

Faults in HVDC Grid and Current Interruption by HVDC CB

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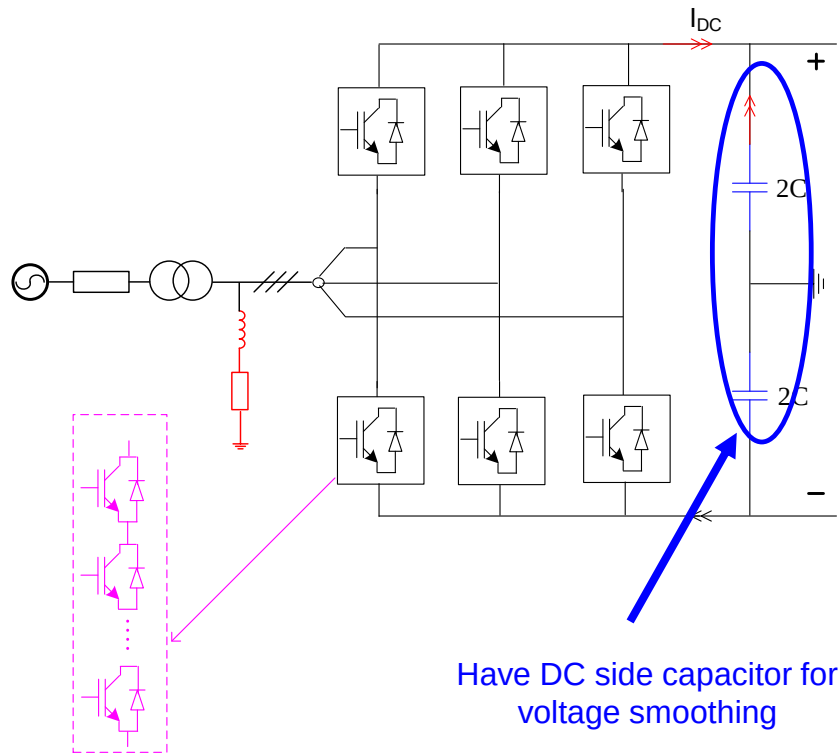
Outline

- Faults in HVDC Grid
- DC fault clearing strategies
- Challenges and important definitions
- Impacts of DC current limiting reactor, fault location
- Fault current interruption by HVDC Circuit Breaker
- Summary

