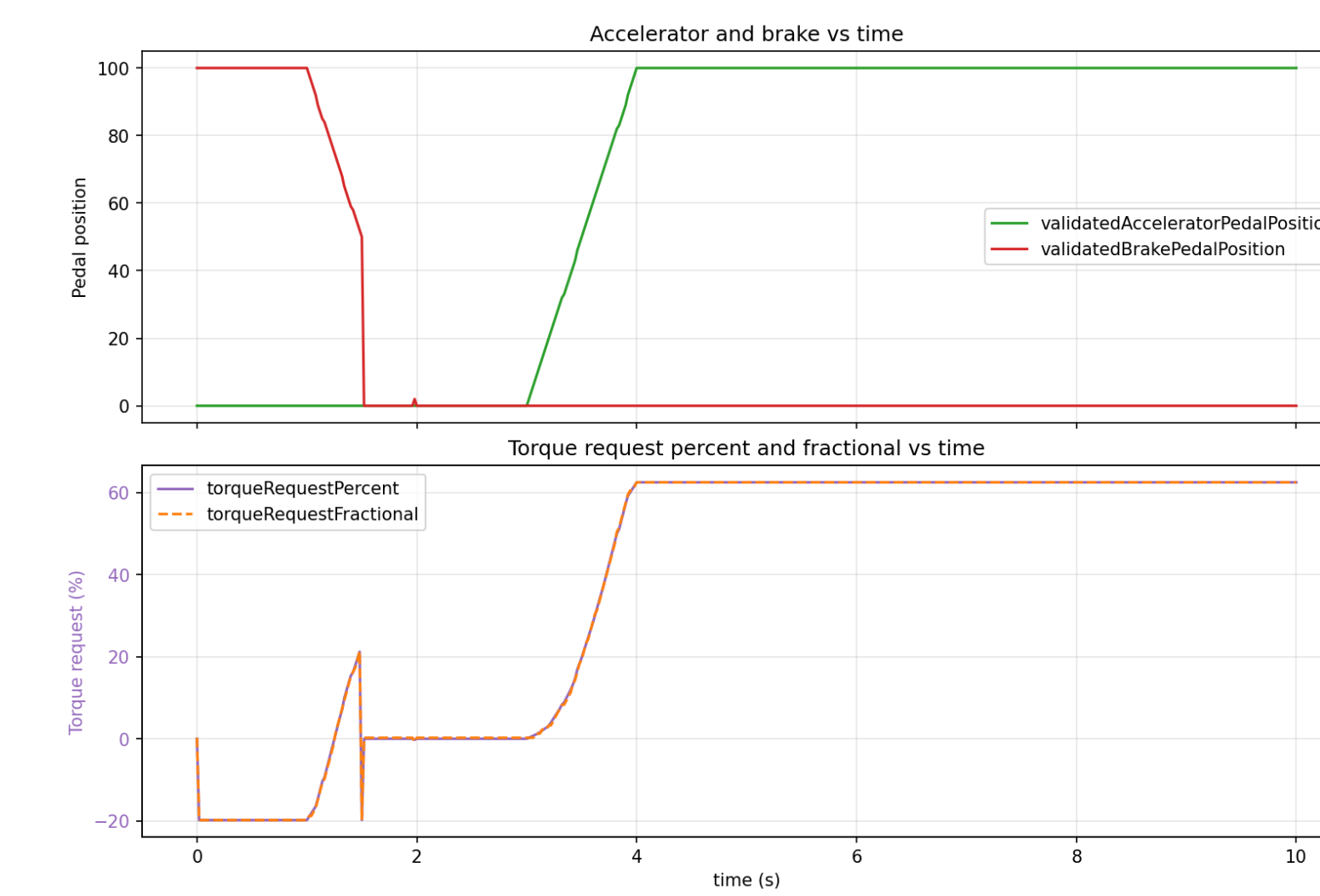
Using the torque request from the driver via the accelerator pedal and the current motor speed, we use the 3-dimensional lookup table below for raw torque request.

Then the raw request is then transformed depending on the current gear state.

Finally, the transformed request is scaled depending on the hardware thermals, operational limits, and overall state of the truck.



Conclusions and Results



Final Results

- Accelerator pedal and brake pedal are prevented from applying to the system at the same time.

- The torque request is based on the accelerator pedal being pressed and current motor speed.

