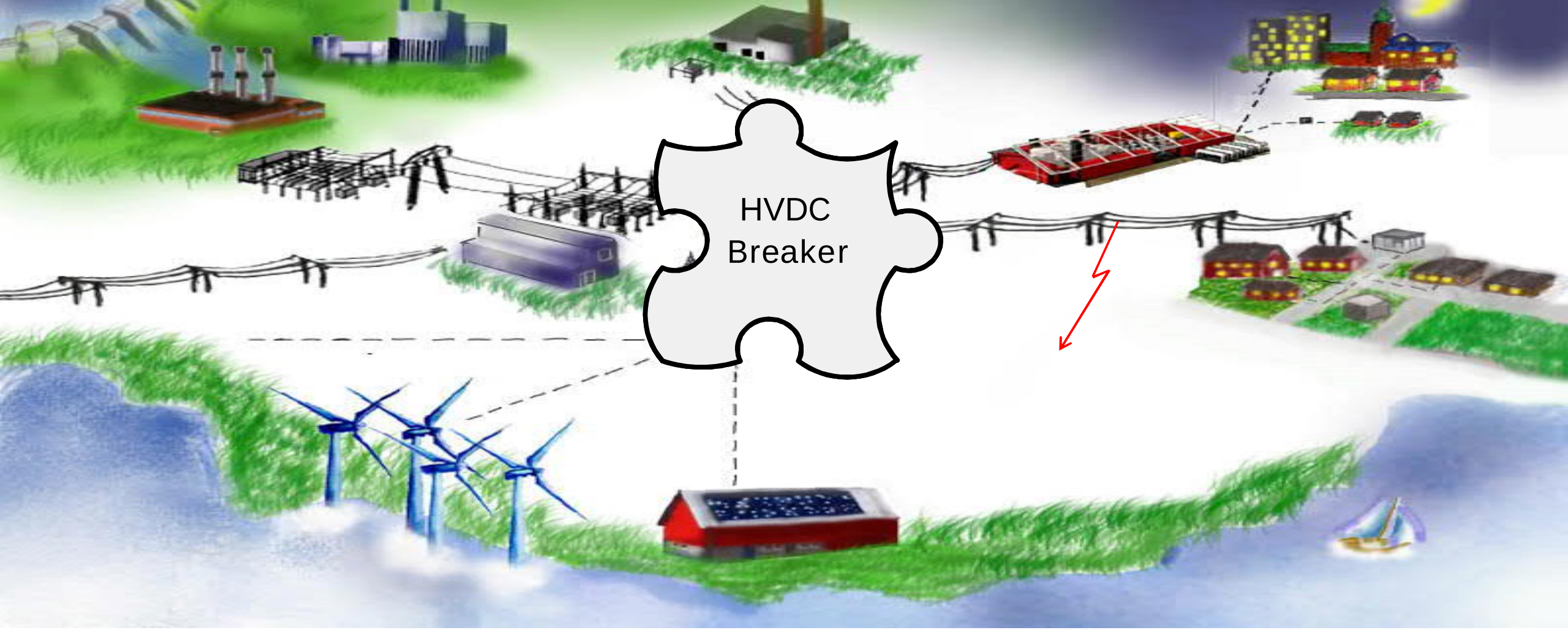


PROMOTION DC CIRCUIT BREAKERS AND DC GRID PROTECTION WORKSHOP, 27TH SEPTEMBER 2019

Hybrid HVDC Breaker

Semere Mebrahtu, R&D Test Engineer of HVDC circuit breaker, ABB Power Grids - HVDC

