VESI: Demonstrator #2
Vehicle Integrated Power Conversion

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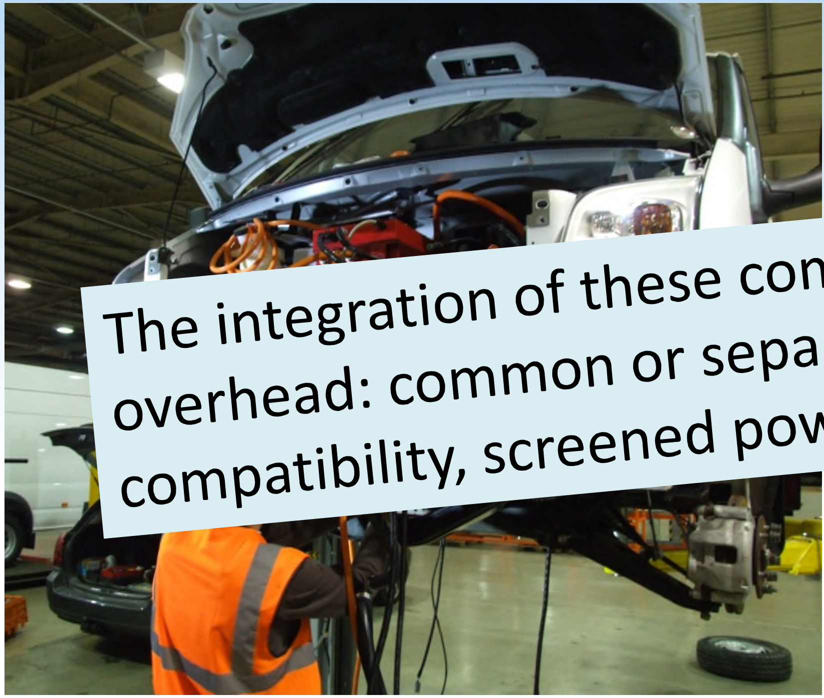
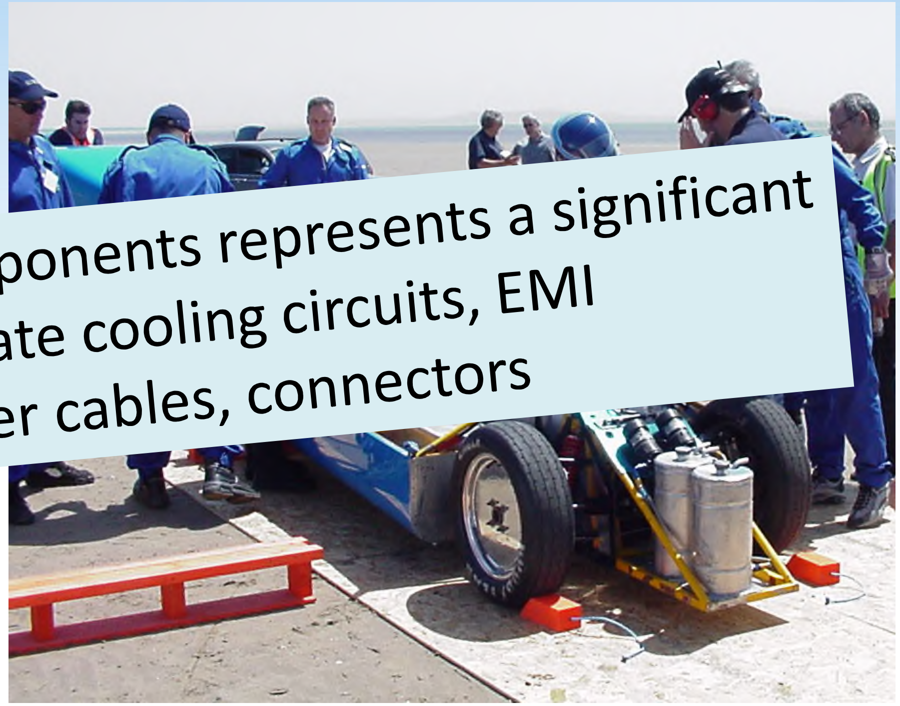
Rationale

The electric powertrain system is often assembled from separate building blocks each having a specific function: motor inverter, DC to DC converter(s), power distribution, electrical machine….