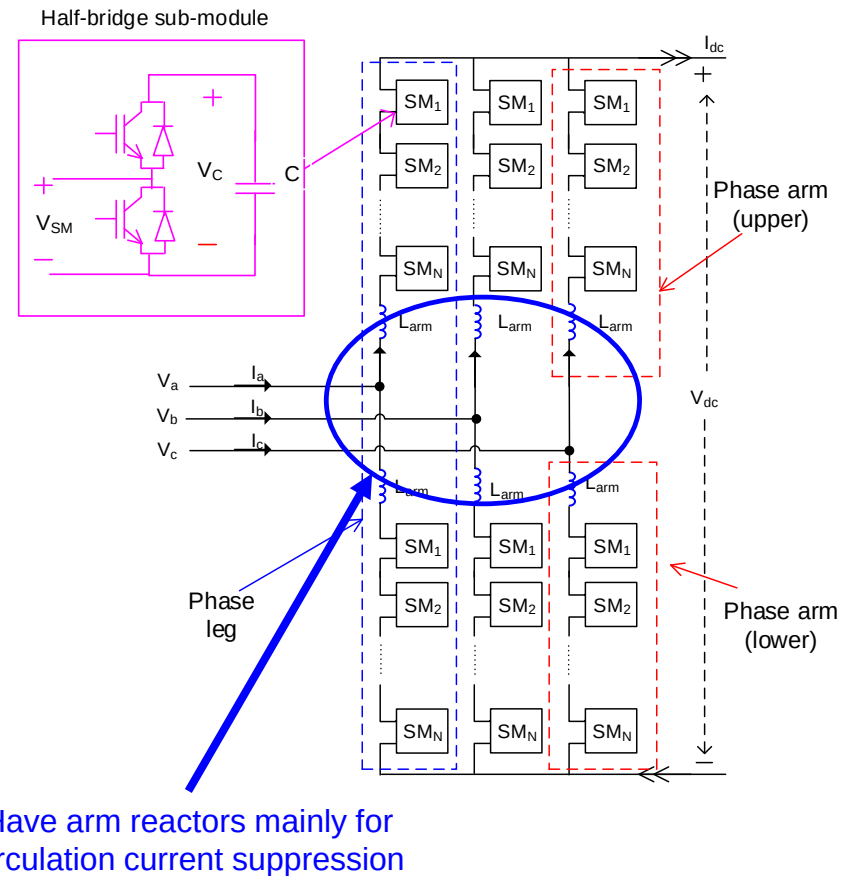


HVDC Converter Topology

2-level converter

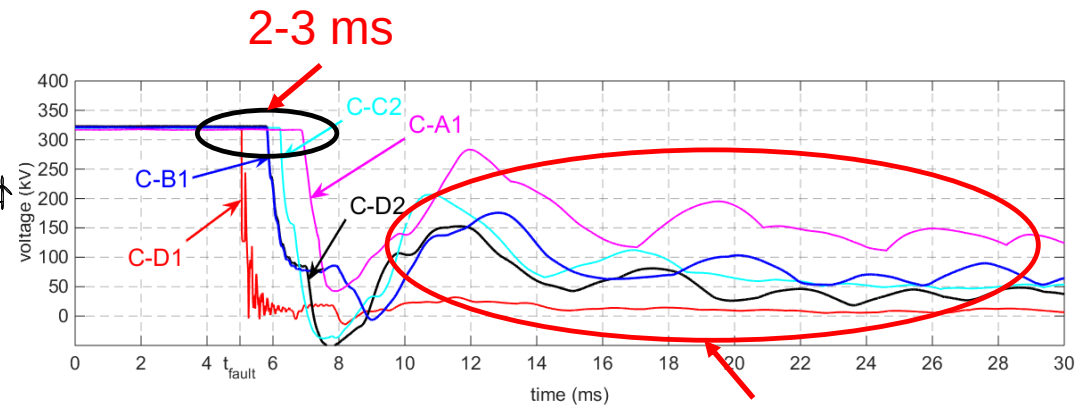
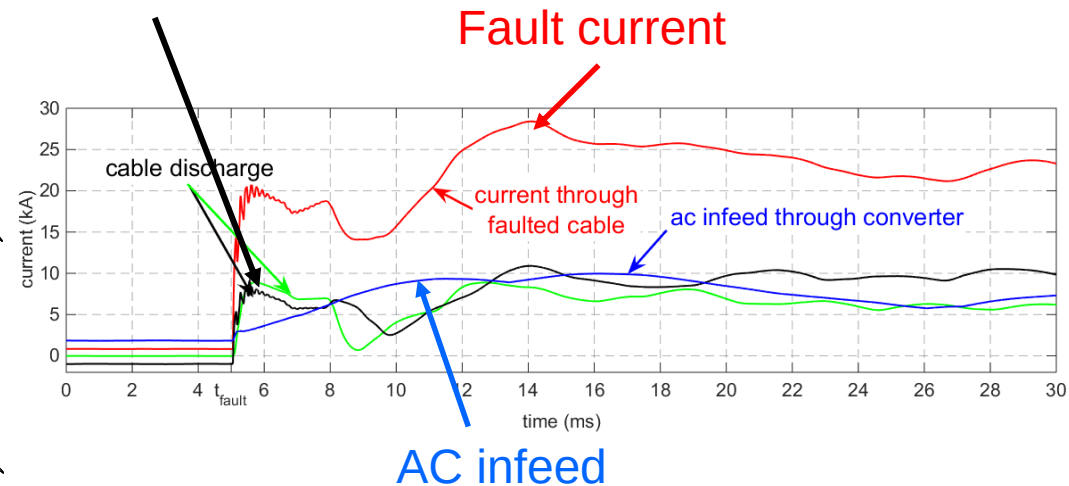
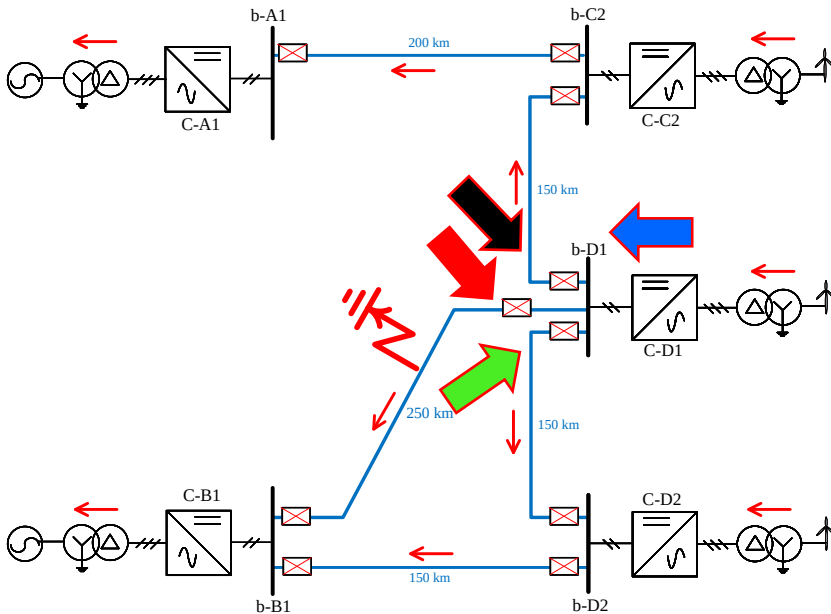


Modular Multi-level Converter (MMC)



