Test in strong background field of a modular element of a REBCO 1MJ high energy density SMES

J Ciceron, A. Badel*, P. Tixador, R. Pasquet, F. Forest****

Univ. Grenoble Alpes, Institut NEEL – G2Elab, F-38042 Grenoble, France
***CNRS, G2Elab - Institut NEEL, F-38042 Grenoble, France**
****SigmaPhi, 56000 Vannes, France**

Contact: jeremie.ciceron@g2elab.grenoble-inp.fr

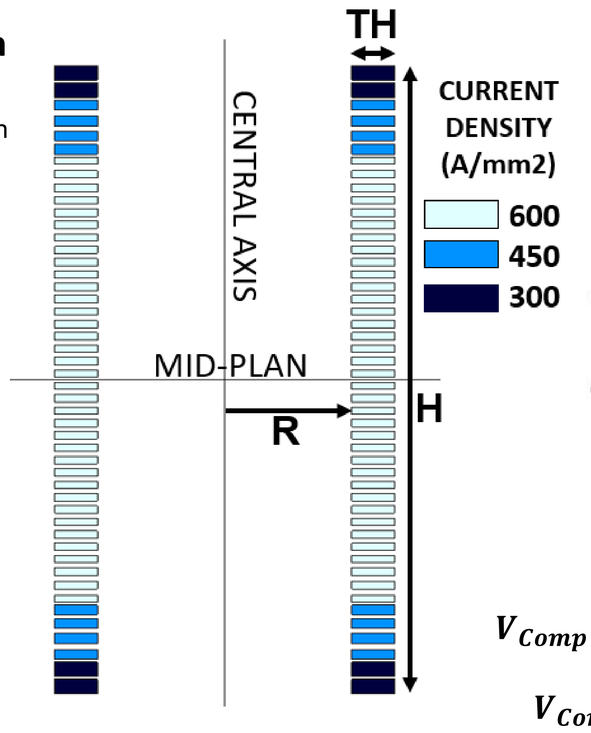
The BOSSE project has the objective to build a SMES with a specific energy of 20kJ/kg (actual world record=13kJ/kg) in the MegaJoule range thanks to REBCO tapes in liquid helium (4.2K). To reach such a high specific energy, high levels of stress and current density are required. A full-size prototype pancake has been tested in background B field up to 8T in Grenoble LNCMI.

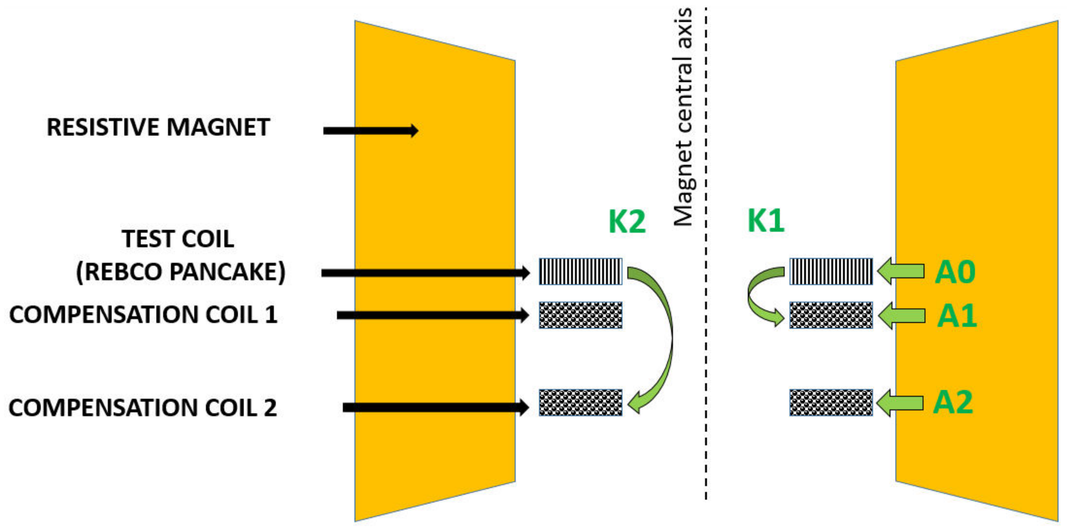
In order to have a precise measurement of the dissipative voltage in the superconductor, we need to compensate both the inductive voltage of the pancake and the electromagnetic noise due to the resistive magnet. 2 compensation coils with different couplings to the tested pancake have been used. A combination of their voltages, analogically implemented, is compensating the pancake voltage except for dissipative voltage.

