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PROMOTioN Testing Event, February 2020, Arnhem, Netherlands

# ABB Hybrid HVDC Breaker

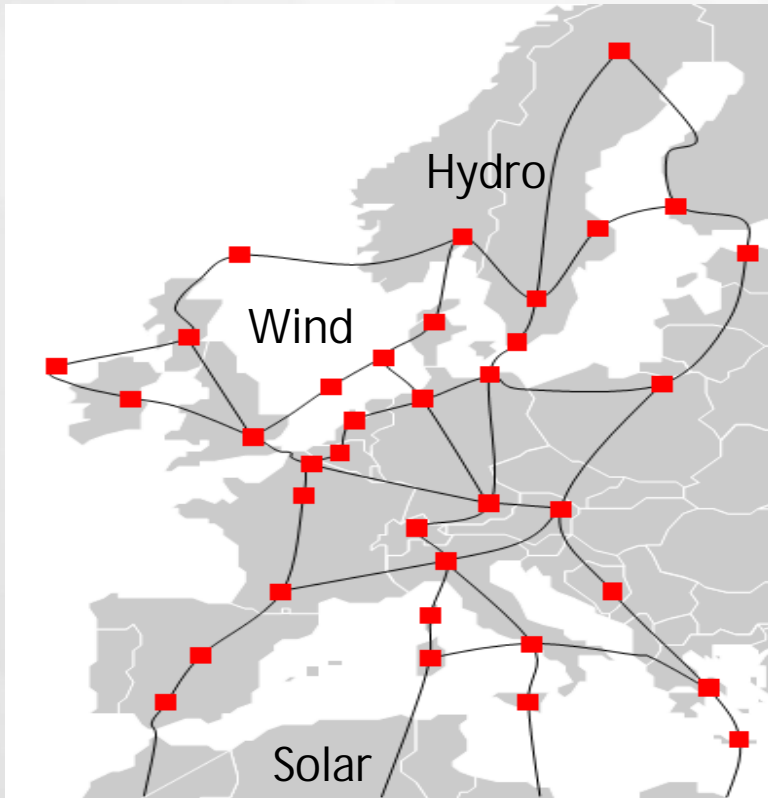
Dr. Arman Hassanpoor, HVDC R&D Manager – Grid Integration - ABB (China) Ltd.



