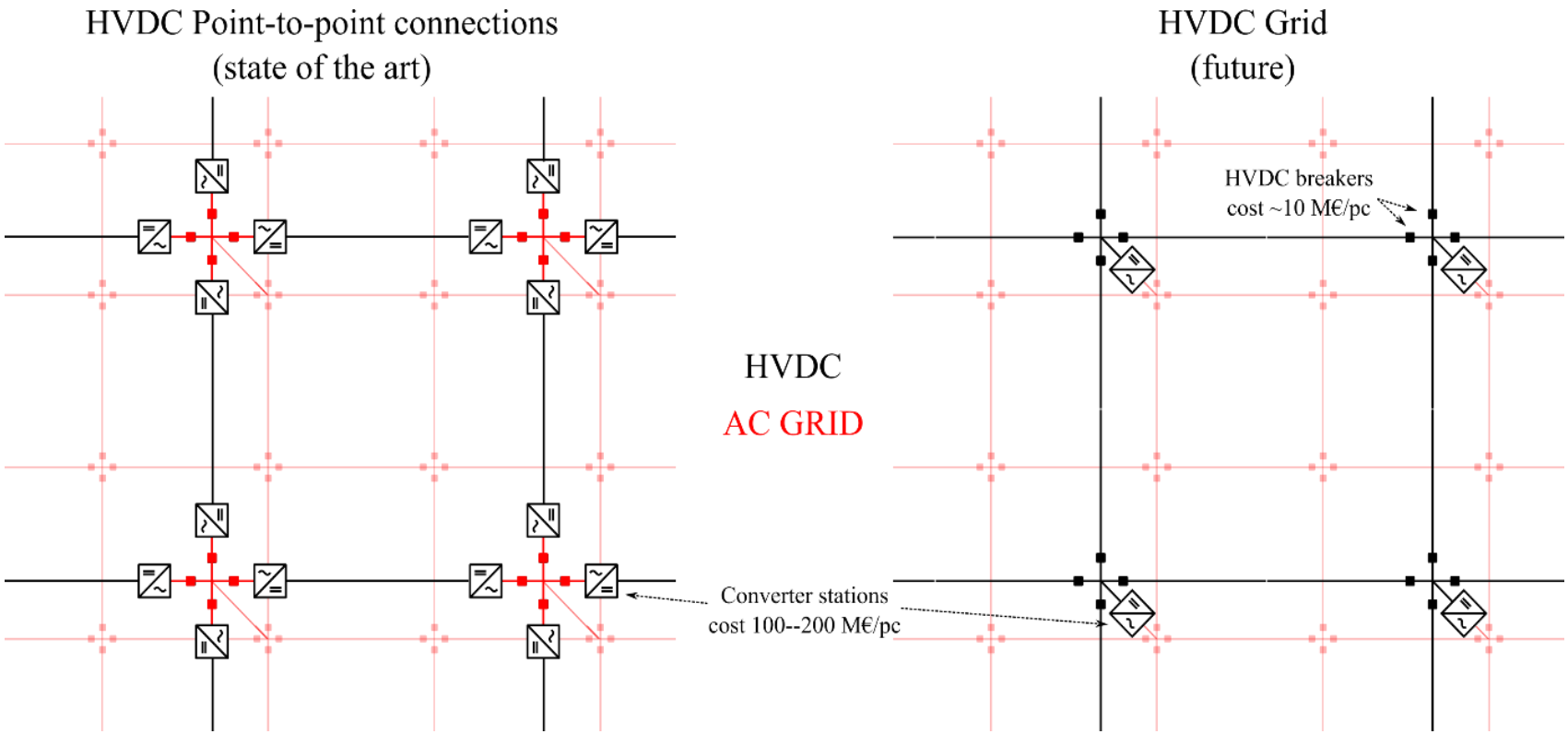
About SCiBreak

- SCiBreak **develops** technology for **fast circuit breakers** for use in DC and current-limiting AC applications.
- SCiBreak AB was founded in 2014 as a spin-out from KTH Royal Institute of Technology, Sweden.
- The name is derived from "**S**hort-**C**ircuit **I**nterrupter/**Break**er".
- Currently around five people (full/part-time) working out of premises outside Stockholm.
- We are supported by the Swedish Energy Agency, Svenska Kraftnät –the Swedish National Grid, and European Institute of Innovation and Technology – EIT Innoenergy.
- PROMOTioN EU2020 Project Partner.

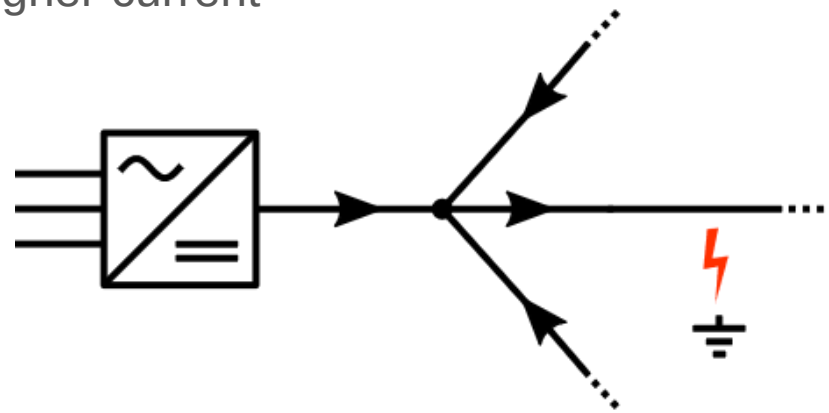
The need for DC circuit breakers



The need for DC circuit breakers

DC grids can have very high short circuit current levels

- low resistance
- inductance only lowers di/dt, not peak current
- more interconnections → higher current

