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Investigation of a Concentric Three-Phase HTS Cable Connected to a SFCL Device

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Introduction

In this work a design is considered with all three phases in a single cable cryostat which transports the coolant (LN_2) in one direction only. The backflow takes place in a separate return line.

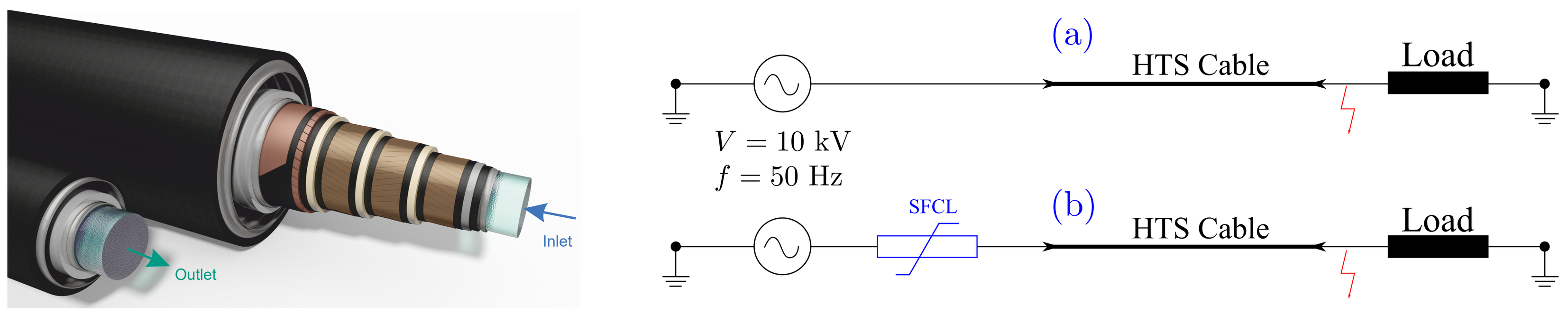

Fig. 1. (left) View of the three-phase concentric HTS cable design with external return of liquid. nitrogen. (right) Electrical system configuration: (a) Circuit only with the HTS cable and (b) circuit with the inclusion of a SFCL device.

An electric short-circuit can damage the HTS cable due to highly dynamic and thermal stresses. Thus, a resistive SFCL in series connection with the HTS cable has been considered.

Cable and SFCL Design

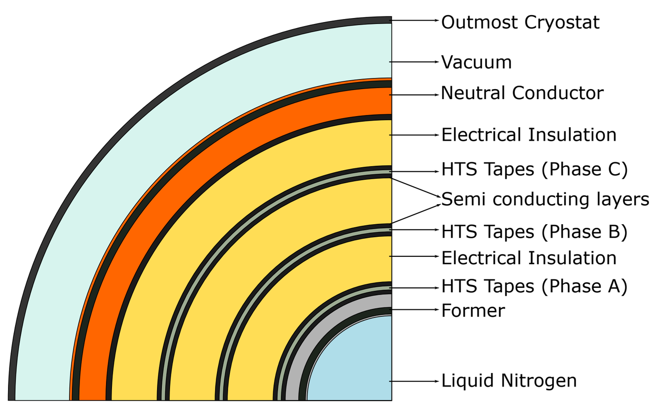

Fig. 2. Detailed sectional view of the proposed HTS cable design.

