2018 CIGRE SESSION

HVDC BREAKER EXPERIENCE IN SGCC

SC A3 Technical Panel on "HVDC circuit breakers“

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国家电网
STATE GRID

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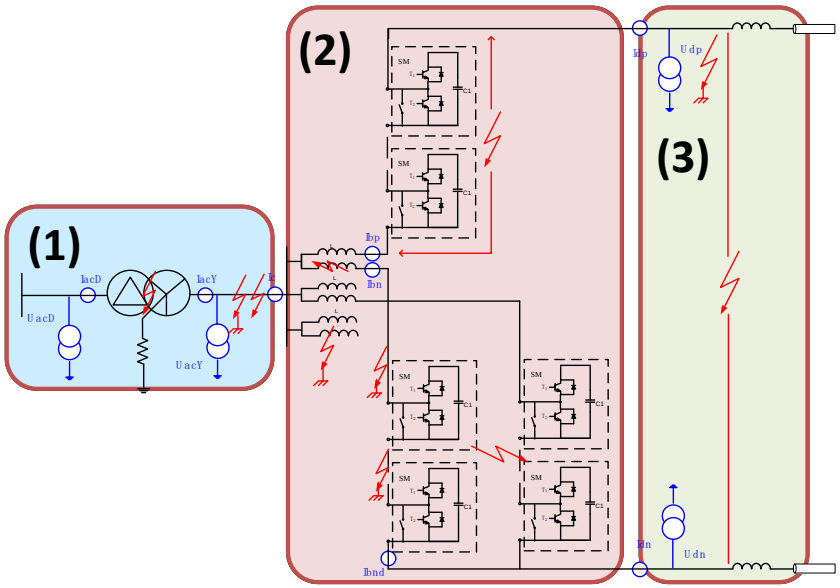
NEEDS & REQUIREMENTS

MT-HVDC systems & DC Grids

(1) Faults in the AC side of the I/T

(2) Faults within converter valves

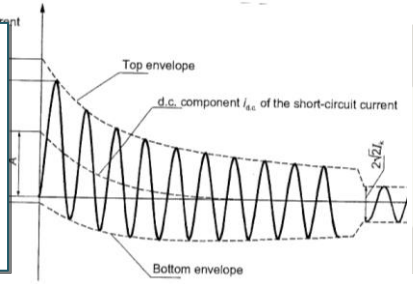
(3) DC faults

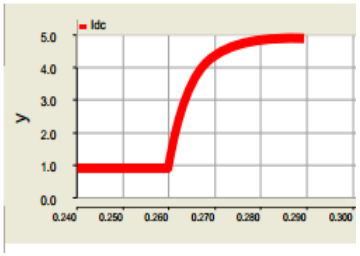


3 challenges faced by HVDC Circuit Breakers

- How to interrupt a DC current without zero crossings ?
- How to interrupt a DC current within very short period (2-3ms) to protect PE devices & prevent spread over of faults ?
- How to limit overvoltages and dispose the energy stored in the system ?

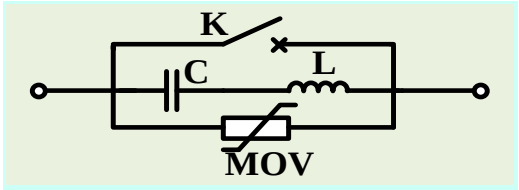
- ✓ Zero crossings vs No zero crossings
- ✓ Higher vs lower impedance
- ✓ Amp decays vs rises quickly