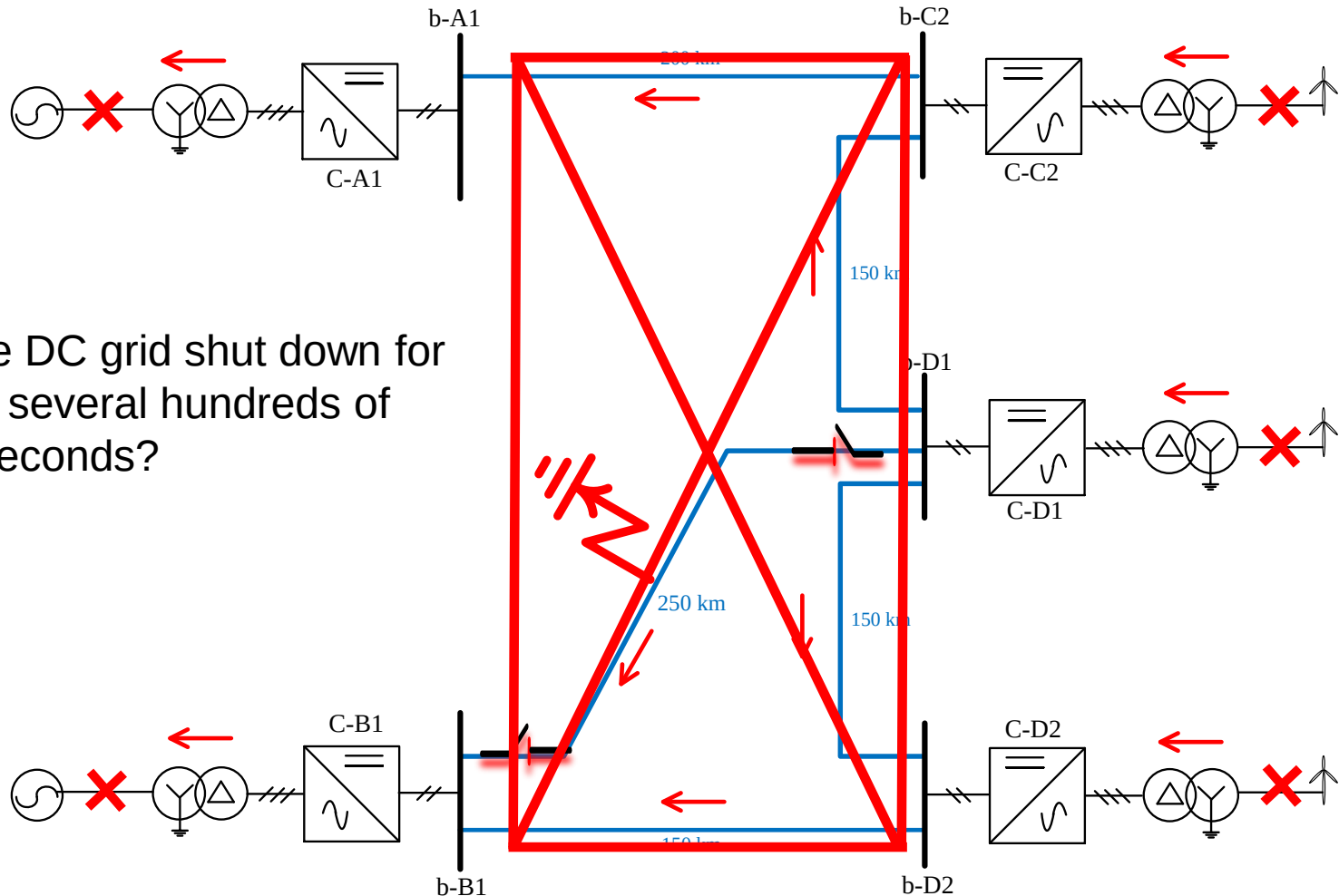
Faults in HVDC Grid

Discharge from cables



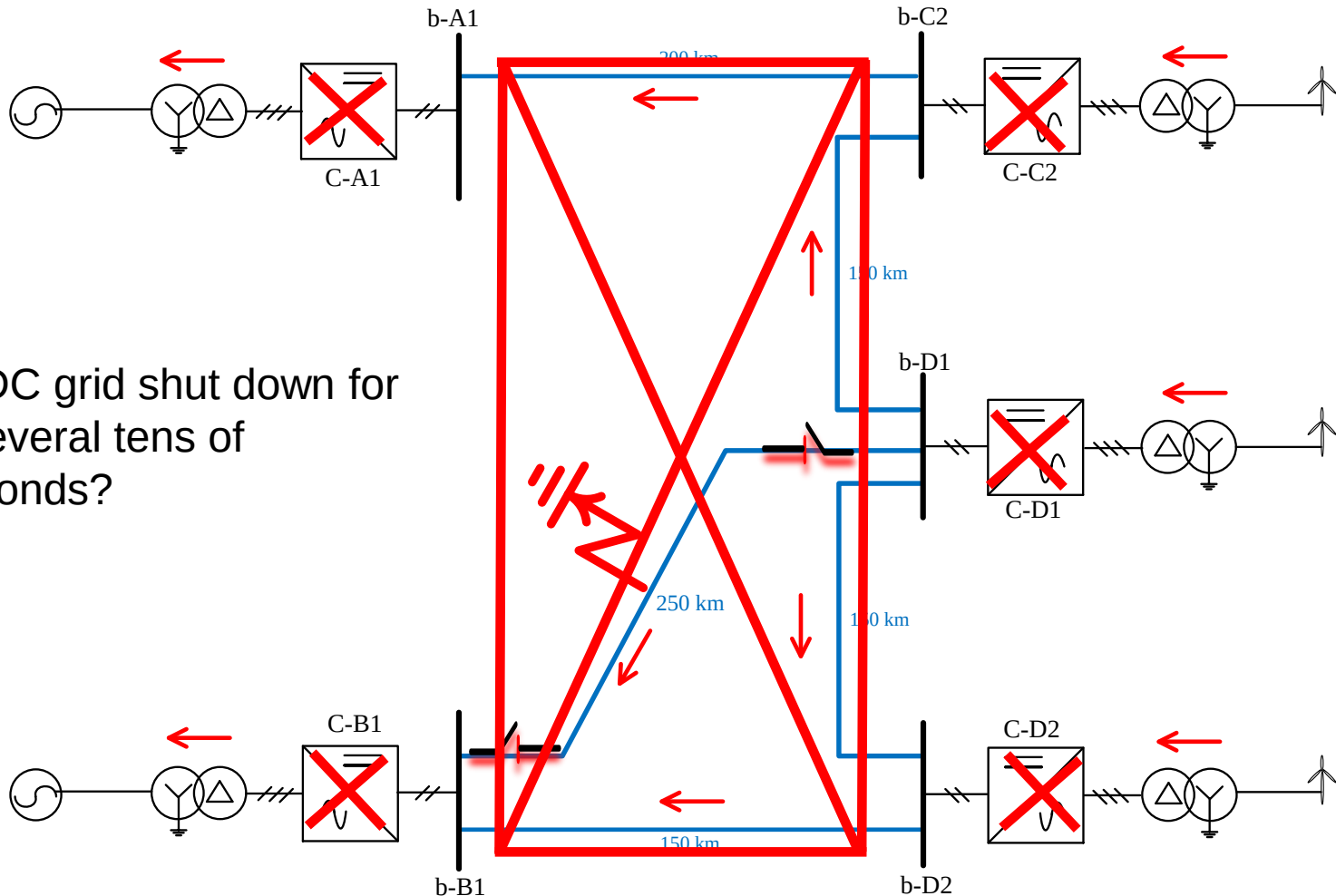
DC fault clearing strategies (using AC CBs)

- Entire DC grid shut down for up to several hundreds of milliseconds?



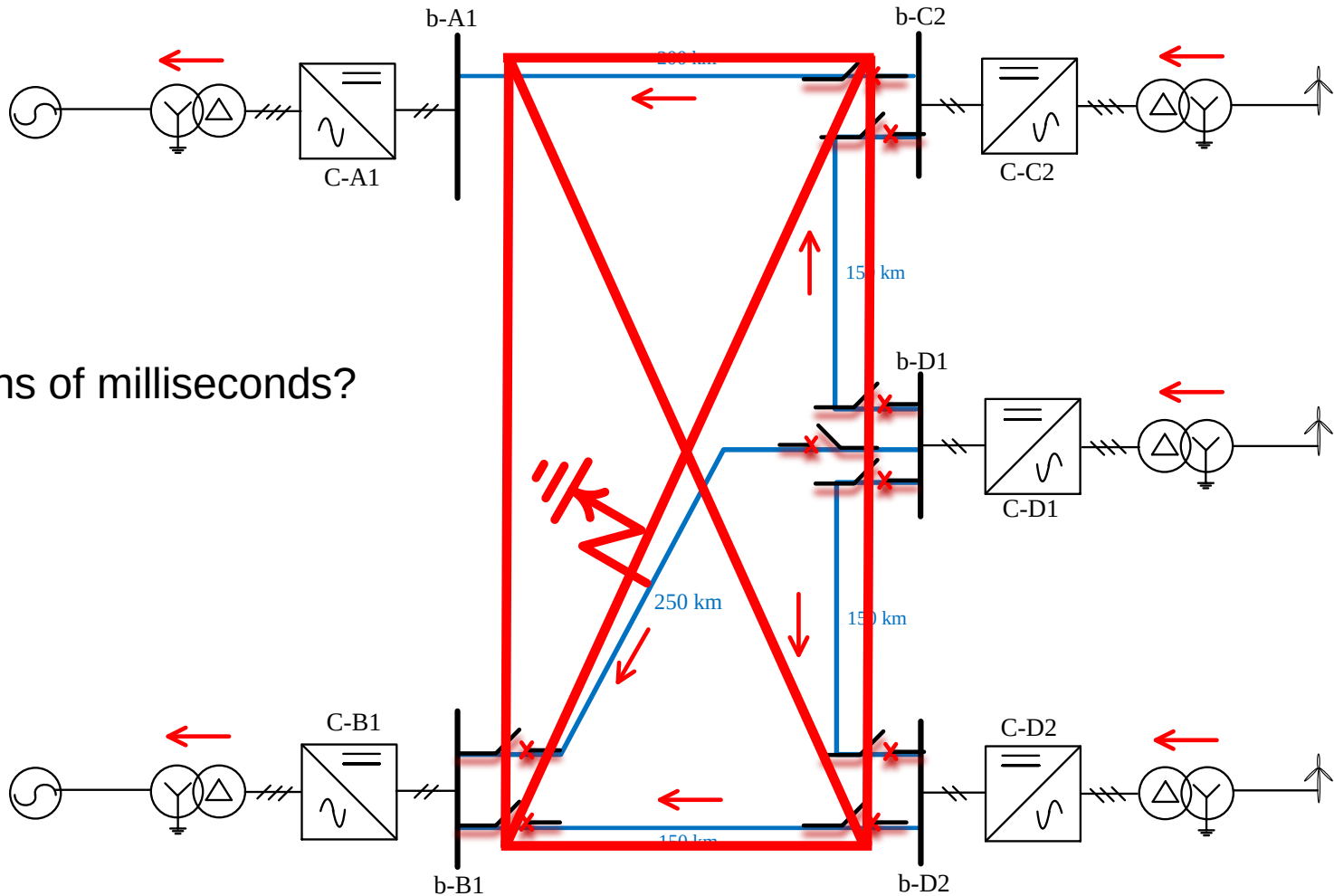
Fault clearing strategies (using converters)