Characteristics and cross-section view of the BOSSE solenoide

6 mm wide tapes are used in central part then 8 mm and 12 mm at extremities

Quantity	Unit	Value
Energy	kJ	942
Operating current	A	486
Current margin	%	57
Longitudinal field	T	13.1
Transverse field	T	5.5
Hoop stress	Mpa	484
Inductance	H	8
Specific energy	kJ/kg	21
Total diameter	mm	240
Total height	mm	508
Coil's thickness	mm	30
Number of turns	mm	222





Principle diagram of the experimental set-up

$$\alpha_1 = \frac{A_1}{A_0}$$

$$\alpha_2 = \frac{A_2}{A_0}$$

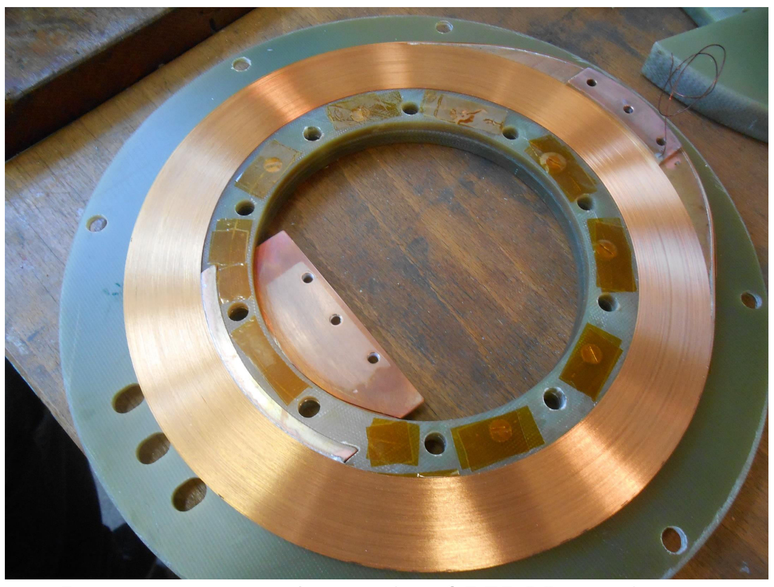
$$\alpha_1 \approx \alpha_2 \approx 1$$

$$k_1 \approx 0.8$$

$$k_2 \approx 0.3$$

$$V_{Comp} = \frac{(\alpha_2 - k_2)V_1 - (\alpha_1 - k_1)V_2}{\alpha_2 k_1 - \alpha_1 k_2}$$

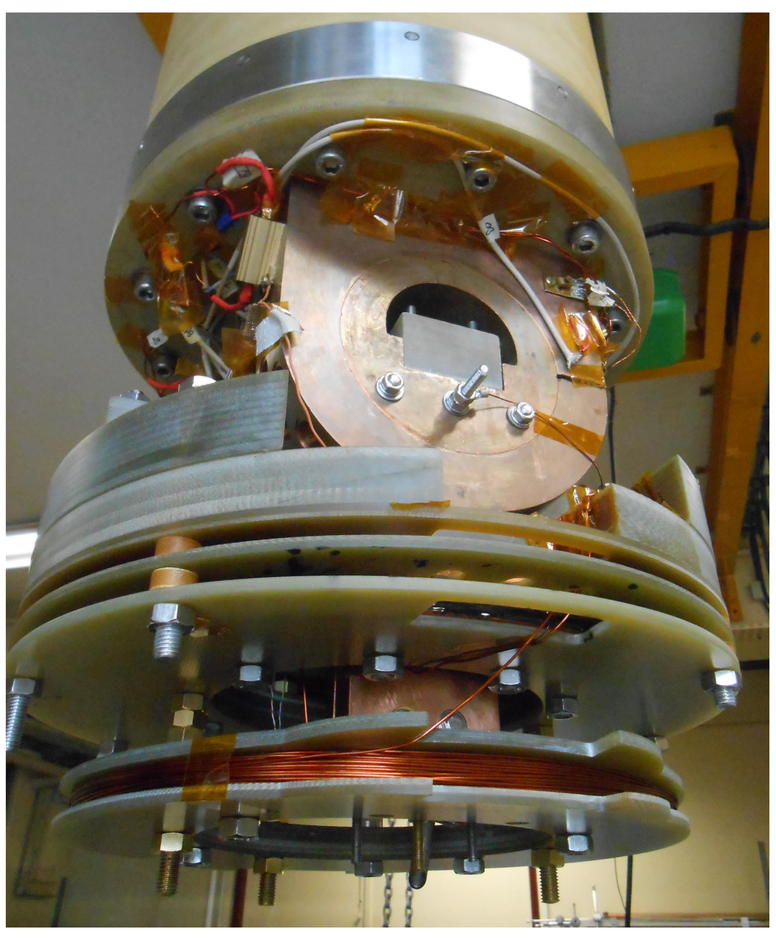
$$V_{Comp} \approx 1.4 \times V_1 - 0.4 \times V_2$$



