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Coated Conductors for Applications 2016
September 11-14, 2016, Aspen, Colorado, USA

CCA2016 Aspen, Colorado
Coated Conductors for Applications September 11 - 14, 2016

Update on the Developments of Coated Conductor High Field Magnets in Japan

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Muto and Iijima (Fujikura)

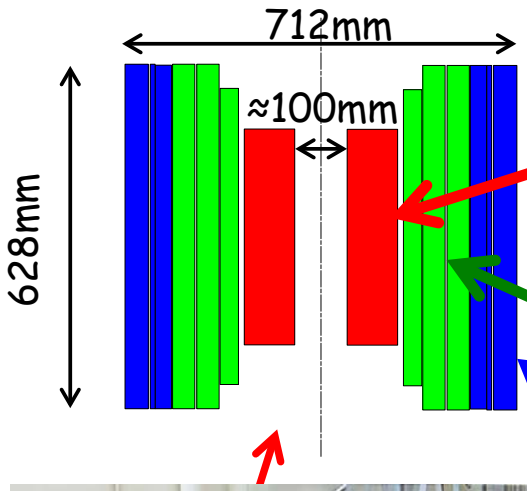
HFLSM Sendai

Recent CC High Field Magnets in Japan

- 25T cryogen-free superconducting magnet (Tohoku Univ.): MEXT
  - 24T(ϕ52mm RT), quench
- 3T-MRI (Mitsubishi): AMED
  - MRI system, Get MRI images at 3 T (ϕ300mm RT)
- 9.5 T-MRI (Toshiba): AMED
  - 9.52T (ϕ40mm cold)
- Accelerator for medical treatment (Toshiba, Kyoto-U, KEK): AMED
  - 3D winding
- 800 MHz(18.8T) and 1.3GHz(30.5 T) –NMR model (RIKEN, NIMS, JASTEC): JST
  - 27.6T (ϕ33mm cold), 27.7 T quench
- 10T Flywheel magnet (Furukawa, JR): NEDO
  - 3.4T(ϕ120mm RT), 300kW operation
- Scribed CC coil (Fujikura)
- Superconducting joint (Furukawa): AMED

  ☙Persistent current operation of 100 A (0.3T) at 20K(Blue: practical system)

25T Cryogen-free Superconducting Magnet (25T-CSM)



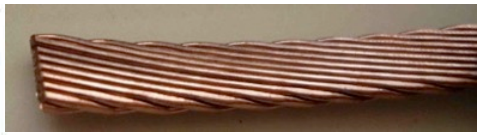
56 GdBCO single pancakes
(11.5T@144A, 407MPa) /
38 Bi2223 double pancakes
(11.5T@203A, 323MPa)