# HVDC Breakers

## Enabler of future grid vision

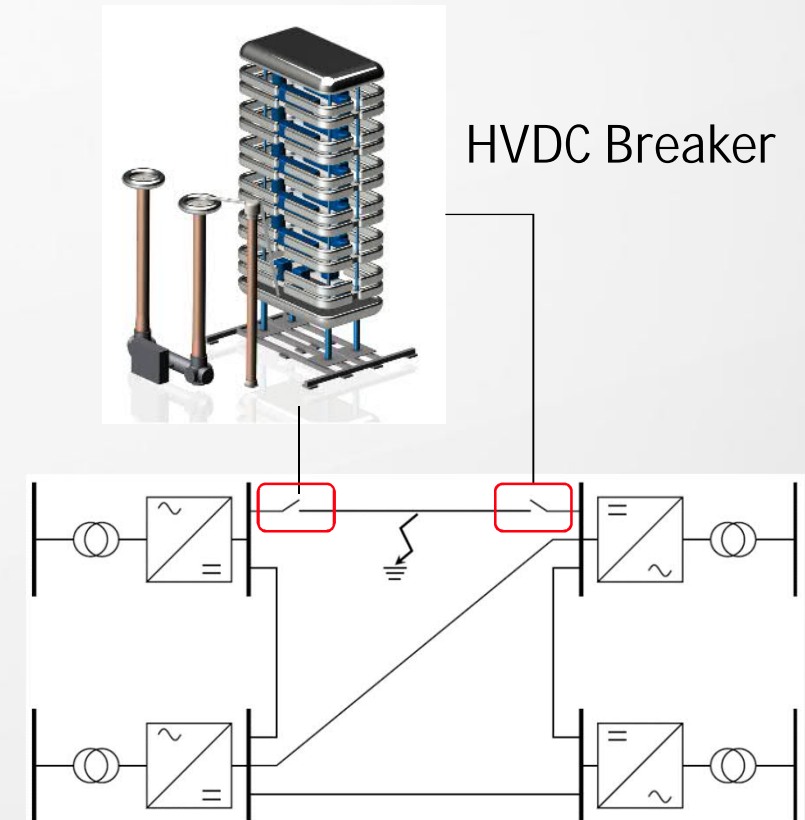
### Super Grid Vision



### Benefits

- Enables integration of remote renewables
- Greater energy efficiency
- Increased availability and security of supply.
- Lower losses than several point to point connections
- Low cost e.g. fewer converters

### Enabler





# HVDC Breakers Challenges

## Reliability

- Conducting load power continuously.
- built-in reliability vs. additional breakers. (ac breaker and half configuration).
- Based on established technology.



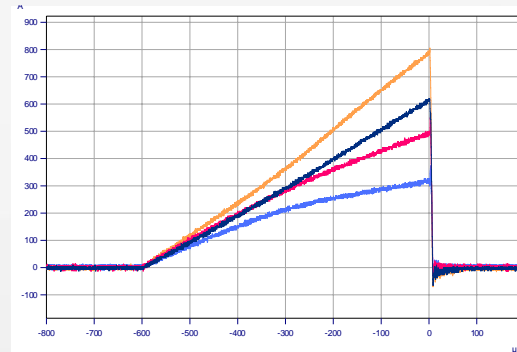
## Footprint

- Maintainability.
- Safety and installation.
- Compact design suitable for offshore requirements.
- Seismic requirement.



## Speed

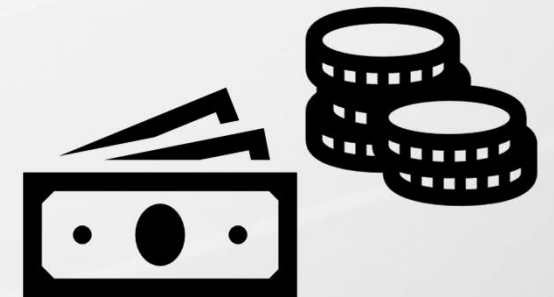
- Low damping in HVDC results to rapid current rise.
- Higher stresses, higher voltage and higher energy to dissipate.
- The faster the better.
- 60 times faster than a blink of an eye.



## Cost

Compromise:

- Reliability
- Footprint
- Speed
- Availability
- Maintainability



# Headlines

## ABB Hybrid HVDC Breaker!

Home / Industry News / 2013 / MIT Technology Review Names ABB HVDC Among Top 10 Technologies

Fieldbus

### MIT Technology Review Names ABB HVDC Among Top 10 Technologies

Source: ControlGlobal.com

Apr 25, 2013

ZURICH – ABB has been recognized by the *MIT Technology Review* for its hybrid high-voltage direct current (HVDC) breaker, placing it among the ten most important technology milestones of the past year. This is an annual list highlighting the top ten breakthrough technologies the editors believe will have the greatest impact on the shape of innovation in the years to come.

### ABB Solves the Code on DC Breaker

Swiss-based ABB Inc. feels the development of a new DC breaker shape the energy grid of the future.

Author — Grant Gerke

Nov 7th, 2012

©ABB

s names ABB as a Top 100 Global Innovator

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Image Copyright: Michael Buholzer, ABB

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11/08/20

Thomson Reuters recognised ABB, the leading power and automation technology group, as one of the world's top 100 innovators, honoring ABB's commitment to drive innovations, commercialisation and intellectual property protection.

