Development of round flexible HTS CORC® wires for fault current limiting applications

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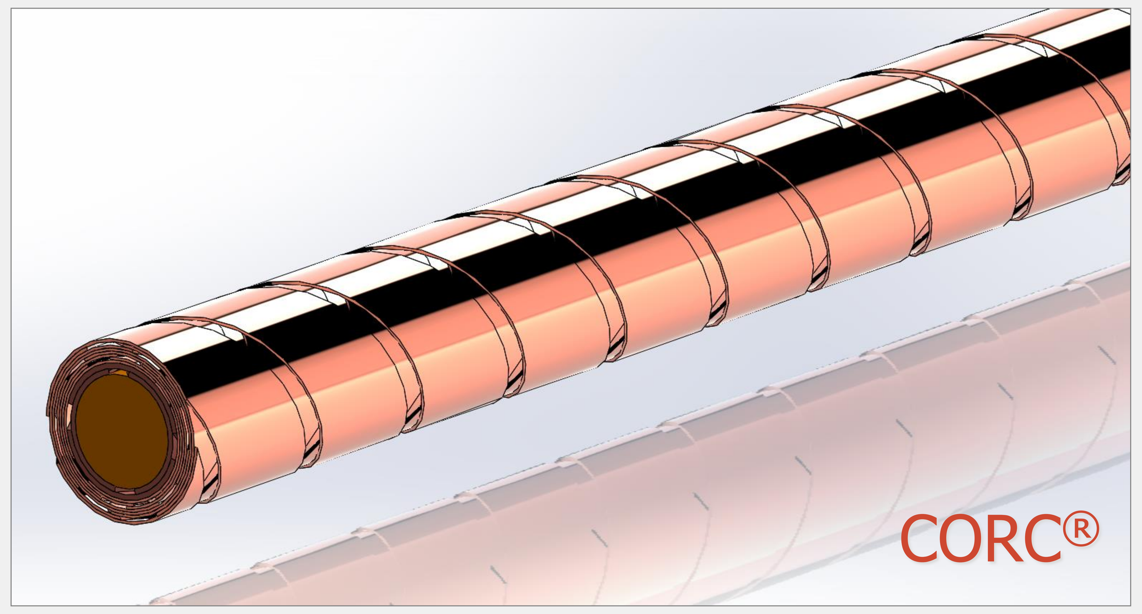
CORC® topology



Conductor on Round Core (CORC®) conductors consist of High Temperature Superconducting (HTS) tapes wound helically around a small former

- CORC® power transmission and Fault Current Limiting (FCL) cables and wires were developed with support of the U.S. Navy and in collaboration with the Center for Advanced Power Systems at Florida State University
- CORC® conductors form a unique solution for power transmission needs in liquid nitrogen or pressurized helium gas

	CORC® power transmission cables		CORC® power transmission wires	
Diameter	6 to 10 mm		3 to 4 mm	
Temperature	77 K	50 K	77 K	50 K
Current	10,000 A	40,000 A	2,500 A	10,000 A
Current density	125 A/mm²	500 A/mm²	250 A/mm²	1,000 A/mm²

HTS tapes are layered and transversed

- Can incorporate any number of normal and superconducting tapes to tailor operating current, normal state resistivity, and thermal management
- Direct contact between each tape and up to 8 other tapes
- Several paths for current sharing adds electrical stability
- Several thermal contacts allows proficient cooling
- Such high level of current sharing is not available in conventional HTS FCL cables that typically require laminates

NAVSEA
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CORC® FCL conductors enable quick protection of integrated power system components from fault currents

