Protections

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INNOVATIVE TOOLS FOR OFFSHORE WIND AND DC GRIDS

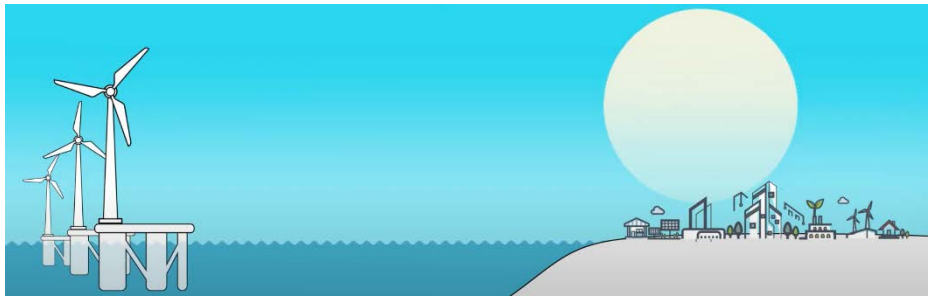
CONTENT

- Context of our work
- Protection in Transmission networks
- AC protections
- DC Protections

Context of our work

Reduce CO2 emissions

Renewable energy sources



Offshore wind farms

Transmission networks

Image source: EDP Renováveis - Wind Float Atlantic project

Power converters (AC <->DC)

HVDC

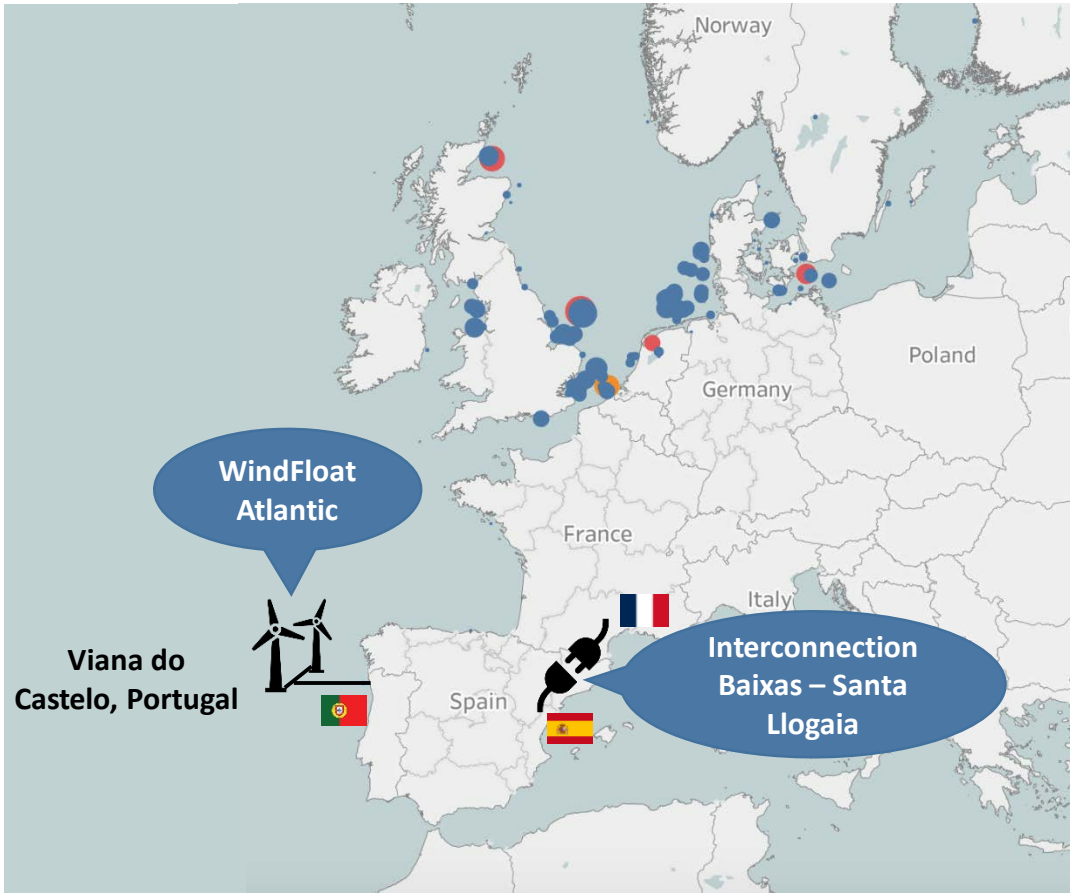


Image source Wind Europe (edited)