VÄNNER  
runnit för bränder  
ela sitt vuxna liv.  
hyler Benny Stern  
berg 60 år.  
DEL 2 SIDAN 14

Ex- m  
rad vind-  
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v till kust  
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är möjlig.

länder och kontinenter, ba-  
lansera laster och stärka  
behäftliga växelströmsnät,  
säger Olof Heyman.

nyelsebar energi. HVDC  
behövs för t ex utveckling-  
en av framtida visionära  
solkradsprojekt.  
✓ ABB satsar mer än 6 mil-  
jarder kronor årligen i

✓ Världens första hög-

ABB

# ABB Hybrid HVDC Breaker Development outline

## Development Outline

- 2009  
(320kV)
- conceptual design
  - Component tests
  - Dead-tank UFD

- 2012  
(640kV)
- LCS tests
  - Live-tank UFD
  - Functionality tests

- 2014  
(500kV)
- BIGT verification tests
  - Plant design

- 2017  
(535kV)
- High power requirements
  - Standing design

## 2020 PROMOTioN (350kV)

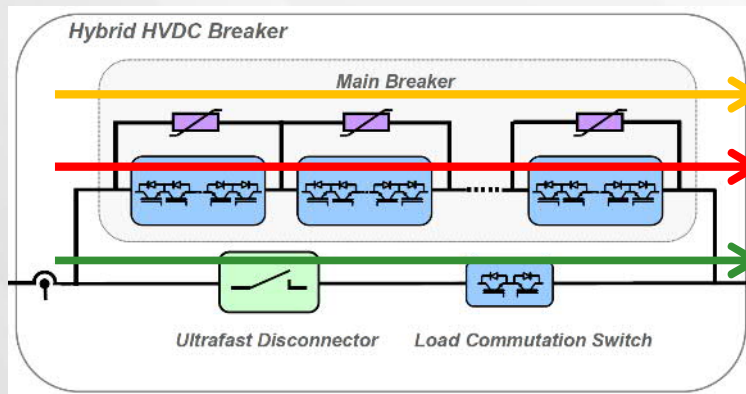
- Full-scale prototype
- Full control functionality
- Prove of modularity
- Full-scale component stresses
- Product level assembly prove

# ABB Hybrid HVDC Breaker

## Operation principle

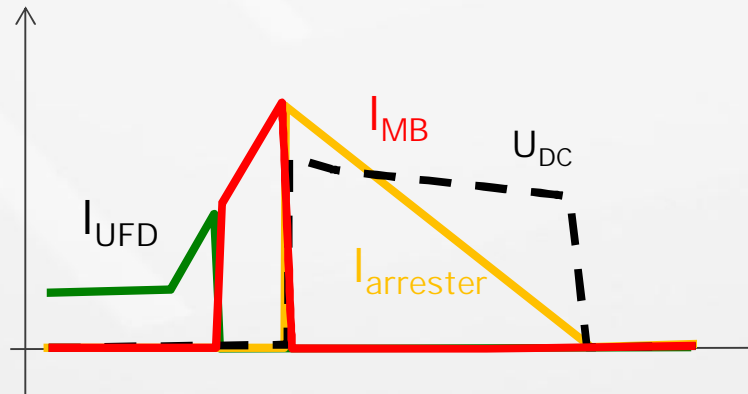
### Schematic Diagram

- Conducting mode: Current flows in low-loss branch
- Proactive control:
  - LCS opens,
  - UFD opens with time delay
- Fault clearance:
  - Main Breaker opens
  - fault current into arrester bank