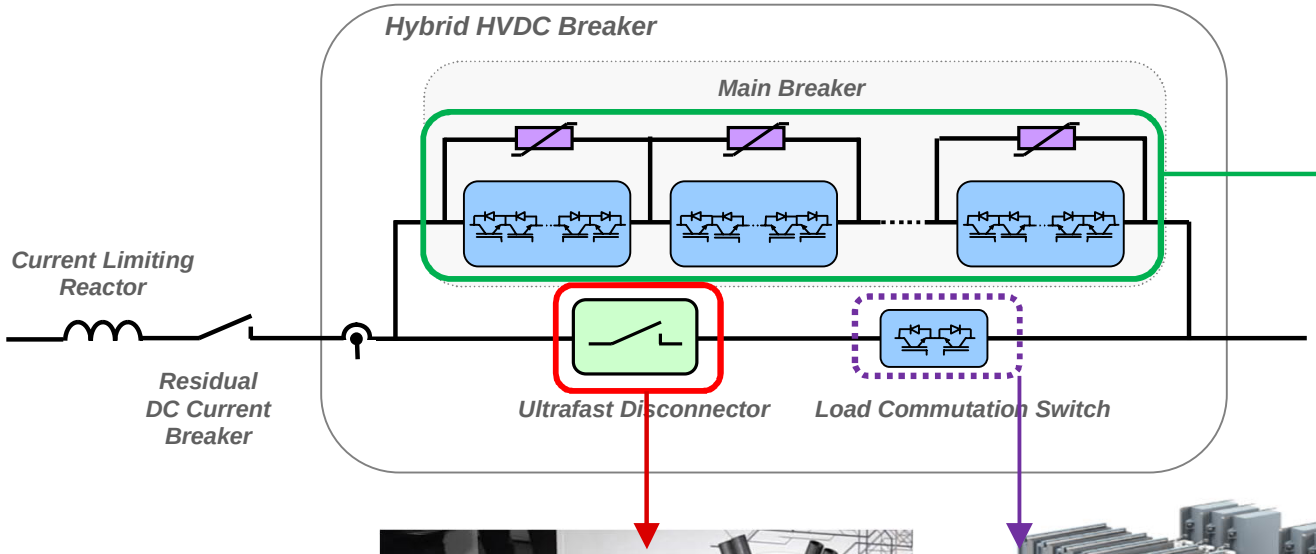
Hybrid HVDC Breaker

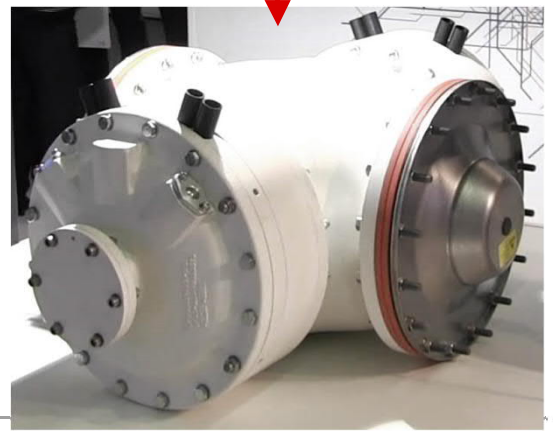
Agenda

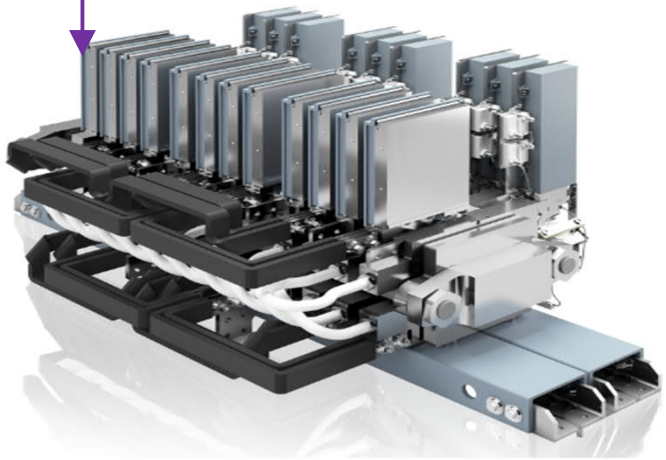
- Introduction
- Current updates on Hybrid HVDC Breaker
- Technology readiness level of Hybrid HVDC Breaker
- Questions

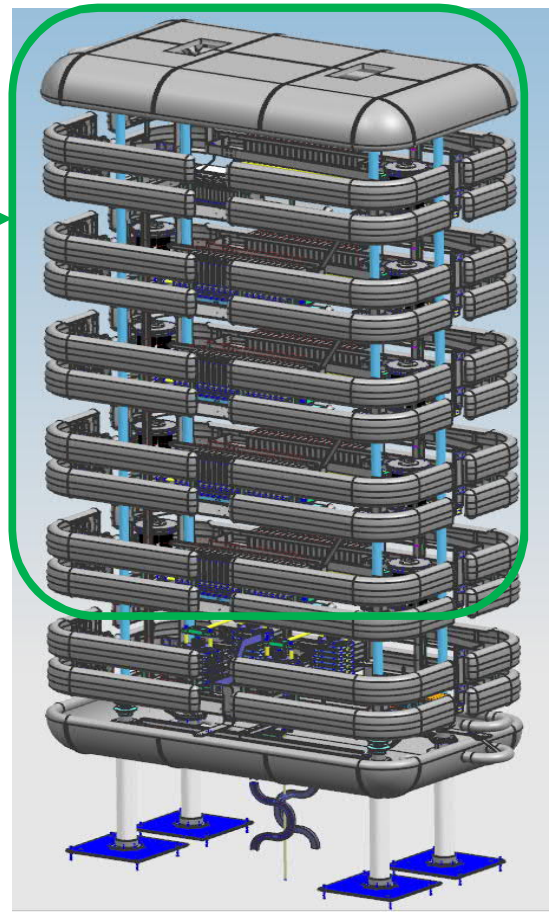
Hybrid HVDC Breaker

Main functional units (350kV)







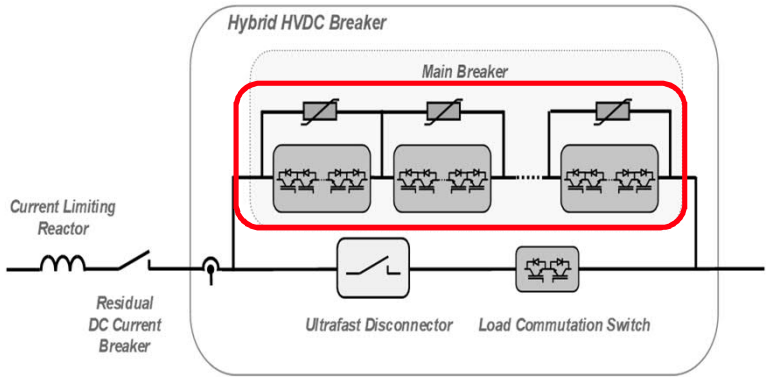


Hybrid HVDC Breaker: Main Breaker Structure

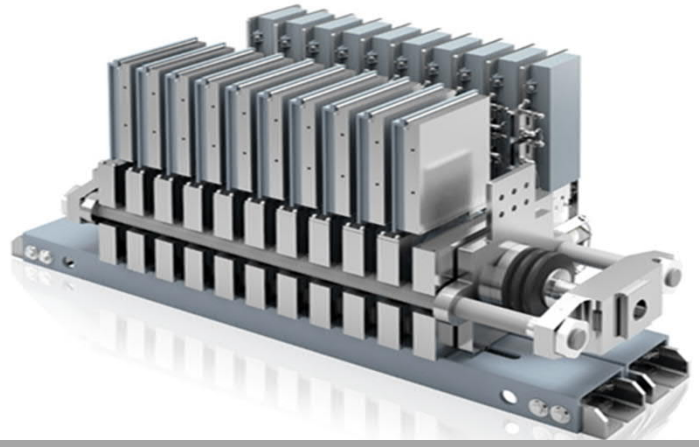
Required functional features:

- Able to break fault current without “delaying” the overall breaking time
- Provide enough voltage to commutate the current to surge arrester
- Block the voltage until the fault current goes to zero & residual current breaker opens or receives a command

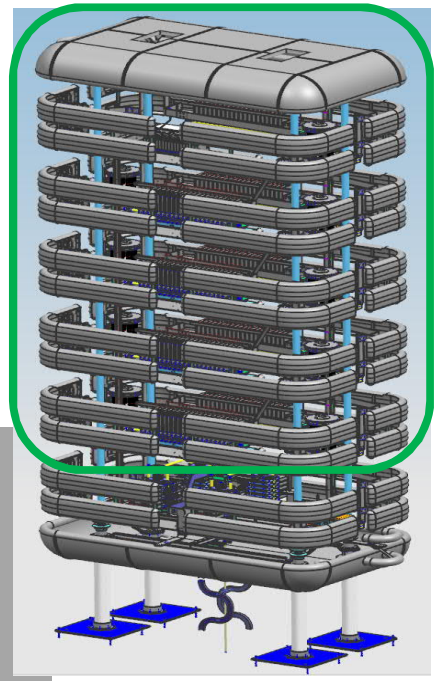
System



Main Breaker Stack



Main Breaker Structure



The Main Breaker design features includes:

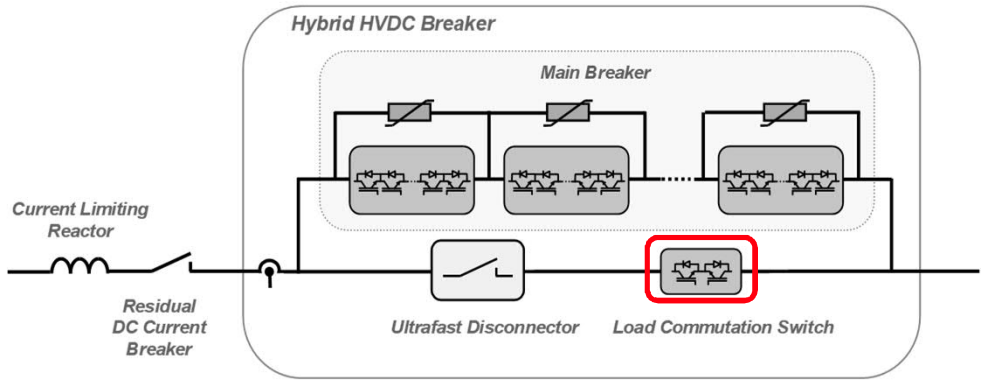
- Compact & reliably designed switching devices
- Snubber circuit ensures uniform voltage distribution
- Optically Power “Gate Units" independent of "DC Breaker" operation features

Hybrid HVDC Breaker: Load Commutation Switch Structure

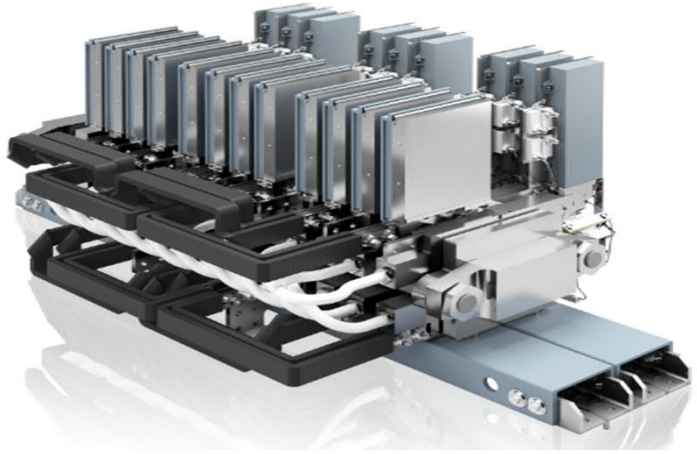
Required functional features:

- Low losses during on-state
- Provide enough voltage to commutate the current to MB
- Block on-state voltage of the MB until UFD opens.

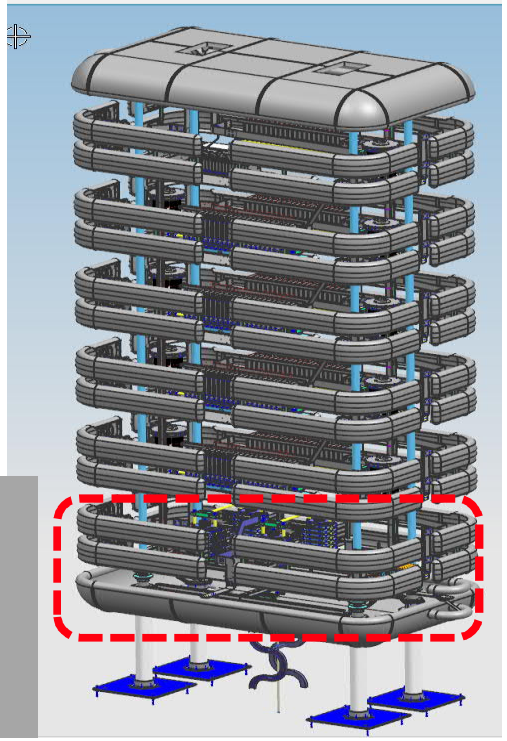
System



LCS Stack



LCS Cell



The LCS design features includes:

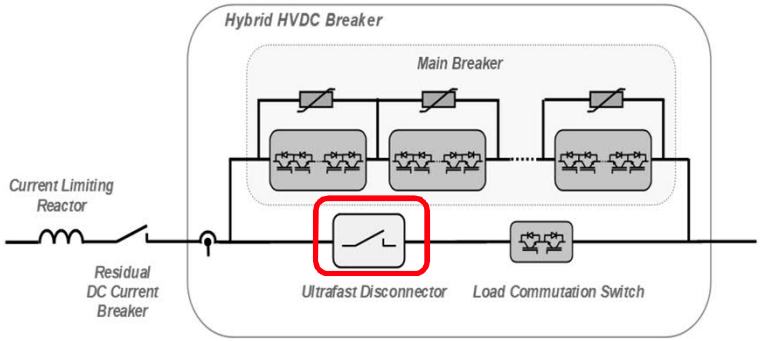
- Compact & reliably designed Stakpak switching devices connected in matrix form
- Snubber circuit ensures uniform voltage distribution
- Optically Power “Gate Units" independent of "DC Breaker" operation

Hybrid HVDC Breaker: UFD structure

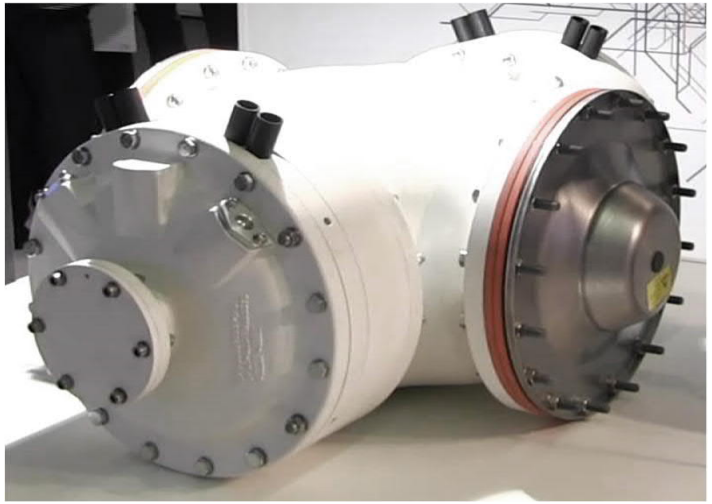
Required functional properties

- Low losses in closed state
- High opening speed
- Fast increase of insulation strength to withstand the voltage during current interruption
- Number of operations. Electrical and mechanical endurance.