- Entire DC grid shut down for up to several tens of milliseconds?



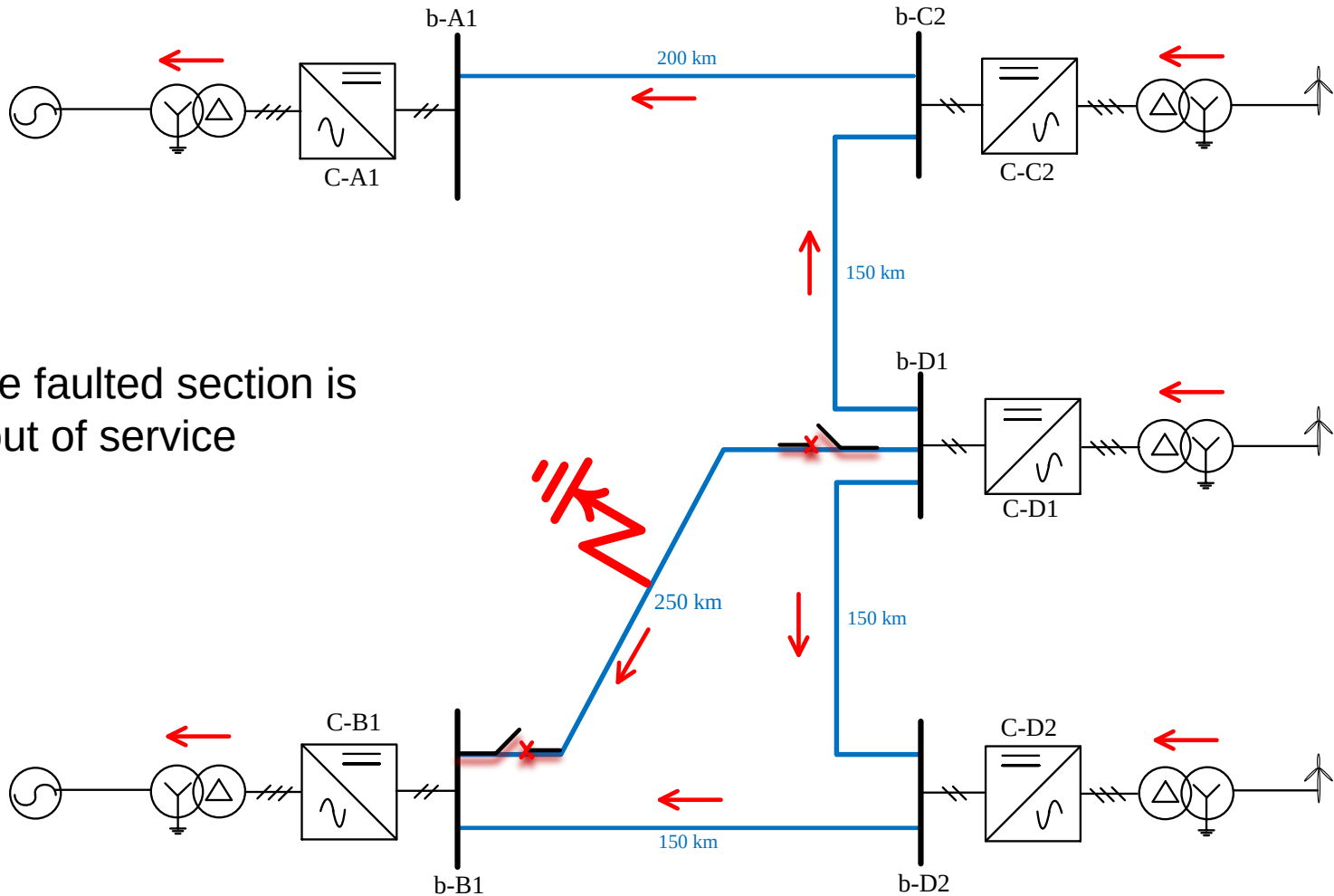
Fault clearing strategies (open grid using dc CBs)

- Few tens of milliseconds?



