ABB Oy Drives, Teemu Ronkainen, 24.09.2014

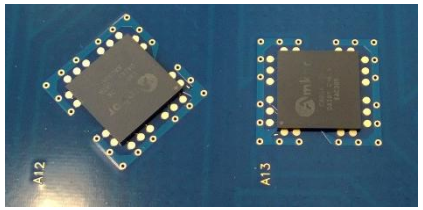
HeavyDrive Project

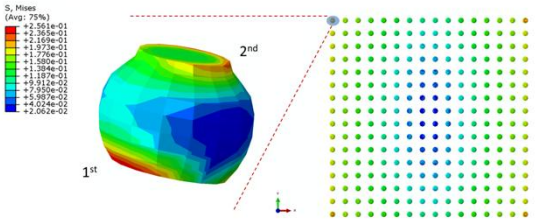
Introduction
HeavyDrive

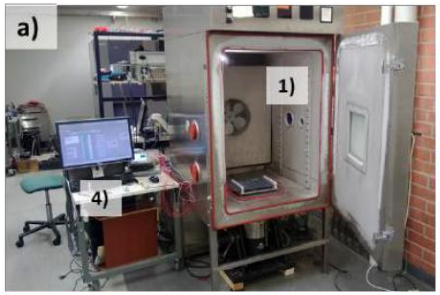
- Part of TEKES Electrical Commercial Vehicles (ECV) program
  - Tubridi and eStorage3
- HeavyDrive project aims to develop and evaluate technology for the next generation HHEV drive
- Focus areas are reliability, new functionalities, compact size and low cost
- Project consists of four sub-projects:
  - HEVI3 at Aalto University: PCBA reliability
  - ACDC at Aalto University: Motor models, DC link stabilation etc.
  - HEI2 at ABB: drive technology in general
  - Thuja at ABB: ABB research and simulation models on HHEV drive reliability

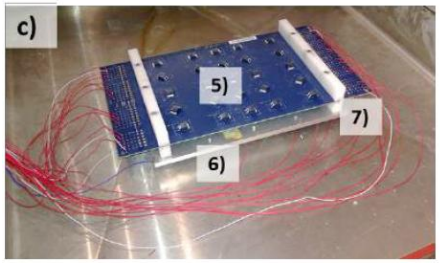
PCBA Reliability Research (HEVI3)

- PCBAs to be simulated and tested in thermal cycling and heavy vibration corresponding the operation environment of HHEV
- Extended to include power semiconductor aging, thermal interface deformation and heatsink efficiency, and vibration tolerant solutions
- Work is being done in co-operation with Aalto University
- Goal to shorten design time by reducing iteration rounds



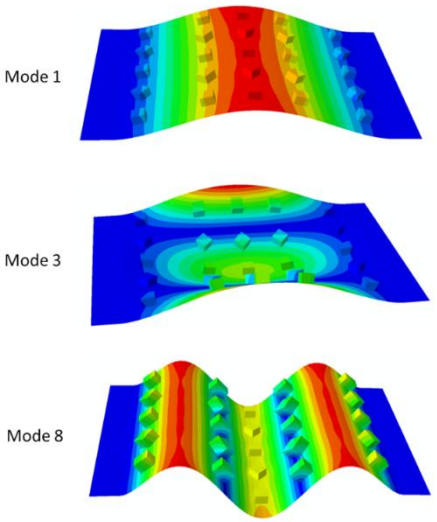






1) Thermal cycling chamber
2) Vibration exciter
3) Shaft extension
4) Control and monitoring system
5) Test board
6) Baseblate
7) Line clamps