SEI type H-Nx

4LPo1D-01

3 CuNb/Nb_3Sn Rutherford solenoid
(14T@854A, 251MPa)

3 NbTi Rutherford solenoid



Cooling system 3LPo2B-04

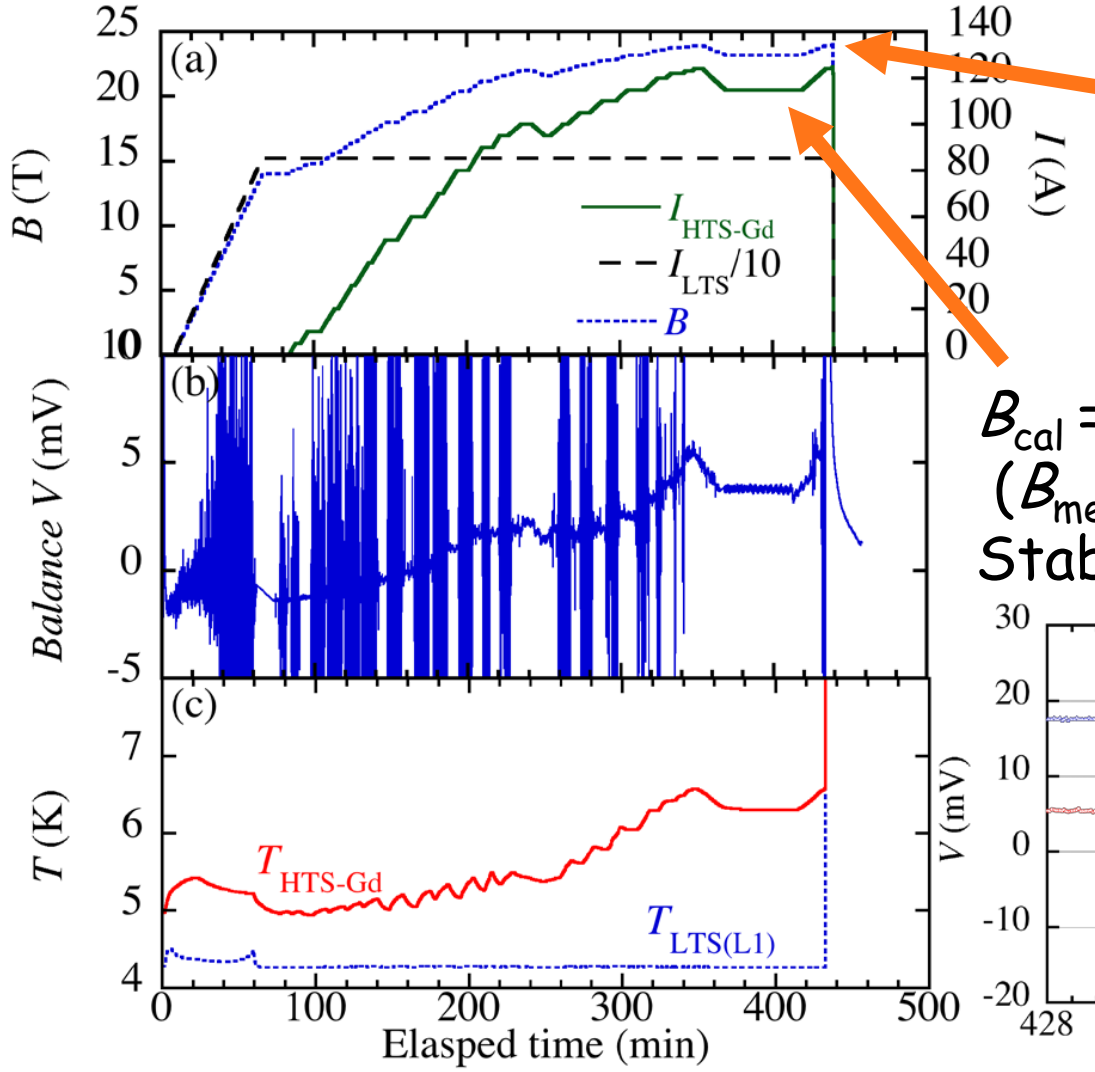
Conduction cooling using He circulation

Shield: 2 x 1 stg GM cryocooler

HTS: 2 x 4K-GM cryocooler
(3W@4.2K, 10W@8K)

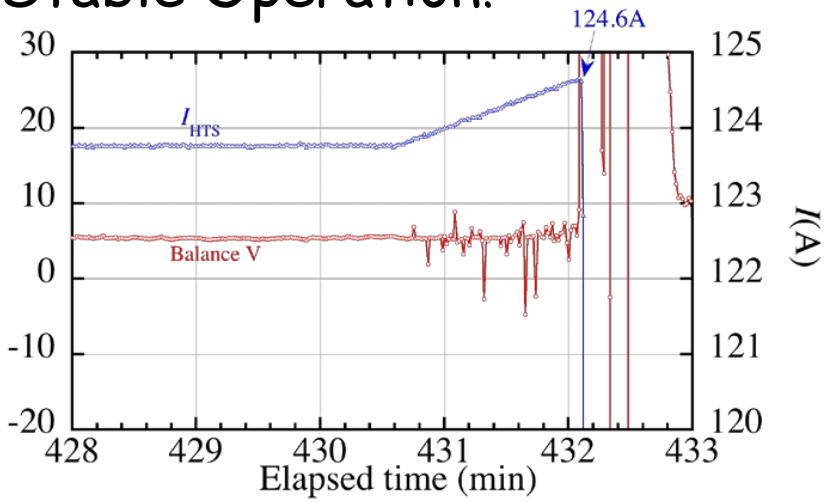
LTS: 2 x GM/JT cryocooler (8.6W@4.3K)