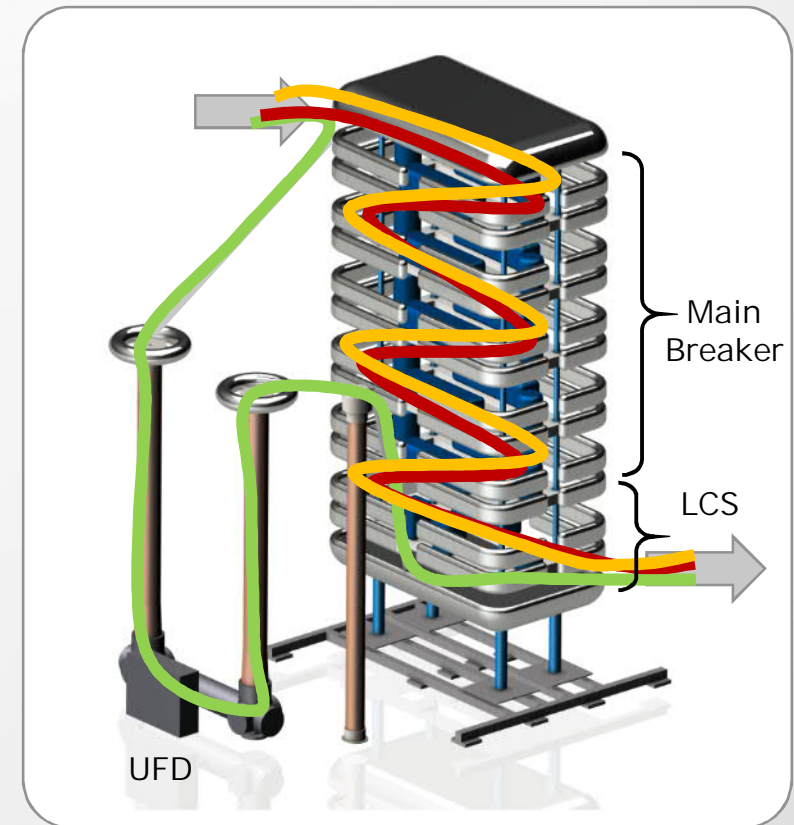


### Operating Principle

- Conducting mode: Load current flow
- Proactive control mode: fault current will be commutated to Main Breaker branch.
- Fault Clearance mode: fault current will be commutated to energy absorption branch.