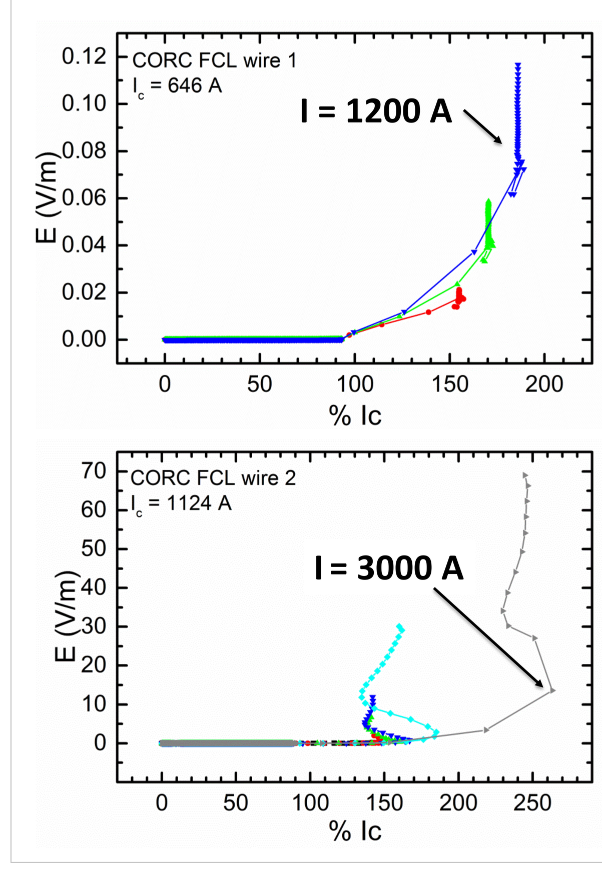
Design of wires for overcurrent testing

Sample name	I_c at 76 K (A)	J_c at 76 K (A/mm^2)	Total wire diameter (mm)	Description
CORC FCL wire 1	646	80	3.2	Typical CORC® power transmission wire
CORC FCL wire 2	1124	99	3.8	CORC® wire optimized for FCL application

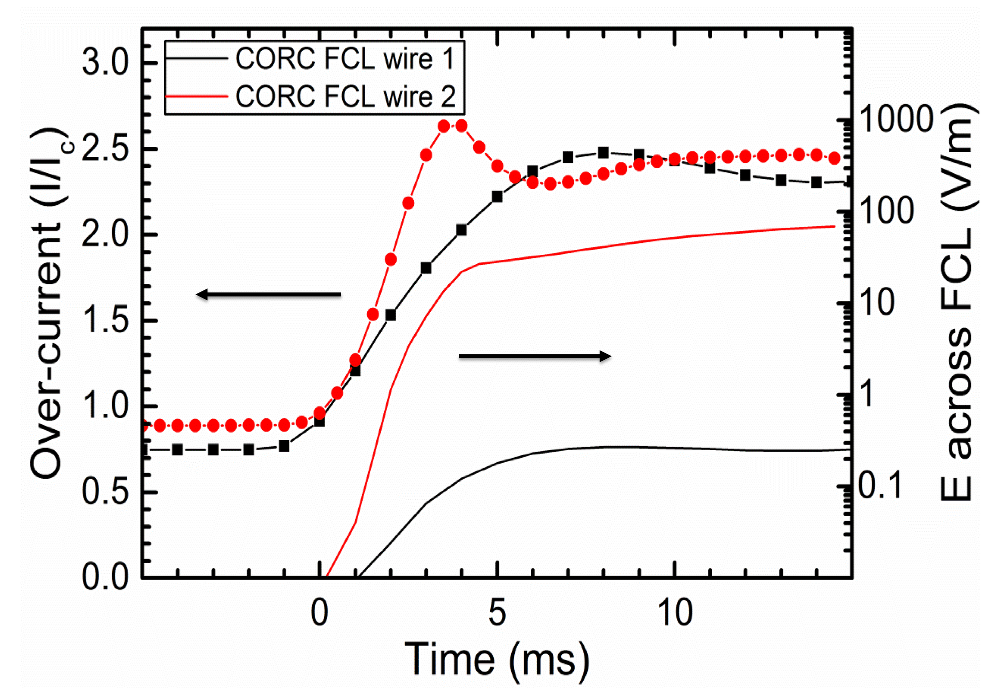
Conductor response to pulsed overcurrents

Overcurrent testing of CORC® FCL wires in nitrogen

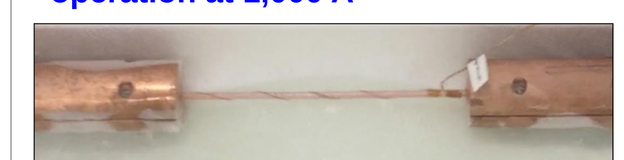
Electric field as a function of various applied overcurrents for both wires



Optimized wire 2 develops orders of magnitude more voltage than wire 1 at same applied overcurrent