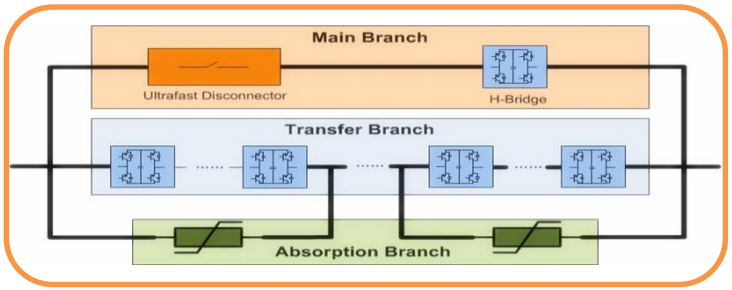
TYPES OF DC CIRCUIT BREAKERS

Mechanical DC Circuit Breakers



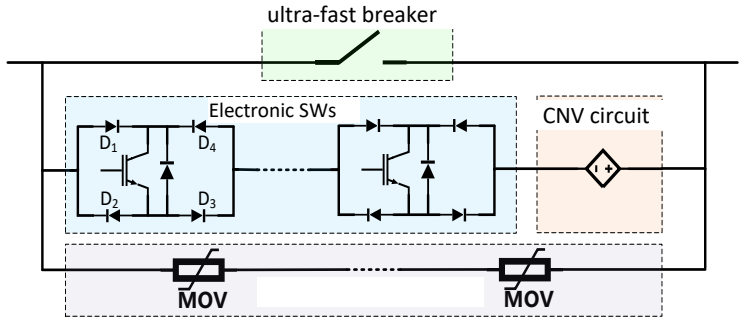
- Zero-crossings created via LC circuit
- Arc interrupted: long breaking time with low on-state losses

Hybrid DC Breakers



- Formed by ultra-fast mechanical AC disconnector & semiconductor switches
- Low on-state losses & fast break features

CNV Hybrid DC Breakers



- Inject opposite DC current by coupling neg. volt (CNV) circuit
- UFB arc interrupted at zero crossing, current diverted to electronic SW
- UFB needs to withstand transient V

APPLICATION OF DCCB FOR ZHOUSHAN

Zhoushan HVDC system

- ±200kV/1000MW
- 400/300/100/100/100MW
- DC cables
- Commissioned in July 2014
- Securing reliable power supply to five islands
- Integration of offshore WF

H DCCB

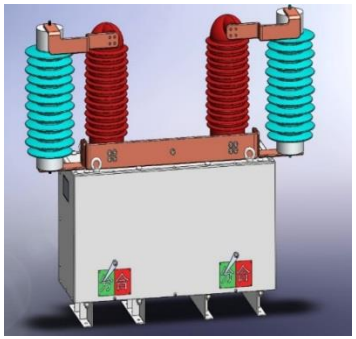
- 200kV DC breaker prototype developed by GEIRI in 2014
- Rated current: 2kA
- Max DC breaking current: 15kA
- Min breaking time: 3ms
- Max. energy to be absorbed: 4MJ
- Module design: 4*50kV

- **The max. P-P DC S/C at converter side of the DC CB: 10kA**
- **The max. P-E over-voltage under P-G fault: 400kV**

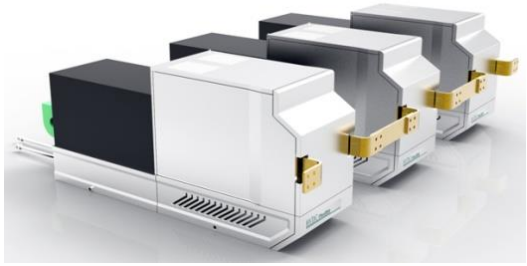
APPLICATION OF DCCB FOR ZHOUSHAN

- To clear the faults in the converter station
- To limit the fault current
- To maintain stable continuing operation
- To realize STATCOM mode under AC grid faults & DC side faults
- To achieve live switch on/off at Zhoushan terminal