25 T-CSM combination test

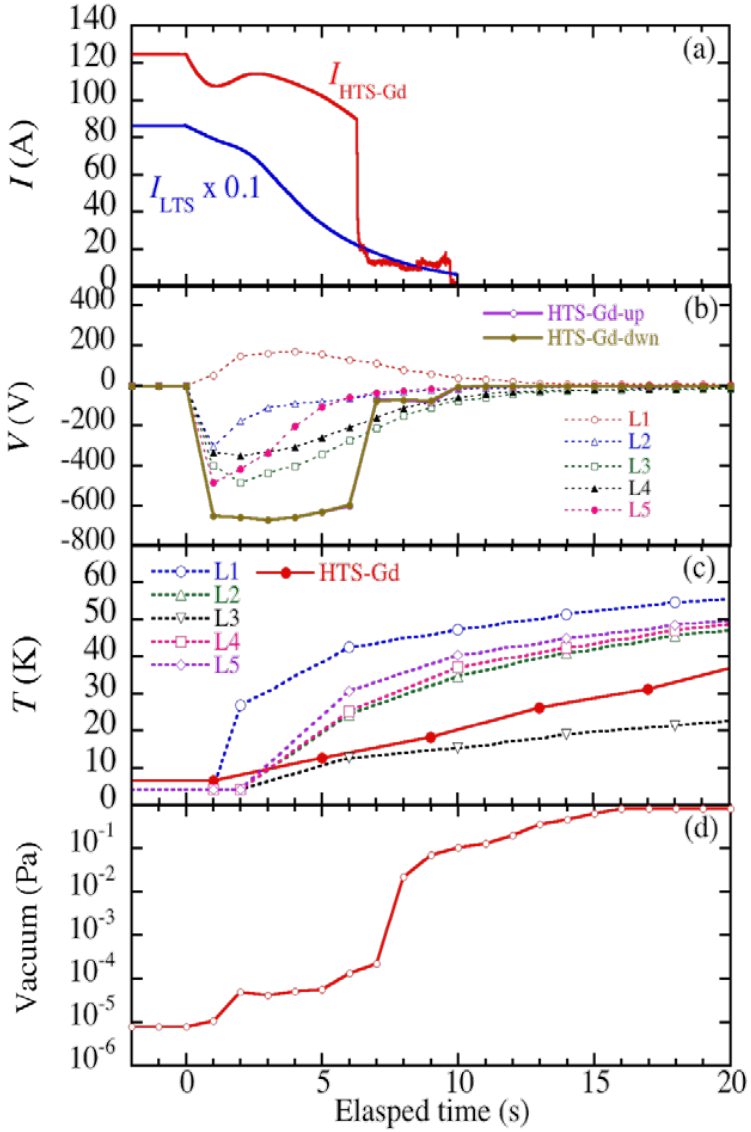


B_{cal} = 24.01 T (124.6A)
(B_{meas} = 23.61 T)
Quench point

B_{cal} = 23.94 T (110A)
(B_{meas} = 23.55 T)
Stable Operation!



V, T, Vacuum profiles after quench



- Quench was detected due to the thermal runaway of HTS coil.
- 650 V x 2 at HTS coil was generated after the quench.
- Drop of I_{HTS} at 6 s past after the quench protection mode.
- Vacuum was deteriorated rapidly at the same time.
- The quench protection seems to work well al least for 6 s after the quench?