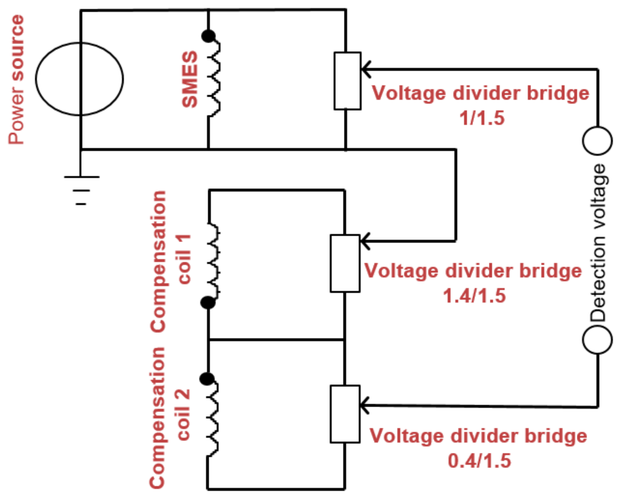
Prototype pancake made of REBCO conductor

Bmax self-field=2.8T for I=500A

The conductor is 6mm wide and 135µm thick (60µm of Hastelloy® C-276, 35µm of buffer, superconductor, silver and copper, 40µm of polyimide insulation)



The prototype pancake with the compensation coils mounted on the probe.