Wind EUROPE

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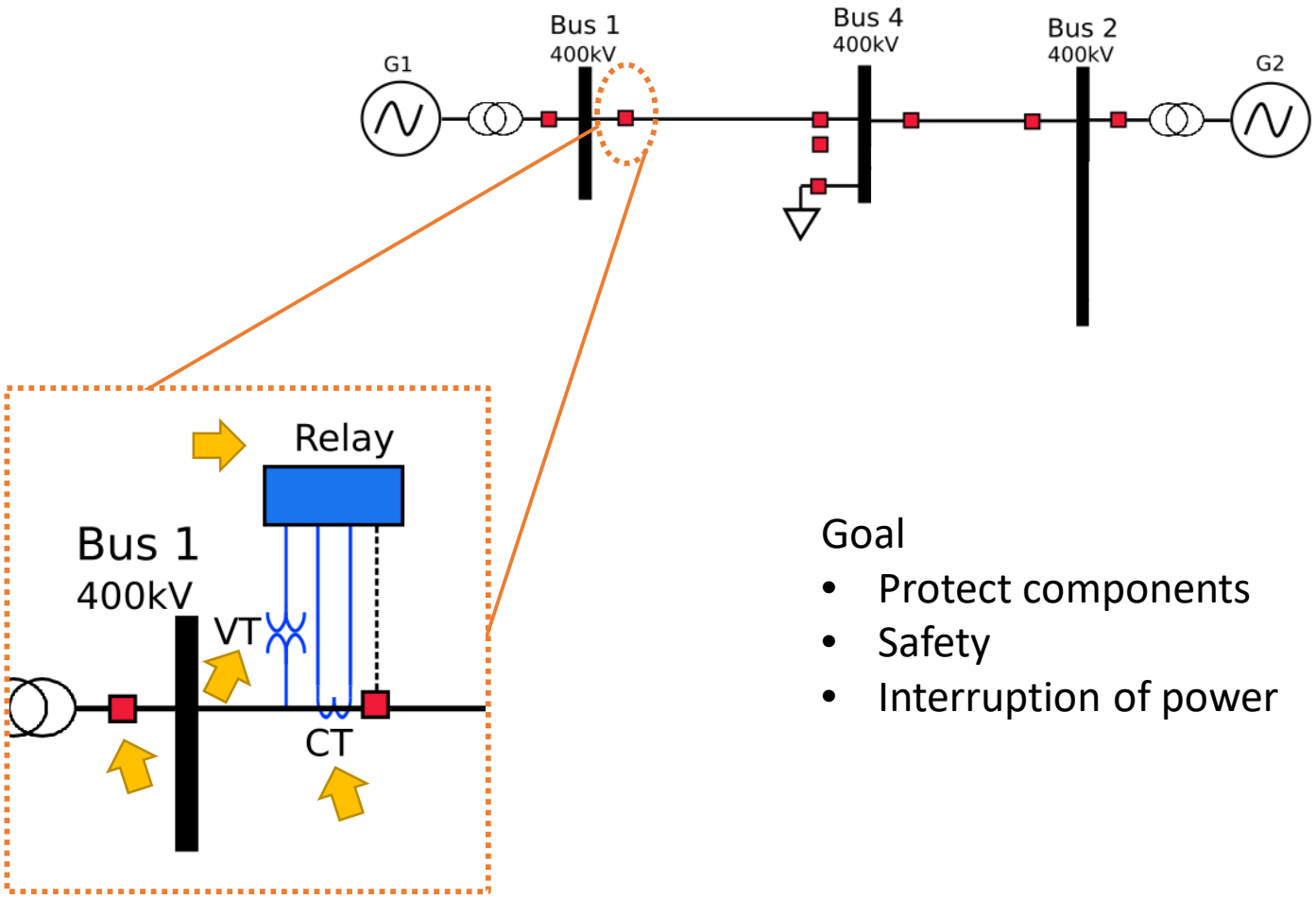
Protections in transmission networks