REBCO Magnet for 300 kW Flywheel

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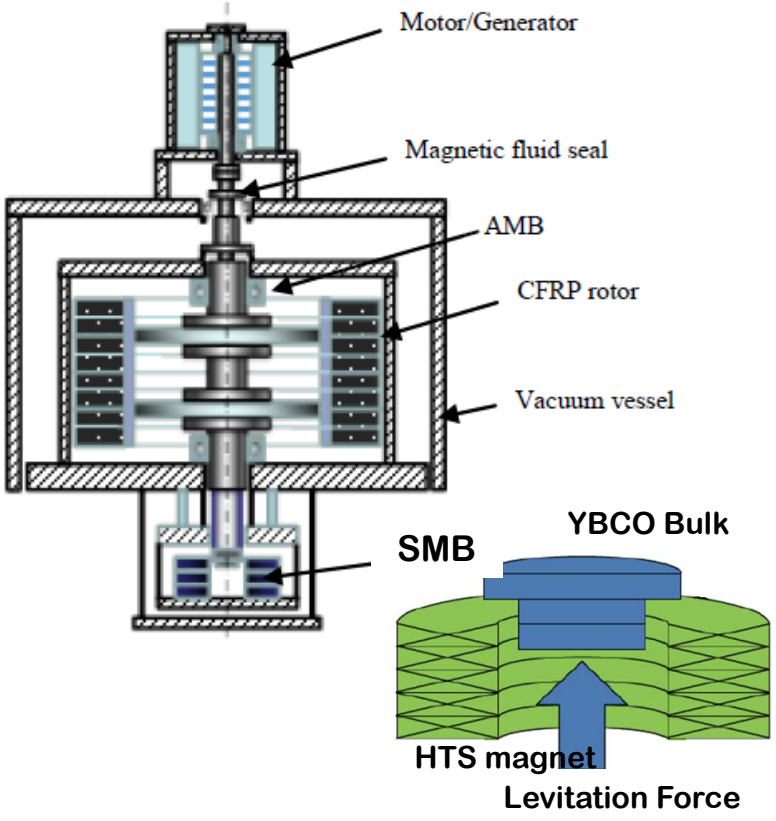
Flywheel energy storage system (FESS) used superconducting magnetic bearing (SMB) was developed in the NEDO PJ in 2015



HTS magnetic bearing

300 kW FESS prototype

Item	Specification
Input/Output capacity	300kW
Voltage	DC600 kV
Storage Energy	100 kWh at 6000 rpm
CFRP rotor dimension	2 m
Rotor weight	3.2 ton
Bearing; Thrust	SMB (REBCO)
Radial	AMB

Reference: S. Mukoyama et al., 'Development of Superconducting Magnetic Bearing for 300 kW Flywheel Energy Storage System' ASC 2016 in Denver USA, 4LOr3B-02