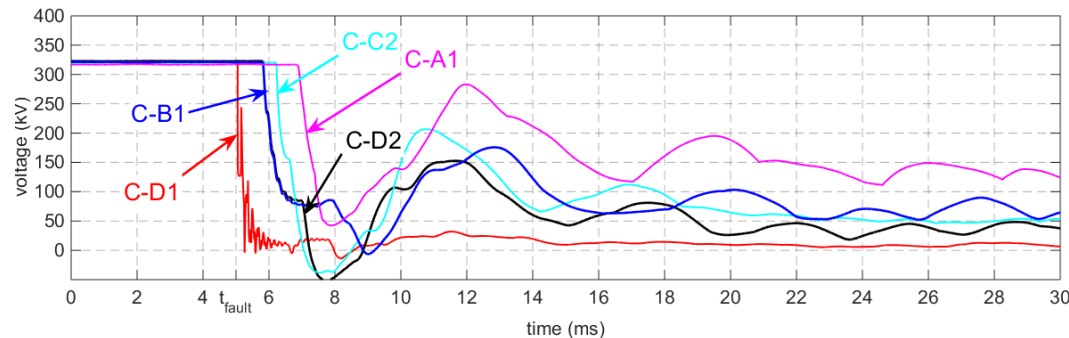
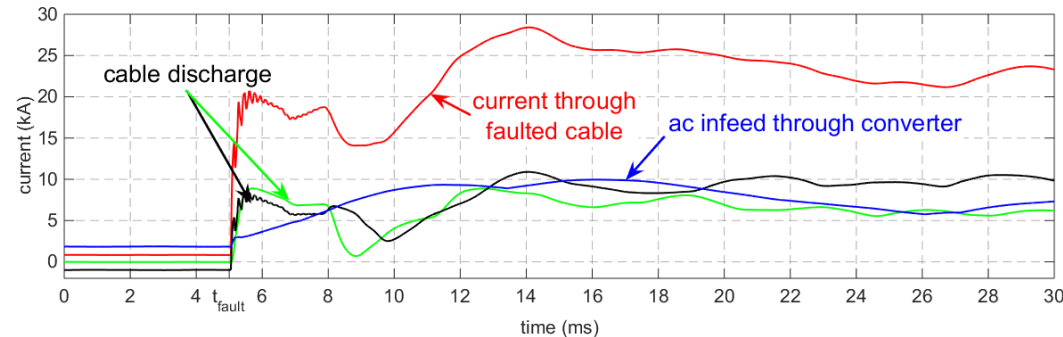
Fault clearing strategies (selective using dc CBs)

