REAL TIME TEMPERATURE MONITORING FOR ELECTRICAL DRIVES

2024

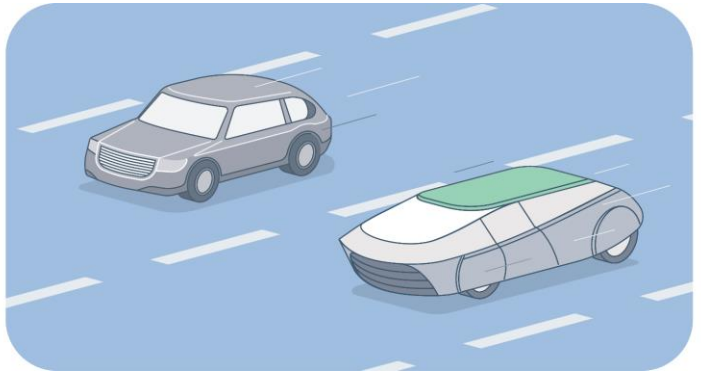
SEG AUTOMOTIVE

SEG Automotive- Who we are and what we do

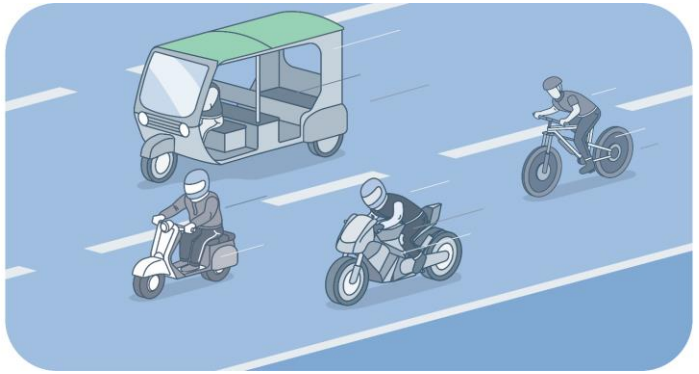
COMMERCIAL VEHICLES

- Starter Motors
- Alternators
- BRM
- High voltage components
- Auxiliary E-motors
- High voltage inverter
- Traction E-motors
- High voltage relay
- E-drive systems

PASSENGER CARS



LIGHT ELECTRIC VEHICLES



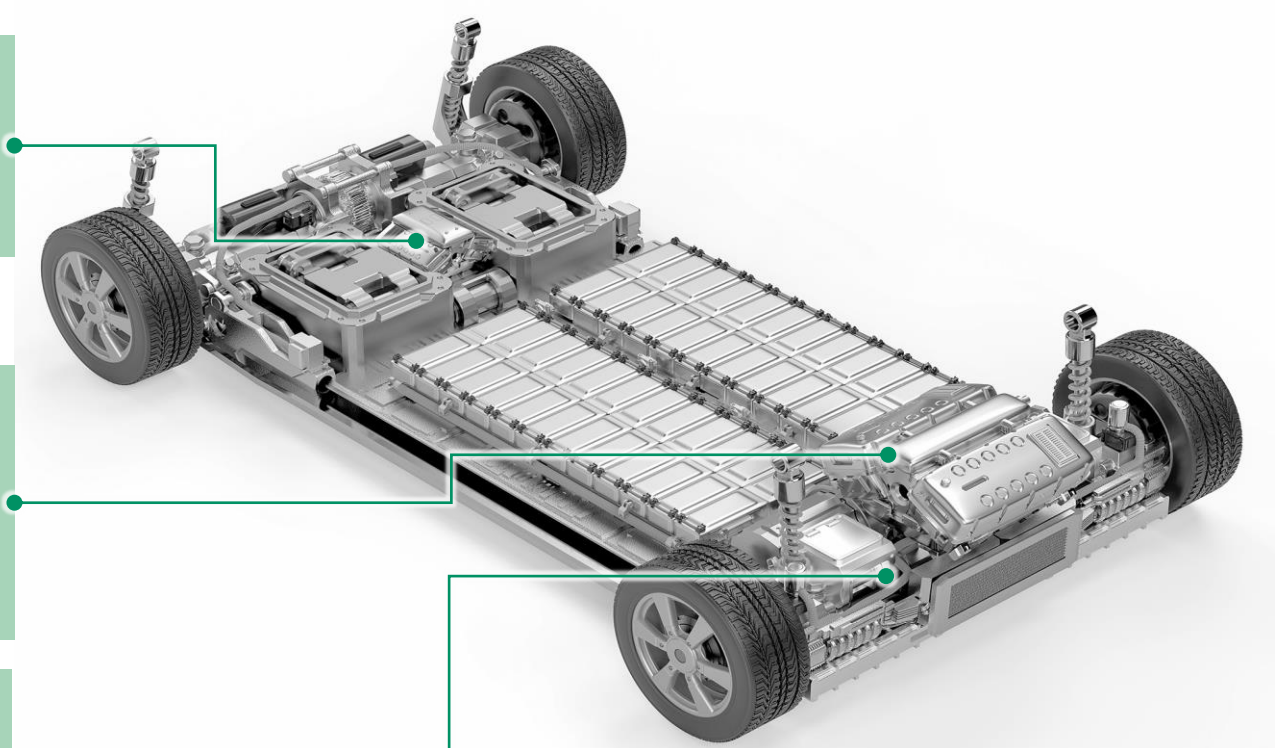
- BRM E-drive
- Mid-mount motors
- VCU for BRM
- Hub-mount motors
- E-bike motors
- Controllers