System



UFD Chamber

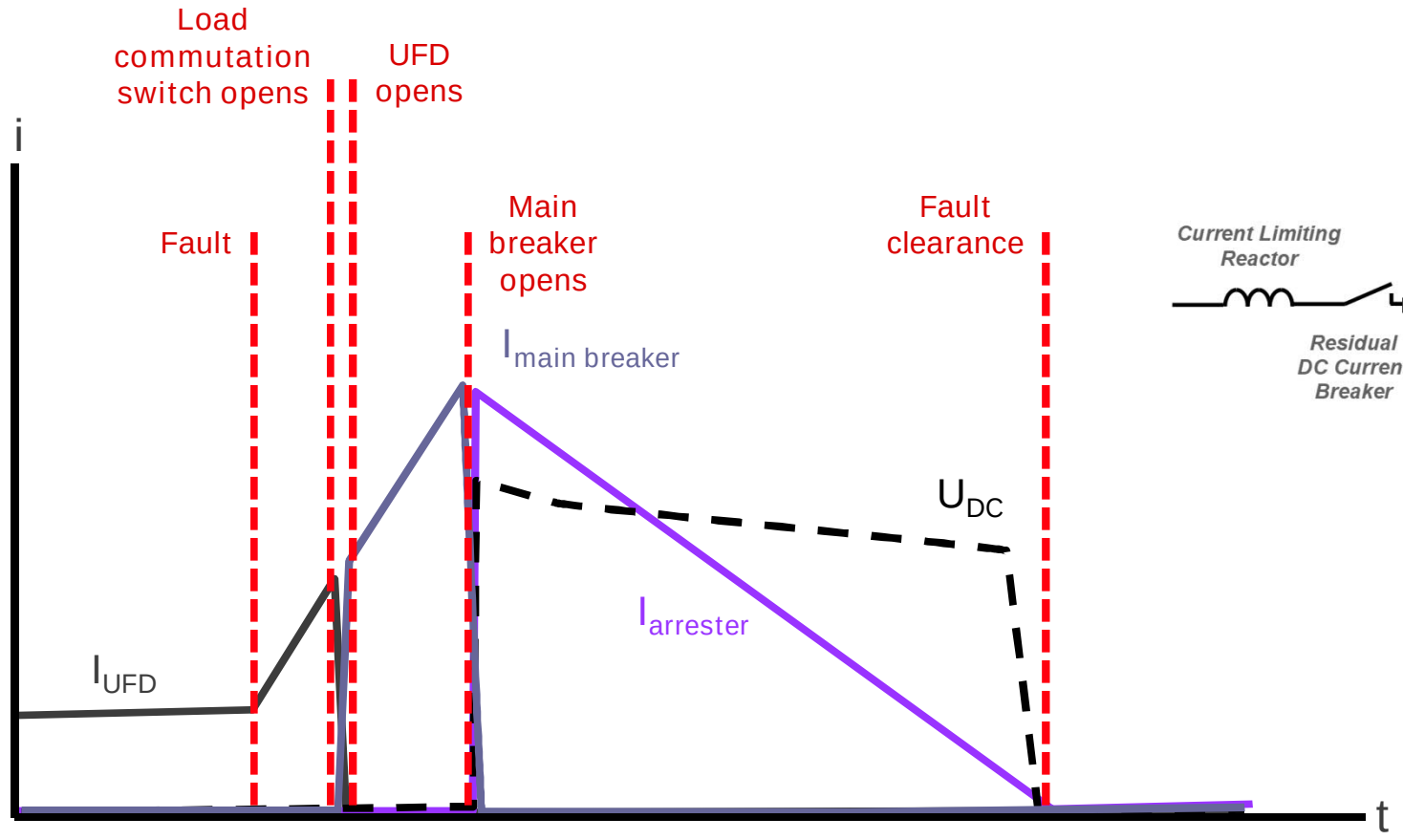


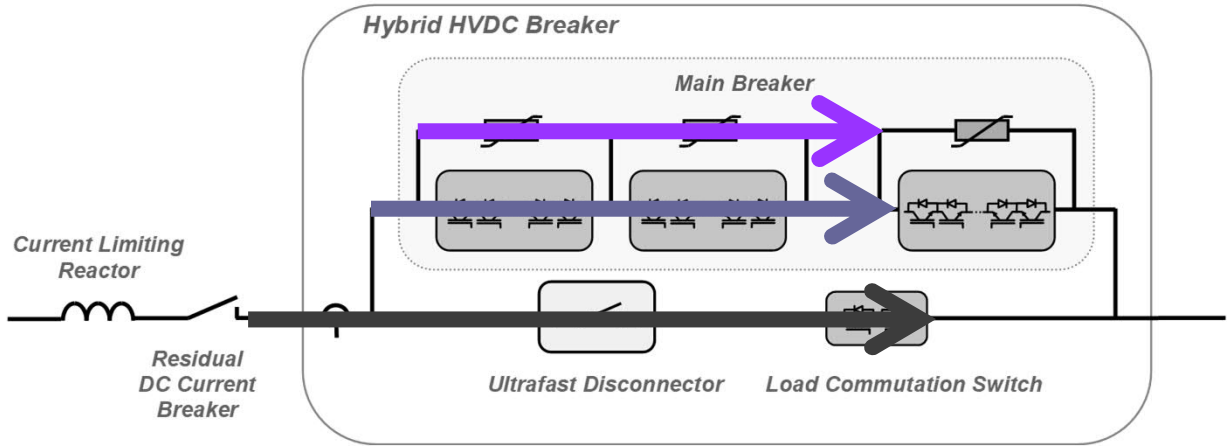
UFD structure

Ultra-fast mechanical disconnector (UFD) is a single unit based on a known gas-insulated switchgear technology

