PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

DC protection research trends opportunities and challenges

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PROgress on Meshed HVDC Offshore Transmission Networks

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Status DC grid protection

- Algorithms for detecting faults for detecting faults are available, including for backup, differential, busbar, with and without communication,…
- Different types of algorithms can operate on the same device resulting in compound protection device
- Different protection strategies are developed
- DC IED have been implemented and lab tested: functionally ok
- First systems are implemented

- ➔ no need for further research?

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Remaining needs for algorithms

- Optimization of different algorithms still needed
  - From good enough to ensuring the combination gives ”the best” outcome
- Continued focus on robustness, fault tolerance, measurement requirements, delays, filtering,…
- Most research on cable systems ➔ OHL & mixed systems
- Flexibility to changing conditions
  - Without adaptive protection?
  - Reclosure
- Taking into account new features
  - E.g. pro-active mode
- Most research towards selective protection, but other options (e.g. using fault-blocking converters)

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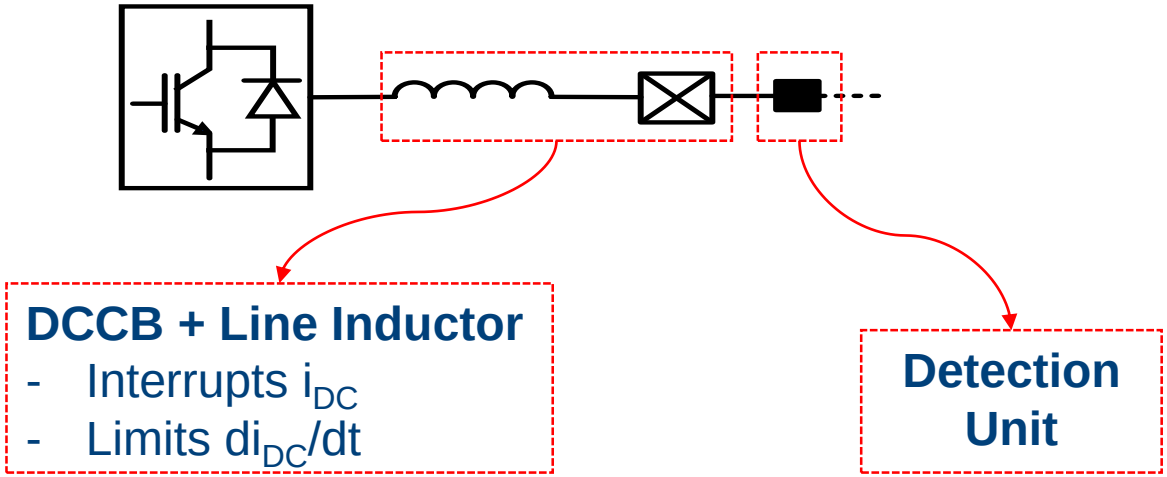
Remaining needs for relays/IED

- Further industrialization steps
  - Making it ready for use in the substation
- Is the IED part of the breaker, or a separate device?
- Which measurements are required?
- Making use of measurement signals from breakers and converters or do we rely on dedicated measurements?



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Remaining needs wrt to communication

- Communication within the substation
- Communication with converters
  - ➔ advanced converter behavior during faults
- Communication/interfacing with measurement equipment
- IEC 61850 (and other)
  - Currently, DC is not supported
  - How to define the protection features?
  - Interfacing with other (AC system)