- Only the faulted section is taken out of service

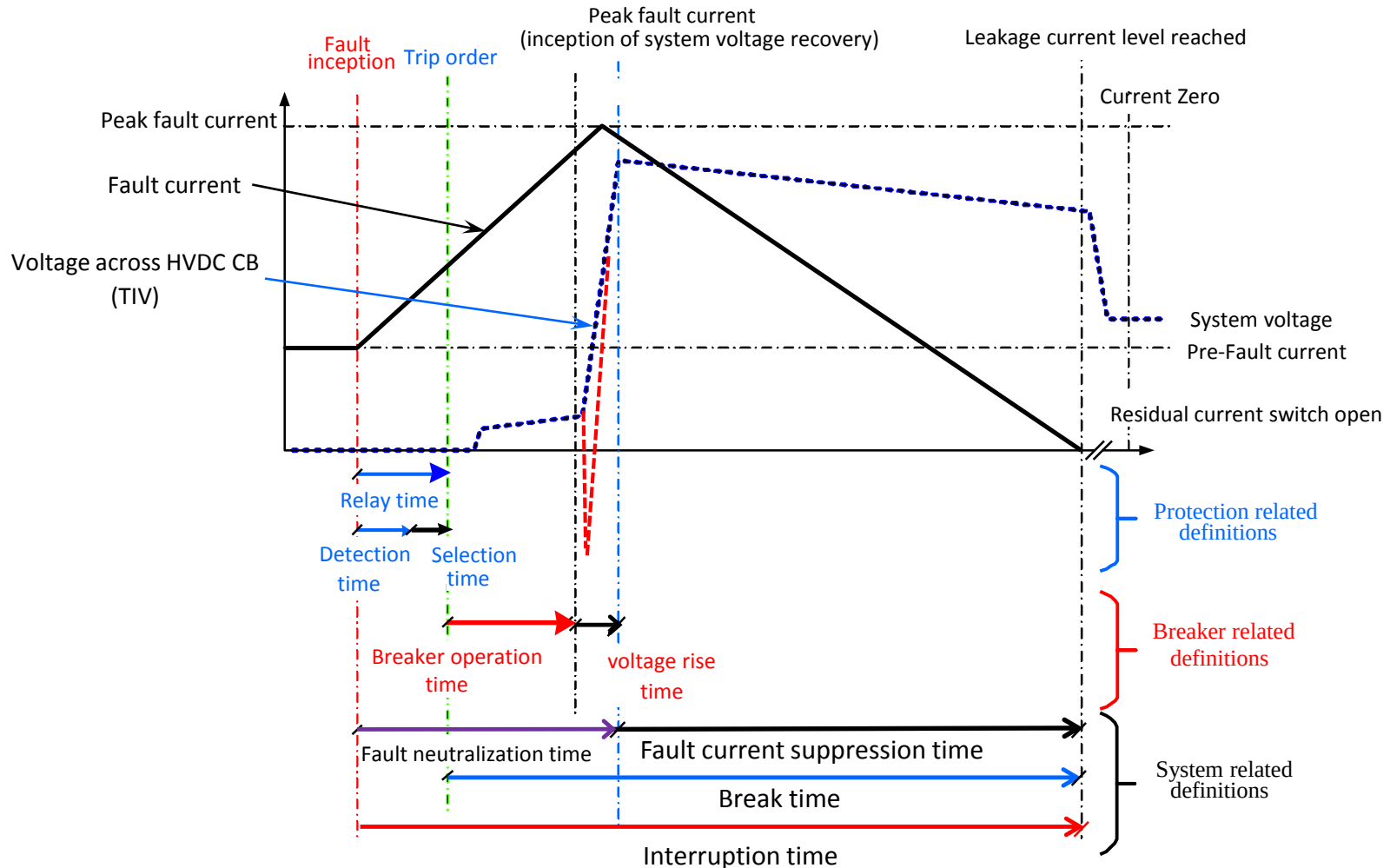


Challenges in DC fault clearing by HVDC CBs

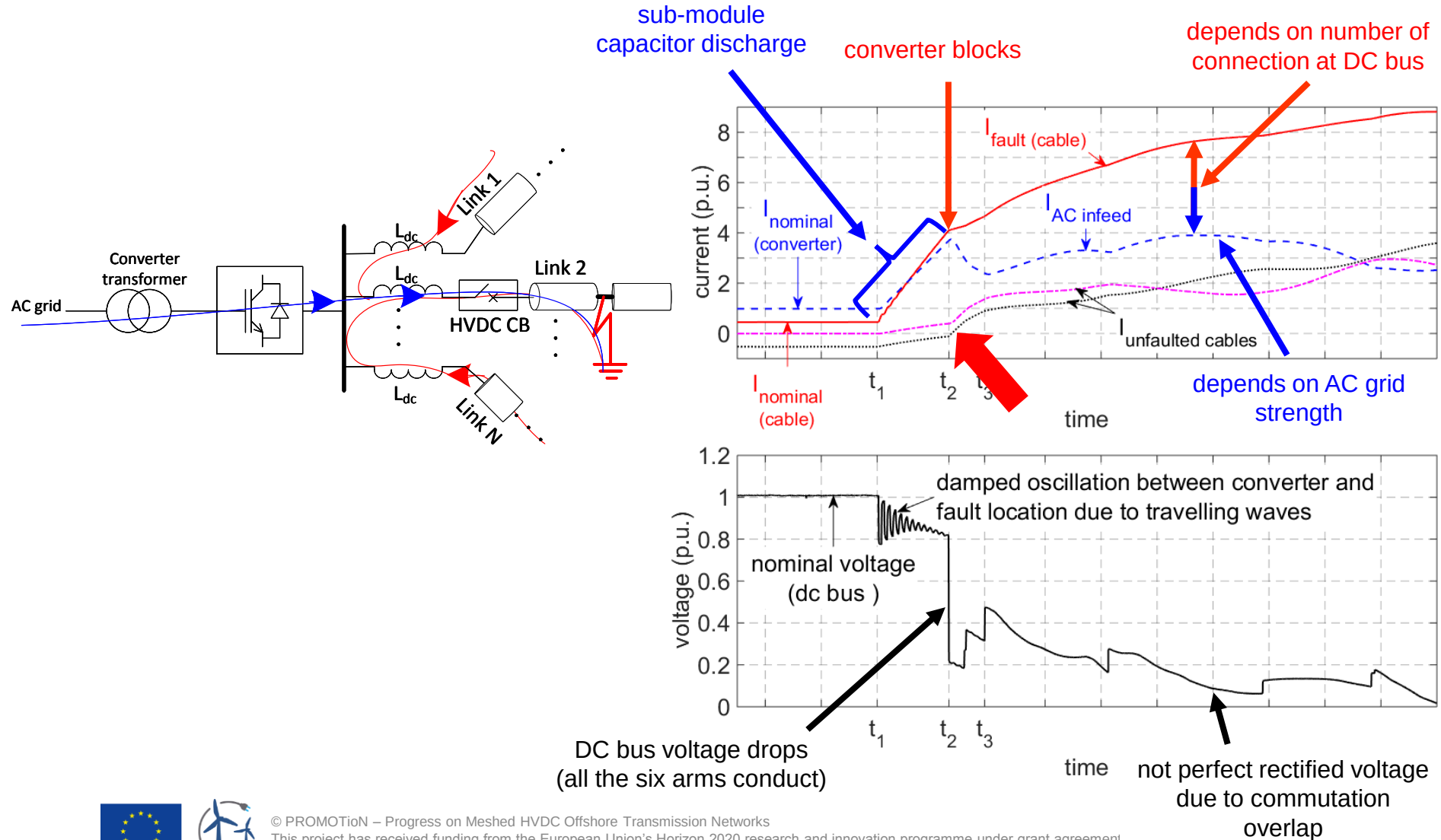
- Speed of protection system
 - Could be too late before the voltage collapse occur
- Speed of circuit breaker
 - Fault current may exceed the interruption capability
- System aspects
 - Can the system sustain the dc fault current? For how long?
 - What is the acceptable voltage profile?
 - Impact on neighbouring AC grid



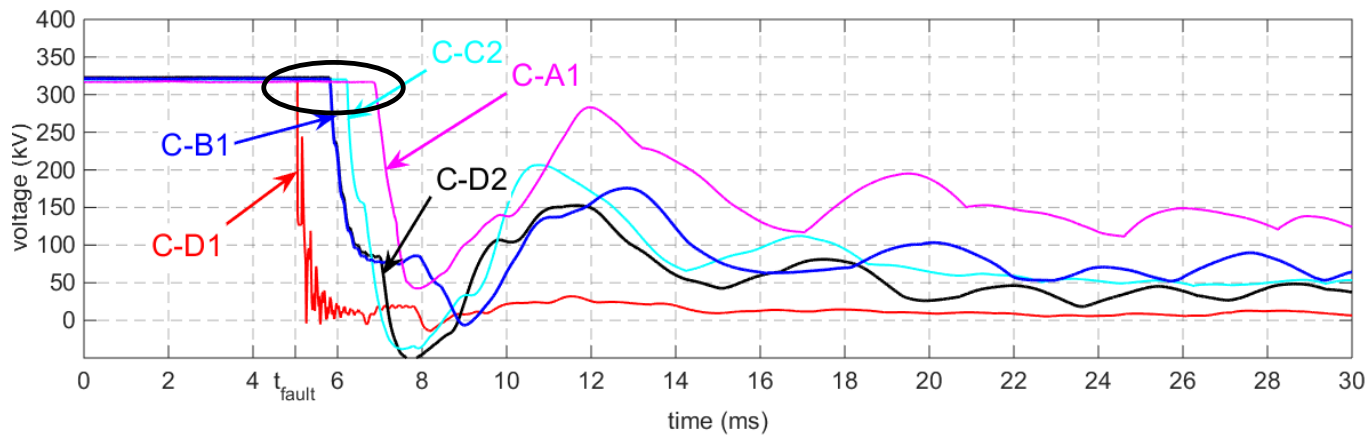
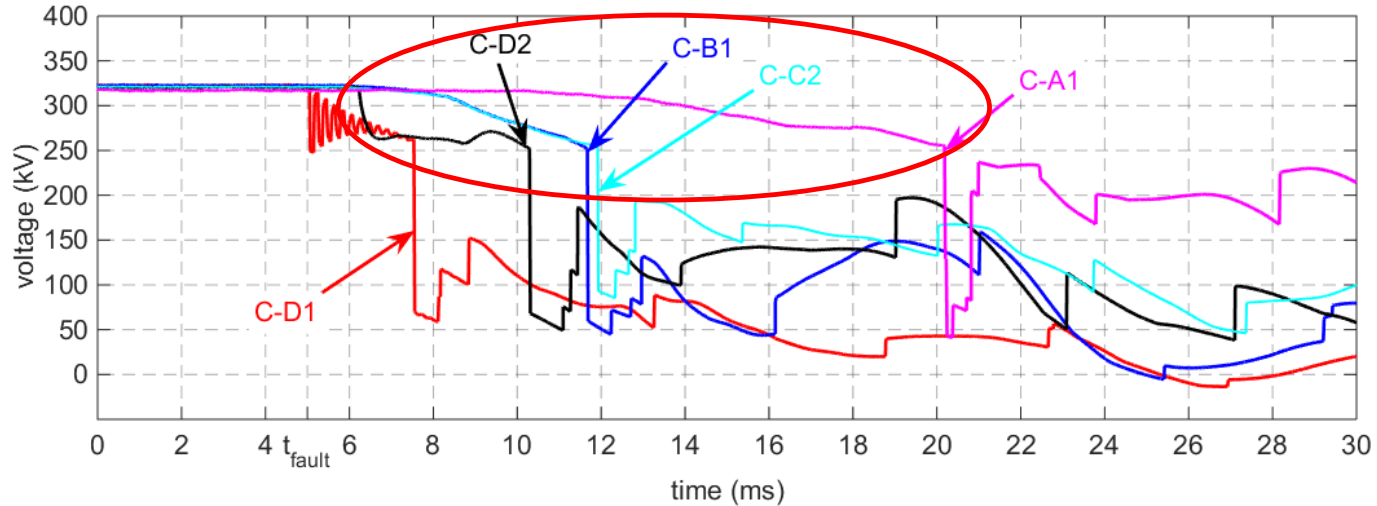
Important definitions (CIGRE JWG A3.B4-34)