### KEMA Test Object



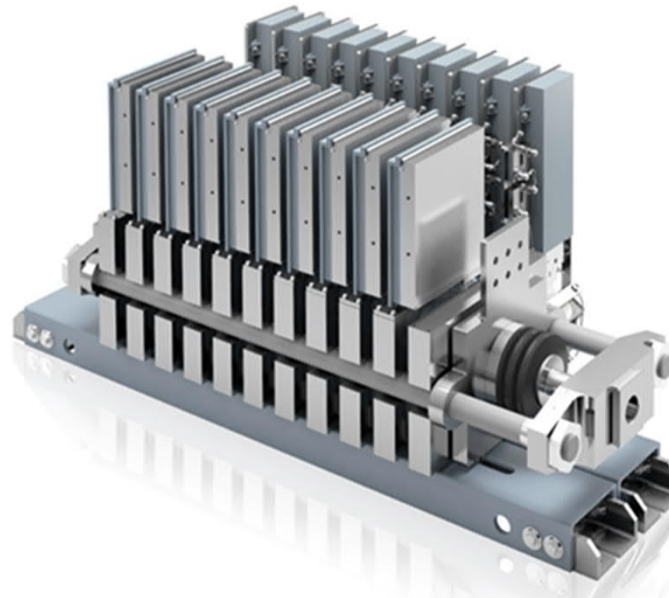


# ABB Hybrid HVDC Breaker Main Breaker Design

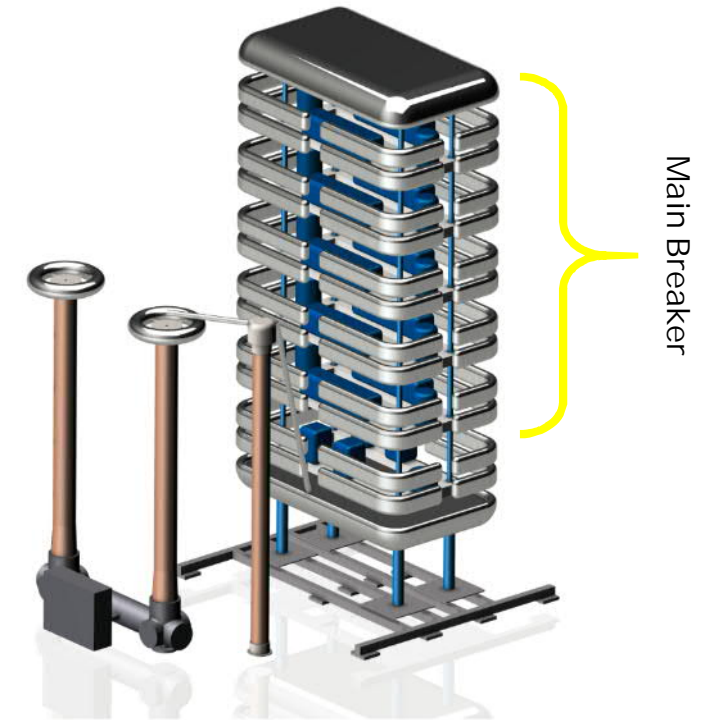
## Design Features

- Compact design with reliable Stakpak BIGTs.
- Snubber circuit ensures uniform voltage distribution.
- "Gate Units" with fiber optical drives provide an independent operation.
- Integrated arrester banks.
- Open blocks for better heating dissipation

## Main Breaker Stack



## Main Breaker Cells

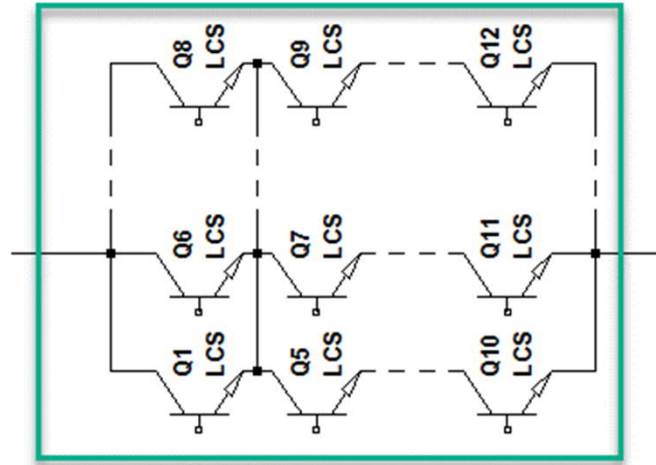


# ABB Hybrid HVDC Breaker Load Commutation Switch

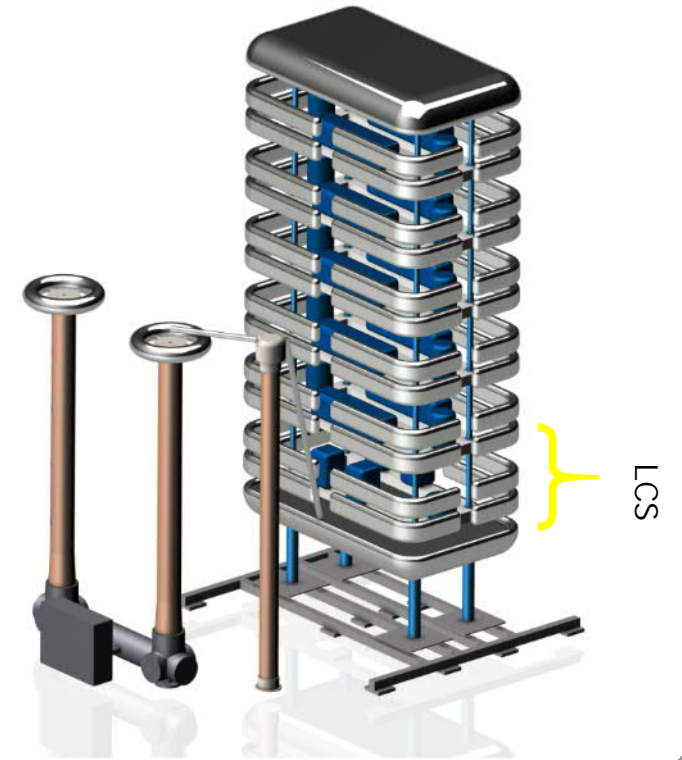
## Design Features

- In-built redundancy
- Scalable design:
  - Parallel stacks to increase current capability
  - Series BIGTs to increase voltage capability
- >13kA current interruption capability
- Even current/voltage distribution

