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Superconductors under dynamic electromagnetic conditions in electric machines

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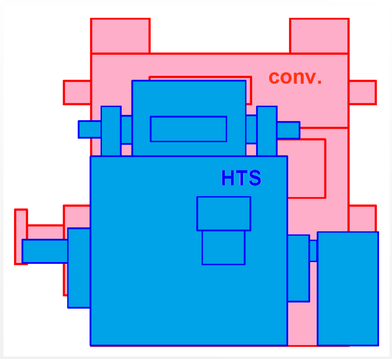
Aim
Research performance of superconductors in electromagnetic field of real-world superconducting machine under dynamic conditions

Research methods
Modelling, simulation and tests under dynamic electromagnetic conditions experienced in a maritime electric propulsion application



Superconductors
High Current Density & Low Losses (DC)

→

Synchronous Machine
Superconducting field (DC) winding

→

Application advantages
✓ Reduce volume and weight
✓ Improve efficiency
✓ Enhance dynamic stability

Siemens HTS1 Demonstrator

HTS machine relocated from Siemens Germany to QUT Banyo Pilot Plant Precinct (PPP) in Brisbane Australia

Siemens HTS1:
- synchronous machine
- 400 kW
- 400 V
- 50 Hz
- 1500 rpm
- technology demonstrator

Siemens HTS1 packed for Australia

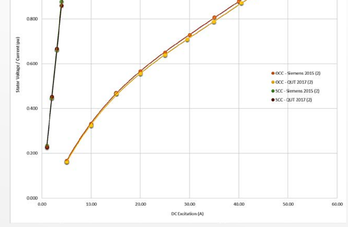
HTS1 rotor coils

HTS rotor pancake coil windings BSCCO-2223 tape

Results of Re-Testing Australia

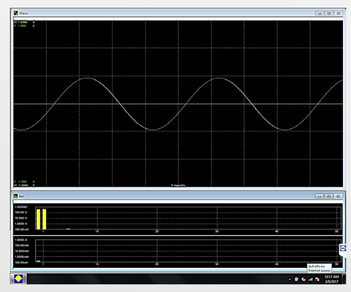
Initial tests completed 2017:
- Open circuit (OC) characteristic
- Short circuit (SC) characteristic
- Harmonic distortion

Results:
- Matched Siemens 2001/2015 within 1-2%



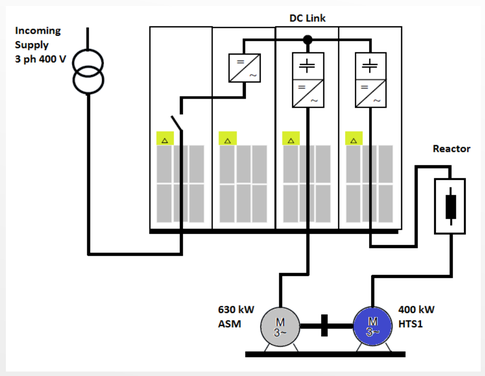
HTS1 characteristics – OC and SC tests

Next steps:
- Converter operation
- Load changes
- Full load tests
- Losses
- Rotor coil characterisation



Harmonic distortion - OC characteristic test

QUT Banyo PPP – HTS1 Test Environment



QUT Banyo – Drive & motor test environment

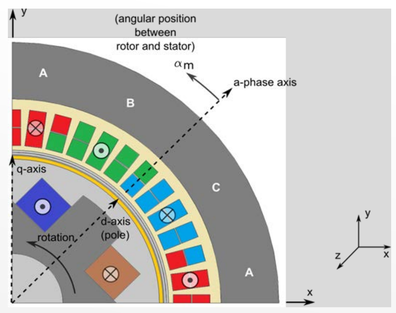
- HTS1 direct coupled to asynchronous motor (ASM)
- Sinamics S120 converter system with regeneration over DC link
- Operation as motor or generator with torque control

Experimental capability:
- Dynamic tests: load changes, overload, speed/torque changes
- Steady state tests: losses, efficiency, temperatures

QUT Banyo – HTS1 Motor Room

Modelling / Simulation

Verify fidelity of modelling / simulation with experimental results



Initial 2D Finite Element Analysis – HTS1 Machine

Multiscale approach

System – Matlab/Simulink

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Device – FEA (COMSOL)

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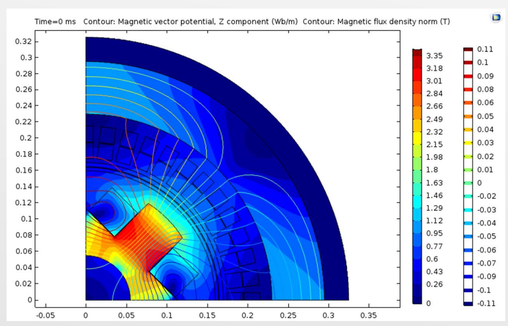
Superconductor – FEA (COMSOL)



The project is part of the Queensland University of Technology (QUT), Australian Defence Science and Technology Group (DST Group) and Siemens joint research agreement to advance the use of HTS technologies in maritime applications.