DC Measurements of NST Superconducting Tapes in the Presence of an Applied Magnetic Field

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Abstract

Measurement of NST Superconducting Tapes in the Presence of an Applied Magnetic Field. MARCUS YOUNG (University of Tennessee, Knoxville, TN. 37996) J. A. Demko (Oak Ridge National Laboratory, Oak Ridge, TN 37831).

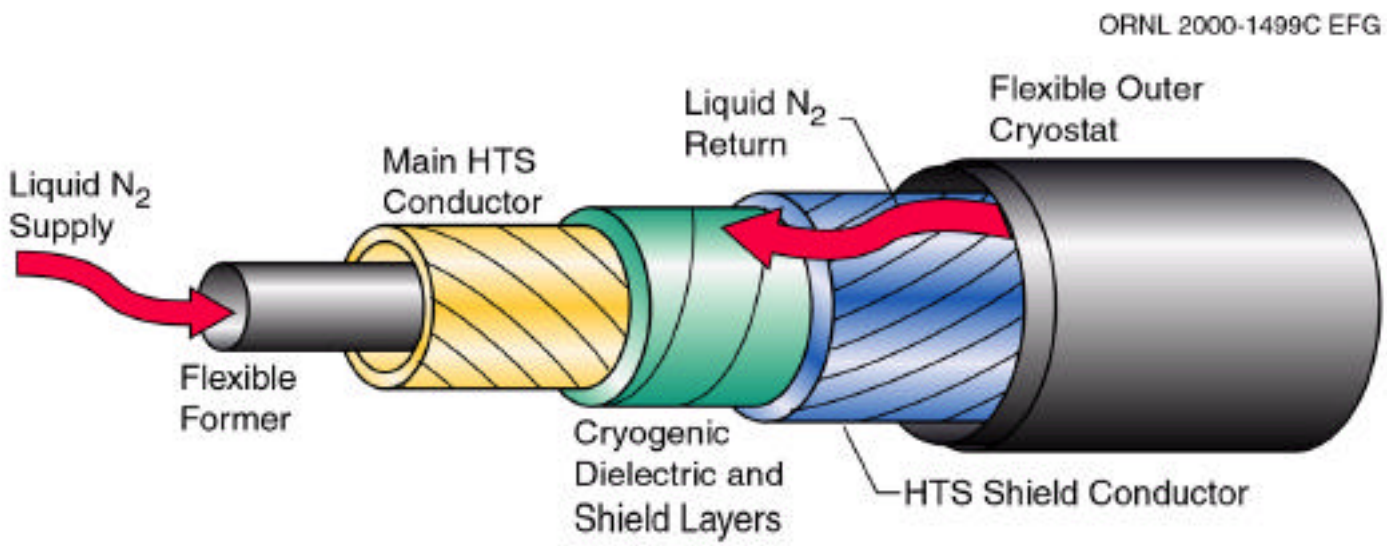
The ability of high temperature superconductors (HTS) to maintain superconducting properties in the presence of a magnetic field must be known for their use in present and future HTS applications. Although the critical current differs according to the manufacturing process, the critical current of HTS tapes generally degrade as the applied magnetic field increases. NST (Nordic Superconductor Technologies) superconducting tapes were constructed from a silver-metal alloy consisting of BSCCO-2223. V-I measurements of these tapes were performed at the Oak Ridge National Laboratory at 77K under DC operating conditions while in the presence of an applied magnetic field. A superconducting cryogenically- cooled magnet was used to achieve the desired magnetic field, and the orientation of the magnetic field was set by the position of the superconducting tape within magnet. V-I curves were taken for both the perpendicular and parallel magnetic field orientations. The critical currents where then calculated and plotted versus magnetic field.

Introduction

As the population continues to rise, and the need for electrical power increases, the ability to meet the demands of today's power consumer becomes increasingly difficult. Today, power grids are overcrowded, aging, and suffer inefficiencies resulting from early twentieth century technology. In an attempt to keep power consumption economical, new ways to produce, transport, and improve electricity are currently underway. One of the improvements considered is the use of high temperature superconductors.