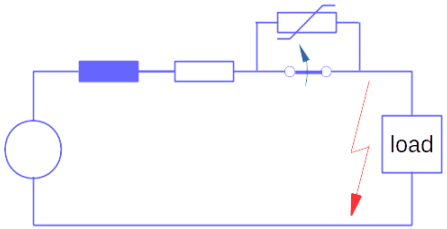


DC circuit breakers needed to

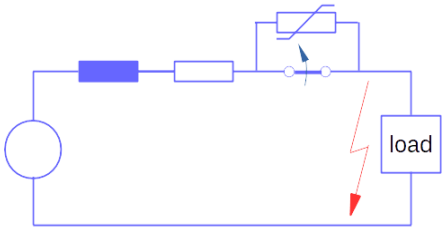
- limit short circuit current levels
- isolate faults

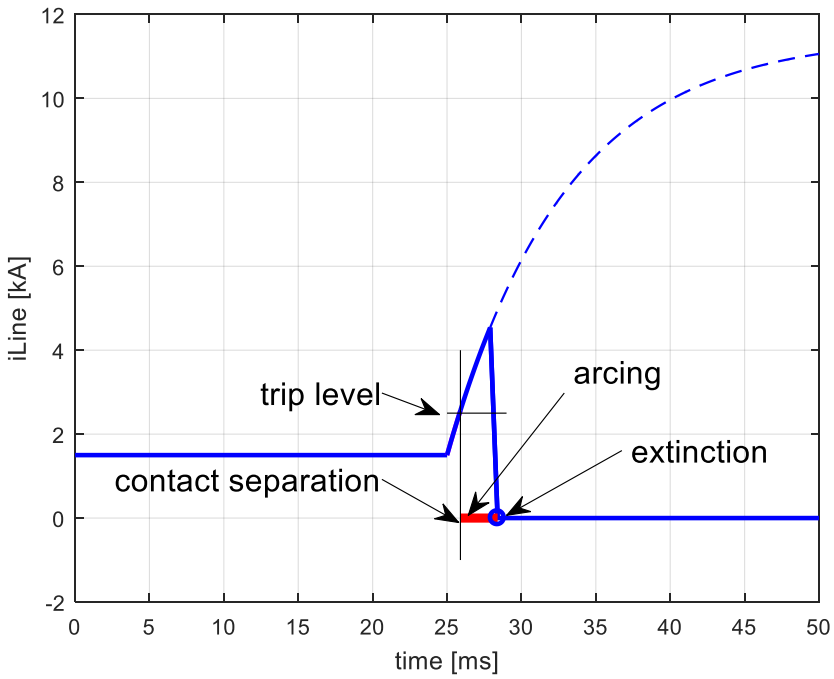
Interrupting (non-zero) current

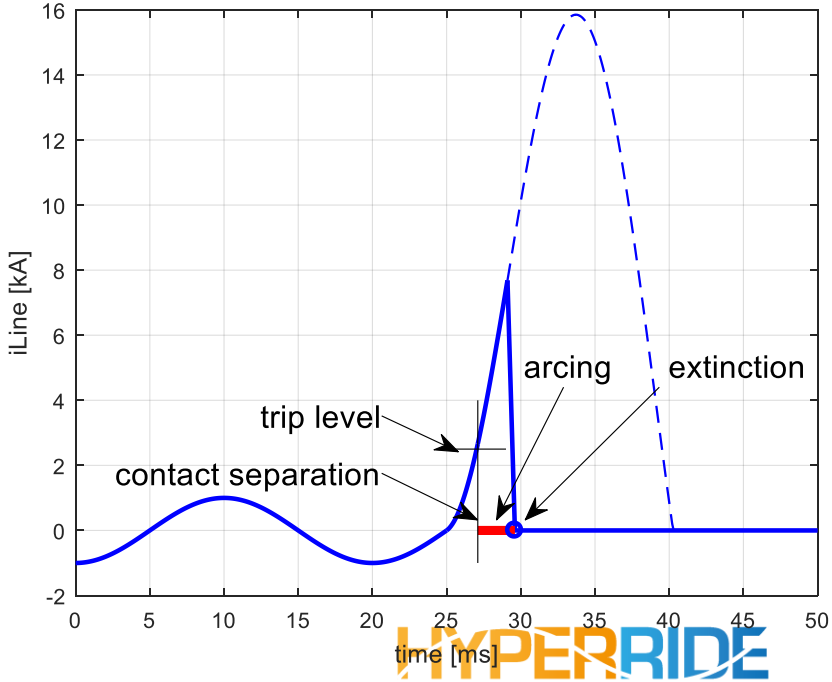
DC



AC







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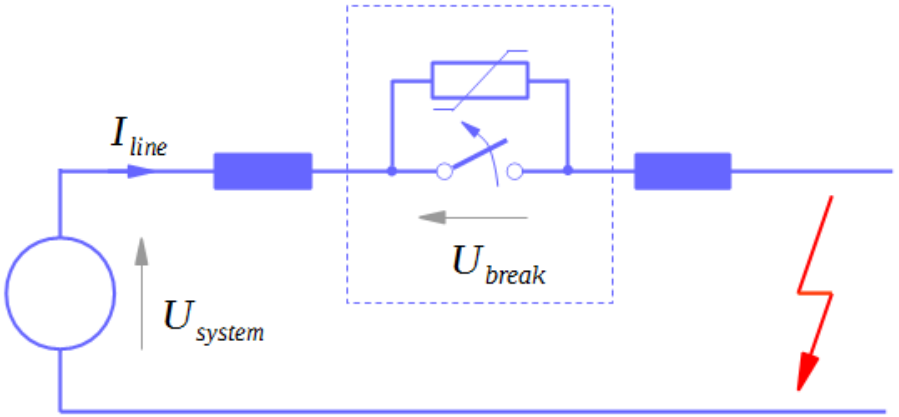
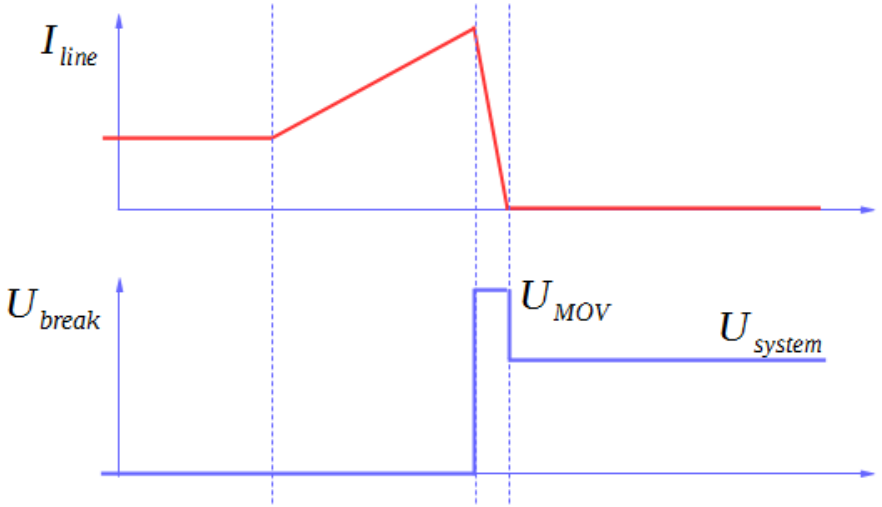