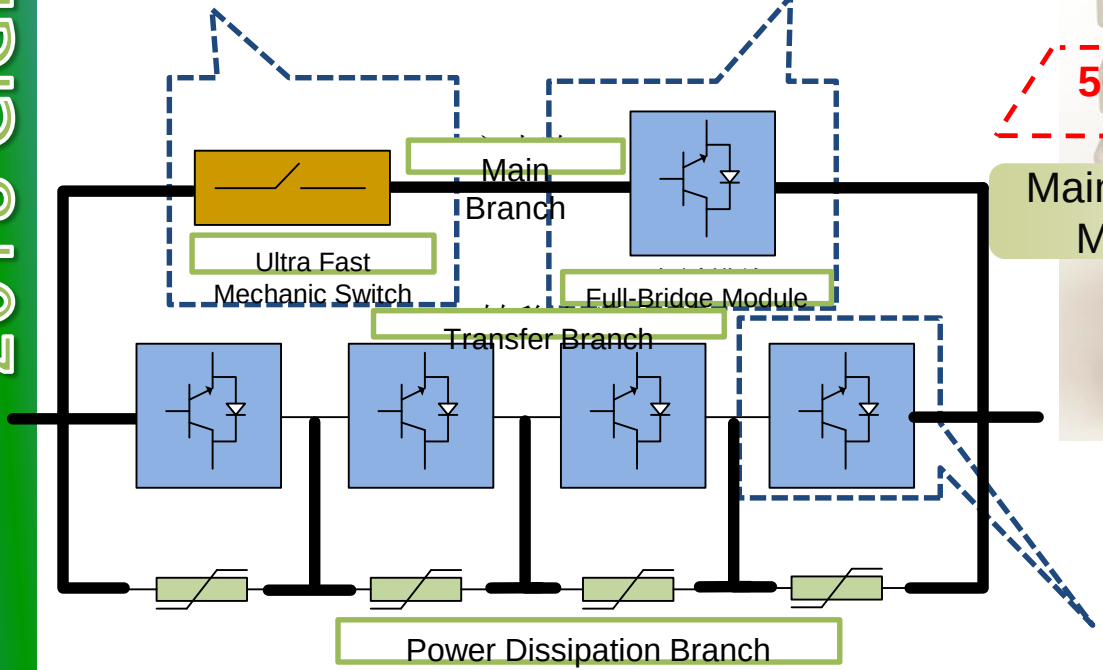
APPLICATION OF DCCB FOR ZHOUSHAN

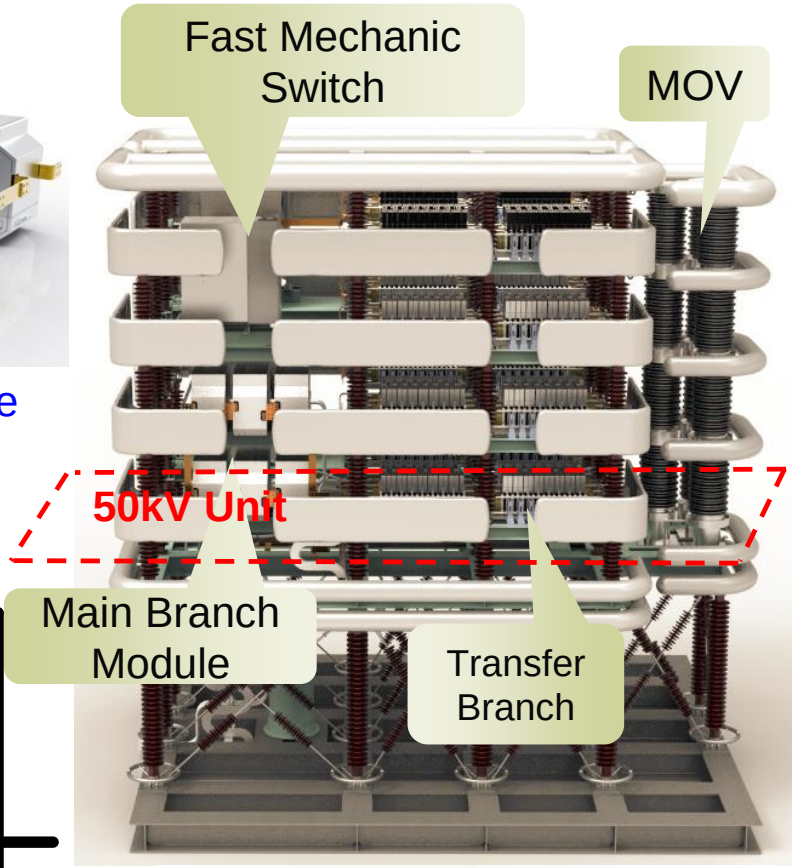


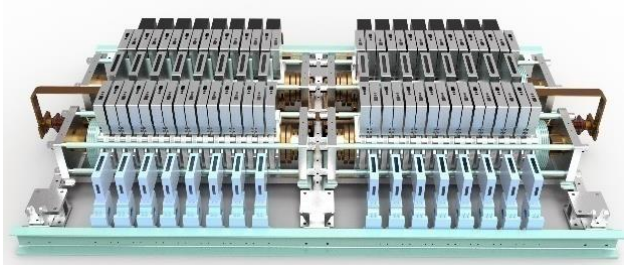
Fast Mechanic Switch



Main Branch Module







Transfer Branch Module

Successful installation of 200kV DC Breaker in 2016

APPLICATION OF DCCB FOR ZHOUSHAN