The integration of these components represents a significant overhead: common or separate cooling circuits, EMI compatibility, screened power cables, connectors

Demonstrator aims and objectives

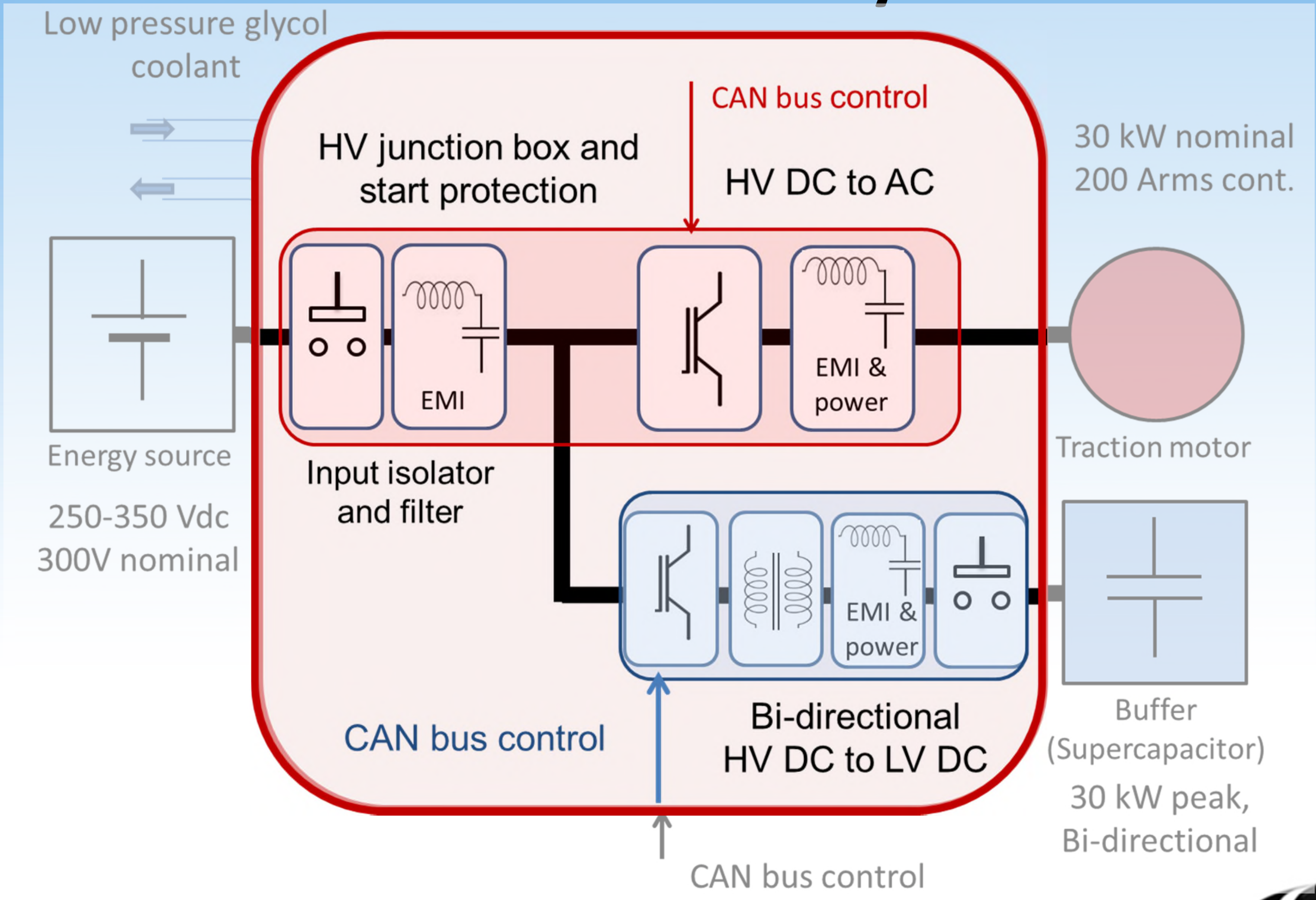
The aim is to integrate multiple functional elements: a propulsion converter, a high power bi-directional DC to DC converter, high voltage distribution and EMI filters, within a single enclosure sharing a common cooling circuit.

