BNL Quarterly Report on Superconducting Magnetic Energy Storage Prepared for ARPA-E Through CRADA No. BNL-C-11-01 with ABB Inc.

Q9 Progress Report and Status of Milestones

Superconducting Magnet Division
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January 11, 2013

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January 10, 2013

Summary

Progress towards Q11 milestone	Actual performance
Task 16. B. Q11: Full scale SMES coil tested. Target field 24 T.	BNL Magnet Division did not have any Q9 milestone. We are working for the next milestone which is in Q11. The stated goal is testing full scale SMES coil with a target field of 24 T. Notes and clarification in milestone chart states, "The tests will generate 80 % field. This test will be conducted without the power converter, and only with a power supply at BNL". In addition we are making progress on advanced quench protection system for reducing voltage during quench. This requires dividing the coil and electronics in several segments.

Major Activities:

Advanced Quench Protection System
Significant progress has been made in the development of the quench protection electronics. A mechanical switch that can go in parallel with an IGBT and could significantly reduce losses has been tested. The software and hardware are being developed and tested with a series of HTS coils. The number of input channels for detecting a quench signal has more than doubled over what was previously used in testing the 10 T coil with twelve pancakes utilized as a part of meeting the Q6 milestone.

Fabrication of pancake coils for outer layer
After the construction of all single pancake coils, the focus has now shifted to the outer layer. 1.7 MJ design requires 16 single outer pancakes. Seven of them have been fabricated so far. Fabrication was interrupted mid-December because of a number of concerns related to the HTS conductor that were observed during the winding of a couple of outer pancakes.

SMES outer coil 77 K test setup
Progress is made in the building fixture for testing of the outer double pancakes at 77 K. Parts received from central shops and those fabricated at SMD are being further machined and assembled. The set-up is now nearly completed and the first double pancake coil should be tested in January.

Q9 Progress Report

Advanced Quench protection and energy extraction systems

Quench protection of coils is a major issue in HTS magnets. This is primarily because quench propagation velocities are several orders of magntitude lower than other superconductivity magnets. We have developed an approach that significantly advances state of art. It relies on (a) first an early detection of the onset of quench despite the large noise and inductive voltage and (b) fast energy extraction (or discharge) from the coil after the quench. Fast discharge, however, creates high voltages that must be addressed in the design. We are working on techniques to reduce the maximum value of these voltages.

First we are dividing the coil into several parts (most likely three). This reduces the inductance and hence the maximum voltage generated. This requires the use of multiple power supplies. We are upgrading our existing power supplies and control systems so that they can accommodate the high currents voltages.

As a concept we are also investigating the use of IGBT switches as shown in Fig. 1. Early results are promosing.

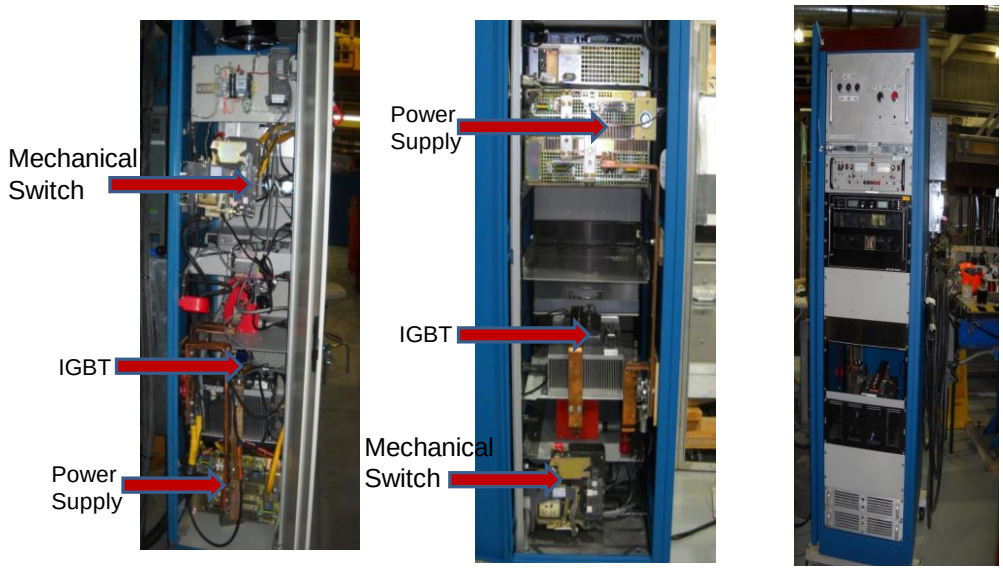

Fig. 1: Views of two power supplies and the energy extraction system. Location of individual component is indicated

We have made further enhancements in the quench detection electronics. The software and hardware are being developed and tested with a series of HTS coils. The number of input channels for detecting a quench signal have more than doubled over what was previously used in testing the 10 T coil with twelve pancakes utilized as a part of meeting the Q6 milestone. Components of the advanced quench detection system (which now consists of two racks) are shown in Fig 2. The basic construction of this was initially carried out for and funded by another project. The system is being upgraded for SMES system to allow higher stand-off voltage and to meet more demanding requirements associated with higher stored energy in the SMES coil.