Hybrid HVDC Breaker

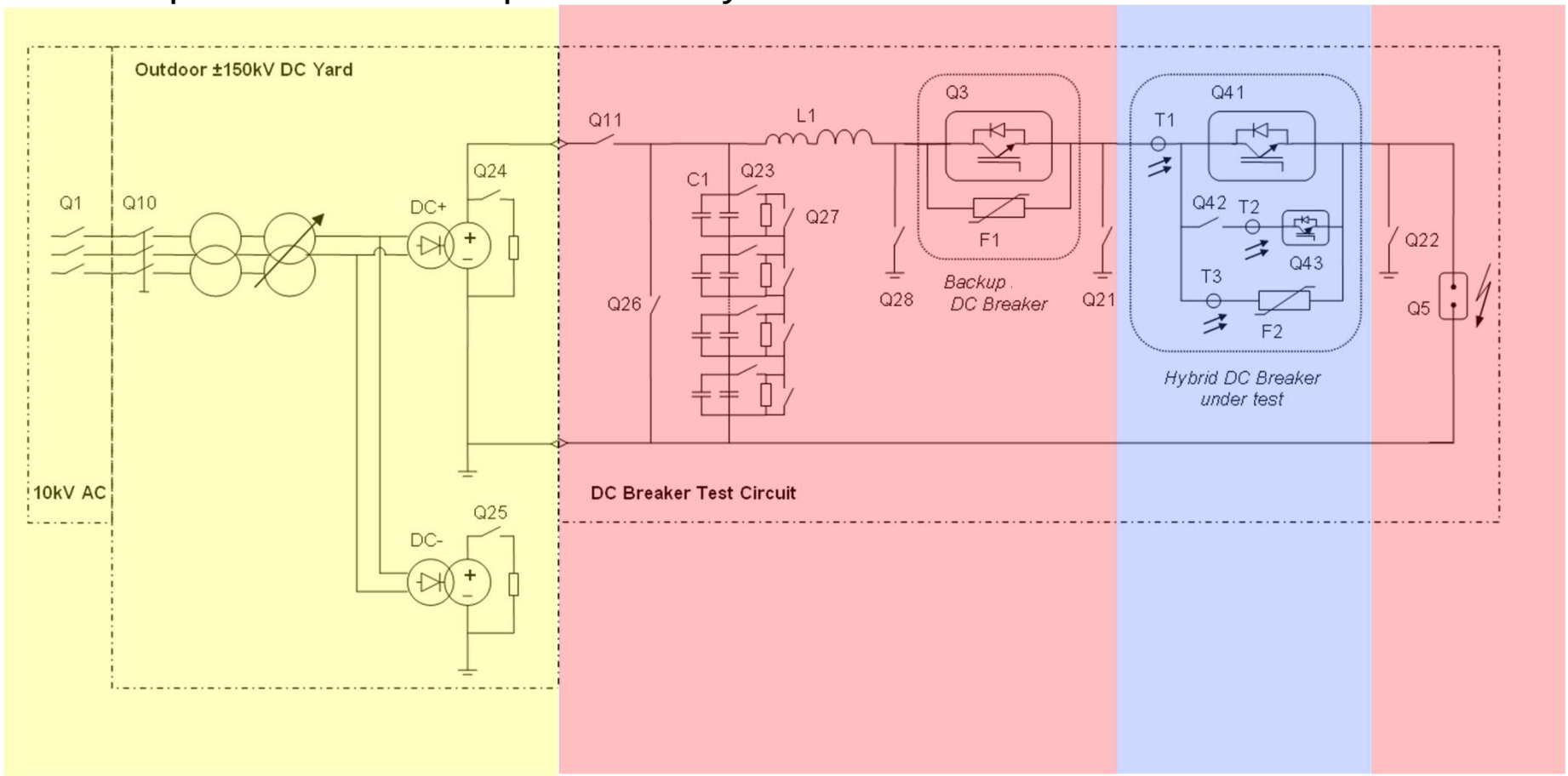
Breaking timeline





Hybrid HVDC Breaker

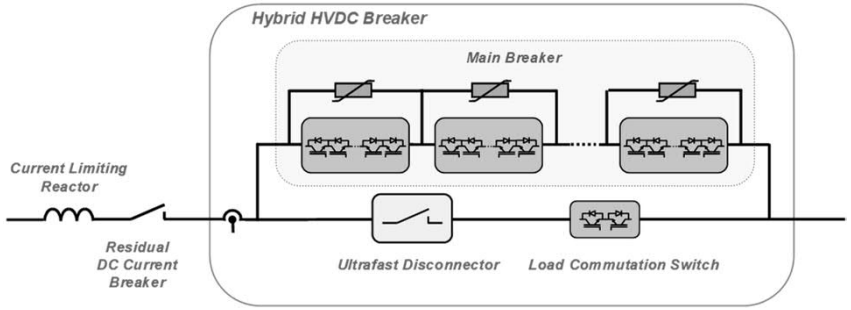
Test circuit used for operational development of Hybrid HVDC Breaker



Power feeding circuit | Pulse generation and protection | Device under test

Hybrid HVDC Breaker

Test program followed during concept verification



Component tests

Component tests includes

- Limit tests, endurance tests
- E.g. Semiconductors switches, Gate drive units, Snubber components
- Position tests

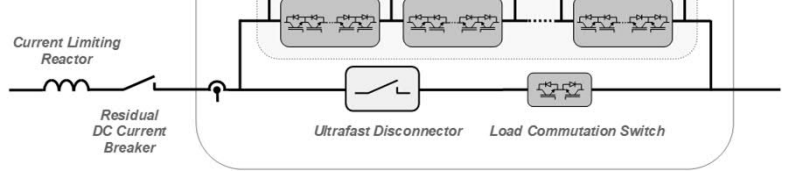
Subunit tests

Subunit tests includes
Operational test for each of the functional units
→ E.g. Ultra-fast disconnector, Main Breaker, Load Commutating Switch etc.

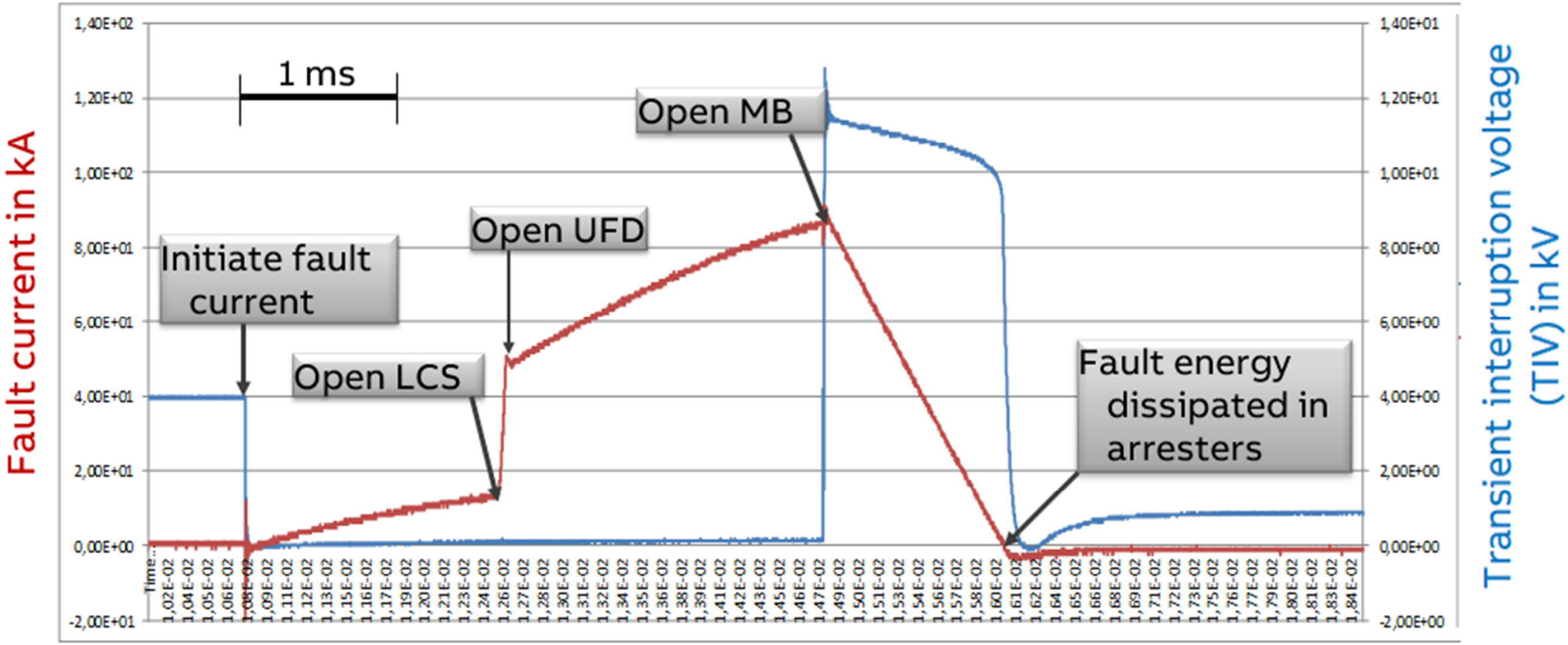
System tests (80kV)