Experimental tests

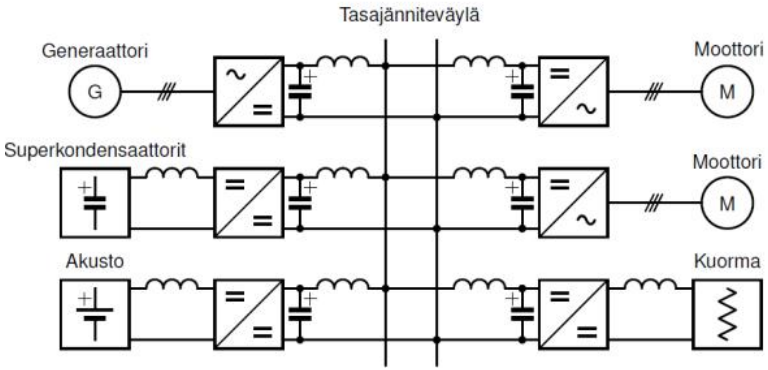


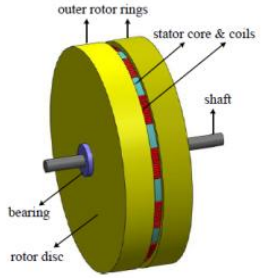
Mode	Effective Mass (g)	Frequency (Hz)
1	2.4E+02	94.1
2	6.2E-20	123.0
3	6.0E-02	237.4
4	1.3E-21	267.2
5	4.6E-18	314.0
6	7.5E-19	456.3
7	1.2E-23	483.0
8	4.8E+01	530.1
9	1.1E-20	586.9
10	2.1E-19	713.7

Abaqus simulation

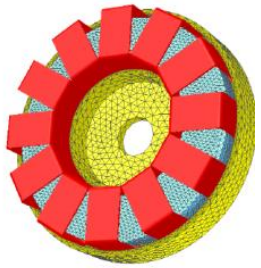
Motor Models and DC Link Analysis (ACDC)

- Sensorless grid converter equipped with an LCL filter, incl. optimization and control algorithms
- Compact grid converter for 4Q and low harmonic drives incl. control design, filter and DC bus capacitor optimizations and control algorithms
- Self-tuning generic AC motor drive incl. controller design and implementation
- Motor drive for HHEV applications incl. models, analysis and experimental verification
- New control method for low capacitance distributed converter system





(a) the entire structure of the assembled motor



(b) 3D auto-mesh: half of the FEA model

Next Generation HHEV Drive (HEI2)

- Project will develop and evaluate technology solutions allowing compact, reliable and cost-efficient inverter implementation for HHEV applications
- Optimized life time and reliability in cyclic load and temperature cycling
- Focus on deeper knowledge about technology limits (trade-off curves) on selected focus areas
- Novel converter concept including main circuit, control board and gate driver technology to be developed and evaluated in practice

Lifetime simulation models (Thuja)

- Project develops calculation methods, building blocks and product concepts for cyclic use in harsh environment
- Simulation models are used to estimate drive lifetime for customer specific mission profile
- In cooperation with VTT to develop a solution for chip temperature measurements with fiber optics

Publications

- ACDC
  - T. Tuovinen, “Model-based position estimation for synchronous reluctance motor drives,” doctoral dissertation, Aalto University, School of Electrical Engineering, Aug. 2014.
  - S. Saarakkala, “Identification and speed control design of resonating mechanical systems in electric drives,” doctoral dissertation, Aalto University, School of Electrical Engineering, Oct. 2014.
  - In addition 4 articles and 6 seminar papers, i.e.
    - Z. Qu, T. Tuovinen, and M. Hinkkanen, ``Minimizing losses of a synchronous reluctance motor drive taking into account core losses and magnetic saturation,'' in Proc. EPE 2014, Lappeenranta, Finland, Aug. 2014.
    - T. Tuovinen and M. Hinkkanen, ``Signal-injection-assisted full-order observer with parameter adaptation for synchronous reluctance motor drives,'' IEEE Trans. Ind. Applicat., vol. 50, no. 5, pp. 3392--3402, Sept./Oct. 2014.
- HEVI3
  - Lasse Skogström, Master thesis, A Novel Approach for Rapid Reliability Assessment of Power Electronics under Combined Vibration and Thermal Loading, 2014.

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