CORC® FCL wire 2 during normal operation at 1,000 A

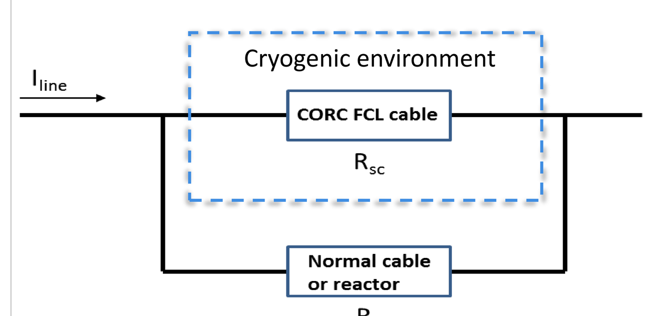


CORC® FCL wire at moment of fault

CORC® FCL wire during recovery

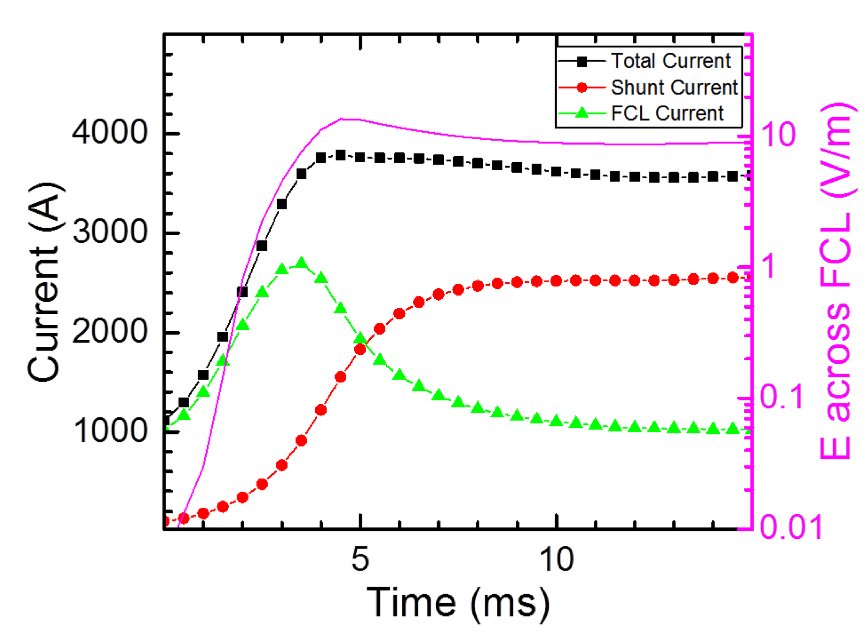
Overcurrent testing of a hybrid CORC® FCL system to 320% I_c

Schematic of experimental setup



Picture of experimental setup

FCL wire develops sufficient voltage to divert overcurrent to parallel resistive path



- Peak current in FCL wire 2,700 A after 3 ms
- FCL voltage 10 V/m after 5 ms
- Current in FCL wire back below I_c after 10 ms, while maintaining ~10 V/m over hybrid cable system
- Constant voltage suggests CORC® wire remains at constant temperature, although dissipation at ~10 kW/m
- Rapid cool down requires switch to isolate the CORC® wire

Conclusions

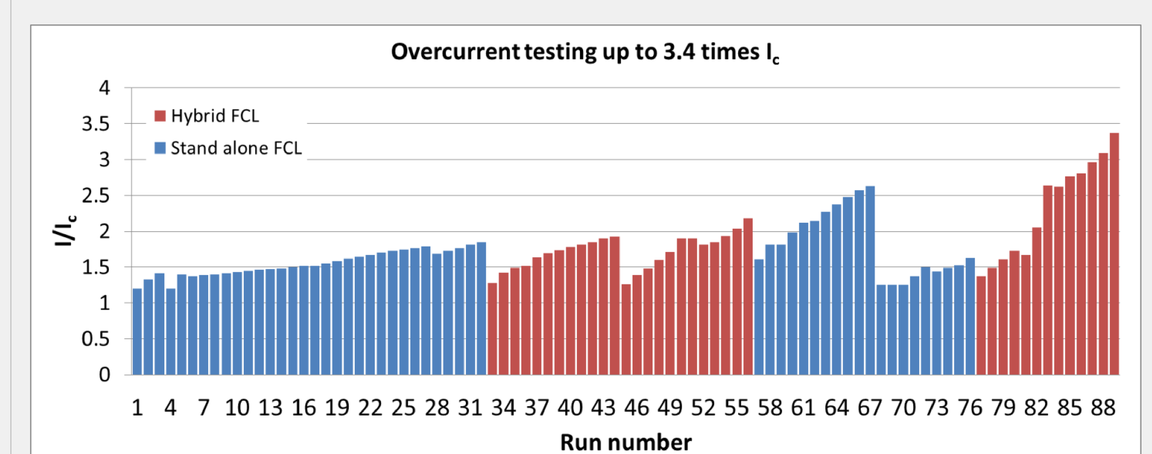
CORC® cables and wires can be operated as Fault Current Limiters

- Current sharing between tapes in CORC® cables/wires allows us to produce FCL conductors without the need for laminates
- low thermal capacity and high normal resistance allow for very fast response to fault currents
- Response time is nearly instantaneous, with voltage rise following the current ramp which takes 3-4 ms rise-time to reach I/I_c= 2.5
- Fast acting CORC® FCL wire demonstrated with 50 V/m after 5 ms of overcurrent in LN2

A hybrid CORC® FCL system was successfully demonstrated

- 10 V/m after current pulse rise-time of 4 ms

Extensive cycling did not degrade the CORC® FCL conductors



Recent test of CORC® power transmission cable in He gas

- 2-Pole CORC® power transmission cable
- 10 meter long twisted pair cable layout
- Results suggest that I_{quench} at 50 K would be > 10,000 A