

# THERMAL MODEL OF ELECTRIC DRIVE UNIT (EDU) FOR SYSTEM-LEVEL SIMULATION

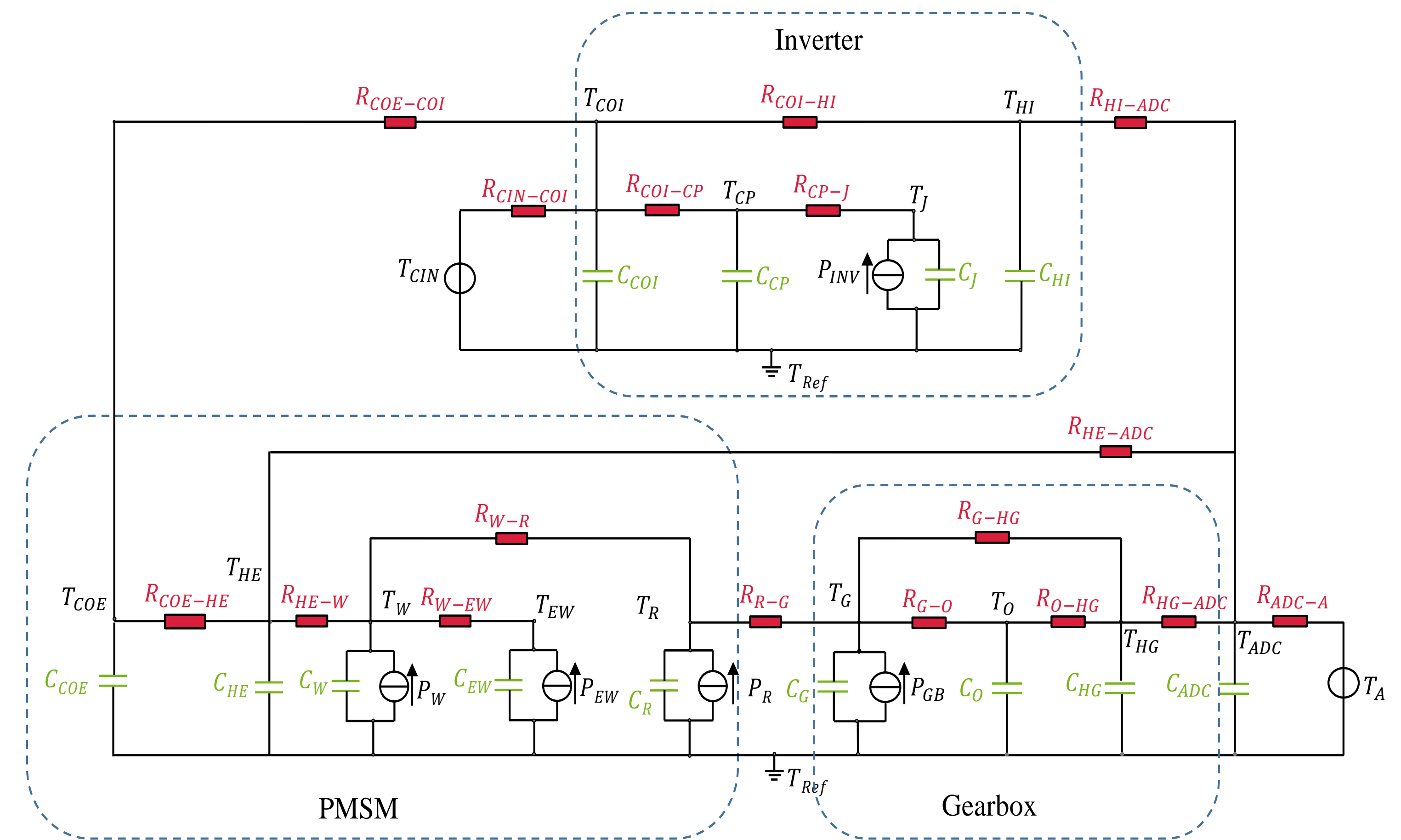
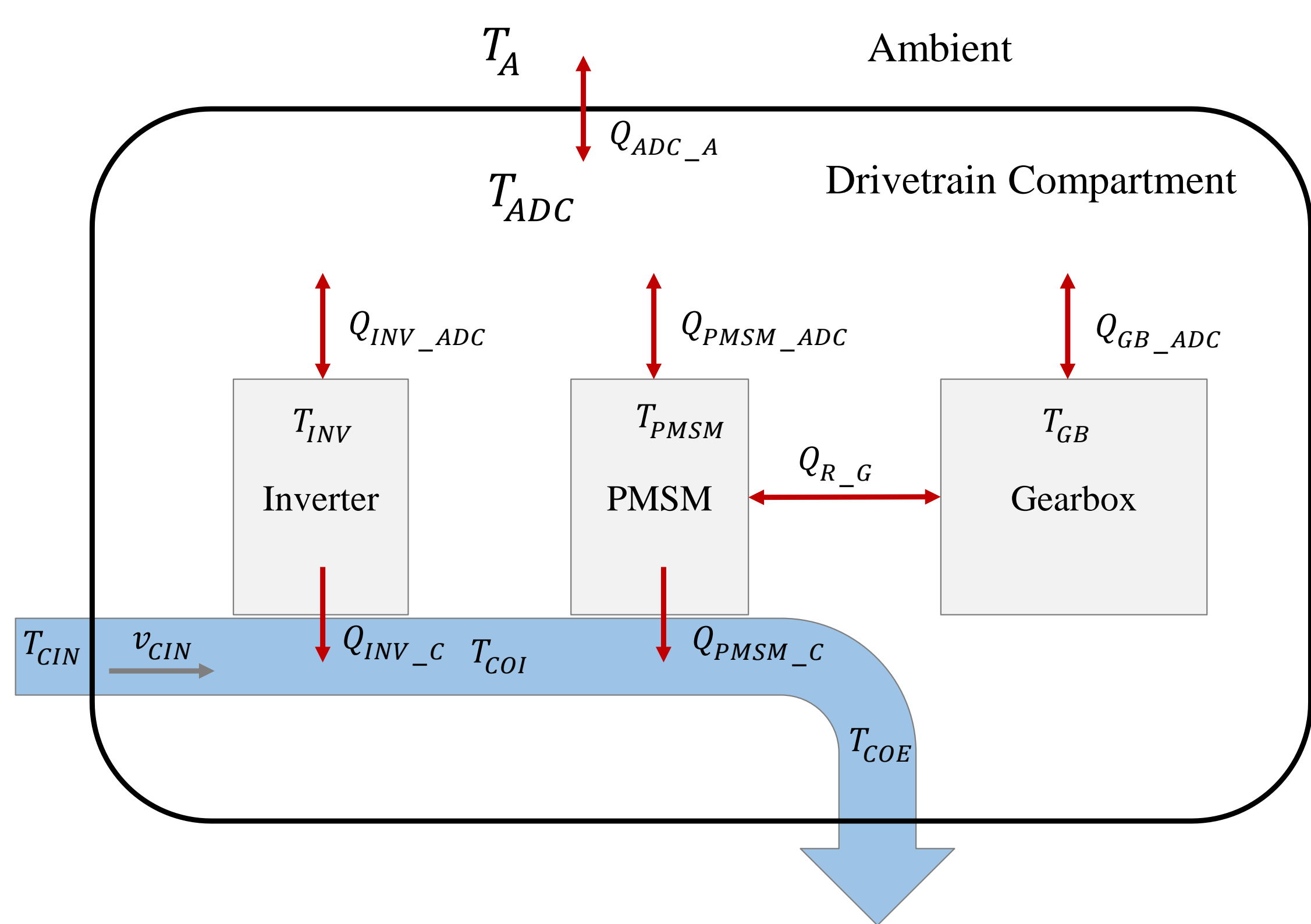
**Abstract**  
Monitoring critical temperatures in the electric drivetrain components is becoming more and more crucial for operational safety and achieving better efficiency. A centralized compact lumped-parameter thermal network model for the electric drivetrain with consideration of thermal coupling between inverter, electric motor and gearbox is set up. The maximum estimation error of circa 7 °C is achieved at the ambient temperature around 20 °C with the realistic coolant profiles.