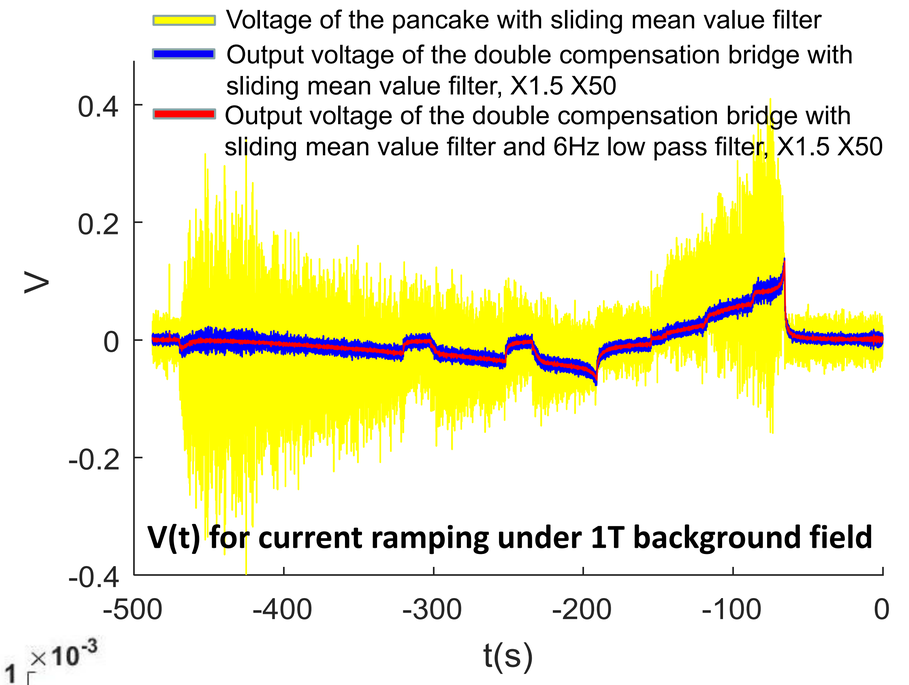


Principle electrical diagram of the double coil compensation

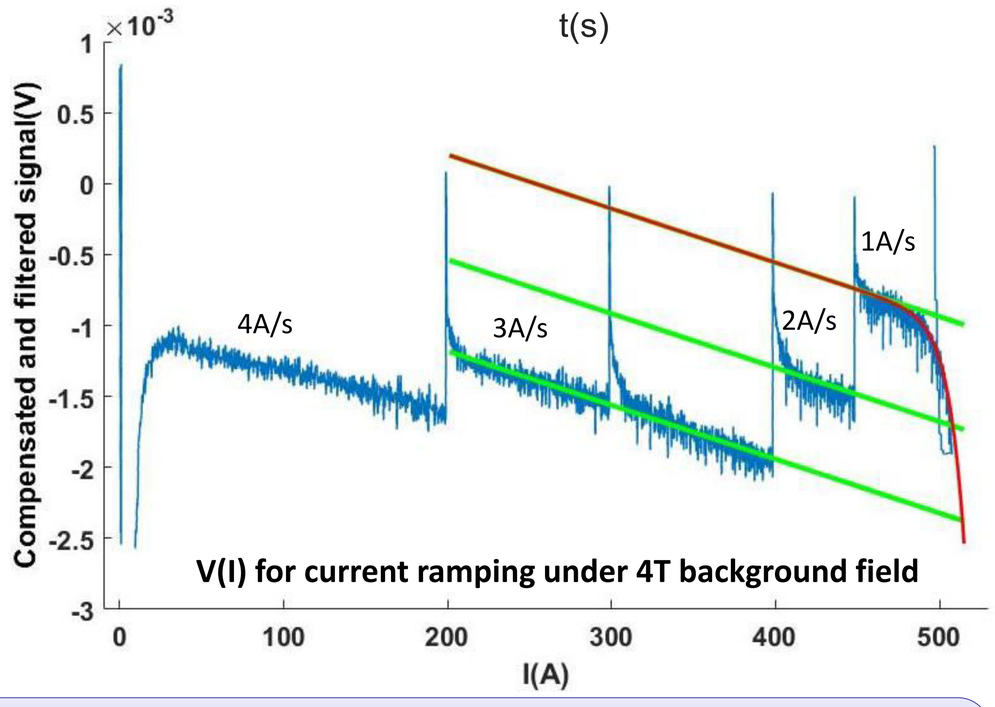
B_{EXT}(T)	I(A)	Stress Rint (Mpa)	Stress Rext (Mpa)
0	480		
1	486		
8	282	300	290
6	341	300	240
5	379	300	200
4	424	300	155
3	476	300	91
8	321	350	322
6	386	350	262
4	473	350	160
6	428	400	280
0	560		
4	504	382	162
2	516		
6	469	450	297
7	430	450	345
7	433	453	347

List of the performed current rampings

The critical current has been reached 4 times, which lead to active protection of the pancake. The pancake finally endured a mechanical failure at an extremity of the external contact.



V(t) for current ramping under 1T background field



V(I) for current ramping under 4T background field

B (T)	I_trig (A)	J_{Eng}/J_{Bare} (A/mm²)	n	Dissipative voltage (uV)
1	486	600/852	60	336
0	560	691/984	143	418
4	504	622/884	55	911
2	516	637/905	40	376
7	433	534/759	≥700	Saturation

Comparison of dissipative events

- Pancake made of a **139m long insulated REBCO conductor**.
- **Protected** at an **engineering current density of 691A/mm²** (i.e **984A/mm²** in the bare conductor without insulation) without background field
- Protected at 600A/mm² (852A/mm² in the bare conductor) under 1T noisy background field.

This work is founded by the DGA in project BOSSE

The authors would like to thank X. Chaud and A-J. Vialle for their participation to this work