Superconducting magnetic bearing

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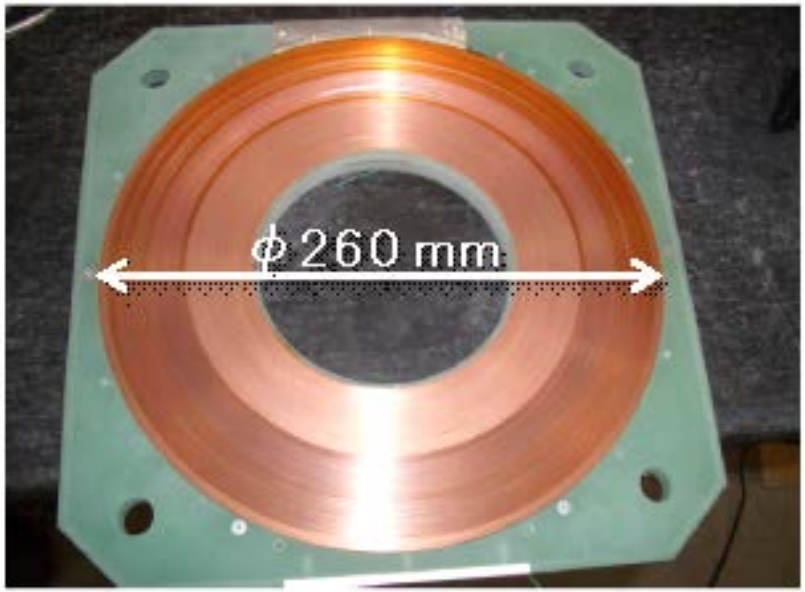
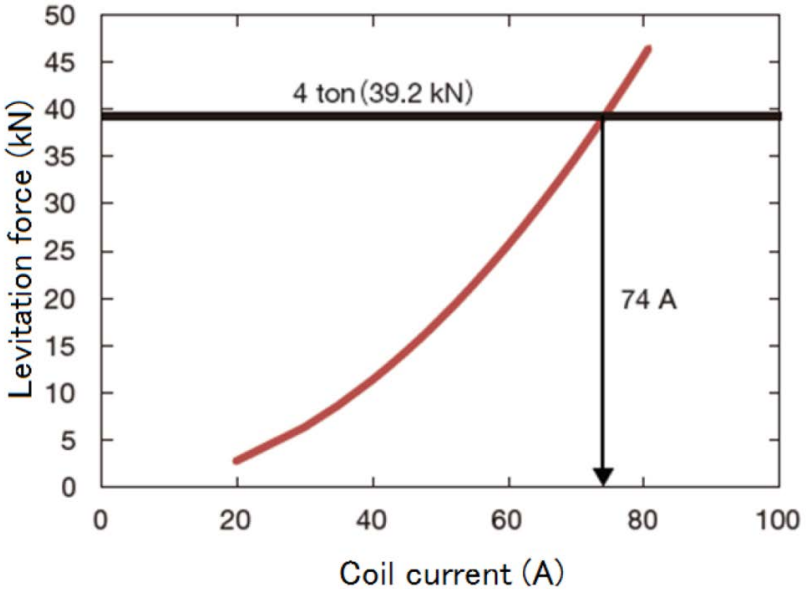
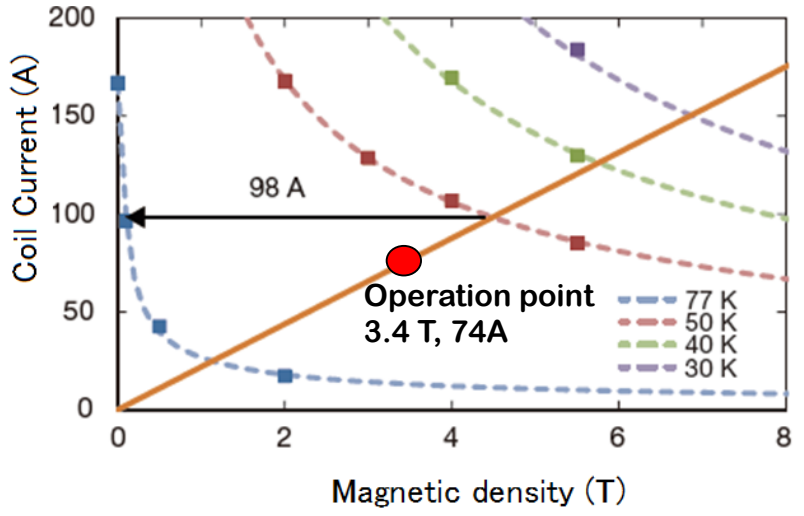


Item	Specification
Wire	REBCO (Superpower)
Width of tape	6 mm
Thickness of tape	0.1 mm
Inner diameter	120 mm
Outer diameter	260 mm
Height of the coil	17.6 mm