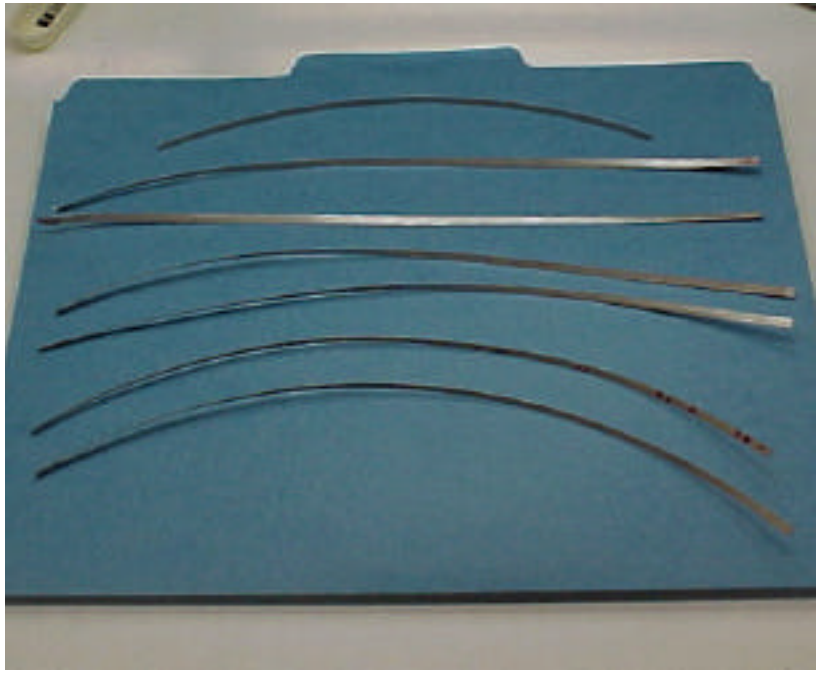
HTS Power Cables

Of the many applications that HTS technology is predicted to improve, power transmission is one of the most anticipated. Presently, Southwire Company in Carrollton, Georgia is using three 30 meter HTS power cables to supply their production facility.