Interrupting (non-zero) current

A **counter-emf** exceeding the driving voltage in the circuit must be inserted.

An **energy absorbing device (typically an MOV)** is required for taking care of the magnetic energy.

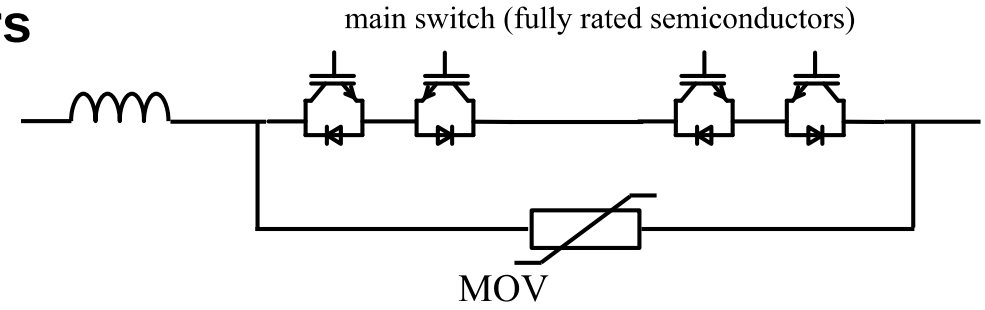




Interrupting (non-zero) current

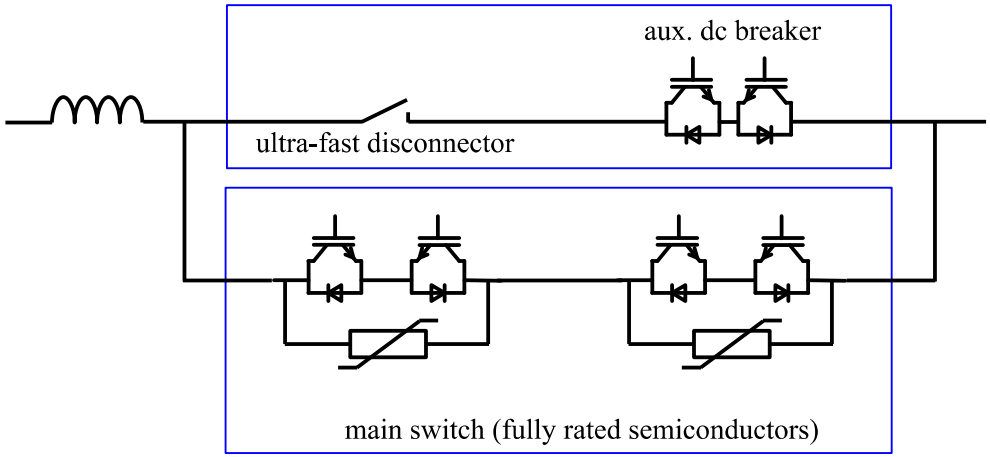
Semiconductor-based breakers

- Fully rated semiconductors
- Semiconductor losses in on-state
- **Lossy, costly**