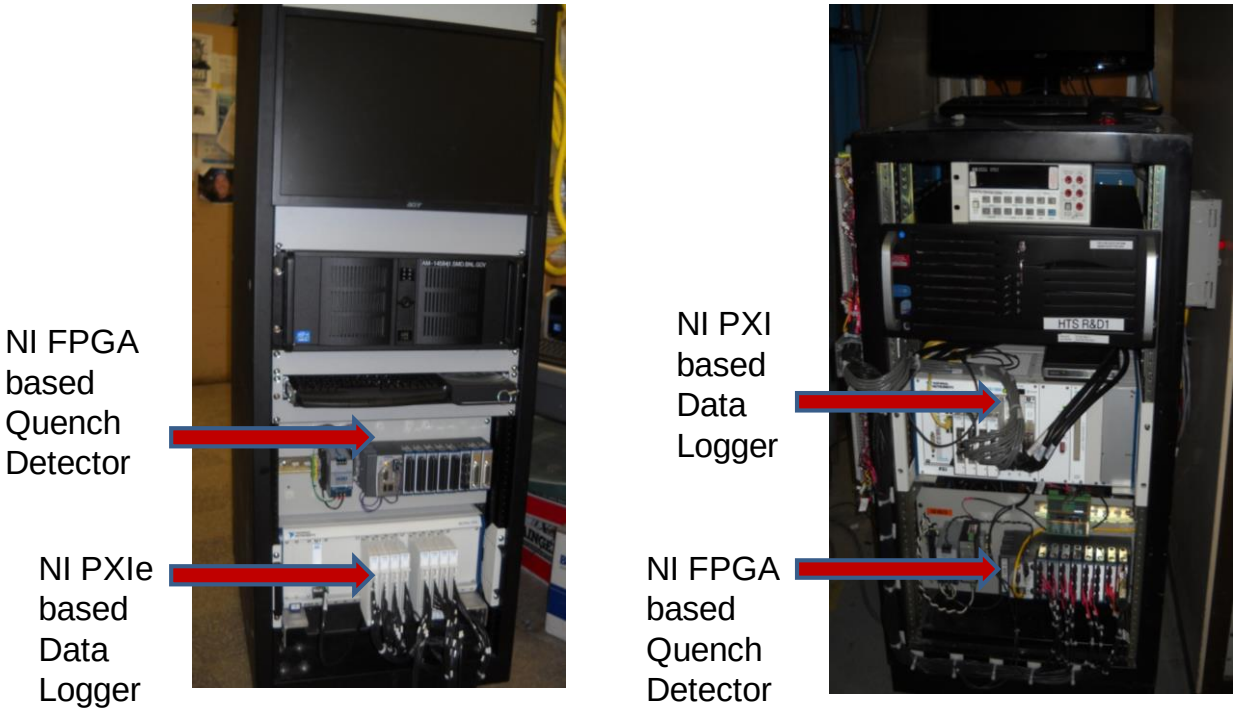

Fig. 2: Control and quench detection system.

Fabrication and Testing of Pancake Coils for Outer Layers

The 1.7 MJ design consists of 28 single pancakes (14 double pacakes) in the inner layer and 16 single pancakes (8 double pancakes) in the outer layer. We have completed fabricating all 28 single pancake coils (last one fabricated this quarter) for the inner and 7 single pancake coils for the outer coil (five of them fabricated this quarter). We have also completed testing all 14 double pancake coils for inner layer at 77 K (last one tested this quarter). These are important quality assurance checks before the coils are integrated in the SMES system. There is a significant amount of instrumentation with a large number of voltage taps installed within the coil to ensure that there are no local defects in the conducor, splice or winding. One such double pancake is shown in Fig. 3 (right). In addition, we have also tested one single pancake outer coil. A test fixture to carry out limited tests for a single pancake is shown in Fig. 3 (left).

