Tohoku Univ. Technology

Passive DC Circuit Breaker

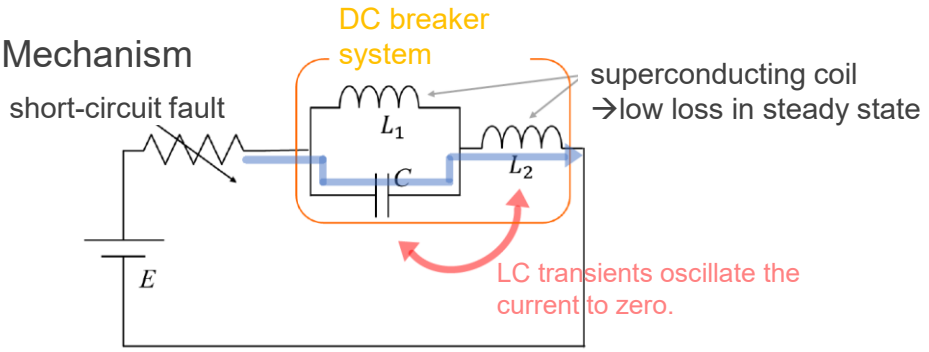
Arc-free, reliable interruption that eliminates shutdown failure, arc damage, noise and space problems.

Overview

Conventional DC circuit breakers interrupt short-circuit faults by opening their contacts and generating an explosive arc. But the current may rise faster than it can be limited, and interruption sometimes fails. The arc damages the breaker and nearby equipment and generates noise, and their large size makes installation sites hard to secure.

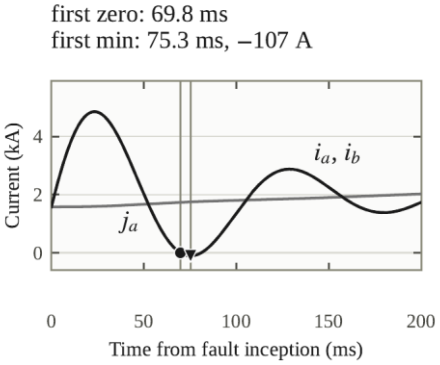
This invention combines a superconducting coil and a capacitor to make the fault current oscillate and create a point where the current becomes zero, at which the contacts open. Powered by the fault current itself, it needs no supply for detection, control or driving (passive), and interrupts reliably without an arc. For 1.5-kV railway DC power supply, the required coil size has been determined numerically for each supply area (urban 130–145 mH, suburban 565–680 mH, rural 230–235 mH), together with the condition for the current to reach zero. Experiments confirm the current reaches zero and can be interrupted there.

Mechanism

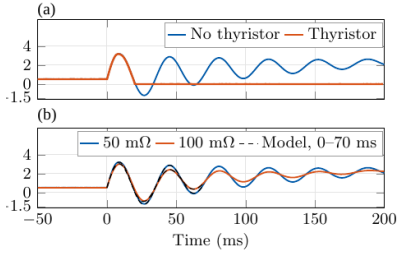


Passive current limiting and shutdown

Analysis: peaks at about 4.9 kA, current zero at about 70 ms (time since the fault)



Experiment: with the switch, the current stops at zero



Lower panel: agrees with calculation for other conditions

Product Application

- Railways (DC traction power supply)
- DC distribution and microgrids
- DC systems for renewable energy (e.g. solar, wind power)
- DC power supply for data centers and factories
- EV fast-charging facilities, ships and other mobile objects

Related Works

[1] H. Sasaki, K. Nishiyama, Y. Nagasaki, M. Tsuda, the 2026 Annual Meeting of the Institute of Electrical Engineers of Japan (March 2026, Sendai, Japan).
[2] Y. Nagasaki, H. Sasaki, S. Okumura, M. Tsuda, "Minimum Inductance and Its Existence Limits for Passive LC Current-Zero Formation in Two-End-Fed DC Railway Feeders," IEEE Trans. Transp. Electrif. (submitted)

IP Data

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