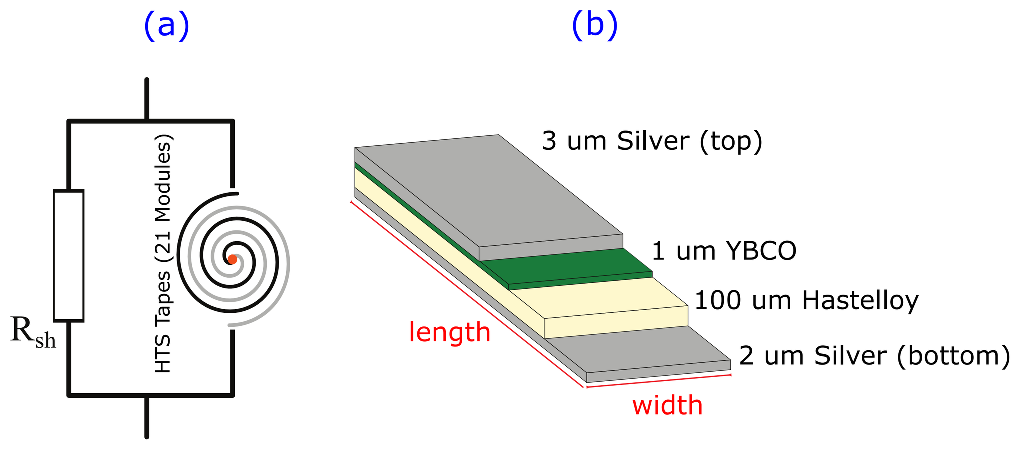

Fig. 3. (a) Topology of the SFCL consisting of HTS tapes and shunt resistor and (b) architecture of the HTS tapes in the SFCL.

Table 1: Description of the simulated studies.

	Thickness of Copper Layer (Cable)	SFCL Connected ?
Study 1	75 μm	no
Study 2	100 μm	no
Study 3	100 μm	yes