Hybrid breakers

- Combines mechanical and semiconductor switches
- Almost lossless while closed
- Fully rated semiconductors
- **Costly**



SCiBreak's Technology

Breaking Capability
Semiconductor vs. Vacuum Interrupter

	Infineon IGBT FZ3600R17HP4_B2	Tavrida Vacuum Interrupter ISM25_LD_1
Type	Unidirectional DC	Bidirectional AC
Continuous load current	3600 A*	800 A
Blocking voltage	1700 V	125 kV
Max. interrupting current	~10 kA **17 MVA**	16 kA **2000 MVA**
Price	~1200 €	~1200 €

*with cooling

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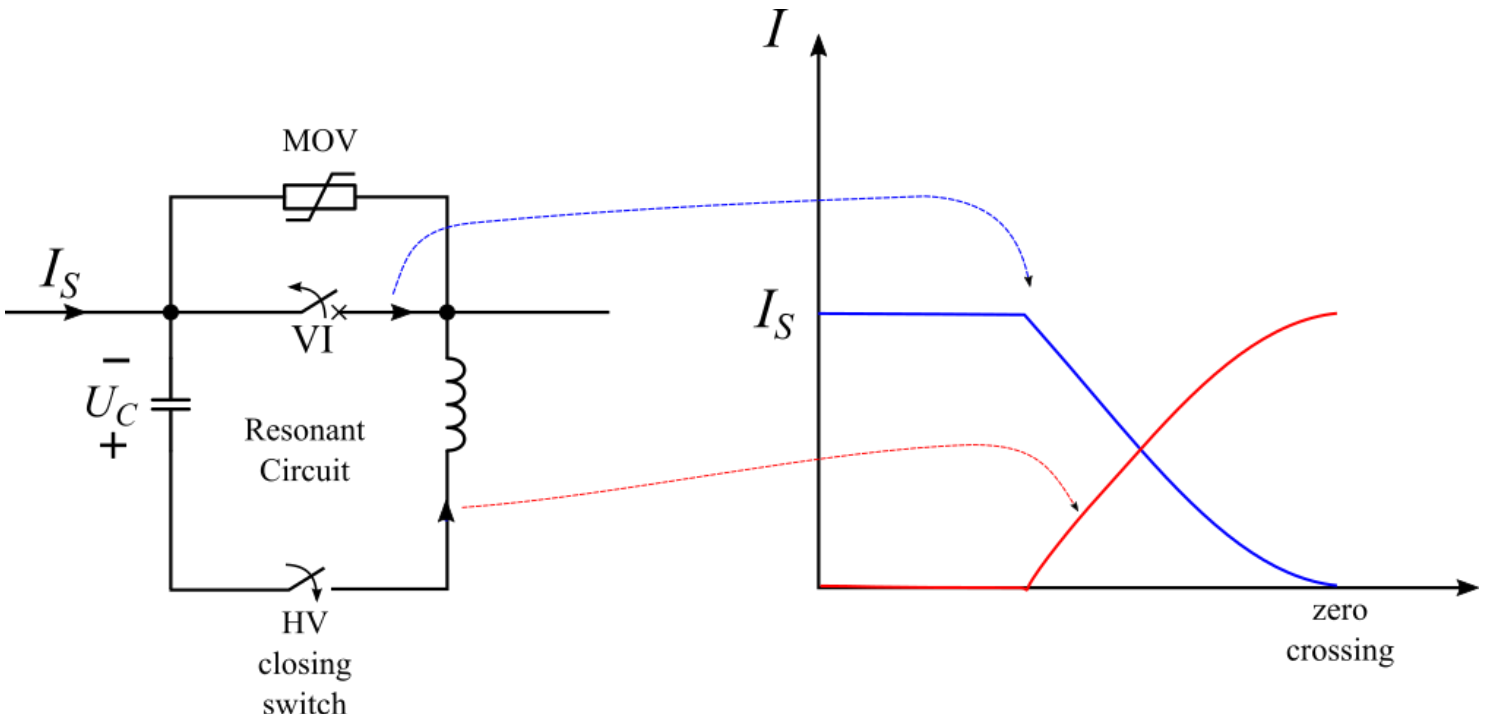
Existing fast DC breakers

Active current injection using capacitor discharge



- ✓ capacitor precharged to high voltage
- ✓ needs high-voltage switch to control discharge operation
- ✓ capacitor stressed by continuous voltage
- ✓ one-shot solution
- ✓ no control of di/dt