Goal

- Protect components
- Safety
- Interruption of power

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AC Protections

- **AC faults & disturbances**
  - Short-circuits (e.g. 3Phase, L-L, L-G, L-L-G)
  - Network parameter variations ($voltage(t)$, $frequency(t)$, $current(t)$)

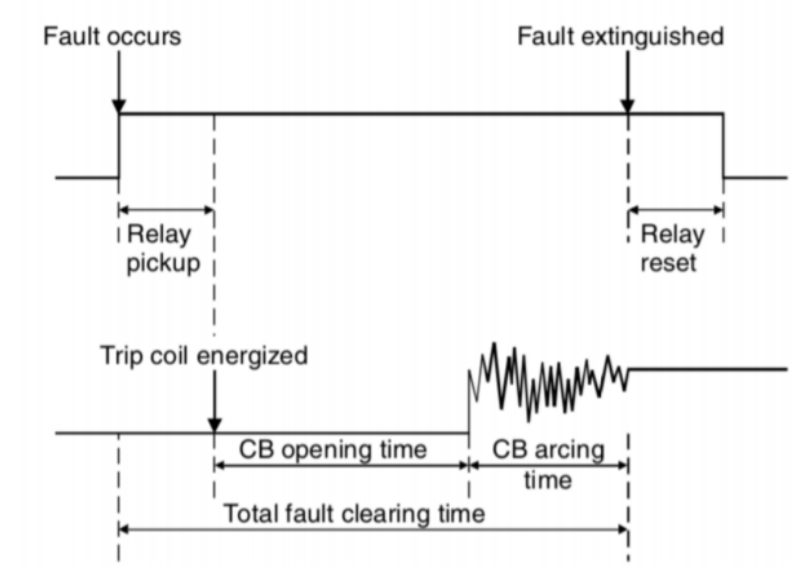
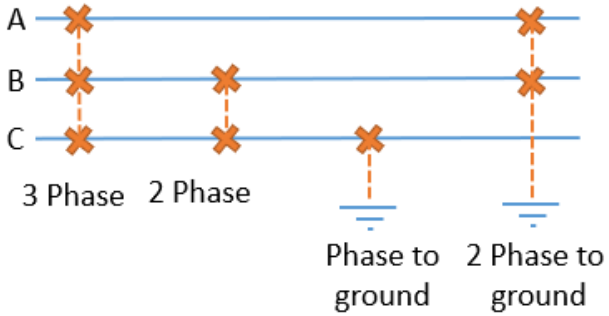


Image source Practical Power System Protection

- **Protection demands**
  - AC circuit breakers
  - Fault cleared typically within 80ms
  - Protection functions: Overcurrent, over/under voltage, distance, differential
  - Protection area: Bus, Generator, Transmission line, Transformer