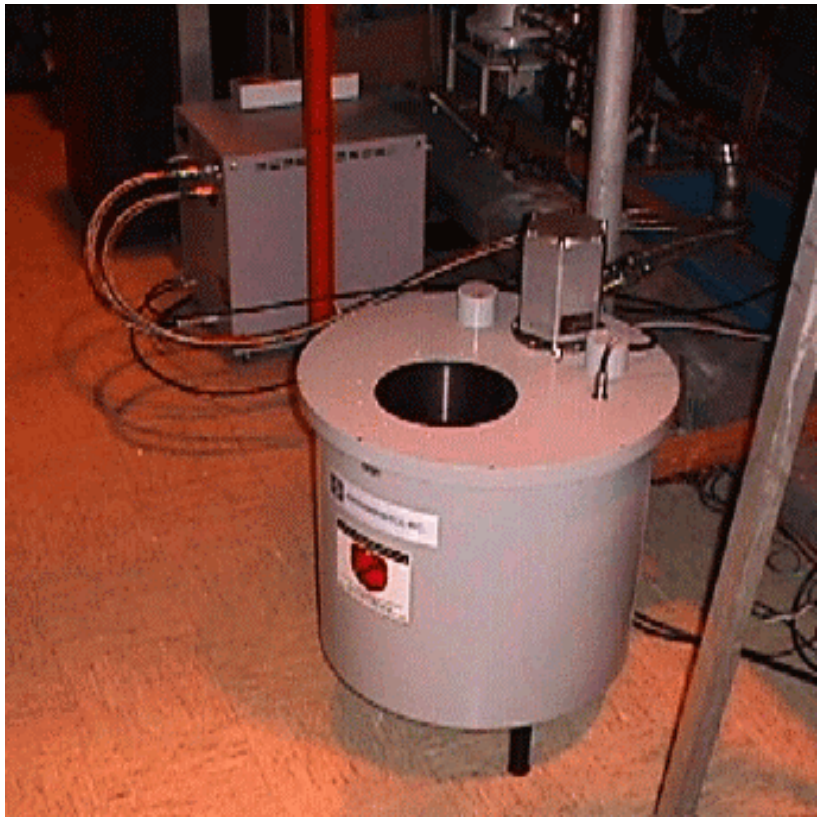


HTS Tapes

HTS power cables are composed of multiple layers of helically wound HTS tapes. The properties of these tapes are a function of material composition and the manufacturing process. One property of interest is the critical current (the current that produces a voltage gradient of 1μV/cm) in the presence of an external magnetic field at liquid nitrogen temperatures.



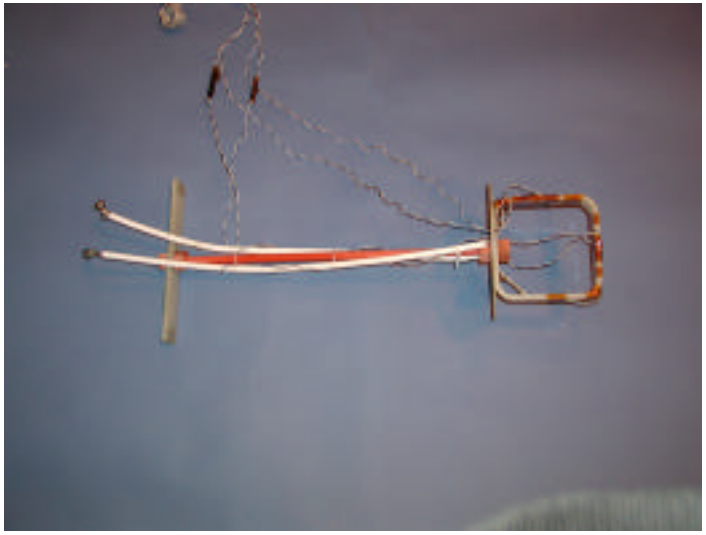
Nordic Superconductor Technologies HTS tapes were tested



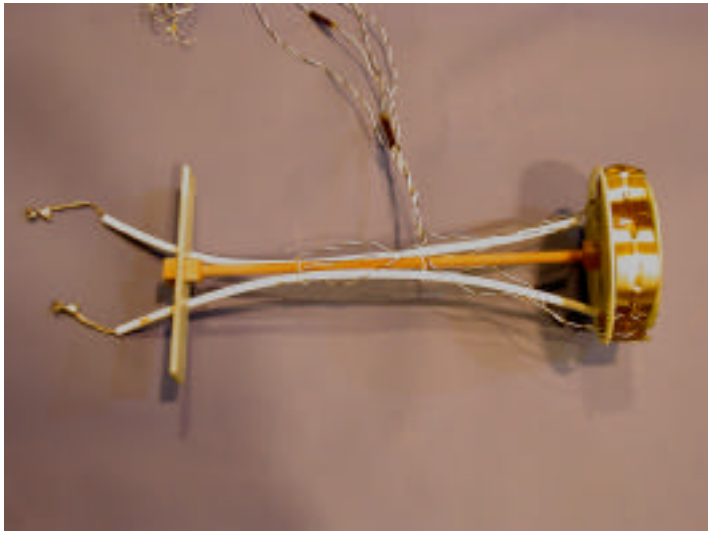
6 Tesla, 22-cm warm bore magnet that is cryocooled to 3-4 K with pulse tube cryocooler.

- BSSCO-2223 in an Ag alloy sheath
- Dimensions: 4.0 x 0.2mm
- Subjected to externally applied perpendicular and parallel magnetic fields in a cryogenically-cooled superconducting magnet.