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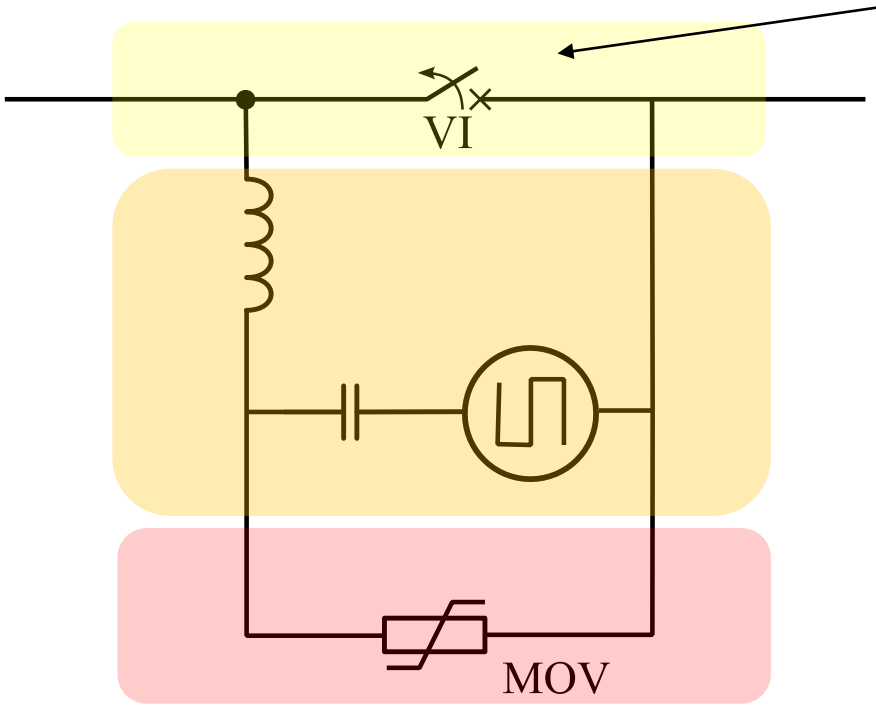
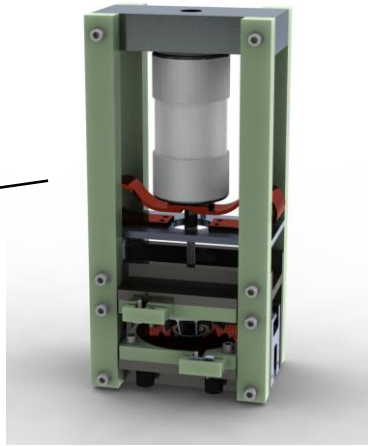
VSC-assisted Resonant Current (VARC)

Conventional vacuum interrupter with fast actuator.

Series-resonant circuit excited by voltage-source converter.

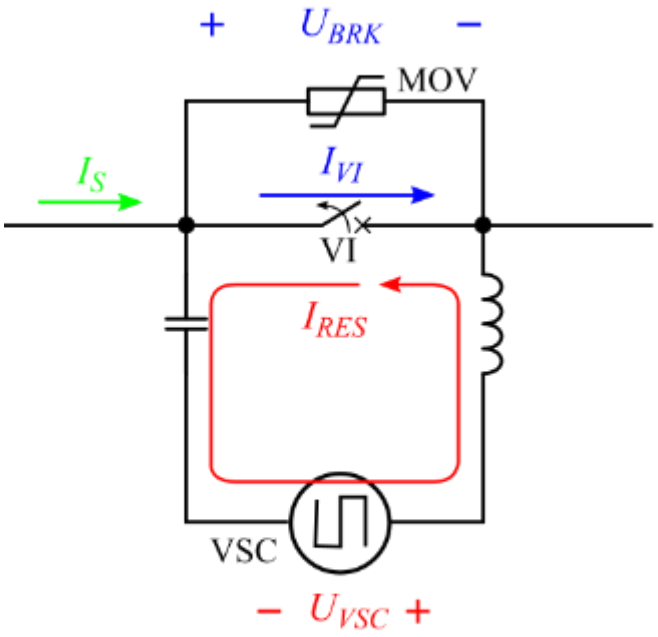
Metal-oxide surge arrester.

