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Full Scale Conduction Cooled Superconducting Undulator Coils – Training, Stability and Thermal Behavior

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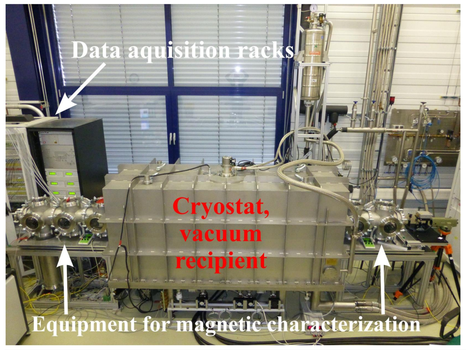
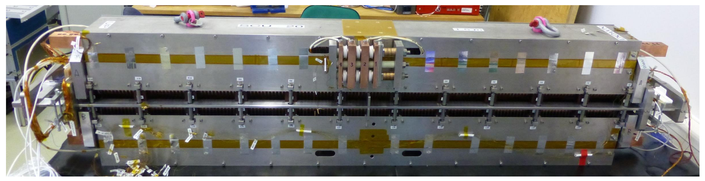
Introduction

Since several years the Institute for Beam Physics and Technology (IBPT) of the Karlsruhe Institute of Technology (KIT) is collaborating with its industrial partner Babcock Noell GmbH (BNG) on the development of superconducting undulators, both for the storage ring ANKA, the synchrotron radiation source run by the IBPT, and low emittance light sources. At present the collaboration is working on a SCU with 20mm period length (SCU20) foreseen to be installed at ANKA. The 1.5m long undulator coils have been tested in a conduction-cooled environment. This contribution describes the training, stability and the thermal behavior of the coils.

Overview CASPER II setup and SCU20 coils



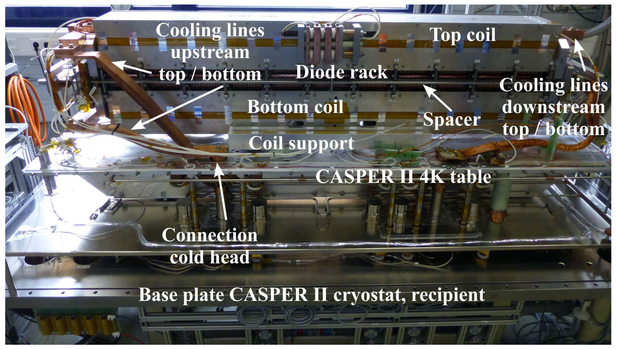


SCU20 main coils (full scale 1.5m)

- Dimension 4K area: 2m x 0.5m x 0.5m
- Not restricted to coil shape
- 8 current leads (500A) powerable individually
- Local field measurements with Hall sensors and field integral determination via stretched wire

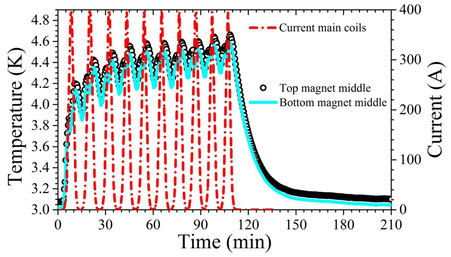
For further details see:
A. Grau et al., IEEE Trans. App. Supercond., vol. 22, no. 3, 9001504

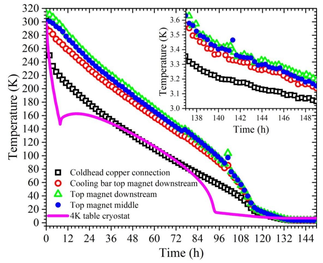
Parameter	Unit	Value
Period length	mm	20
Number of full periods	-	74.5
Magnetic gap	mm	8
Operating current	A	395
Field on axis at 8 mm gap	T	1.187
Ramp time to operating current	s	<300
Temperature	K	4.2

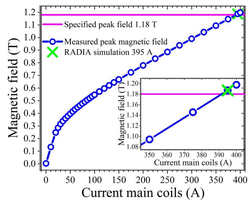


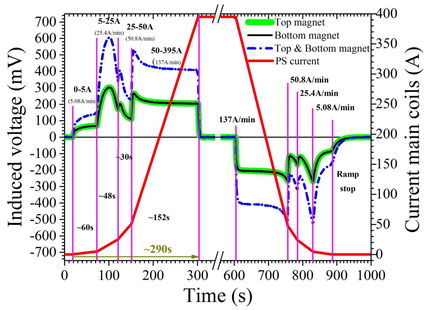
Thermal behavior, ramping, peak magnetic field and stability

- Cooldown time ~6 days.
- Cooling power 1.5W per magnet.
- Minimum coil temperature 3.1K.
- Temperature gradient along cooling line 0.1K. (coldhead to coil middle, stable state)
- Temperature rise during 10 times ramping 1.6K.



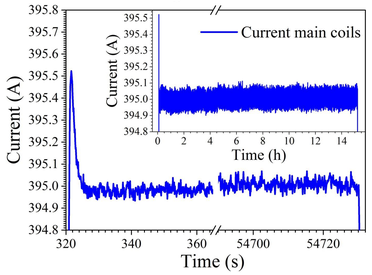




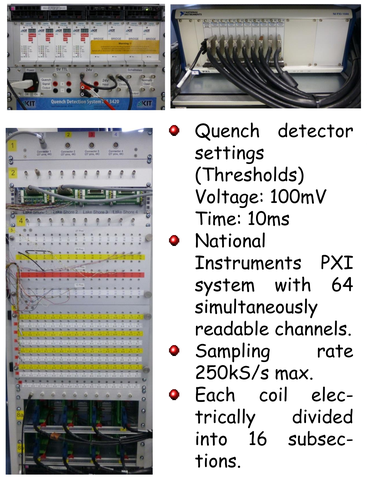


- Peak magnetic field 1.187T reached for 395A.
- Ramping time <300s. (0A – 395A)
- 4 different ramping steps (5.08A/min – 137A/min)
- Temperature rise during one ramp 800mK.
- Initial temp. at full current restored after 45 min.
- Max. ramp rate used 211A/min.
- Max. induced voltage 620mV

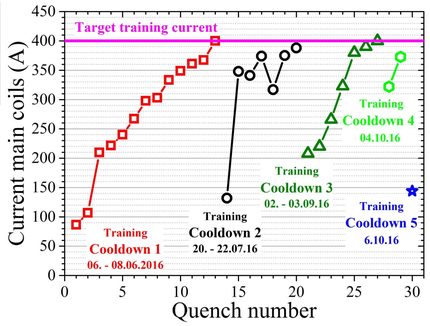
- Overshoot after ramp stop (~0.1%, negligible)
- Stablilized after 5s.
- Long term stability for 15h far below 0.1A.
- Stability results confirmed (7 days) during final acceptance test out of the ring.



Quench diagnostics and training



- Quench detector settings (Thresholds) Voltage: 100mV Time: 10ms
- National Instruments PXI system with 64 simultaneously readable channels.
- Sampling rate 250kS/s max.
- Each coil electrically divided into 16 subsections.



- Target training current 400A.
- Overall number of quenches 30 (5 cycles).
- Number of quenches reduced after each thermal cycle.
- Max. ramp rate used 211A/min (larger than needed for ramping in 300s)

Summary

The 1.5m long SCU20 main coils have been tested in a horizontal, conduction-cooled environment. A peak magnetic field of 1.187T at 8mm gap is reached for 395A, Training to operating current has been performed and the cooling concept has been proven. The coils are installed in the final cryostat and the site acceptance test out of the ANKA storage ring is being performed.