The hardware development incorporates the underpinning tools and methods developed within the VESI project.

The objectives are to demonstrate:

I. Volume , weight and cost saving through a shared enclosure and cooling, and integrated inter-converter connections and filtering ;
II. Reduced electromagnetic emissions compared to the individual elements;
III. Improved compatibility and function.

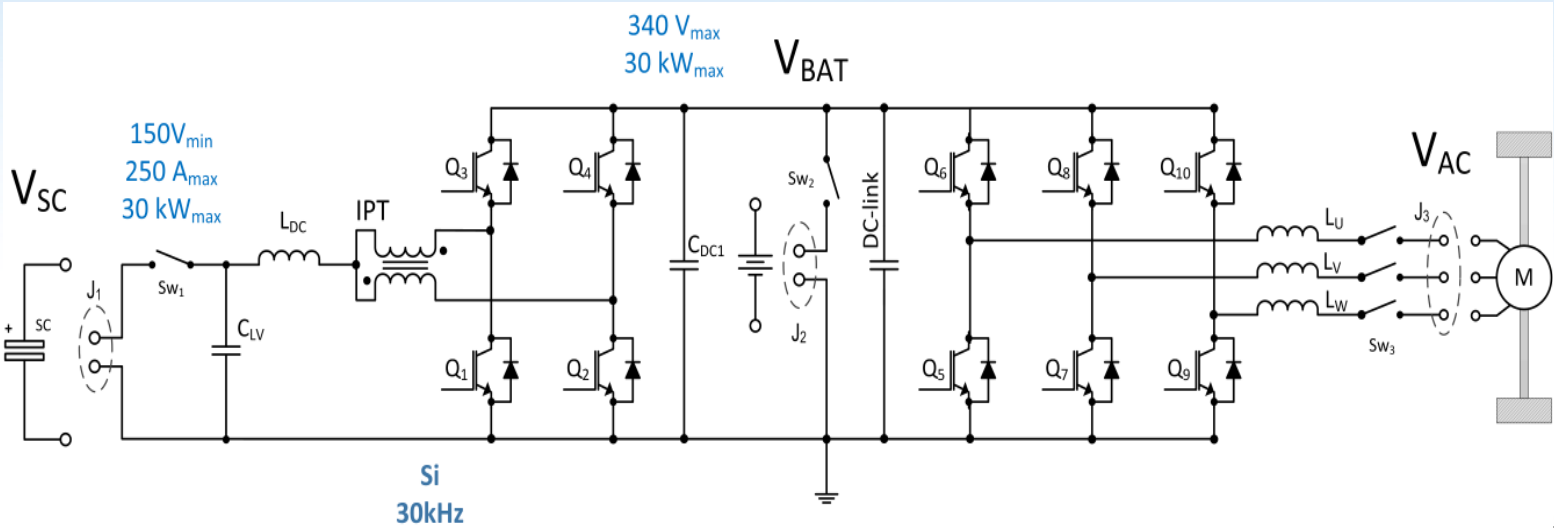
Demonstrator system



Power Conversion System overview

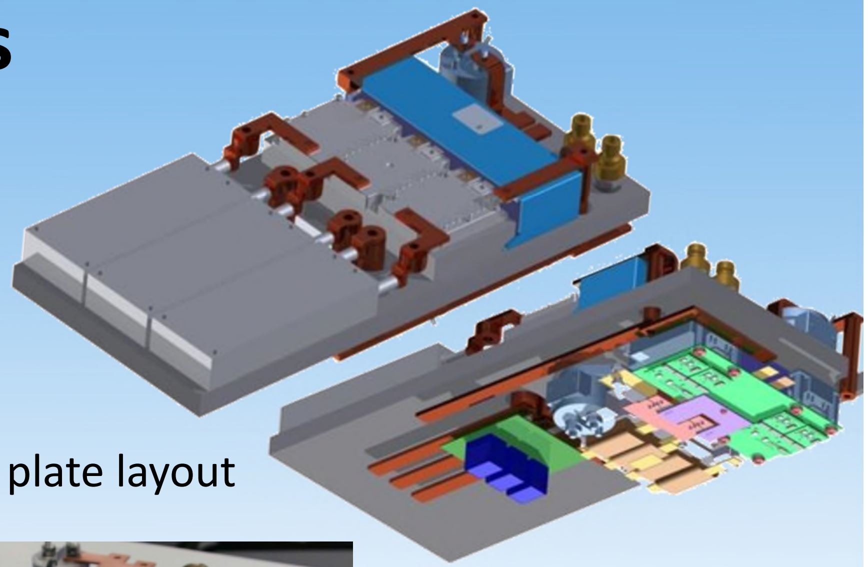