Hybrid HVDC Breaker system tests includes
Operation principles of Hybrid HVDC Breakers
→ Breaking operations
→Operation of the control and protection system
→Factory system test (FST) on overall control system (MACH system)

Hybrid HVDC Breaker



Tests results from the concept verification tests



Hybrid HVDC Breaker

Planned concept test at KEMA and it’s purpose

The upcoming test on Hybrid HVDC Breaker demonstrates

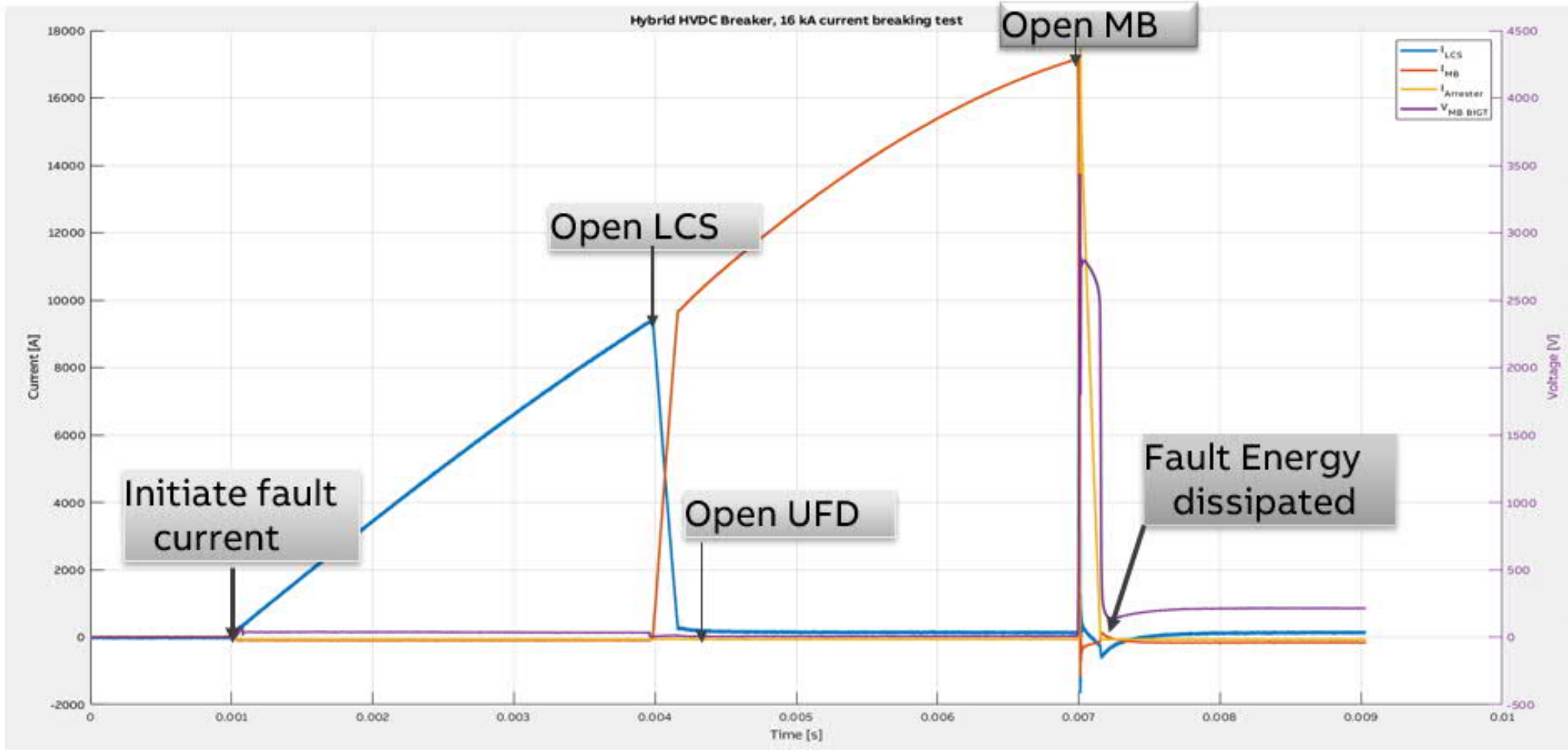
Hybrid HVDC Breaker system functionality (350kV)

- To check the adequacy of the Hybrid HVDC Breaker and associated electrical circuits in the Breaker with regard to current, voltage and energy stresses and demonstrate performance of the Hybrid HVDC Breaker at system level.
- To confirm the capability of surviving /suppressing the designed peak fault current and system voltages, including overvoltage due to loop inductance.
- Adequacy and reliability of the included control and protection system
- Distribution of stresses, in particular with the voltage division within cells

To withstand system voltage after the fault suppression.