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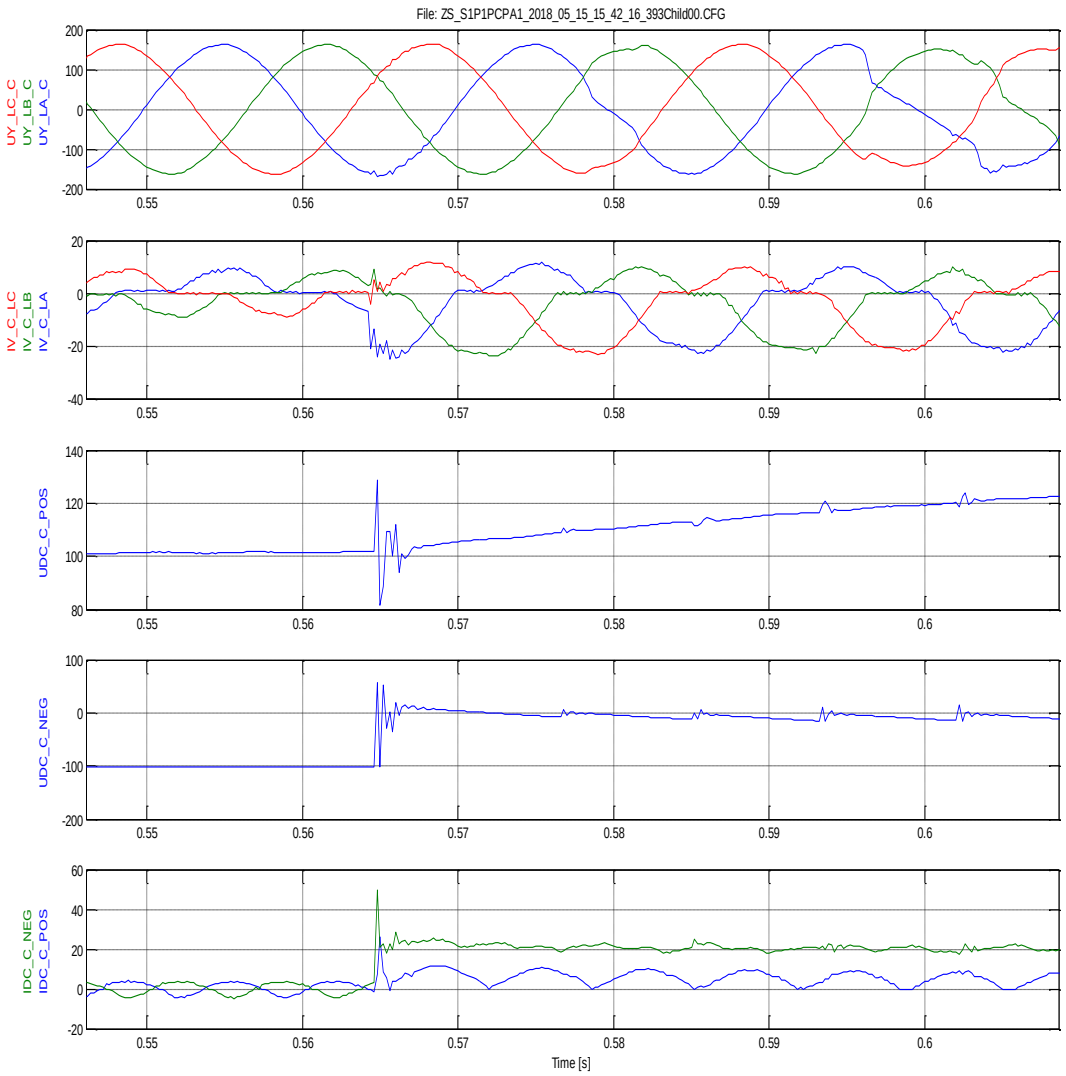
- DC cable was pulled out and damaged
- Cable was repaired
- Converter was de-blocked
- Repair was not undertaken properly
- Negative pole to ground fault occurred during charging process
- System detected the fault
- DC CB tripped