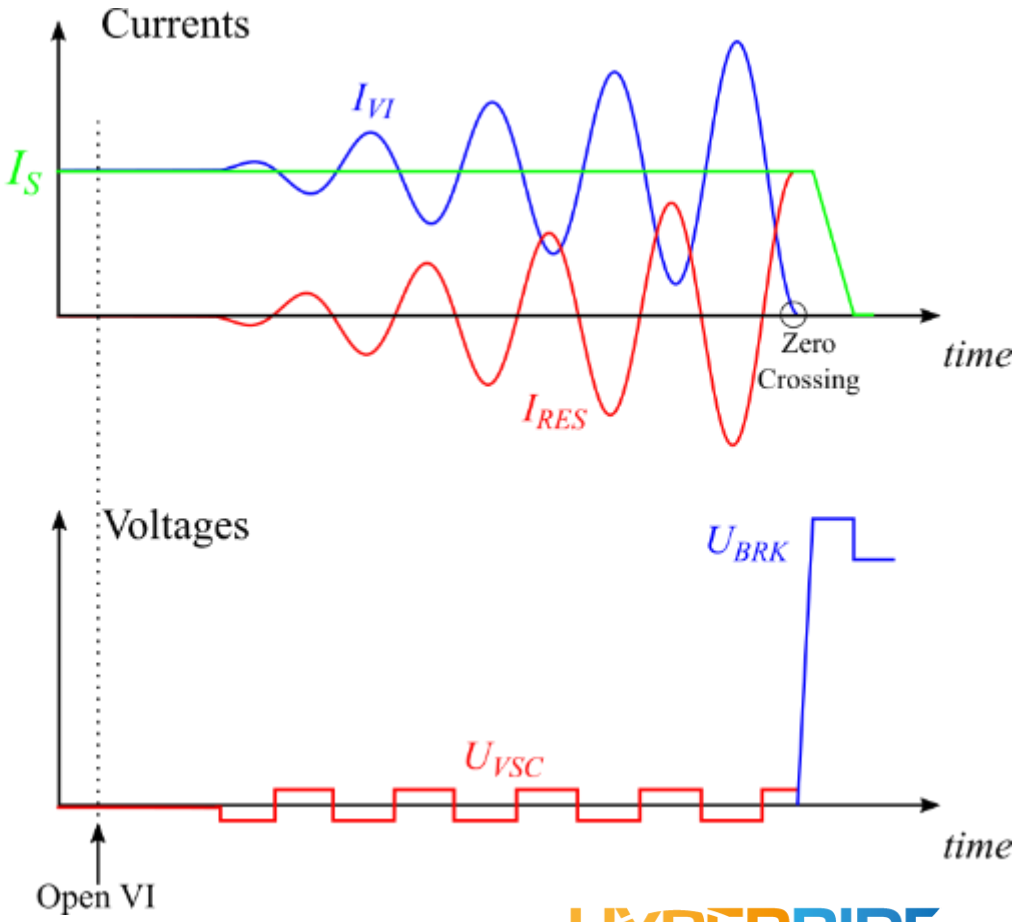




VI & actuator

VSC-assisted Resonant Current (VARC) Interruption



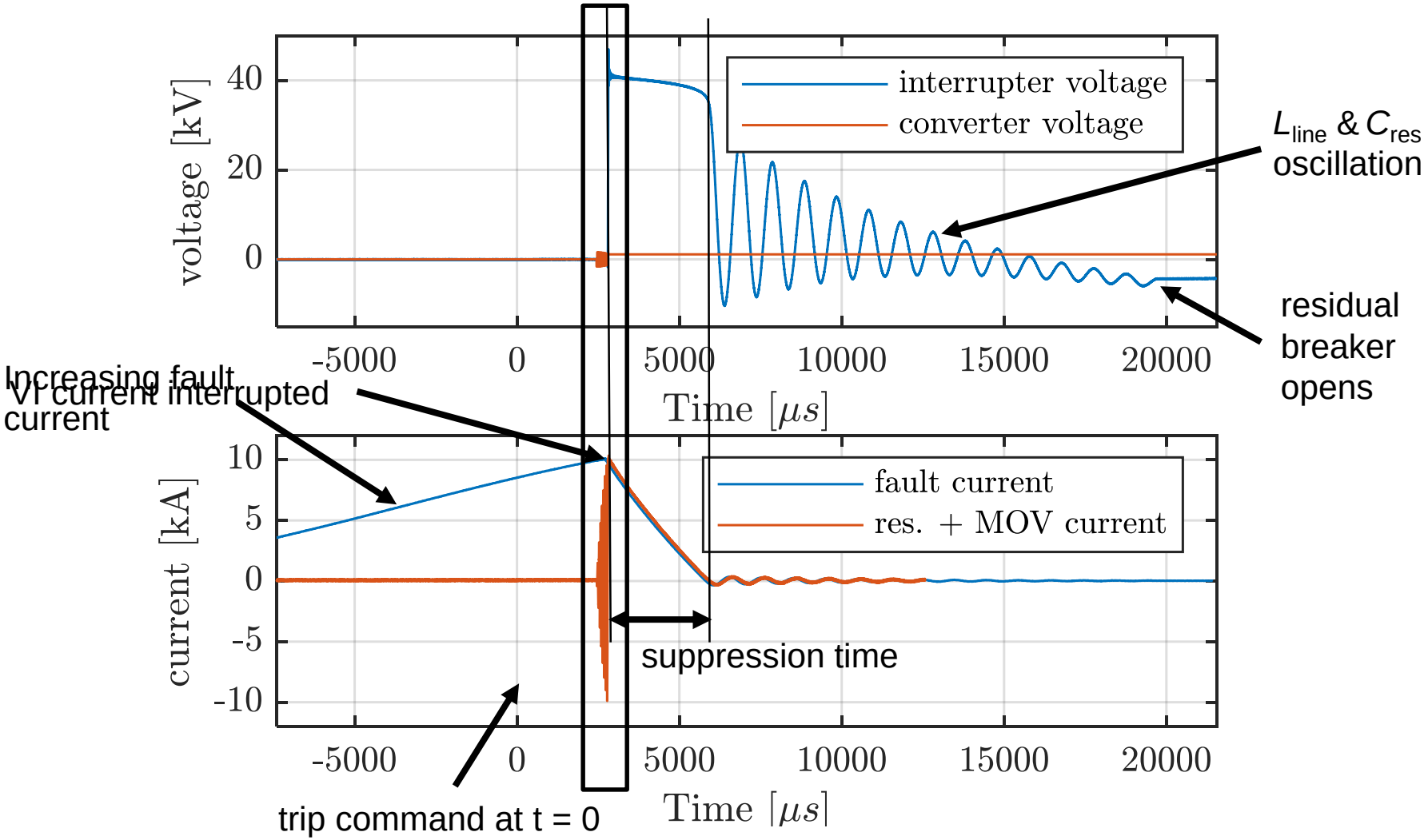


VARC Breaker Module

- 40 kV TRV
- 10 kA interruption
- < 3 ms to neutralisation

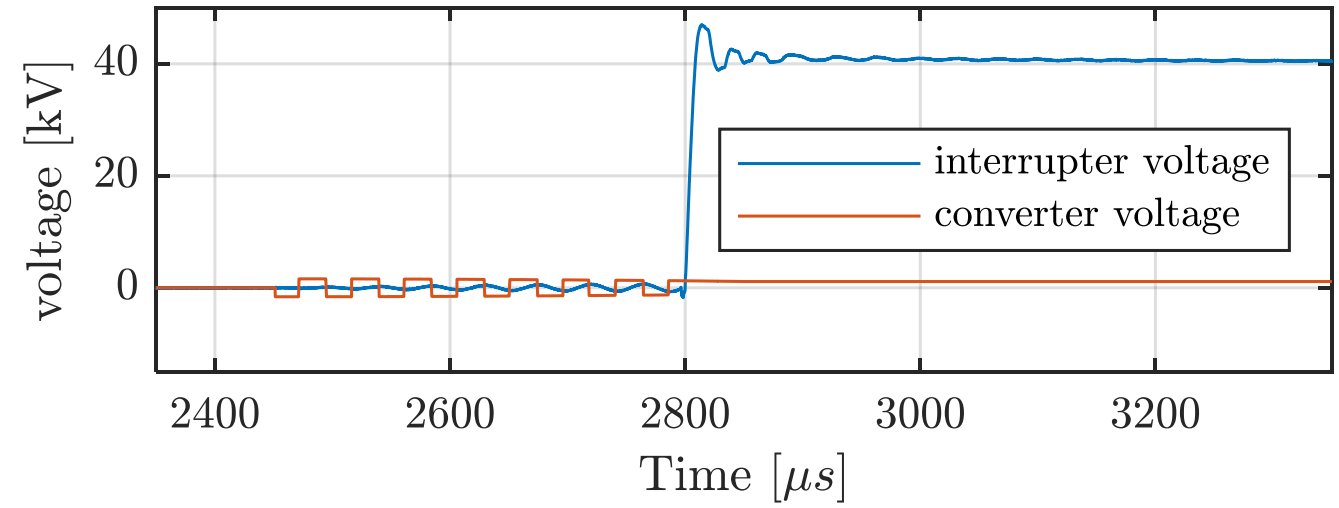
size: 2.2 x 1.7 x 1.6 m
weight: 800 kg

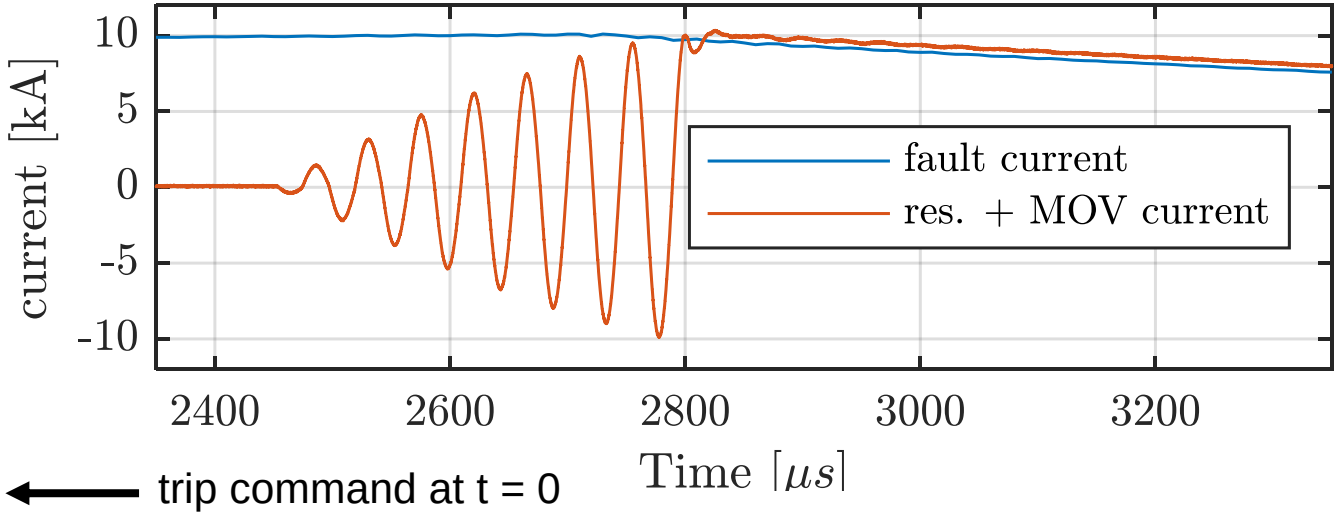
VARC Interruption



Data from testing at DNV GL in Arnhem, June 12th 2018

VARC Interruption – close-up





trip command at t = 0

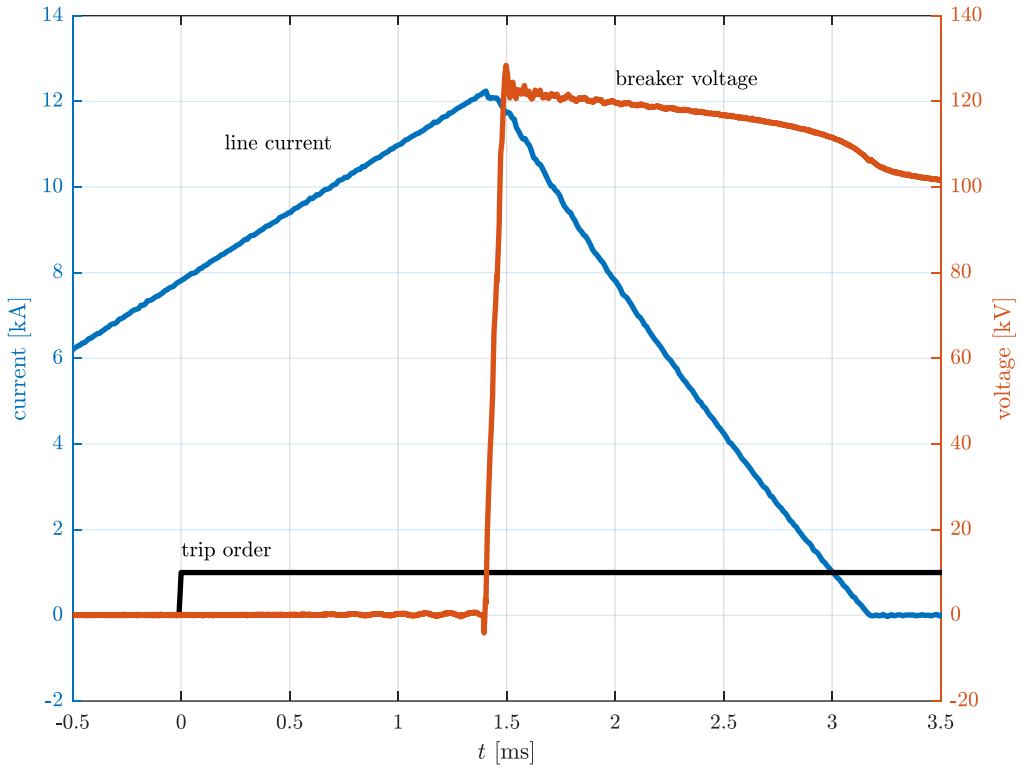
Data from testing at DNV GL in Arnhem, June 12th 2018

VARC HVDC CB Testing

80/120 kV, 15 kA SCiBreak VARC circuit breaker (3 modules in series)

PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

KEMA Labs



12 kA interrupted against 120 kV MOV voltage in less than 1.5 ms.

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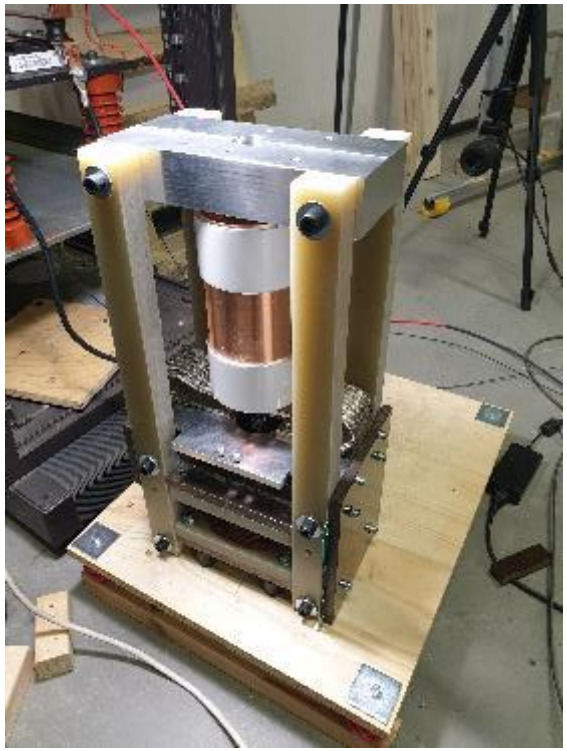