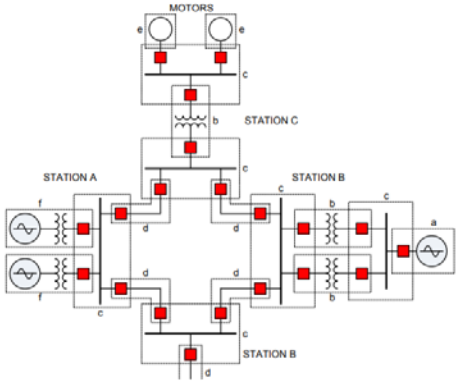


Image source IEEE Std C37.113-2015

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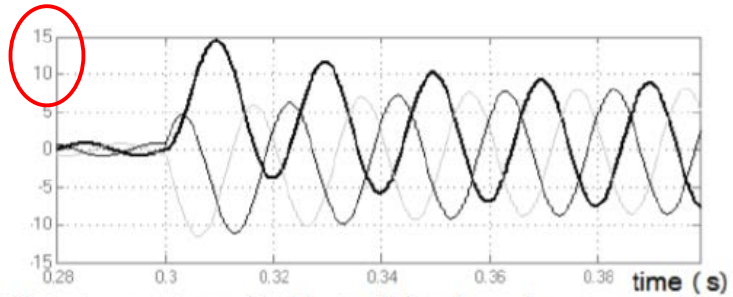
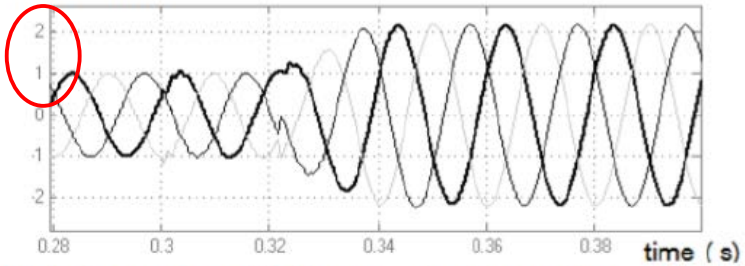
AC protections challenges today



(a) Output current provided by traditional synchronous machine (in pu value)



(b) Output current provided by converter (in pu value)

Managing & defining settings

Coordination or interaction w/ DC Protection

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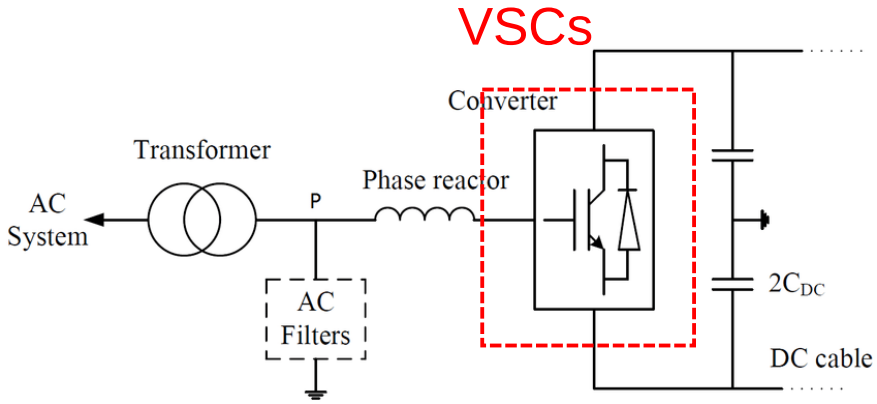
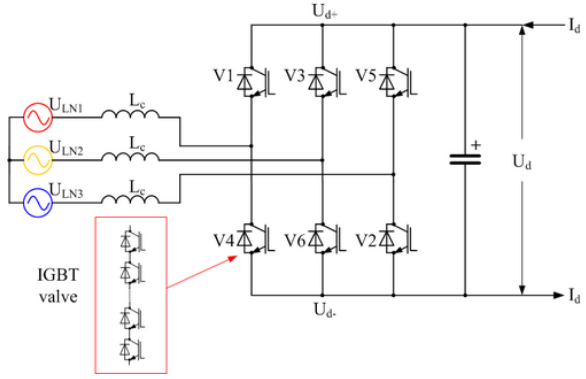
DC protections

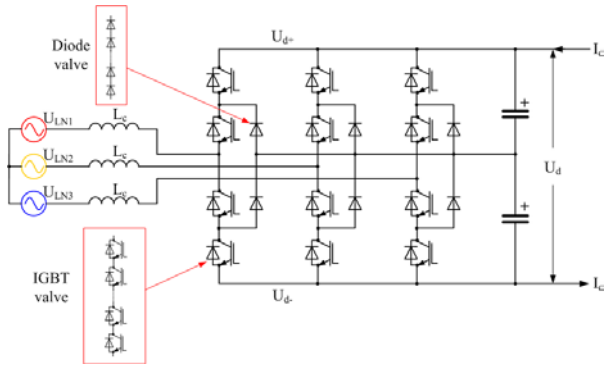
- **VSC converters**
  - Two-level converters
  - Three-level converters
  - Modular multilevel converters (MMCs)