APPLICATION OF DCCB FOR ZHOUSHAN

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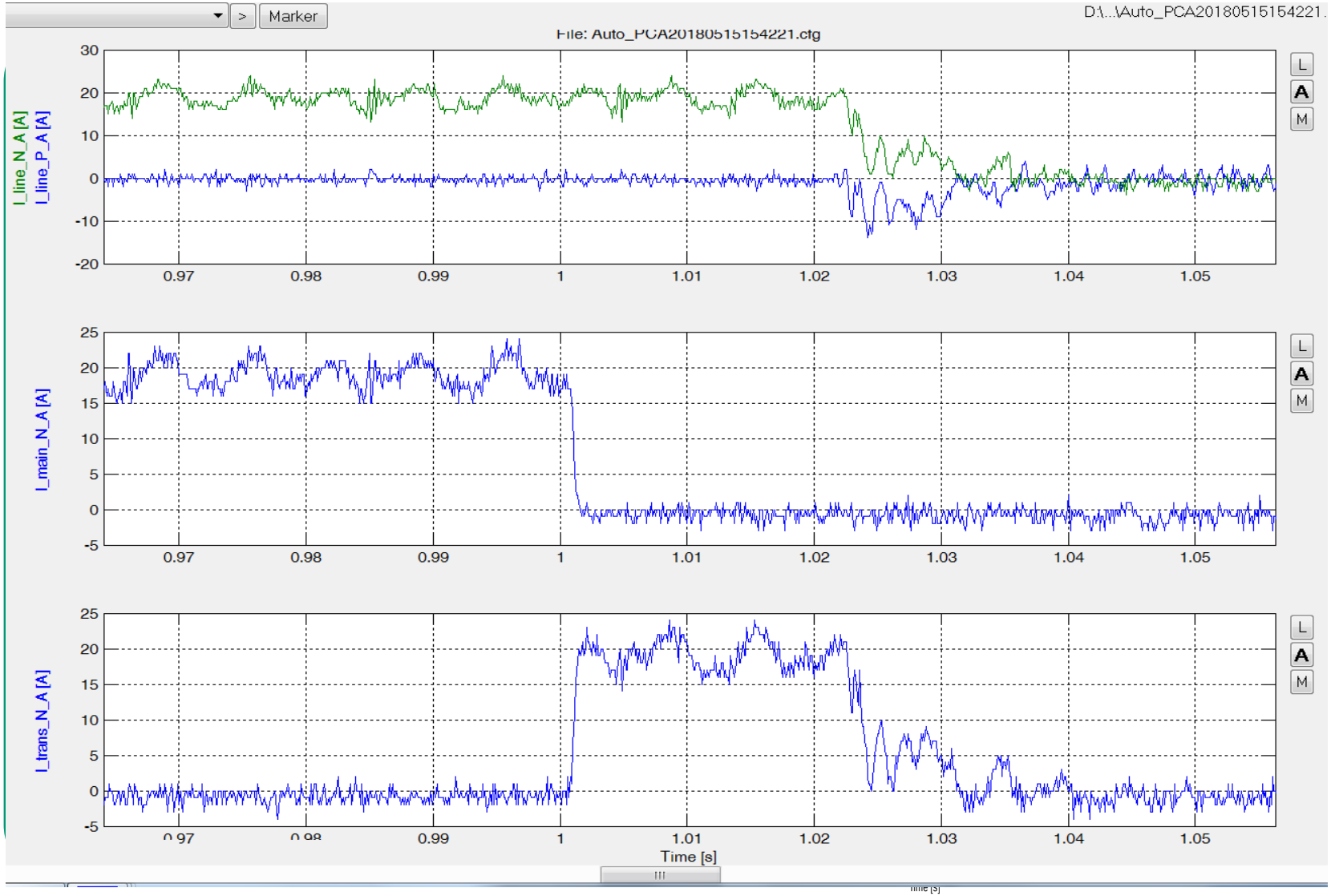
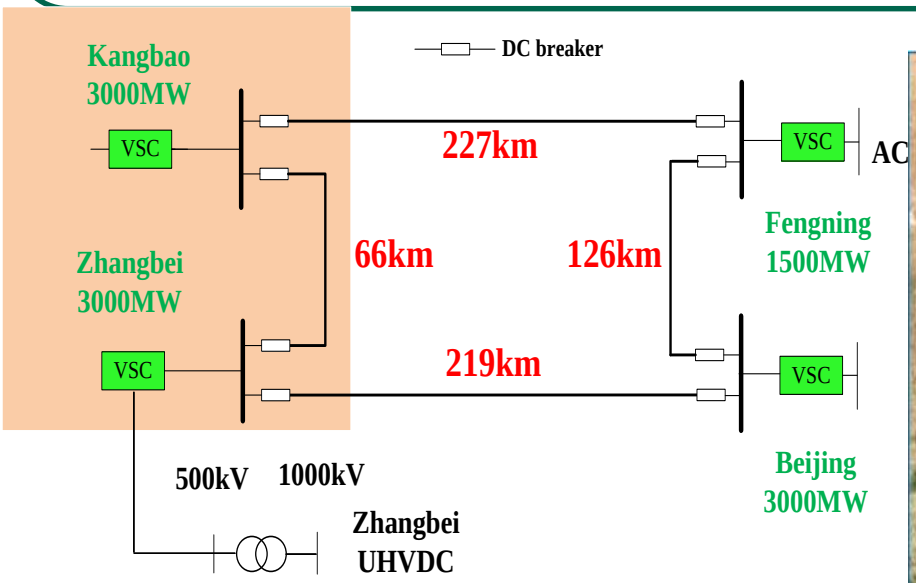
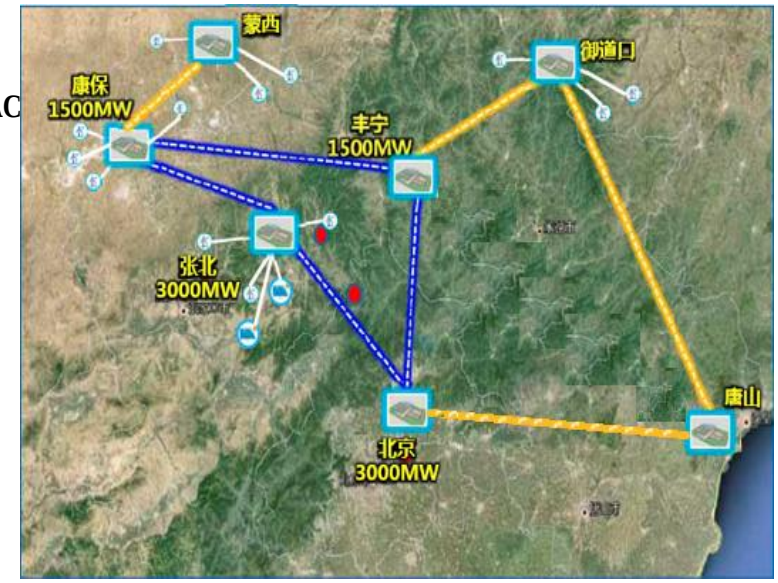