Thermal Management – Product Specific Requirements

E-Drive Products
- Inverter and Motor as main heat sources
- Active protection methods
- Active thermal management e.g. heat up battery
- Oil-/Water Cooling /Air Cooling for LEM

Mild Hybrid Machines
- Boost Recuperation Machine
- Close to combustion engine
- Ambient temperatures might be higher than Emachine temperature.
- Active protection methods + withstanding of ambient temperature
- Air-/Water Cooling

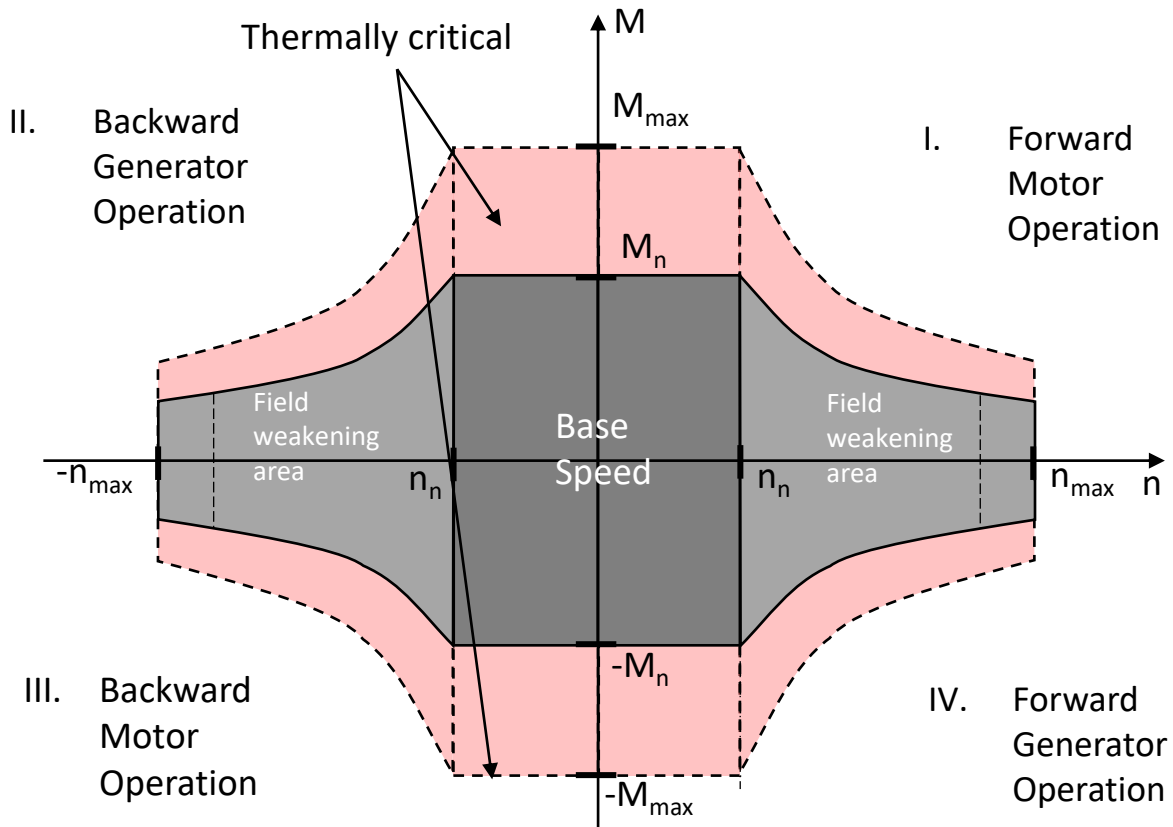
12V Machines for ICE
- Starter Motors
- Generators
- Withstanding of ambient temperature
- Design based on Hotspot