The system combines fully rated (30 kW nominal, 50 kW peak) components in a single enclosure:

- Bi-directional DC to DC converter interface to super-capacitor buffer store
- Inverter drive for an IPM propulsion motor
- Battery interface and start-up circuit
- Common-mode and differential mode EMI filters
- CAN bus control of all elements

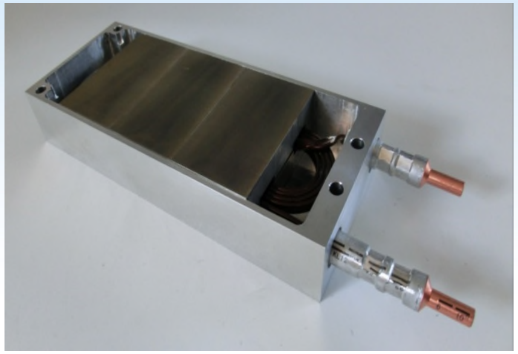


Status

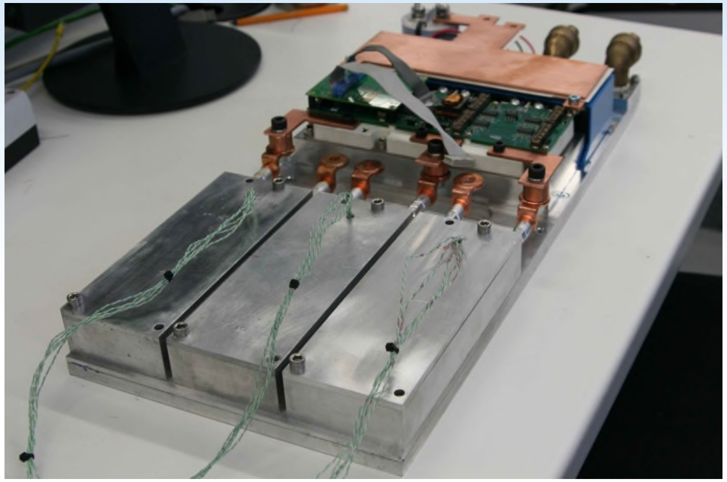
- Integration completed and power converter tests underway
- Integrated system testing planned for next month