**Conclusion**  
An accurate low-order LPTN model for monitoring critical temperatures for electric drivetrain regarding the thermal coupling of components is introduced. The cross-validation results show a satisfying performance of the identified thermal model. The proposed thermal model and parameter identification method can be easily applied with vehicle-level measurements to avoid the time consuming and costly thermal measurement on the component test bench.

## Lumped parameter thermal network (LPTN) model

- Heat transfer is abstracted by equivalent electric circuit diagrams.
- 13 nodes were used to simulate the temperatures
- A global linear parameter-varying identification approach with a-priori system knowledge was applied to parameterization of the LPTN model

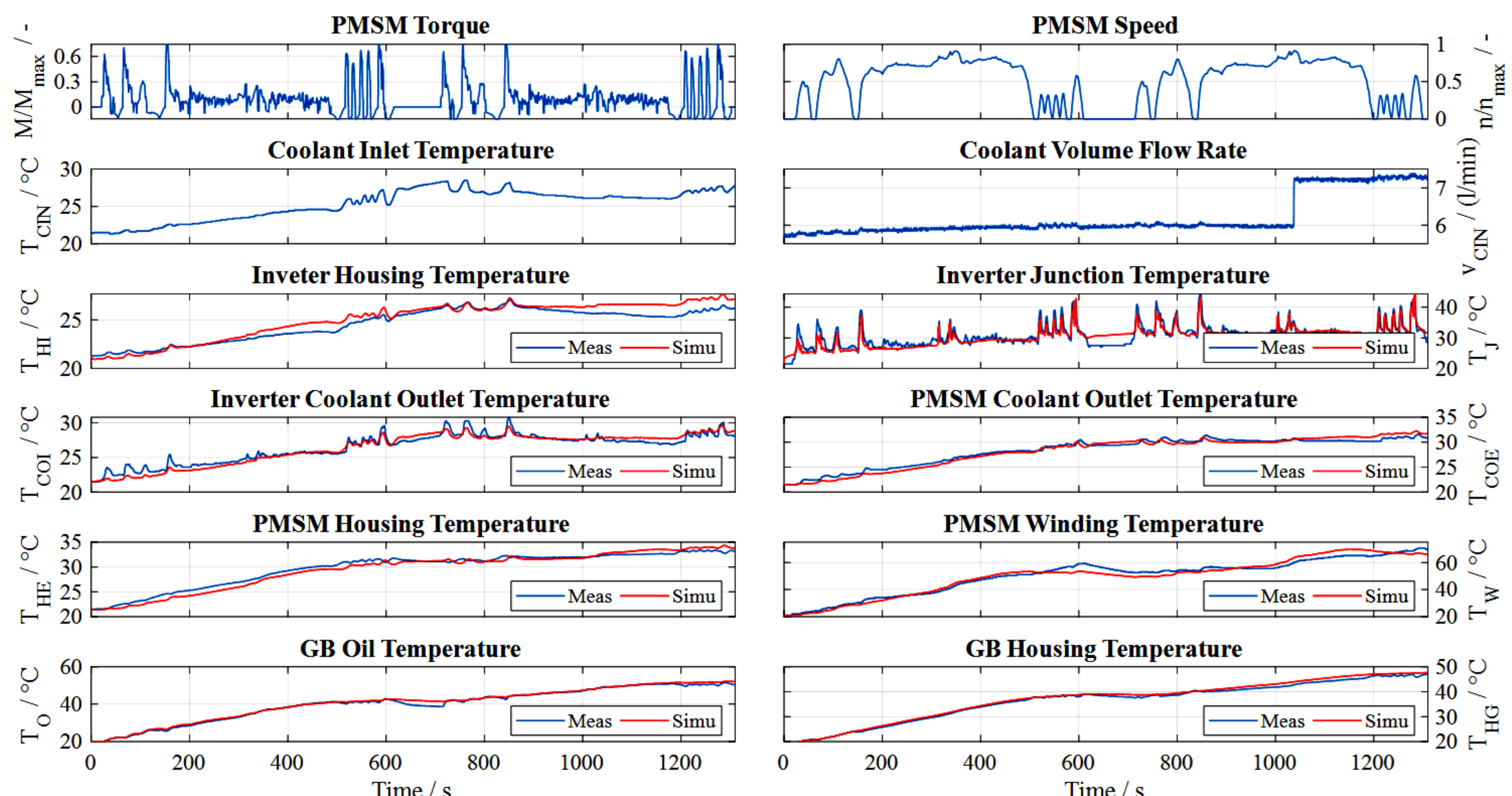
PMSM	Permanent Magnet Synchronous Machine	GB	Gearbox	T	Temperature
ADC	Air Drivetrain Compartment	A	Ambient	G	Gear
CIN	Coolant Inlet	P	Losses	O	Oil
COI	Coolant Outlet Inverter	C	Coolant	R	Rotor
COE	Coolant Outlet Electric Machine	W	Winding	EW	End Winding
HI / HE / HG	Housing Inverter / Electric Machine / Gearbox	J	Junction	CP	Cooling Plate



## Cross-Validation (Cycle: US06 @20°C)

- The thermal model was validated with measurement data of an A-Class vehicle
- The thermal model has a reasonable level of detail and can meet the requirement for accuracy.

Nodes	Max. Deviation	Avg. Deviation
Inverter Housing	1.41 °C	0.43 °C
Inverter Junction	6.64 °C	0.17 °C
Inverter Coolant	1.88 °C	0.11 °C
PMSM Coolant	1.42 °C	0.13 °C
PMSM Housing	1.57 °C	0.30 °C
PMSM Winding	6.37 °C	0.22 °C
Gearbox Oil	2.76 °C	0.47 °C
Gearbox Housing	1.61 °C	0.61 °C



B. Chen et al., "A Comprehensive Thermal Model For System-Level Electric Drivetrain Simulation With Respect To Heat Exchange Between Components," 2020 19th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), 2020, pp. 558-567.