Current Activities

VI with ultra-fast actuator

- Thomson coil-based actuator
- Open (6mm) approx 1-2 ms.
- Powered by thyristor-discharged capacitor bank



Advantages of VARC

- low **number of semiconductors** (one 10th of bidirectional semiconductor string for full MOV voltage)
- only **vacuum interrupter** in **normal current path**
- **low stress on passive components** in normal operation
- mostly uses standard **off-the-shelf components** (VIs, standard power electronics)
- converter **commutates at zero current**
- automatic **adaptation** of current pulse amplitude to interrupted line current
- operation is **independent of line voltage before fault**
- fast **reclosing** is possible

Speed & Energy

- All(?) proposed DC circuit breakers have limited current interruption capability.
- Current rate of rise must be limited, often by inductors which increase cost, size and losses.

Trade-off between maximum interruption current and speed,
where speed is generally more important.

Faster circuit breaker allows interruption at

- lower current → lower dissipated energy

  or

- same current, smaller series inductance → lower dissipated energy
  lower steady state losses

HVDC circuit breakers operate in 2 — 5 ms, too slow for MVDC?

Hyperride Project

- Hyperride — HYbrid Provision of Energy based on Reliability and Resiliancy via Integration of Dc Equipment.
- Horizon 2020 project 2020-2024
- Focus on demonstrators and high technology readiness level (TRL)
- SCiBreak to build:
  - 5 kV DCCB for demonstration in Aachen MVDC grid.
  - 14 kV DCCB in collaboration with EATON

SCiBreak VARC MVDC circuit breaker concept rendering

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