Common plate layout



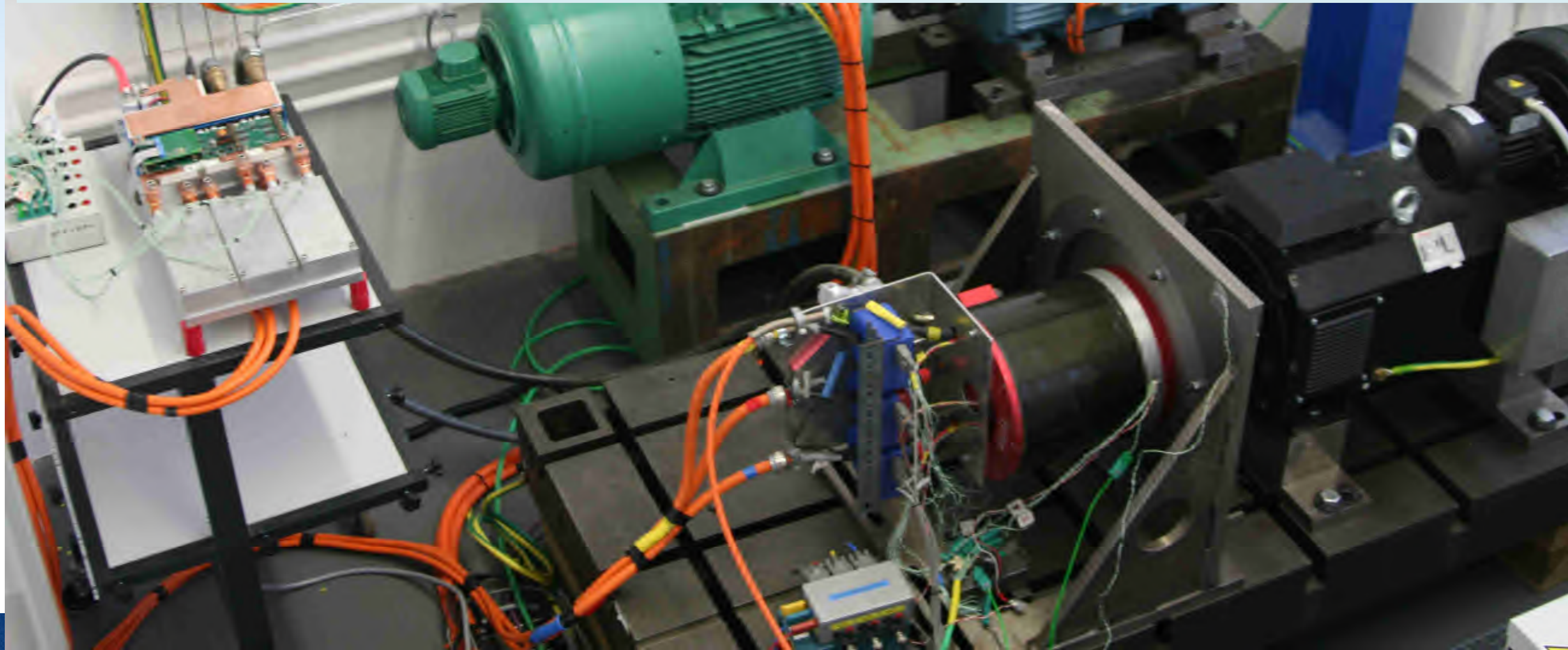
Costumed compact line filter



Assembly of DC to AC drive and output line filter

Test bed

- Dynamometer test cell at UoB established
- 30kW continuous IPM traction motor loaned by Tirius
- 30kW DC supply available to emulate battery input
- Peak buffer store to be loaned by Manchester
- HBM Genesis eDrive instrumentation