Sample Holder



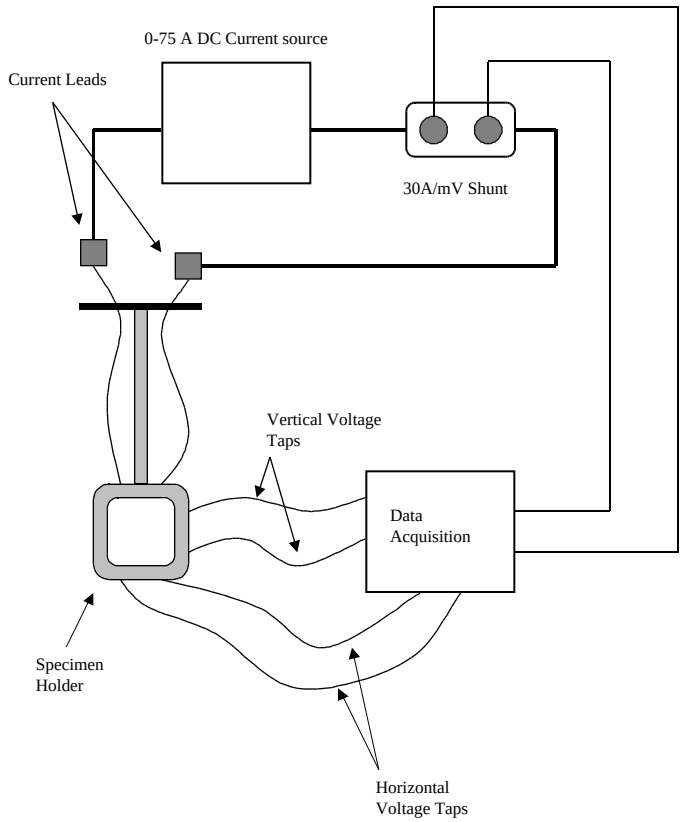
Perpendicular arrangement

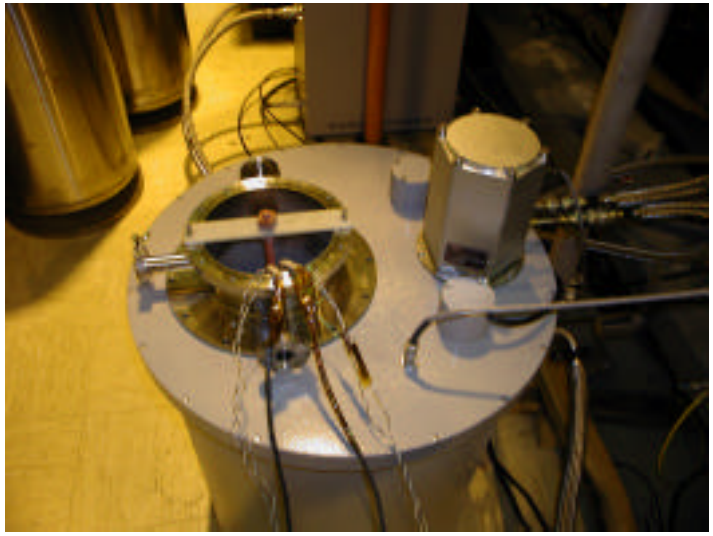


Parallel arrangement

In order to place the NST tape in the proper magnetic field orientation, a non-magnetic sample holder was constructed from G-10. The sample holder was designed to withstand liquid nitrogen temperatures and to protect the NST tape from mechanical stress.

