## Scientific Article

# Fault Current Limiter based on High Temperature Superconductors

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**High Temperature Superconductivity (HTS) is being explored for current limiter application because of its strong non-linear *E(j)* characteristics. ABB has recently developed a 6.4 MVA Superconducting Fault Current Limiter (SCFCL).**

## Introduction

Main benefit can be realised if the short circuit currents can be reduced in electrical power systems. SCFCL is ideal for such application, i.e. negligible impedance in normal operation and passive limitation of fault current through the superconducting to the normal conducting transition.

Presently the largest HTS prototypes utilise Bi-2212 ($Bi_2Sr_2CaCu_2O_{8+\delta}$) bulk material [1, 2]. Other materials being developed include YBCO films and Bi-2223 wires.

## *E(j,T)* characteristic of HTS

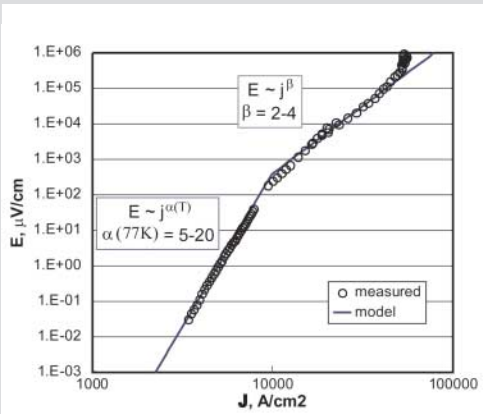


Fig. 1: Measured and parameterised *E(j)* characteristic of Bi-2212 at 77K.

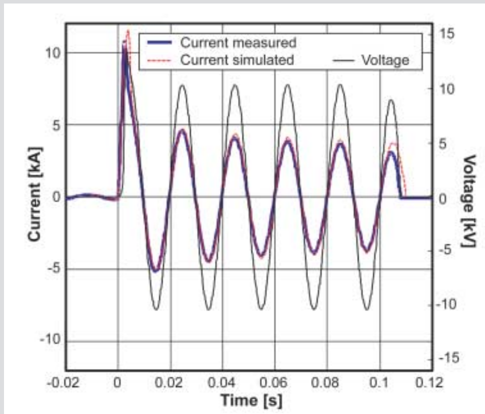


*Fig. 2:* Short-circuit test of 6.4 MVA SCFCL based on Bi-2212.

As the most critical parameter, the *E(j)* characteristic of Bi-2212 is shown in Fig. 1, where two regions with the high and low power laws correspond to the superconducting and the flux flow states, respectively. Not shown here is the normal conducting state, which appears at higher current. Such behaviour can be parametrised (Fig. 1), forming the basis for simulation.
During a fault, the current is effectively limited by the fast increase of resistance with increasing current, i.e. *j*, which also leads to warming-up and even quench of HTS.

## Conductor based on Bi-2212

For resistive type SCFCL long length HTS conductor is directly connected in series to the line. Such conductor should exhibit (1) low ac-losses (2) high mechanical strength to withstand transient stresses and (3) thermal stability to avoid "hot-spots". ABB has developed a low AC-losses composite consisting of meandered Bi-2212 plates, steel as electric bypass, and fibre reinforced plastic as reinforcement, which has led to the 6.4 MVA SCFCL demonstrator.

## Test and simulation of 6.4 MVA device

A resistive demonstrator rated for 800 $A_{rms}$ has been successfully tested to 8.3 $kV_{rms}$ (Fig. 2), corresponding to a rated power of 6.4 MVA. The single phase device limited a prospective fault current of 20 $kA_{rms}$ to 2.7 $kA_{rms}$ after 100 ms, in agreement with simulation.

## Application outlook

SCFCL is particularly suited for applications with high prospective fault current. For example, SCFCL can (a) bring added value to existing grids, where the prospective fault current $I_{pf}$ has reached the design value of the breakers, e.g. grid coupling [2] and (b) enable design of novel power system with high short circuit power. It is believed that niche application of SCFCL will precede large scale application which will arrive with the realisation of both low cost conductor and cost effective reliable cooling.

### Research Group

The global technology group ABB employes around 8'100 people in Switzerland. It serves manufacturing, process and consumer industries as well as utilities.

ABB Switzerland focuses on the development and sale of IT-assisted automation systems and solutions as well as high and medium voltage equipment.

One of the group's eight research centers is located in Switzerland in Baden-Daettwil. It employs some 165 people from over 20 countries. Two-thirds of them are scientists.

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### References

[1] W. Paul and M. Chen, IEEE Spectrum, (May 1998), 49.
[2] W. Paul, M. Chen, M. Lakner, D. Braun, W. Lanz, Physica C 354(2001), 27.