Hybrid HVDC Breaker

Current and expected test results



Hybrid HVDC Breaker

Concept verification

Verified concept (80kV)

Peak current: 9 kA

Internal current commutation time: < 3 ms

Rated voltage : 80 kV

Planned concept at KEMA tests (350kV)

Peak current: 16 kA

Internal current commutation time: < 3 ms

Rated voltage : 350 kV (System voltage)

Increase parameter ratings

Hybrid HVDC Breaker

The technology readiness level, TRL

TRL with regard to Hybrid HVDC Breaker

- The technology has been ready since 2012 → when ABB publicly announced Hybrid HVDC Breaker.
- →Show stopper for the realization of DC-grid

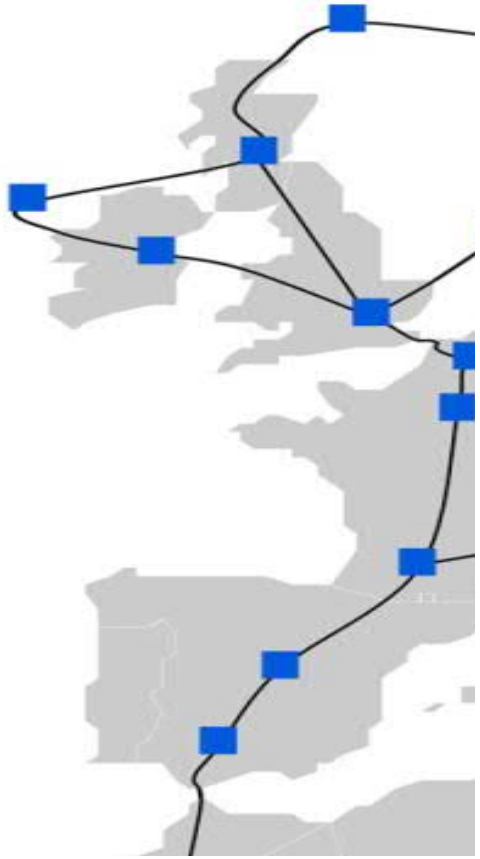
Investment readiness level, IRL

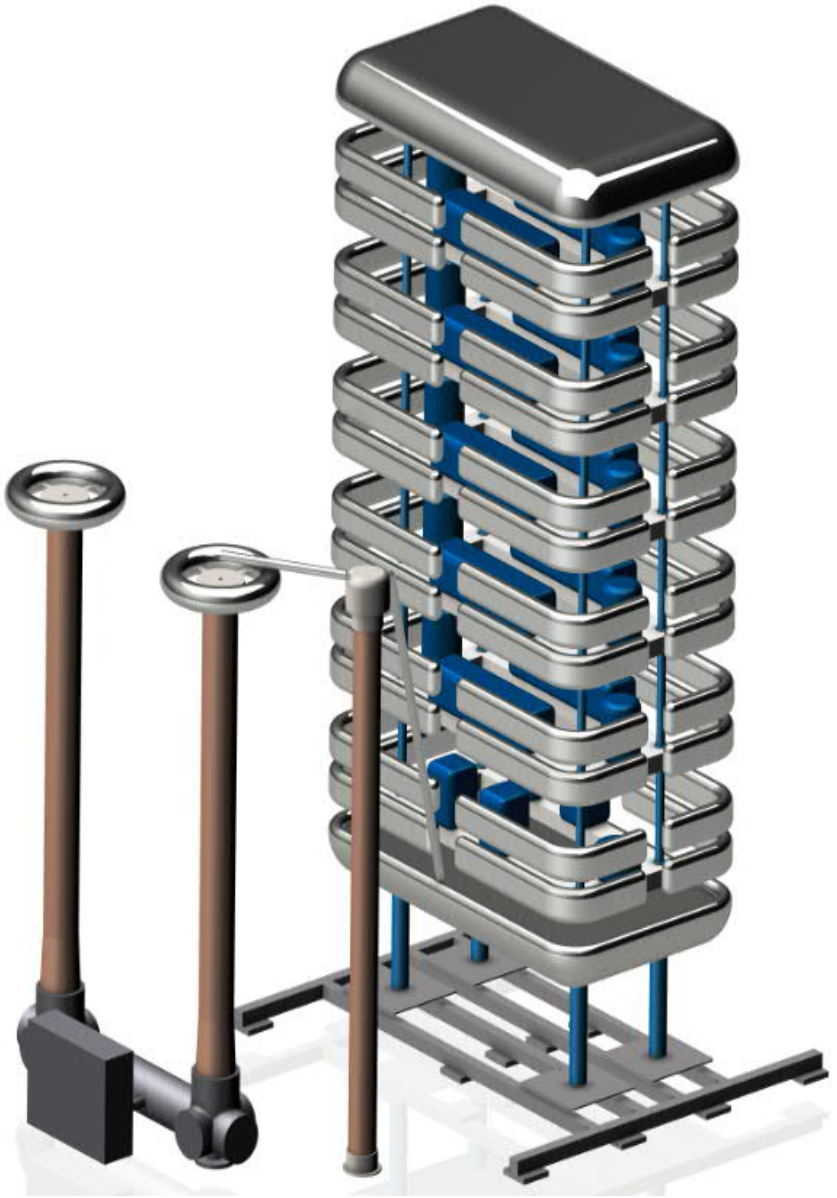
- The market readiness for the deployment of HVDC Breaker technology is still an issue.
- Global rules/regulations for operation multi terminal HVDC network required for market acceptance

Hybrid HVDC Breaker

Technology readiness level, TRL

HVDC- Grid is not a vision anymore, thanks to the technical developments of Hybrid HVDC Breaker !!





Thank you & Questions?