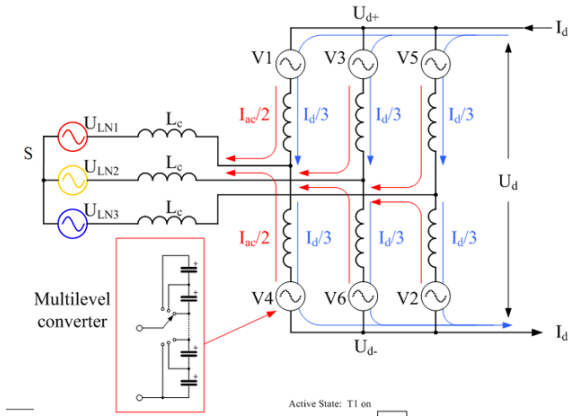
Hybrid AC/DC system with VSCs



Two-level converter



Three-level converter

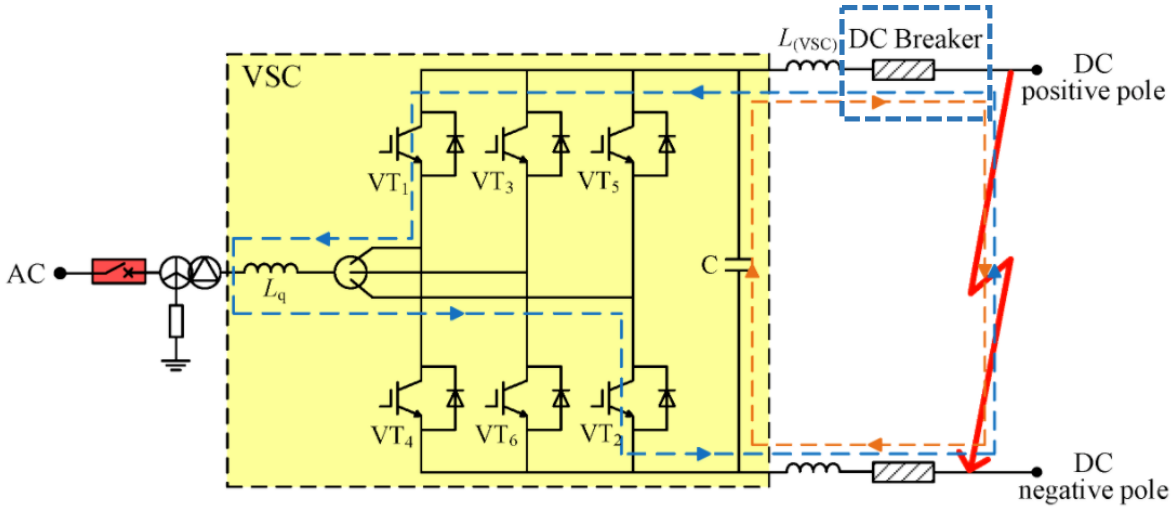


MMCs

DC protections

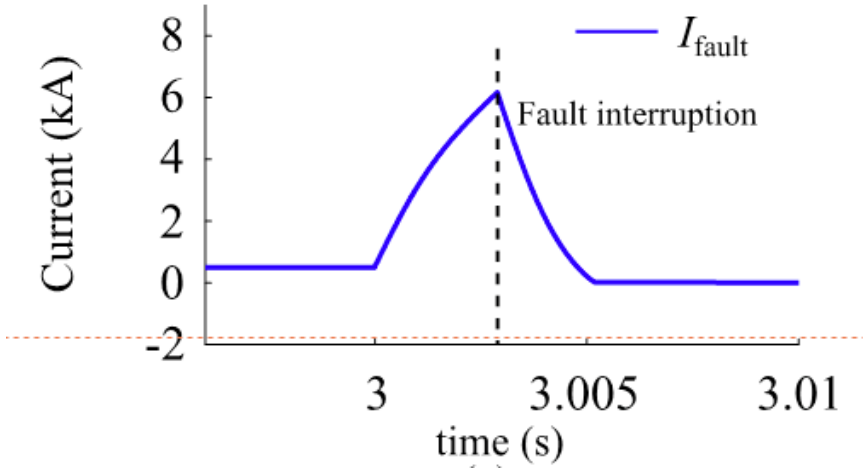
- **DC faults**
  - No zero crossings (dc current)
  - High rising rate of current (di/dt)
  - Low capability of overcurrent (IGBTs)