Thermal Derating – Heat-Related Reduction in Performance

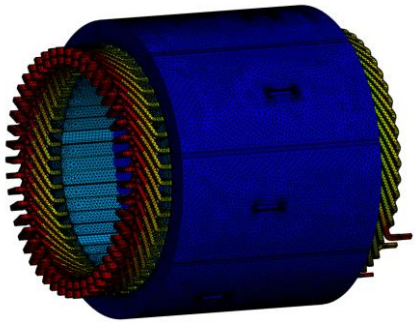
Common Restrictive Components in eDrives:

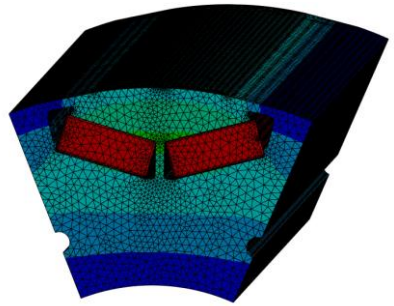
- **Inverter**:
  - Limiting Factor for Base Speed
  - The temperature of Power MOSFETs restricts the maximum phase current.
- **E-Machine:**
  - Limiting Factor above Base Speed
  - Rotor magnet temperature
  - Stator winding temperature



Different Real-Time Requirements:
Inverter: Thermal time constant in range of ms
Emachine: Thermal constant in range of seconds

Why smart Real-Time-Monitoring is needed





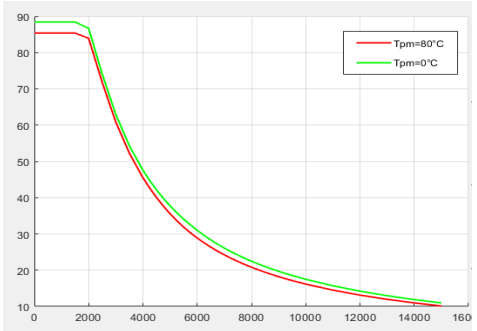
Design Phase:

- **Highly Meshed Models:** Utilize detailed 2D/3D FEM models and CFD simulations to optimize the thermal and electromagnetic behavior of the electrical machine and inverter.
- **Derived Information:**
  - Loss models for iron, magnet, and windings.
  - Sensor placement positions / identification of thermally critical points
  - Switching and conduction losses of power switches (electrical simulation, datasheets).
- **Verification**: All simulations are verified by testbench measurements.

Complex Models can not be computed in Real-Time and need to be reduced in complexity

Real-Time Estimation & Monitoring:

- **Sensor Placement**: Due to cost, reliability and manufacturing constraints, sensors cannot be placed at all thermal relevant points
- **Reduced Models**: High-accuracy models are too complex for embedded code, so reduced models are created to retain essential thermal characteristics for real-time systems.
  - Created through expert knowledge or mathematical optimization of complex FEM models.
  - Must retain physical relationships to calibrate simulated behavior with real measurements.



Smart model reduction techniques needed to maintain accurate temperature information in hot spots.
AI may help to compensate aging effects, manufacturing tolerances and model deviations.