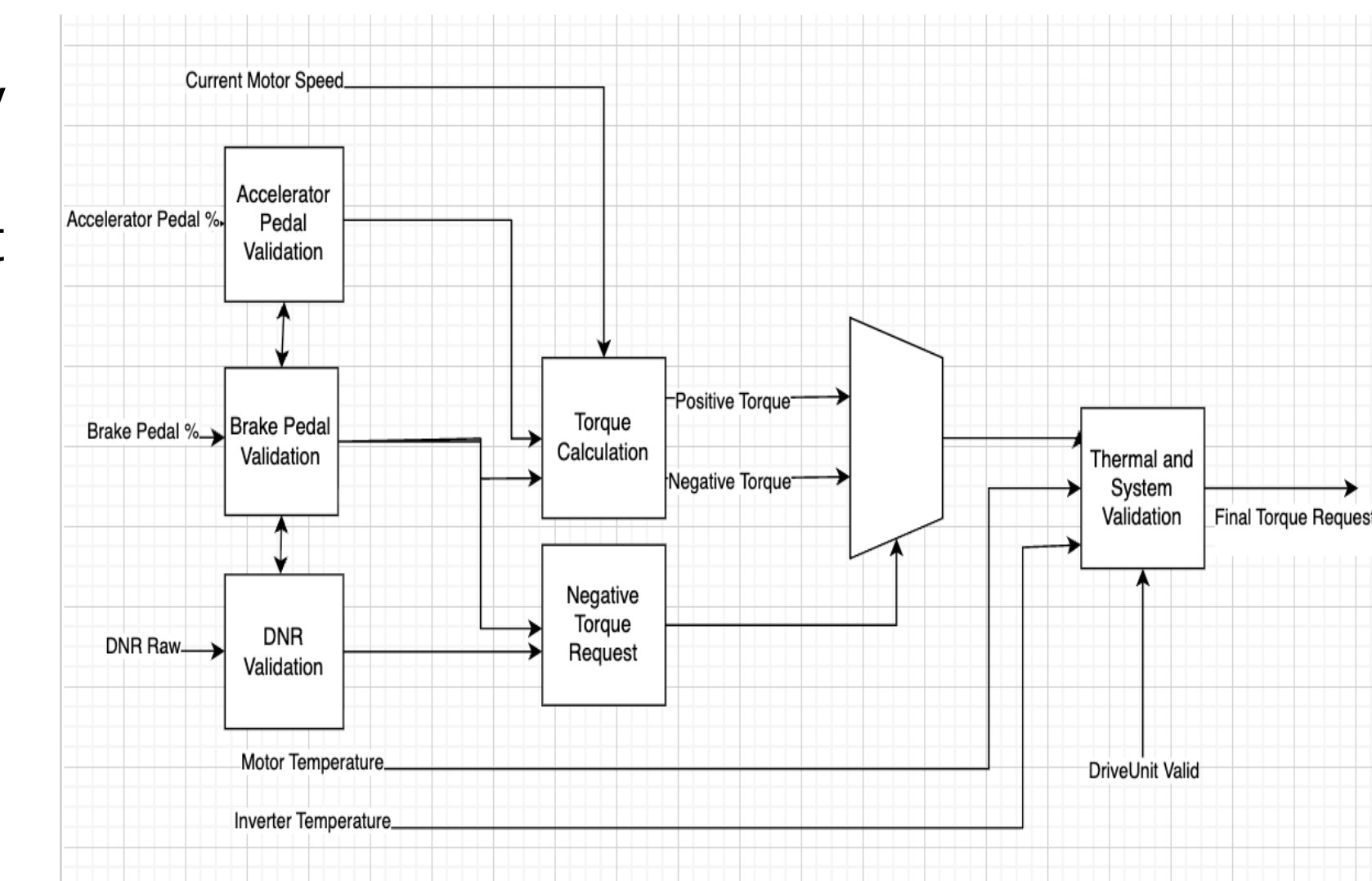
- Torque cannot reach 100% based on the torque map and current motor speed, per safety standards.

Block Diagram

- The leftmost validation blocks verify that inputs from accelerator and brake pedal as well as raw DNR input are within expected values.

- Selects between positive and negative torque request based on brake as well as DNR.

- Block to validate system functionality based on motor thermals and drive unit readiness.



Future Work

For our powertrain logic to be implemented into the final design of the electric truck, user inputs using hardware and wiring harnesses must be designed to connect to the central electronic control unit to deliver input messages to the torque logic.

Improving this logic would be to add comfort features such as hill hold, adaptive cruise control, and predictive control. These features would ease handling for the driver.

Once these have been implemented, additional testing would need to be done to verify that the torque system accurately applies torque to the motor.