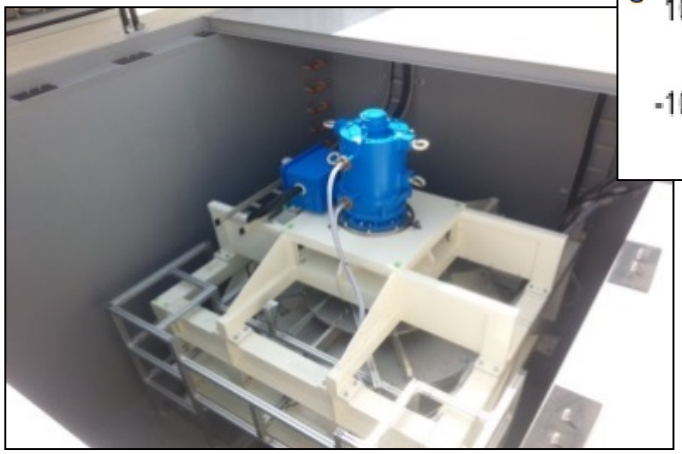


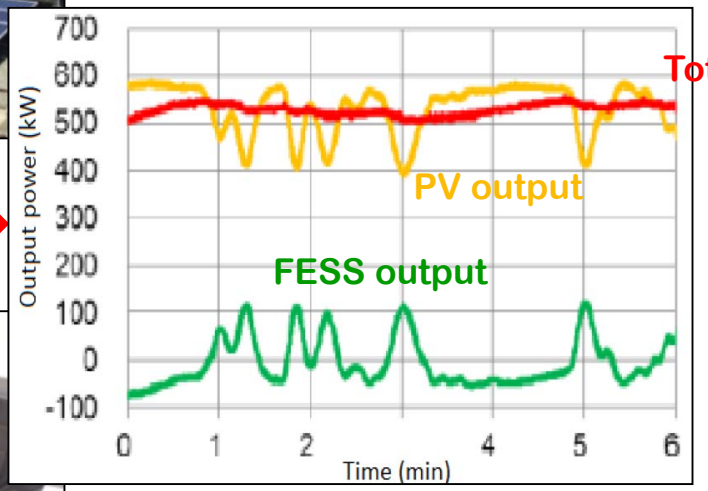


Field test in the mega-solar plant

FURUKAWA ELECTRIC

Electrical power





FESS was demonstrated in real network by connecting to a 1MW photovoltaic plant.

1 MW PV plant in Mt. Komekura facilitated by Yamanashi prefecture office for the demonstration

Load test

- **Weight load : 4,000 kg**
- **Current loading test : over 3,000 hours**
- **Thermal cycle : over 20 times**

Technical Issues of RE123 Coated conductor

1) Degradation due to delamination
   - Polyimide electric-coating (Riken)
   - Wax impregnation (Furukawa, Riken)
   - Teflon coated polyimide (Toshiba, Mitsubishi)
   - Dry winding
2) Quench protection against hotspot
   - Dump resistor (most cases)
   - Quench heater (NHMFL, USA)
3) Reduction of magnetic field quality due to shielding (magnetization) current
   - Prediction and rearrange
   - Magnetic field monotor
   - Scribe (Fujikura)

Summary

Item	Purpose	Bmax	Jcon	Inner dia.	Top	Winding	Delamination	Shealding current	Protection	Comments
Unit		T	A/mm2	mm	K					
RIKEN	Proto-type NMR	27.6 (28)	396	40	4.2	Layer	Wax impregnation	Overshoot	Dump resistor	Quench at 27.7T
Tohoku U.	User magnet	24.0 (24.5)	222	90	7	SP	Teflon coated Polyimide	Field monitor	Dump resistor & Large margin	Quench at 24T
Mitsubishi	MRI	4.5	212	320	20	DP	Teflon coated Polyimide	Overshoot	Dump resistor	MRI Image
Furukawa	300kW FW	3.4	130	120	30-50	DP	Wax impregnation	-	Dump resistor	Yoroi
Toshiba	R&D for MRI	13.5	689	40	(20)	SP	Teflon coated Polyimide	-	-	B-distribution at 130A(6.2T)

- ✓ A few prototype applications using CC were developed successfully.
- ✓ Critical issues of CC for magnets are being improved recently. But some high field magnet developments were failed due to the local degradation of the CC. Those may be originated from the thin layered tape structures. This problem is a critical issue to be clarified.