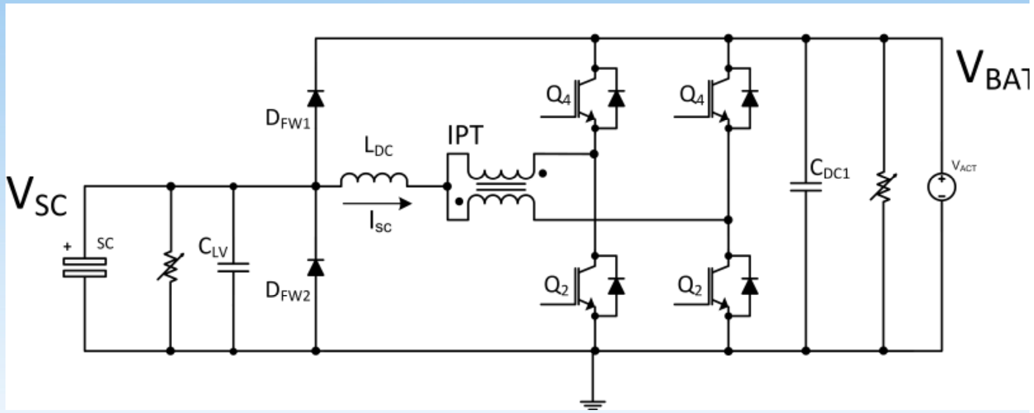


DC-DC Converter - Overview

- DC-DC converter demonstration
  - V_{SC} = 120-240 V, V_{BAT} = 340 V,
  - Max power = 30 kW. Max current = 250 A.
- Key achievements / innovations
  - High frequency magnetics modelling and design
  - Control system modelling and design

DC-DC Converter Demonstration

- Dual interleaved
- IPT + single inductor
- IGBTs at 30 kHz
- Digital controller
- Validation
  - Continuous power and thermal tests
  - 41 F supercapacitor