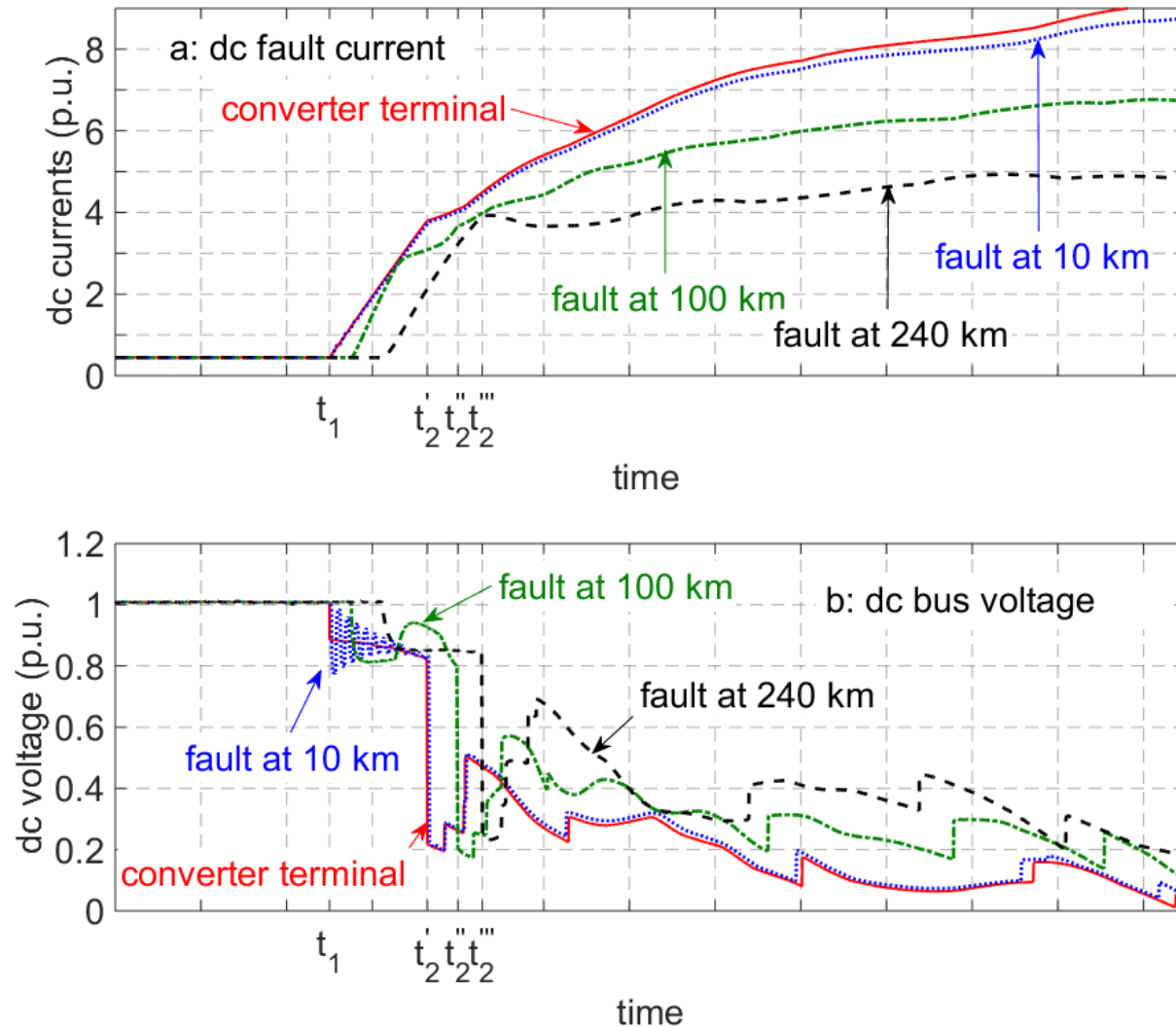
Fault current with DC current limiting reactors