Results

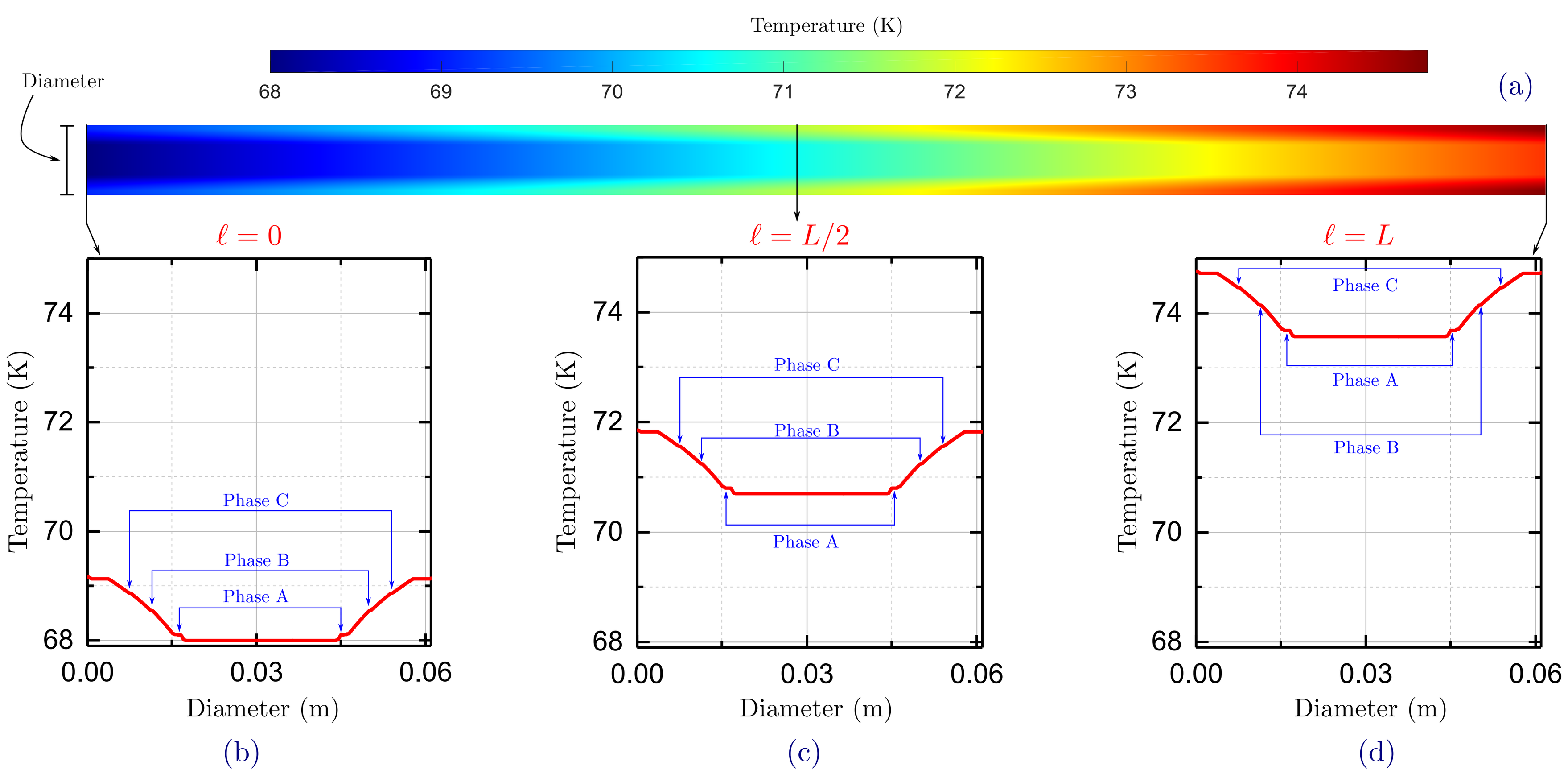

Fig. 4. Temperature profile of the HTS cable (a) along the length and cross sections profiles (b) at the beginning of the cable (ℓ=0), (c) at half length (ℓ=L/2) and (d) at the end of the cable (ℓ=L).

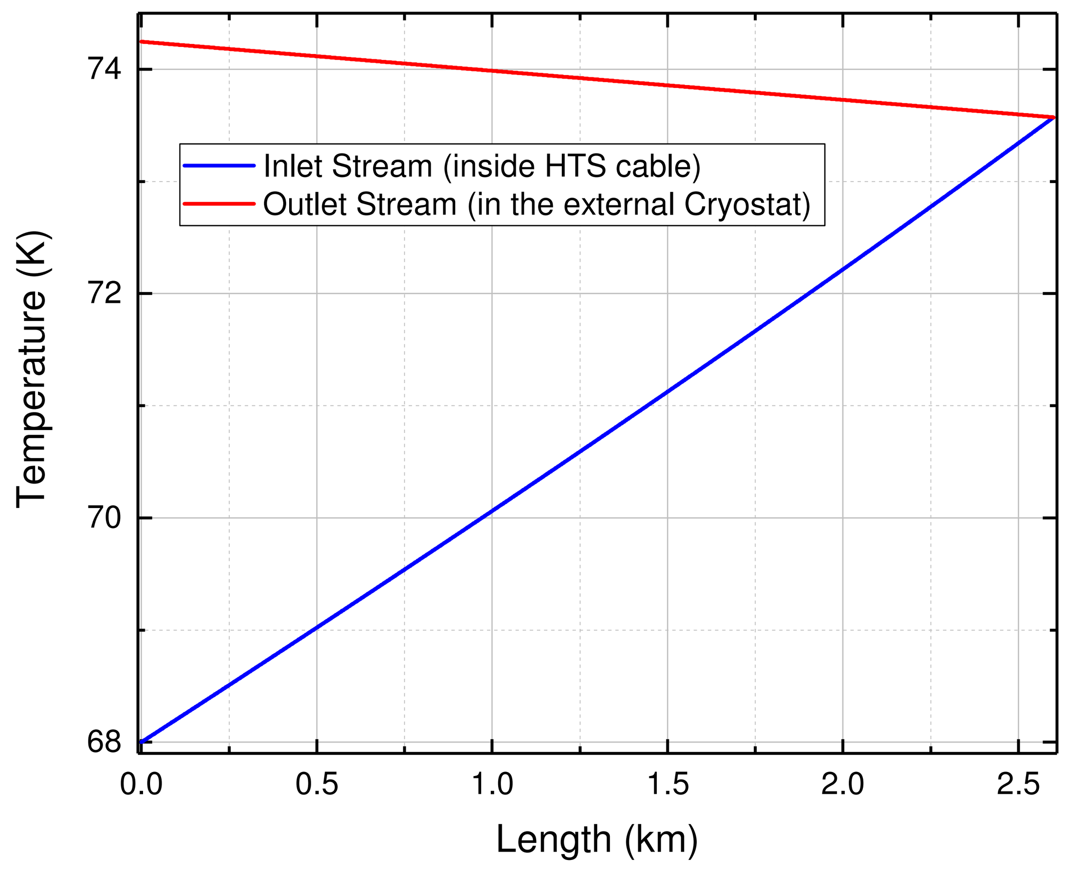

Fig. 5. Temperature of the LN_2 along the cable length. Curves represent the LN_2 stream in the internal cryostat and its return in the external cryostat.

