Impact of Stabilizer on the DC Carrying Coated Conductors under Perpendicular AC Magnetic Fields

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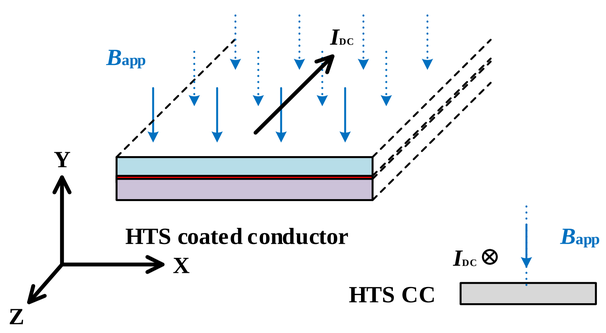
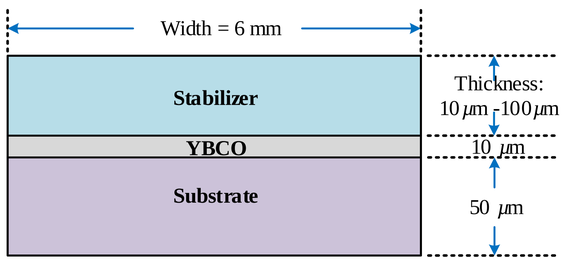
Introduction

When a type-II high Tc superconductor carrying a direct current is subjected to a perpendicular AC magnetic field, a direct current (DC) voltage will appear. This phenomenon is dynamic resistance effect. Generally, the high temperature superconducting (HTS) coated conductor has a stabilizer layer. This paper analyses the impact of stabilizer on the DC electrical field, stability, and loss. We built a thermal coupled numerical model and used it to analyse the impact of stabilizer. Our work reveals the impact of stabilizer on the dynamic resistance, dc voltage, and power loss. This work will help design AC magnetic field controlled persistent current switches (PCSs) and evaluate its power loss.

Numerical Modelling





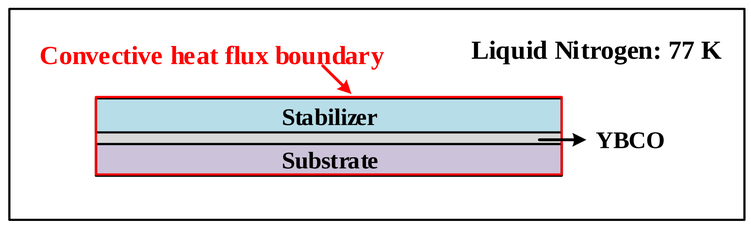
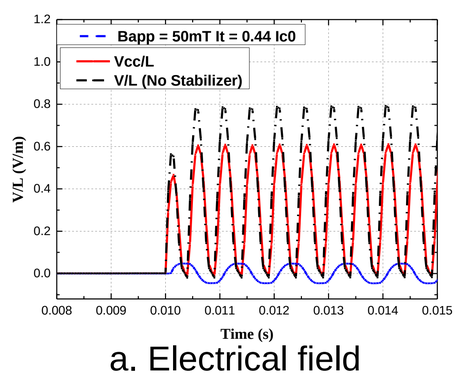
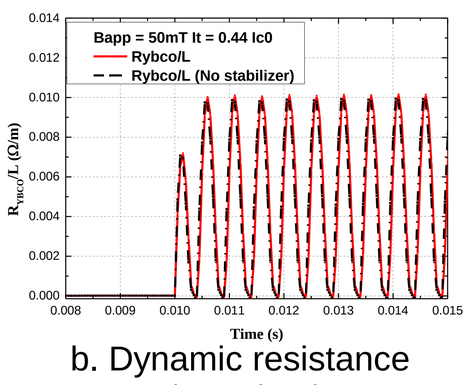


Fig.1 Schematic view of the 2D infinite long model for an HTS coated conductor (CC), including an electromagnetic module and a thermal module.

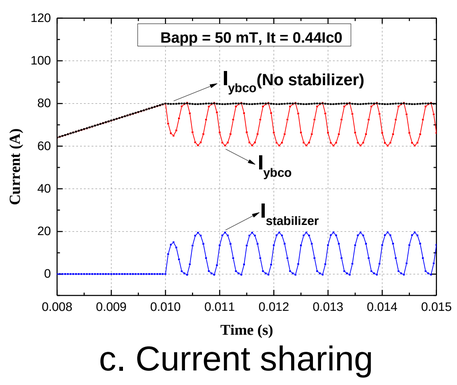
Impact of Stabilizer



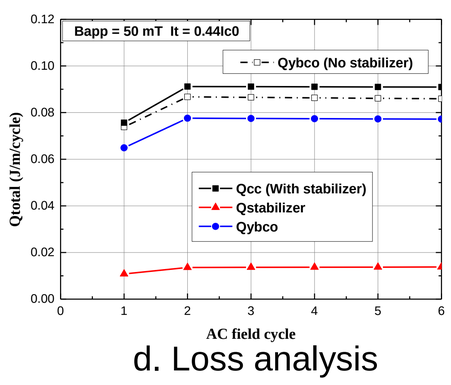
a. Electrical field



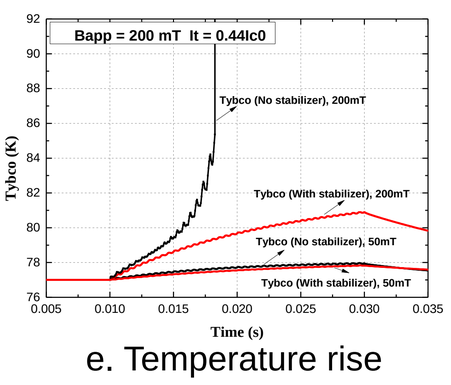
b. Dynamic resistance (YBCO layer)