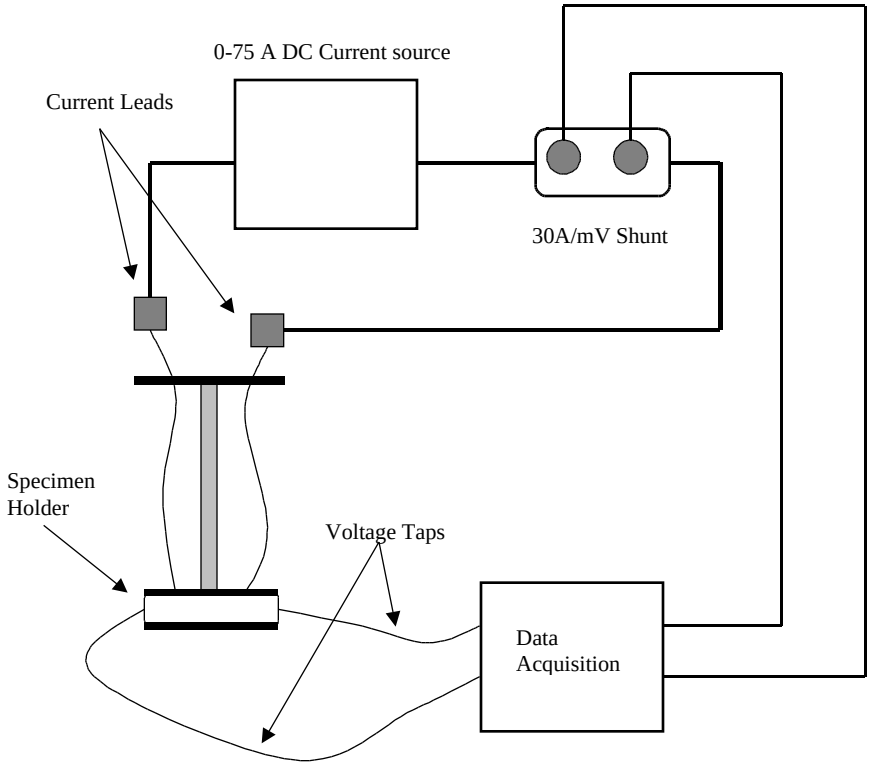
Perpendicular Field

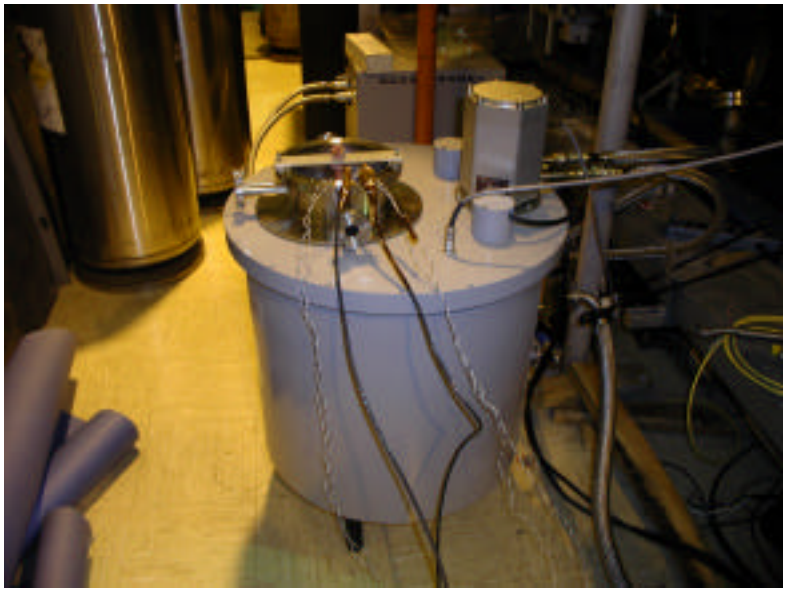




The NST tape was secured to the sample holder as shown in the above schematic. The NST tape secured in holder was then placed in the magnet as shown in the picture.