## LCS Stack



## LCS Cell



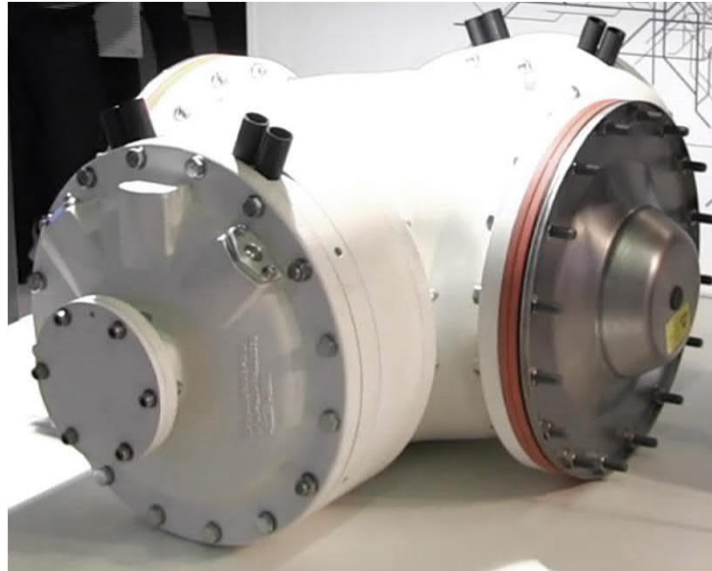


# ABB Hybrid HVDC Breaker Ultra Fast Disconnecter

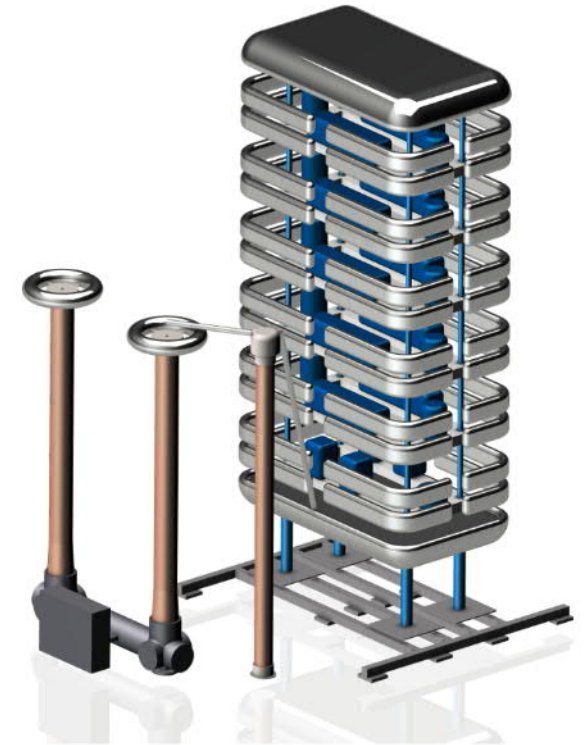
## Design Features

- Dead-tank fast mechanical switch based on a known gas-insulated switchgear technology
- Multiple overlapping contacts with double motion and dual current path
- High current carrying capability
- Fast residual current interruption after contact separation.
- Fast build up of dielectric withstand (double motion).

## UFD Chamber

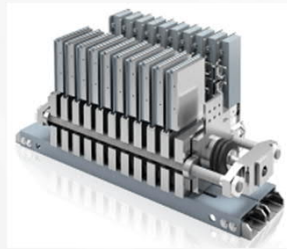
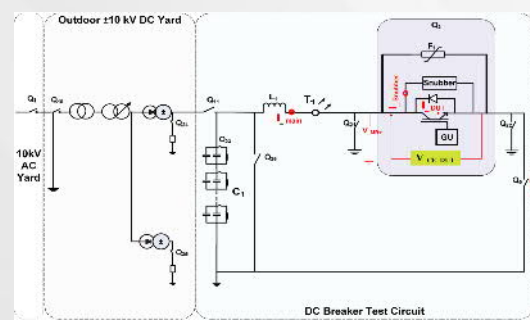