DCCBs



DC faults

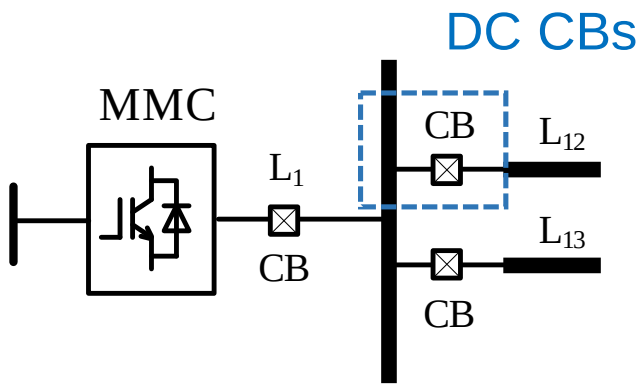
- **Protection demands**
  - DC circuit breakers
  - Interrupted fault within 3-5 ms
  - 10-20 kA fault current



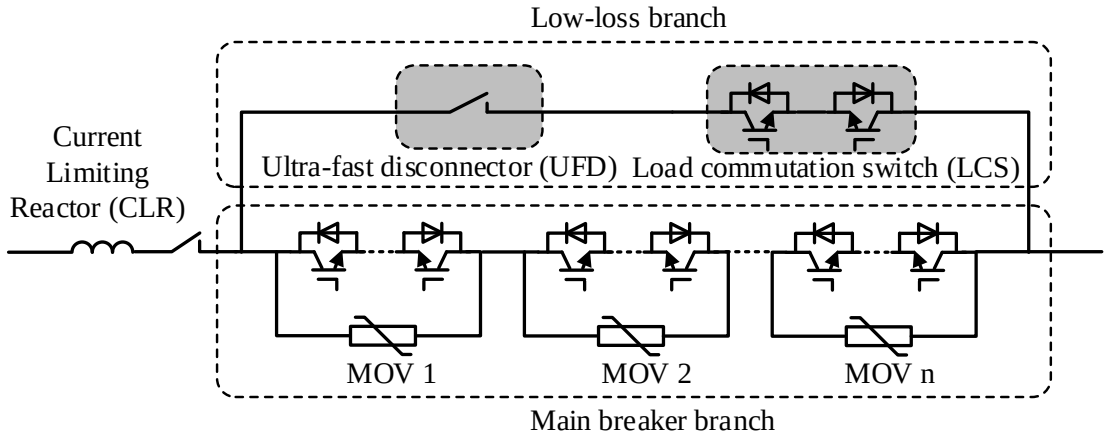
Fault current

DC protections

- **Protection devices**
  - DC circuit breaker
  - Converter with fault blocking capability