APPLICATION OF DCCB FOR ZHANGBEI

- Zhangbei VSC-HVDC project, ±500kV, 4 terminals, Symmetric bipolar
- Zhangbei (3000MW) & Kangbao (1500MW) as sending stations (WP & SP)
- Fengning (1500MW) as ES & Beijing (3000MW) as receiving station
- Expandable DC grid in the future (7T), OHL
- Half bridge MMC + DC breakers, isolating DC line fault by DC breakers
- 4 breakers each station, 4*4=16 DC CB in total

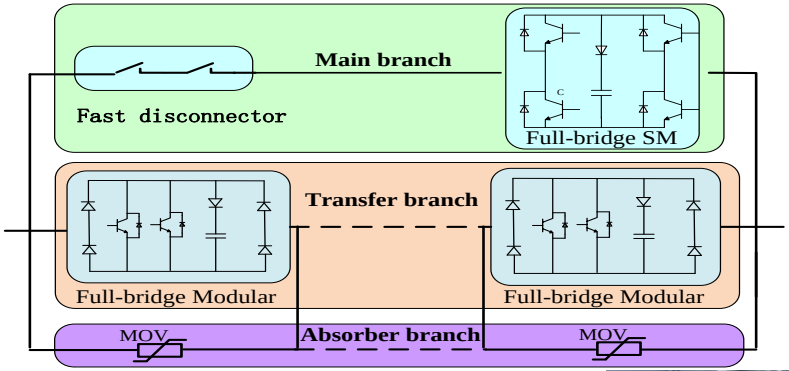


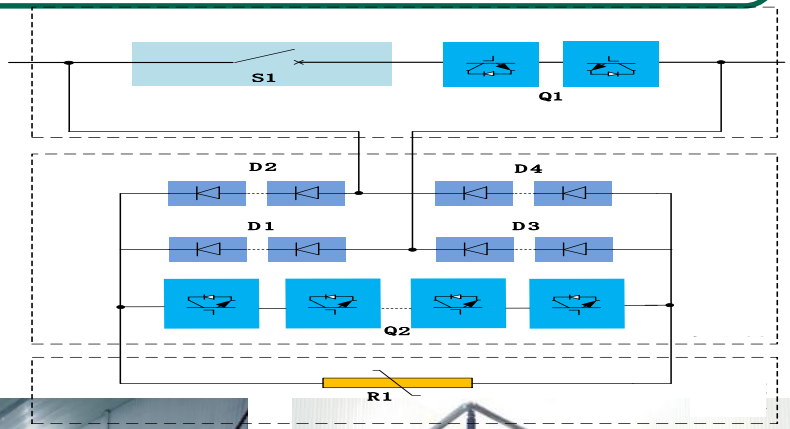
Zhangbei DC Grid



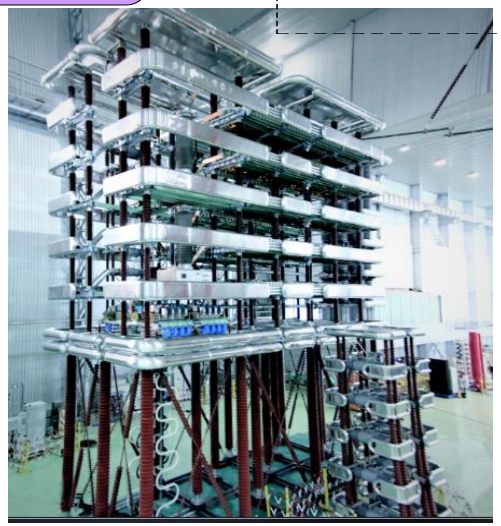
APPLICATION OF DCCB FOR ZHANGBEI

- To be manufactured by 5 companies
- 3 different technologies :
  - 2 * Mechanical DC Circuit Breakers by one manufacturer
  - 12 (4+8) * Hybrid DC Breakers by two manufacturers
  - 2 * Coupling Negative Voltage (CNV) Hybrid DC Breakers by one manufacturer