## UFD Unit

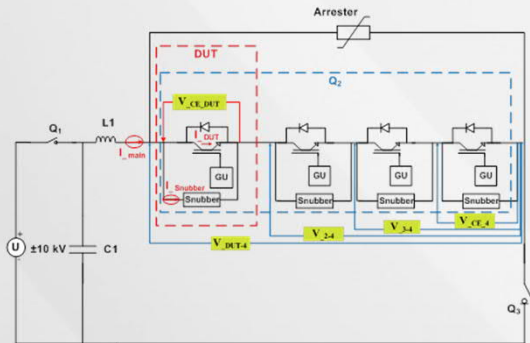


# ABB Hybrid HVDC Breaker Component tests

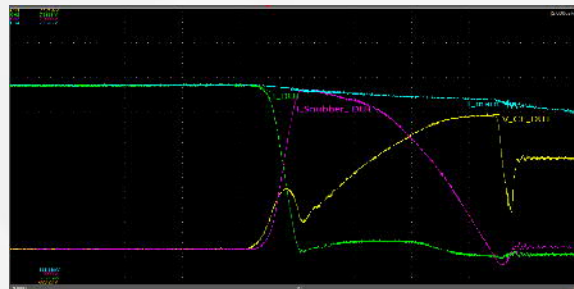
## Tests on breaking capability



Stack test 16kA



BIGT single device test 25kA

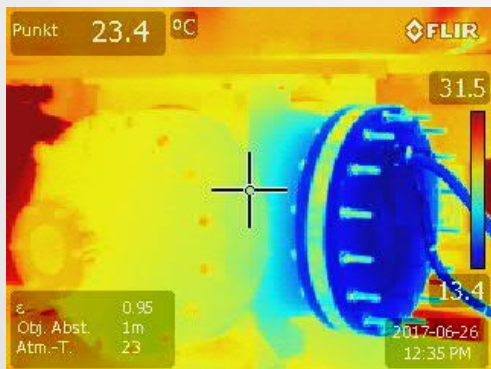


## Technical Data

- Current interruption test:
  - Single device (9kA, 16kA, 25kA, 30kA)
  - Stack (9kA, 16kA)
- Voltage sharing test
- Snubber verification test
- Temperature rise test
- Counter voltage capability test
- Failure mode test

# ABB Hybrid HVDC Breaker Ultra Fast Disconnecter tests

## Tests on UFD



## Technical Data

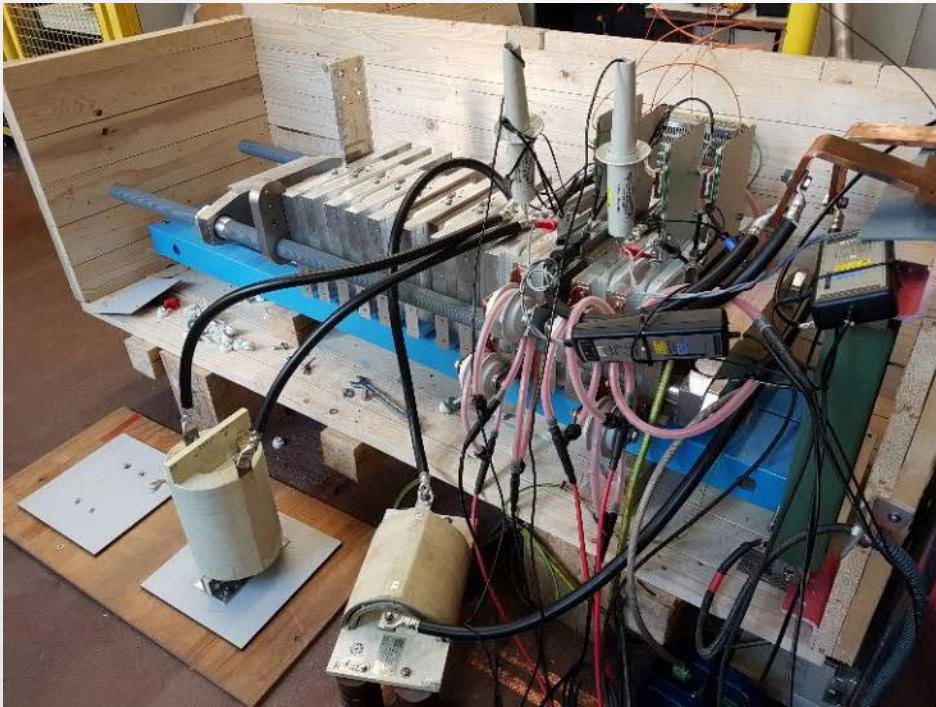
- Dielectric test
- Temperature rise test
- Endurance test for 2500 operation along with current interruption
- Power test after endurance test
- Operation time
- Short time current test