DC terminal



Topology of DC CBs

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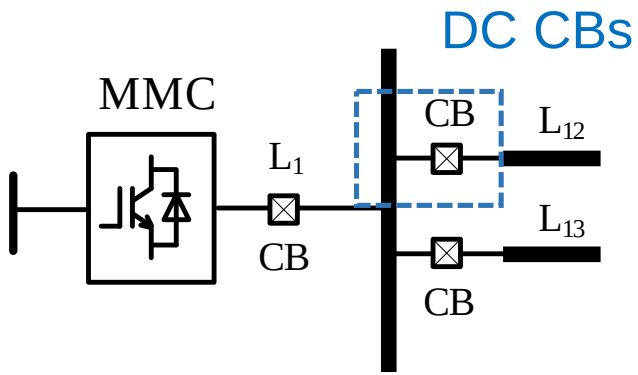
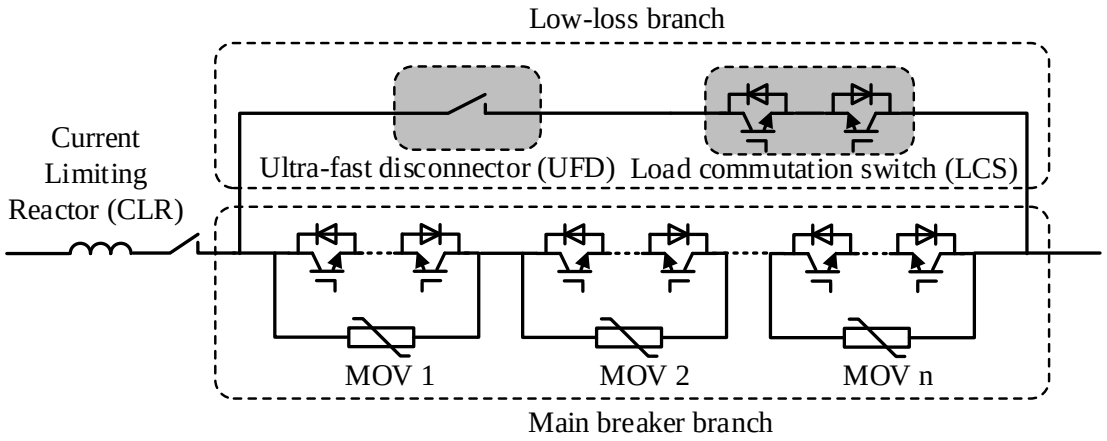
DC protections

- **DC circuit breaker**



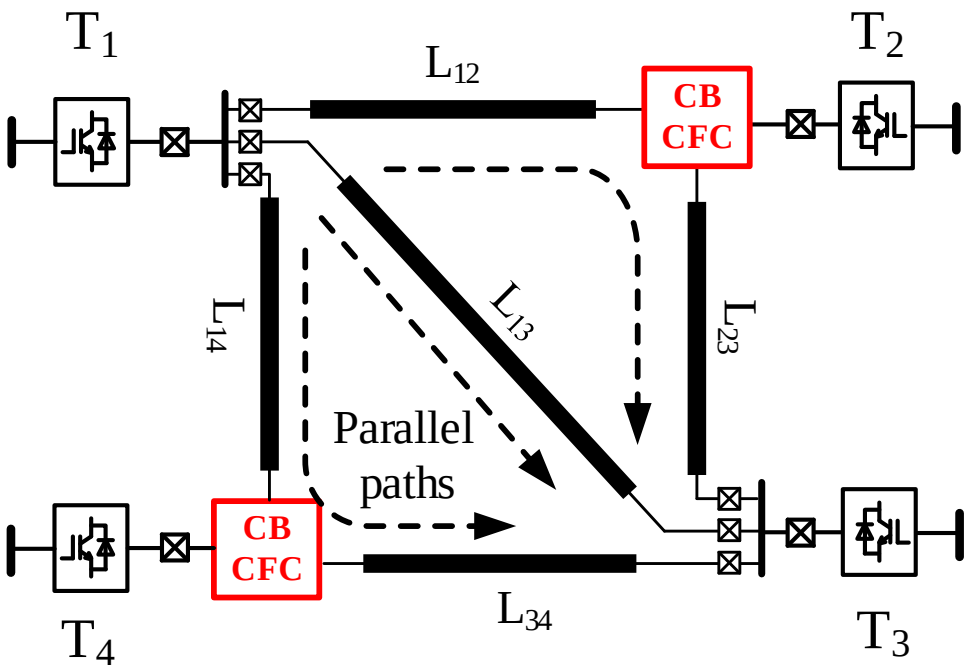


Topology of DC CBs

Prototype of a DC breaker

DC protections

- **Summary for dc protection**
  - DC protection is still a challenging issues
  - High di/dt of fault current (4-5kA/ms)
  - High fault current (20 kA)
  - High speed (3-5 ms)
  - Protection devices (DCCBs) are expensive
- **Research topics**
  - Converters with fault blocking capability
  - DCCBs with lower costs
  - New devices (such as IGCT, BIGT, SiC devices)



MTDC networks

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Thank you for your time

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