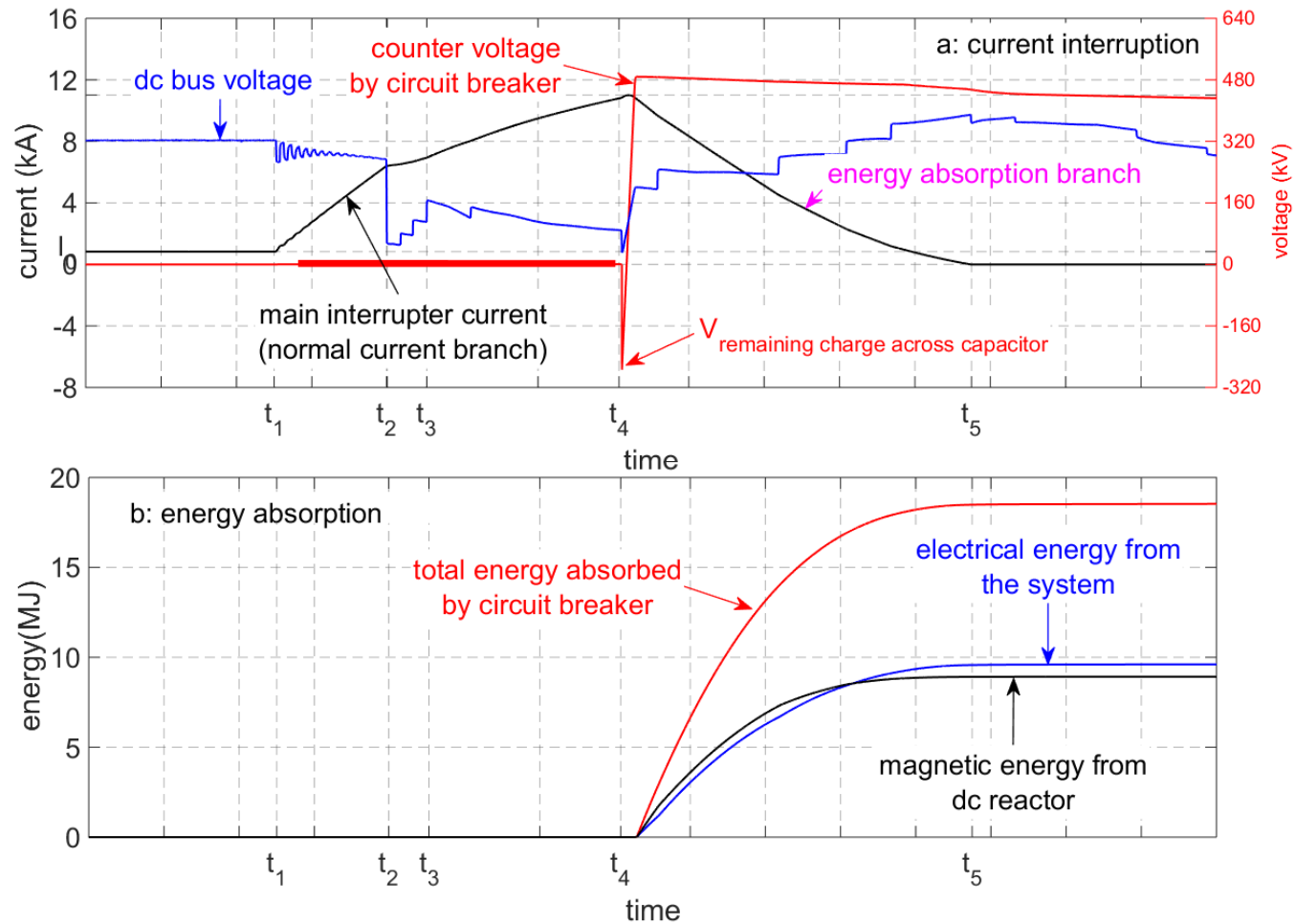
Voltage at converter terminals



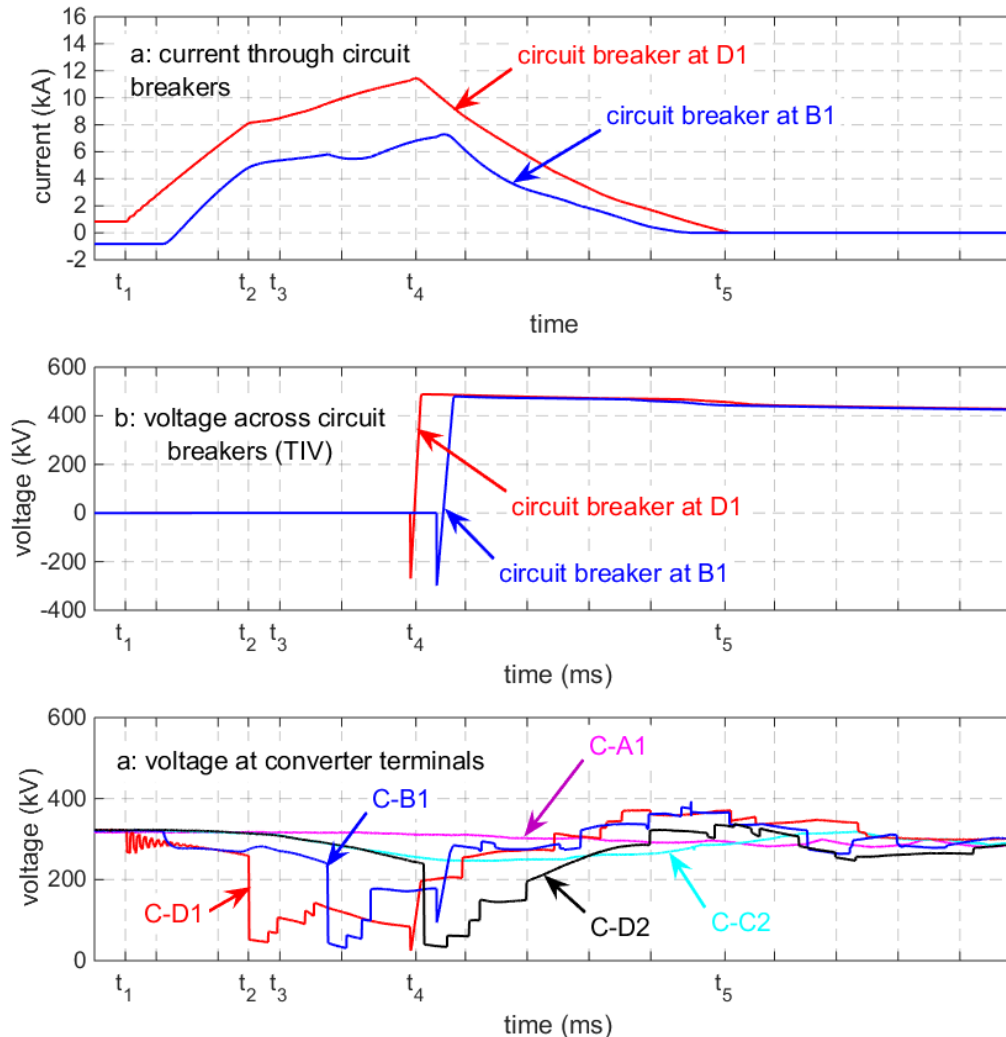
Impact of distance of fault location



DC Fault current interruption using HVDC CBs



DC Fault current interruption using HVDC CBs



Summary

- HVDC circuit breakers are essential for fast selective fault clearing in multi-terminal HVDC grid
- Fast discharge of capacitive elements during the first few milliseconds after fault could be challenge
- Series inductors are used to bridge DC circuit breaker speed of operation and current interruption capability
 - Series inductors prolong time before converters' terminal voltages fall below minimum threshold for operation
- System voltage starts to recover not at the end current interruption but rather the moment the circuit breaker start to build counter voltage
- HVDC circuit breaker absorbs not the energy in current limiting reactor but also the energy coming from the rest of the system





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Thank you for your attention!

Questions?



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APPENDIX

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