# ABB Hybrid HVDC Breaker

## Load Commutation Switch tests

### Tests on load commutation switch



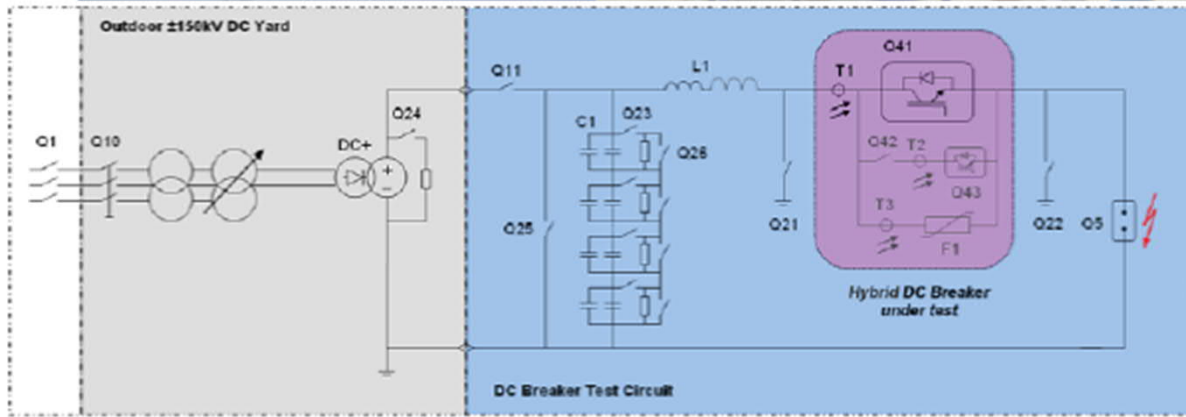
### Technical Data

- Current sharing tests
- Voltage sharing tests
- Failure modes
- Turn-off capability up to 13kA

# ABB Hybrid HVDC Breaker

## System level tests

### System Tests



### Technical Data

#### Functionality tests

- Interrupting 9kA and 16kA to ensure the commutation and interruption capability

#### Failure mode tests:

- Ensure safe operation in different failure modes e.g. failed BIGT in main breaker stack

# ABB Hybrid HVDC Breaker

## Dielectric tests

### Dielectric Tests



Live-tank UFD 500kV dielectric test

### Technical Data

#### Dielectric tests on UFD:

- Dielectric test on live tank UFD structure 500kV terminal to terminal
- Long-time withstand dc capability
- Full TIV withstand test after residual current interruption opening

#### Tests on standing structure:

- Switching impulse test to ground on standing structure



# ABB Hybrid HVDC Breaker Summary

## Design Features

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- StakPak BIGT module
- BIGT failure rate is low. Small risk for LCS and MB.
- BIGT uses reliable and tested gate unit
- UFD uses energy storage at potential and CT/VT as charger
- Easy maintenance access due to separate structures of components.
- Self protection of HHB is important for reliable operation of DC grid

## Advantages

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- Designer of HHB is also developer of BIGT and GIS.
- BIGT developed for Power Transmission
- Full understanding of BIGT and GIS features.
- Supplier with System knowledge
- No commutation capacitor in HHB
  - Less fire risk
  - Faster operation at all currents

# ABB Hybrid HVDC Breaker

## Global footprint

### Global Organization (what's the strength + experience from Light)

Sweden:

- Conceptual design
- Tests

Poland:

- Electronics development

Strong support from **ABB** global Corporate Research in: USA, Sweden, Switzerland, Poland, India, Germany and China

Switzerland:

- UFD development
- Semiconductor development

China:

- Project management
- Mechanical design

India:

- System development

Utilizing the power of whole global **ABB** footprint worldwide

**ABB**