c. Current sharing



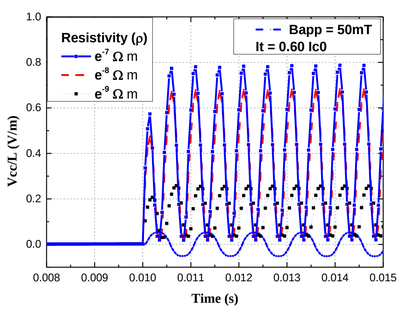
d. Loss analysis



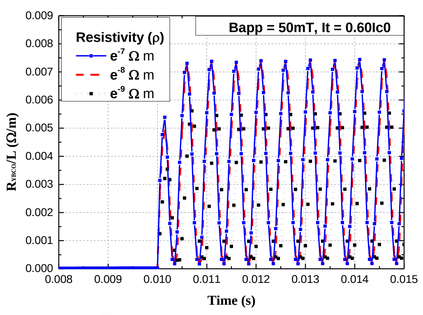
e. Temperature rise

1. The stabilizer reduces the dc voltage and dynamic resistance of the direct current carrying coated conductors under perpendicular AC magnetic fields.
2. The stabilizer increases the stability of the CC, especially under high field magnitude, because of its current sharing ability.
3. The stabilizer introduces additional ohmic losses, including loss generated by its shared transport current and loss caused by its eddy current.

Resistance of Stabilizer

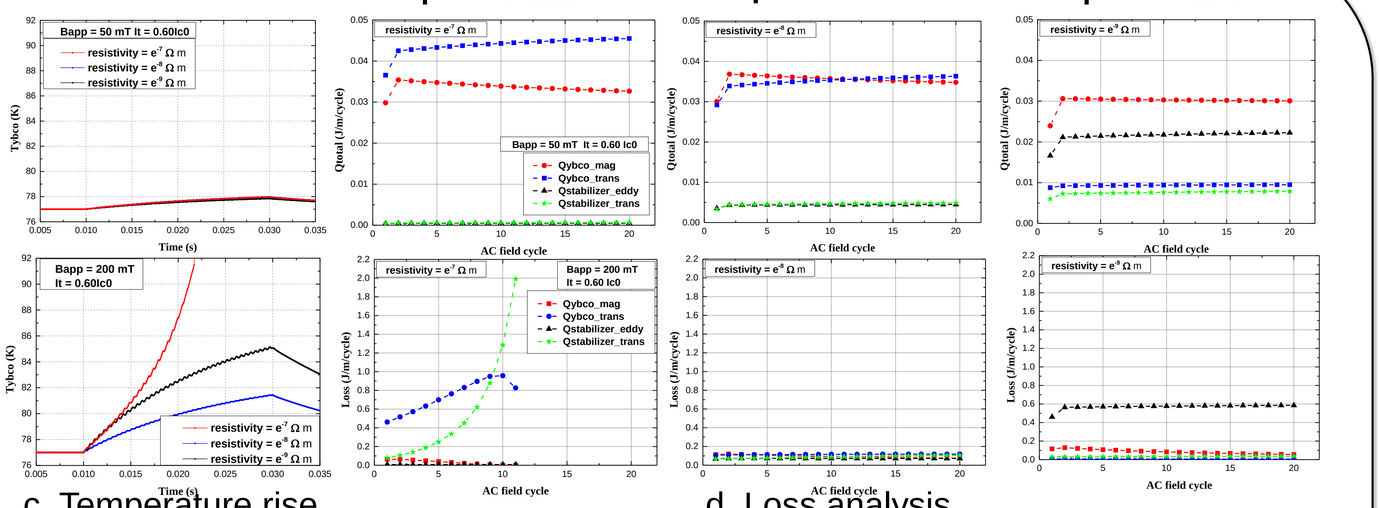


a. Electrical field



b. Dynamic resistance (YBCO layer)

$$\frac{R_{d\perp}}{L} = \frac{4af}{I_{c0}}(B_{a,\perp} - B_{th,\perp})$$



c. Temperature rise

d. Loss analysis

1. The stabilizer has a shielding effect, which is significant under high AC field magnitude.
2. The shielding effect becomes more significant when the resistance of the stabilizer decreases.
3. A strong shielding effect generates a large eddy current loss. It also decreases the dynamic resistance of YBCO (high *T*c superconducting) layer, because it has shielded a part of the applied AC field from the YBCO layer.

Conclusion

1. The stabilizer reduces the dc voltage and dynamic resistance of the direct current carrying coated conductors under perpendicular AC magnetic fields, but increases the stability of the CC under high field and high frequency.
2. Both transport current sharing phenomenon and AC field shielding effect are observed in the stabilizer, which introduces a transport current loss and an eddy current loss respectively. The shielding effect can decrease the dynamic resistance of YBCO layer. The shielding effect and the eddy current loss are significant under high field magnitude with high frequency.
3. The influence of stabilizer's resistance on the total loss of DC carrying CC under perpendicular AC magnetic fields is complicate. A high-resistance stabilizer leads to high transport current loss of the CC, while a low-resistance stabilizer leads to high eddy current loss.
4. The CC can be used in AC field-controlled PCSs, which should be carefully designed according to different application scenarios. To design a fast switching-off and high resistance PCS, the stabilizer is not preferred. But to build a frequent-switching, stable, and safe switch, stabilizer should be introduced. For different switch designs, the material and thickness of the stabilizer should be chosen case by case.

Reference

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