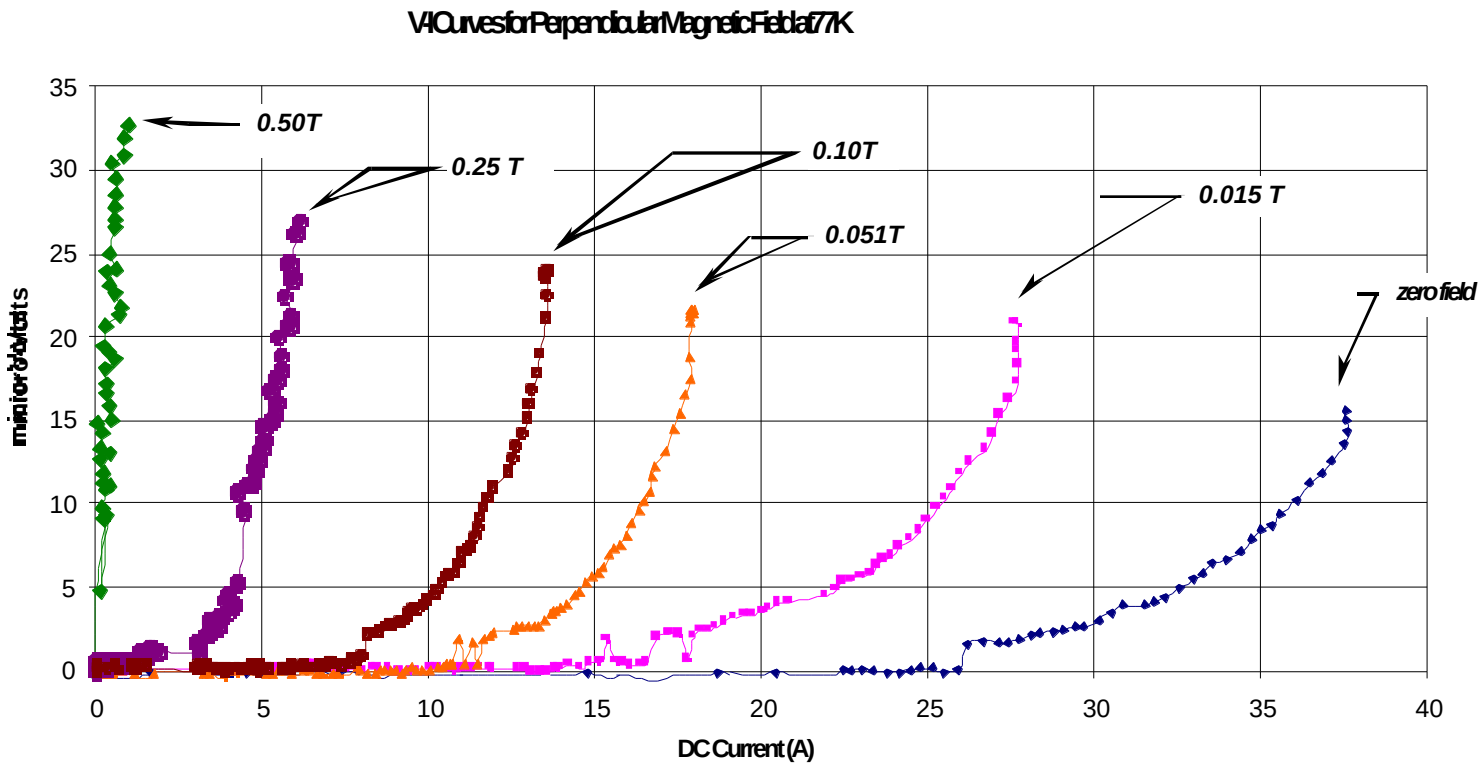
Parallel Field





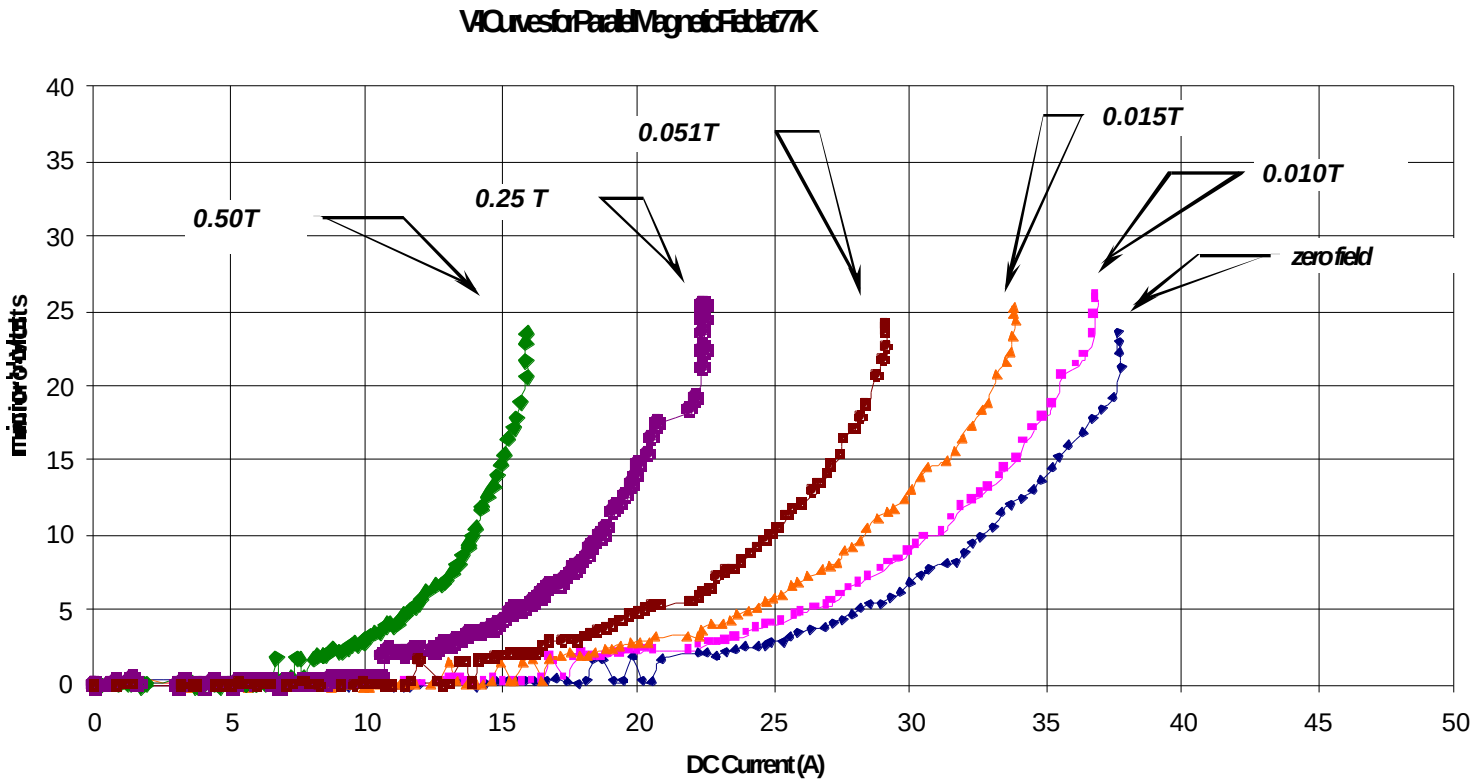
The NST tape was secured to the sample holder as shown in the above schematic (Notice that the square ring which holds the NST tape has been turned to a horizontal orientation). The NST tape secured in holder was then placed in the magnet as shown in the picture