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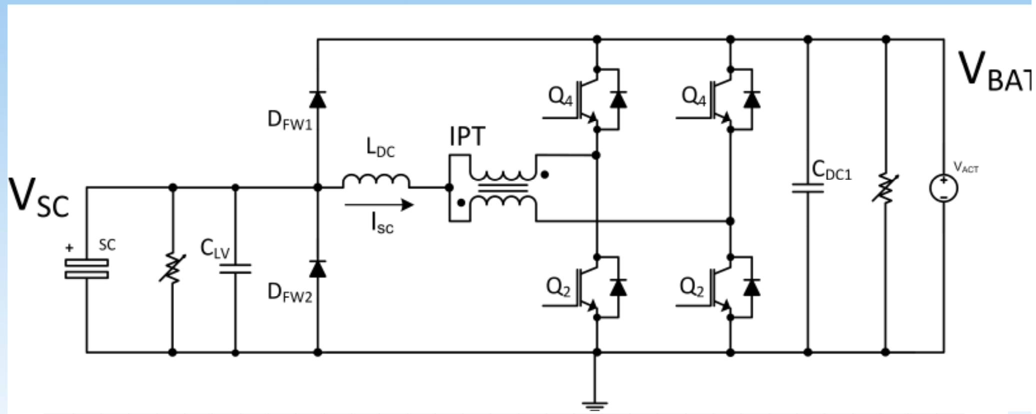
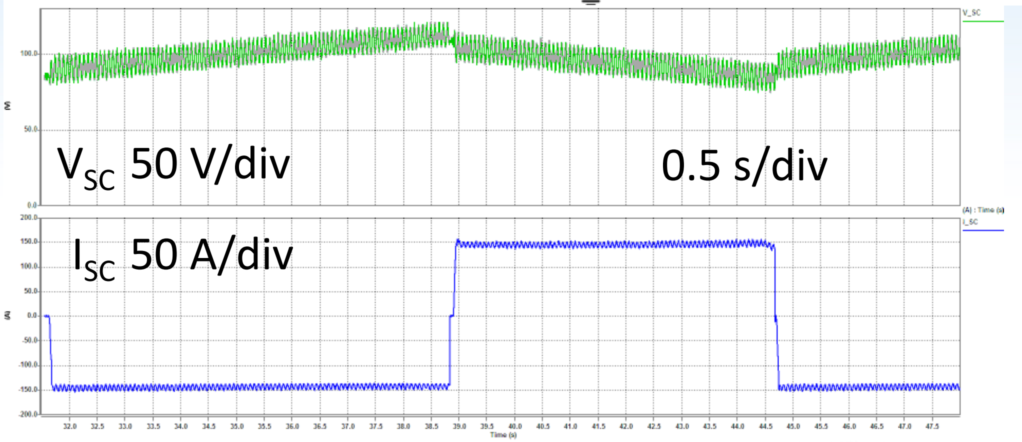
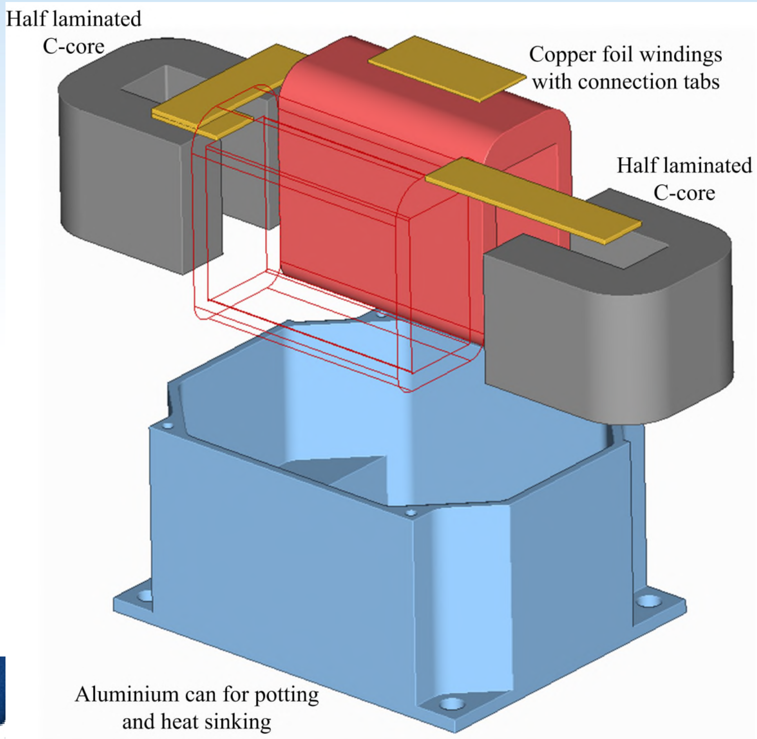
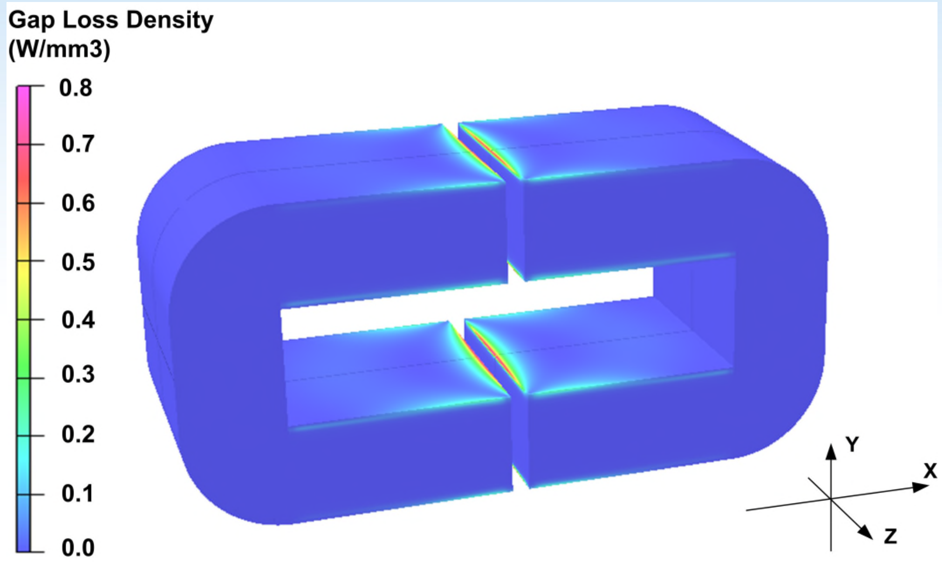