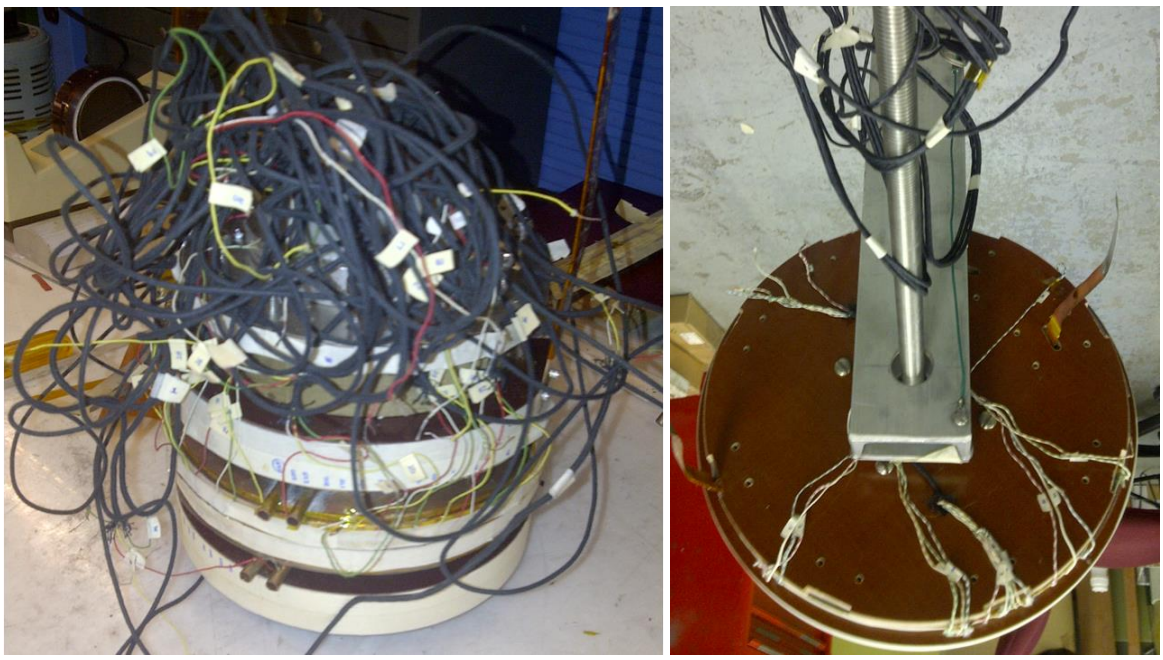

Fig. 3: A double pancake coil for inner layer just after the 77 K test (left) and a simpler single pancake coil test set-up for limited test (right).

Fabrication of Fixture for Testing Double Pancake Coils for Outer Layers

A Fixture for testing the outer coil is being prepared. Parts received from BNL central shops and those fabricated at SMD are being further machined and assembled. Additional parts, as needed, are being fabricated. The fixture should be ready in the middle of January 2013, and the first test of the outer double pancakes is expected by the end of January 2013. A few parts are shown in Fig. 4.

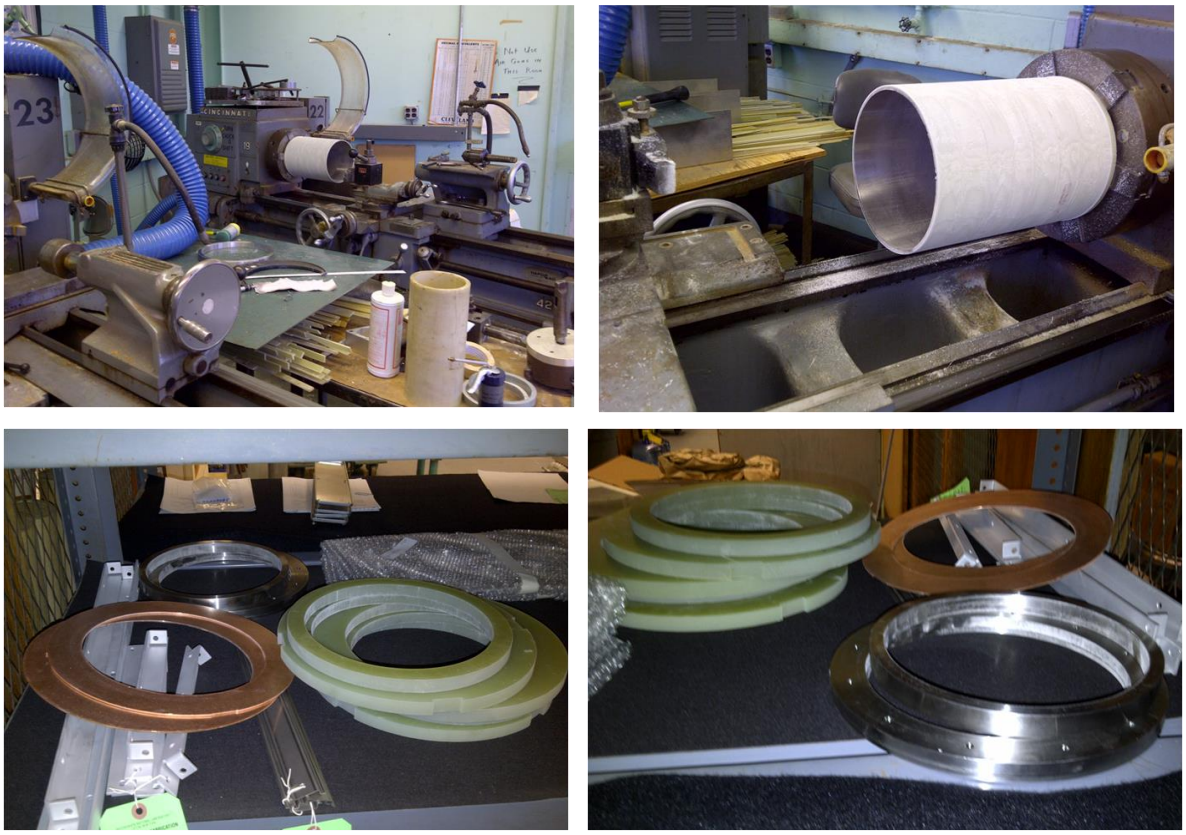

Fig. 4: Parts for making fixture for testing outer double pancake coils at 77 K.