Perpendicular Field Results



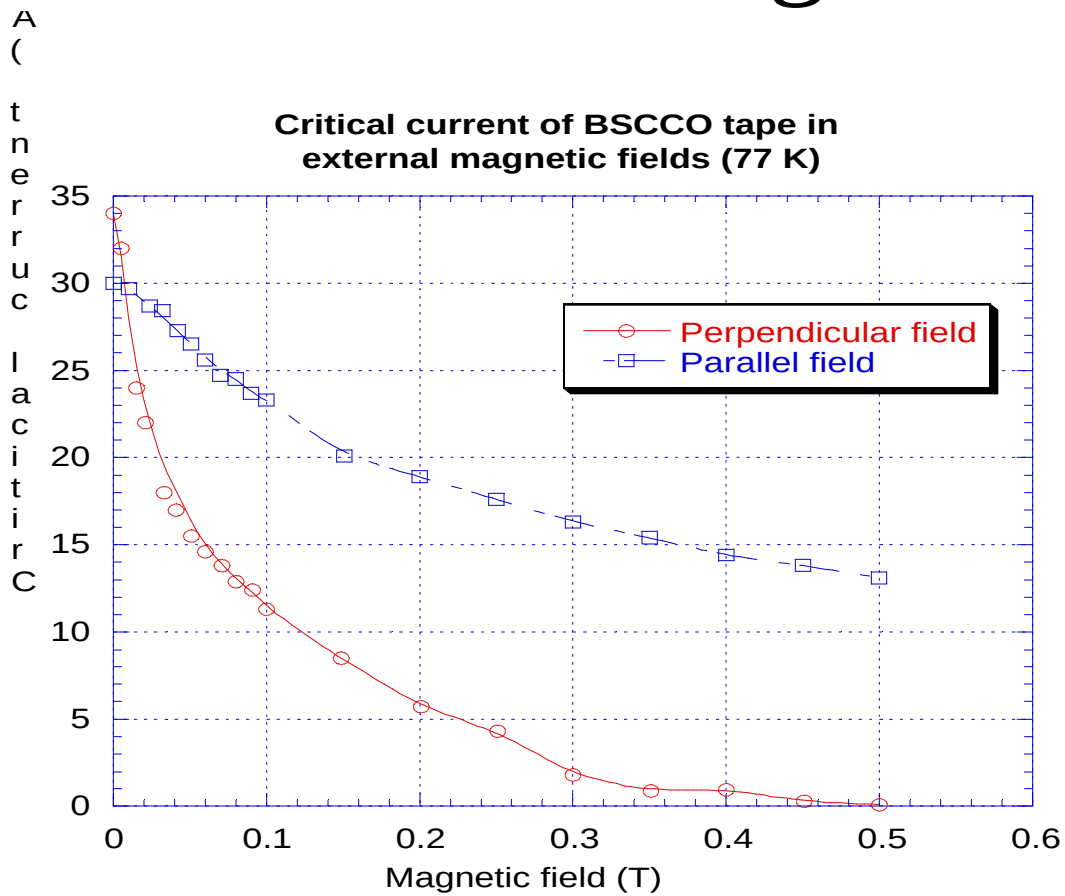
An external perpendicular magnetic field was applied to the NST tape and its magnitude was incremented from 0T to 0.5T. V-I curves were generated from each field value.

Parallel Field Results



An external parallel magnetic field was applied to the NST tape and its magnitude was incremented from 0T to 0.5T. V-I curves were generated from each field value.

Critical Current Degradation



The critical current, determined from the measured V-I characteristics, depends on the external magnetic field applied to the sample.

Conclusions

- The difference between the zero field current for the perpendicular and parallel fields is due to thermal cycling. Two main effects of thermal cycling are:
  - Thermal contraction upon cool-down, expansion on warm-up of the silver matrix and HTS fibers, which produce mechanical stresses that may degrade tape performance.
  - Liquid nitrogen can seep into the tape through micro cracks in the silver. Upon warm-up, the liquid expands into gas and can produce bubbling of the silver.

- Critical current degradation appears to occur more rapidly due to the perpendicular field than the parallel field. However, the externally applied magnetic field regardless of orientation, causes significant critical current degradation within the NST HTS tapes.

Summary

- Electric power demand continues to increase and existing power grids are deteriorating with age.
- HTS power cables are expected to be an important part of the solution to the power problems.
- These HTS power cables are composed of many individual HTS tapes.
- The characteristics of HTS tapes are a function of material composition and the manufacturing process.
- DC measurements were performed on NST tapes for both perpendicular and parallel magnetic field orientations at 77K.
- Critical currents vary between both field orientations at zero field as a result of thermal cycling.
- External magnetic field causes significant critical current degradation with the perpendicular field having the greatest effect.

Acknowledgements

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