H-F Inductor Design

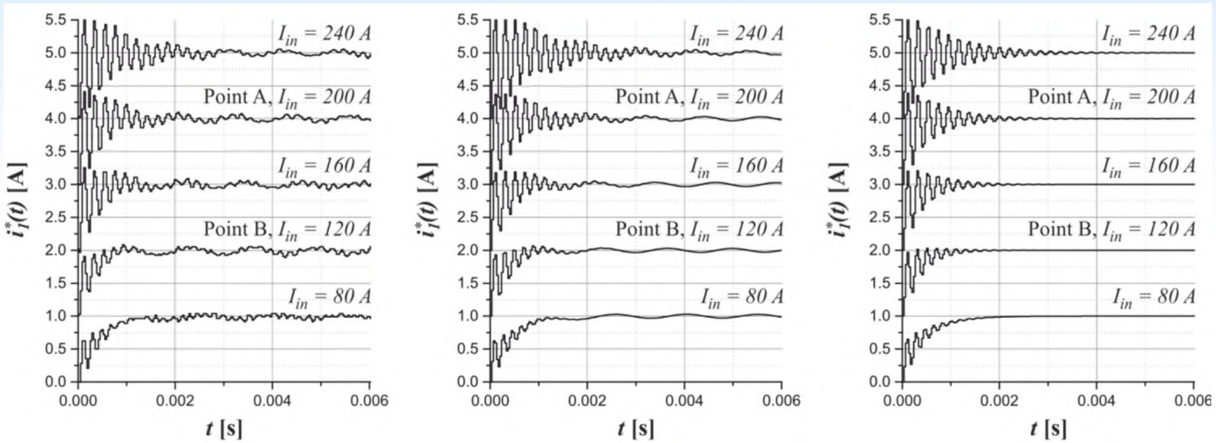
- Enhanced gap-loss modelling in nanocrystalline cores leading to better optimised designs





Control System Modelling

- Interleaved sampling creates interaction and instability – not predicted by averaged models
- Enhanced averaged model developed



Saber New model Standard model

Phase current unit step responses

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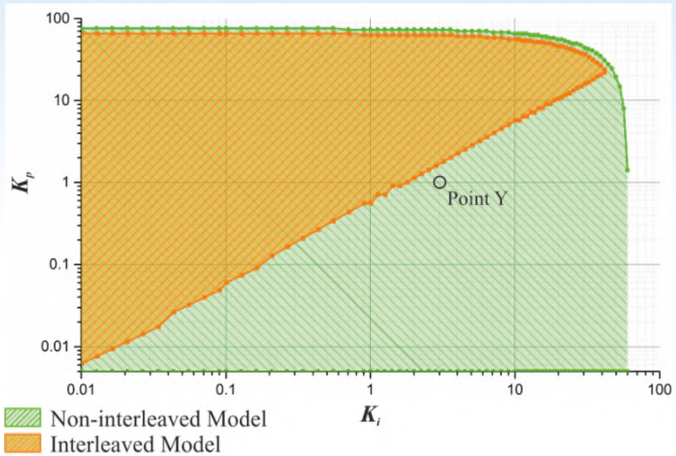
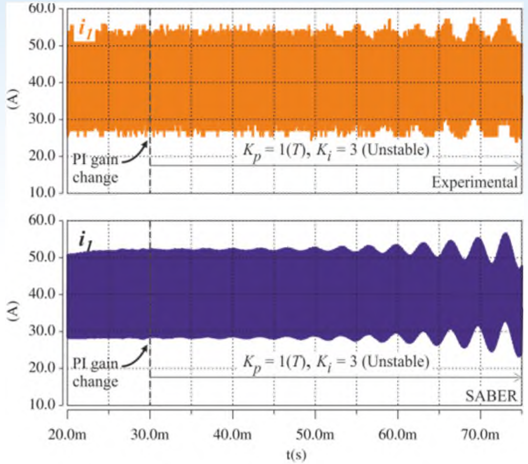


K_p : K_i design space



Measured phase current

Simulated phase current

Switching to unstable design point

Conclusion

- Dedicated full-scale platform developed for system integration and energy management research.
- Enhanced design tools developed and demonstrated for magnetics and interleaved converter controller, which will support on-going collaborative research.