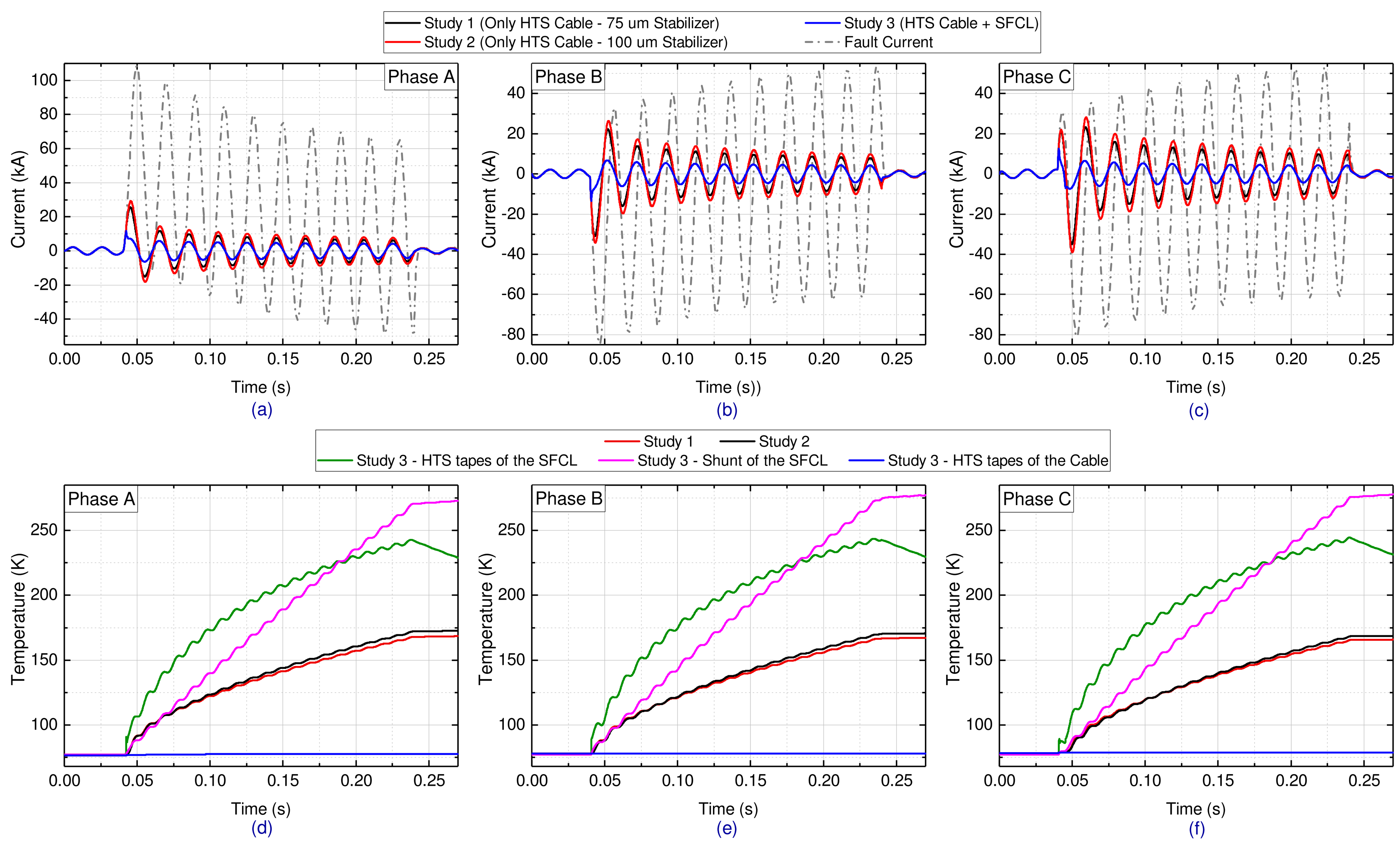

Fig. 6. Fault current and limited current for each studied case in (a) Phase A, (b) Phase B and (c) Phase C. Increase of temperature of HTS tapes in the cable and in the SFCL as well as temperatures of the shunt in the SFCL for each case in (d) Phase A, (e) Phase B and (f) Phase C.

Table 2: Results of the fault analysis for each study.

	Fault Current (kA_{RMS})	Limited Current (kA_{RMS})		
		Study 1	Study 2	Study 3
Phase A	50.0	7.1	8.6	3.7
Phase B	43.3	9.0	11.0	3.7
Phase C	42.1	10.7	13.0	3.7

Conclusions

Under fault conditions, the cable can protect the system by itself. It is shown that by controlling the thickness of the copper layer the limited current can be managed. The connection of a SFCL has proven to be a good option to protect the overheating of HTS tapes and to avoid the boiling of the LN_2 in the cable.