Item	Parameters
Vr	535kV
Ir	3.3kA
B T	2.53ms
B I	26kA
R T	300ms
TRV	810kV



APPLICATION OF DCCB FOR ZHOUSHAN

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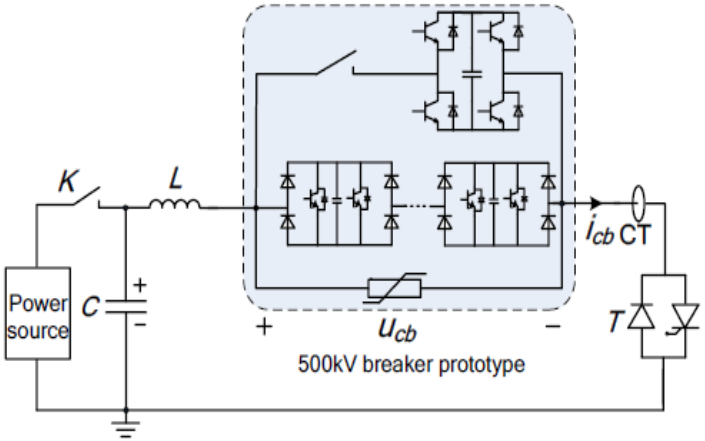
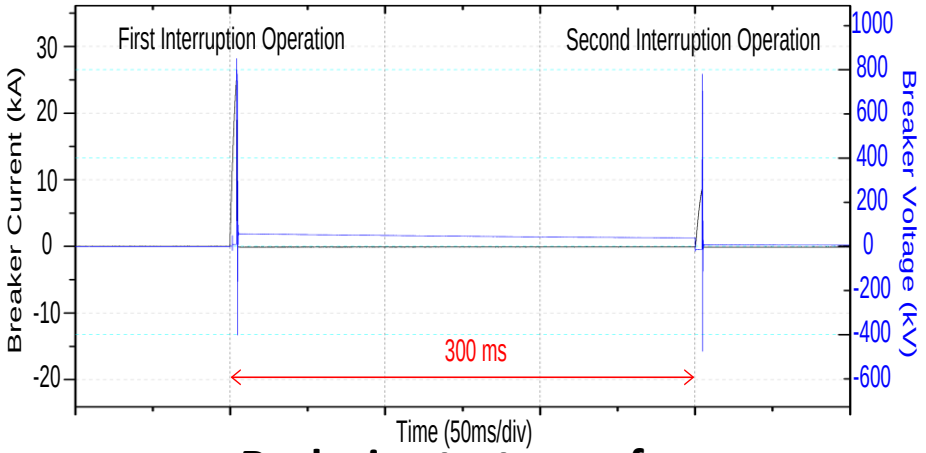
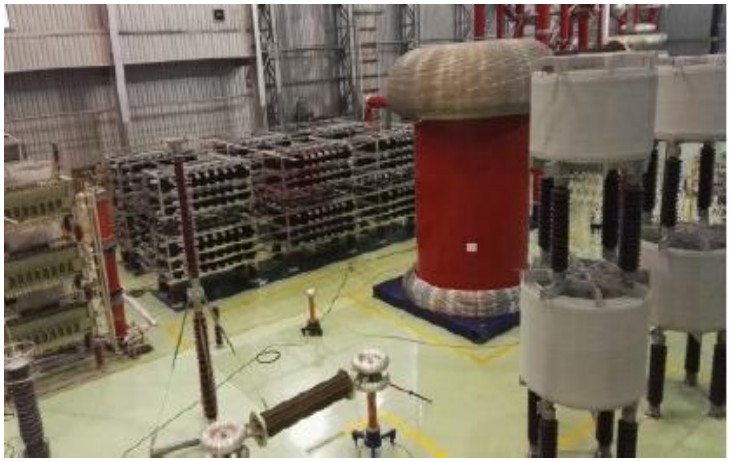


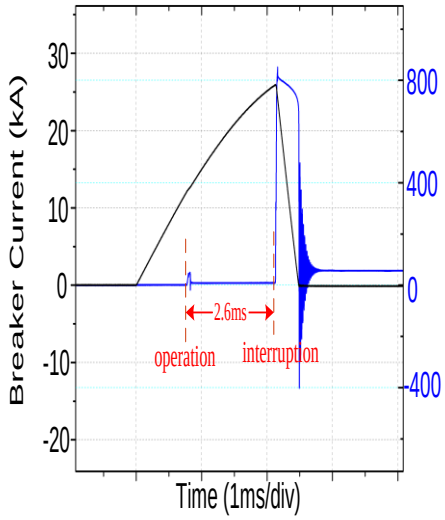
Interruption test circuit



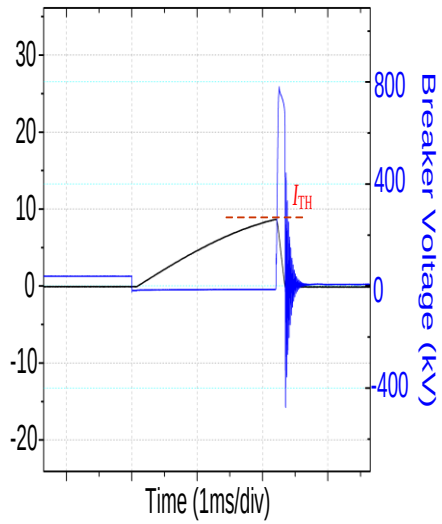
Reclosing test waveforms



Interruption test facility



1st interruption



2nd interruption

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Thank you!