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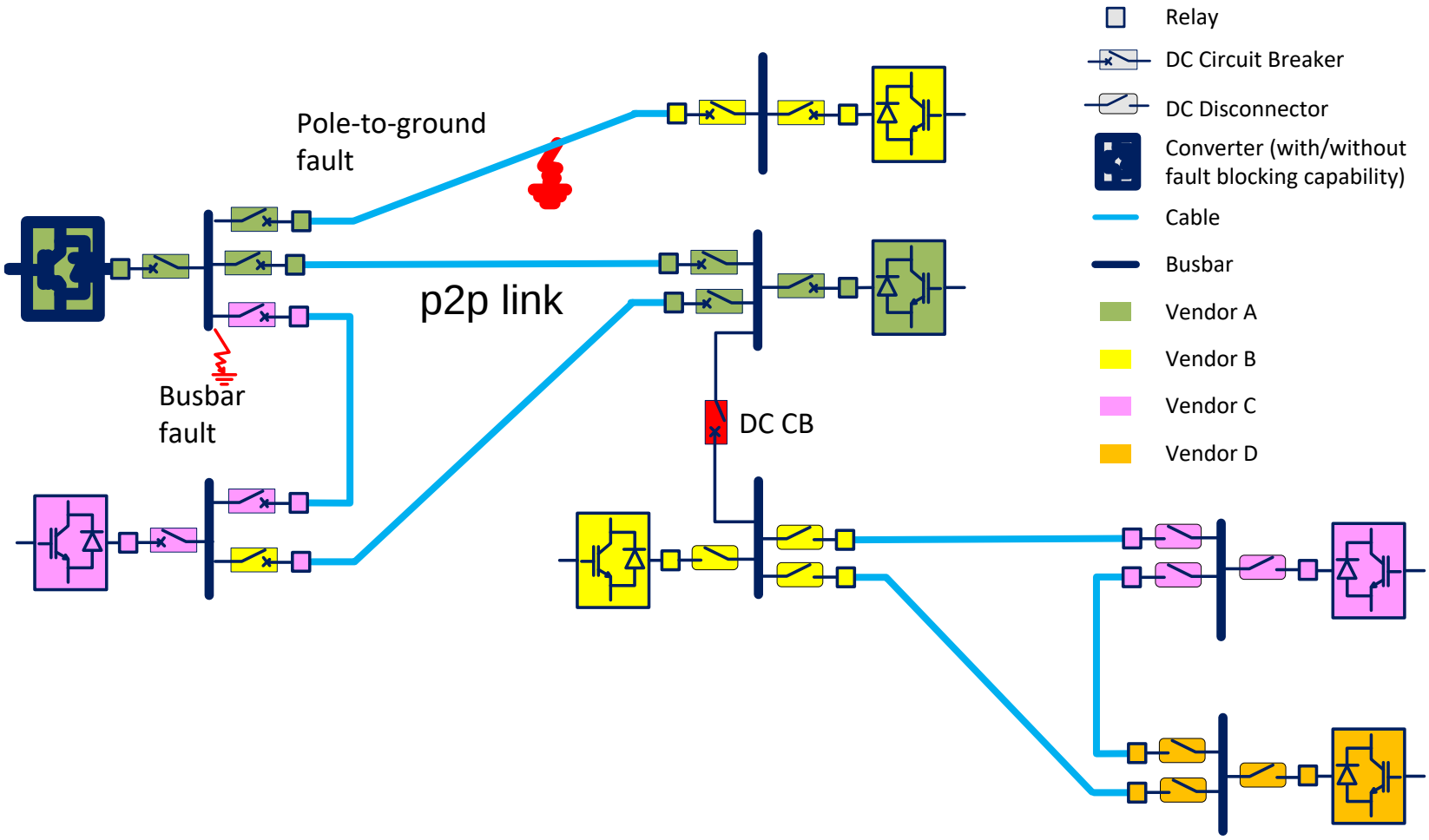
Remaining needs: multi-vendor and multiple protection strategies



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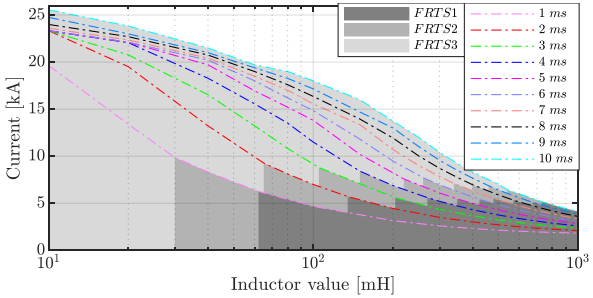
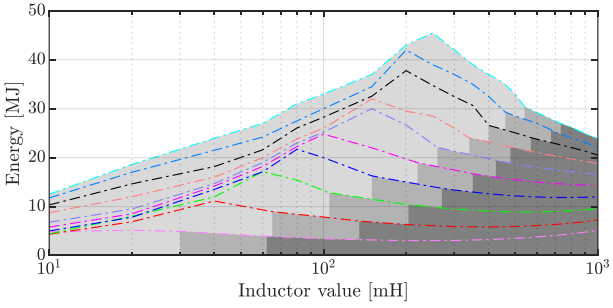
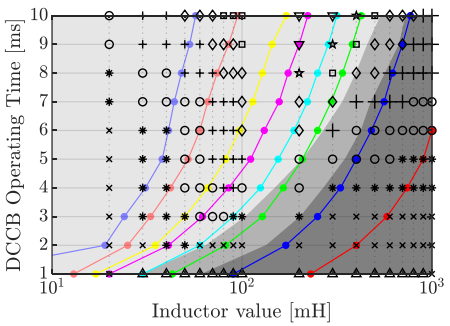
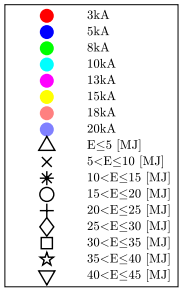
Remaining needs wrt standardization

- Testing and test procedures
- Protection classes
- We need to define functional requirements & interfaces
  - Which signals to send/receive
  - To converters
  - To (all types of) breakers
  - Inductor part of breaker?
  - Relay part of breaker?
- Definitions
  - What should be on the nameplate of a relay
  - What should be on the nameplate of a DCCB









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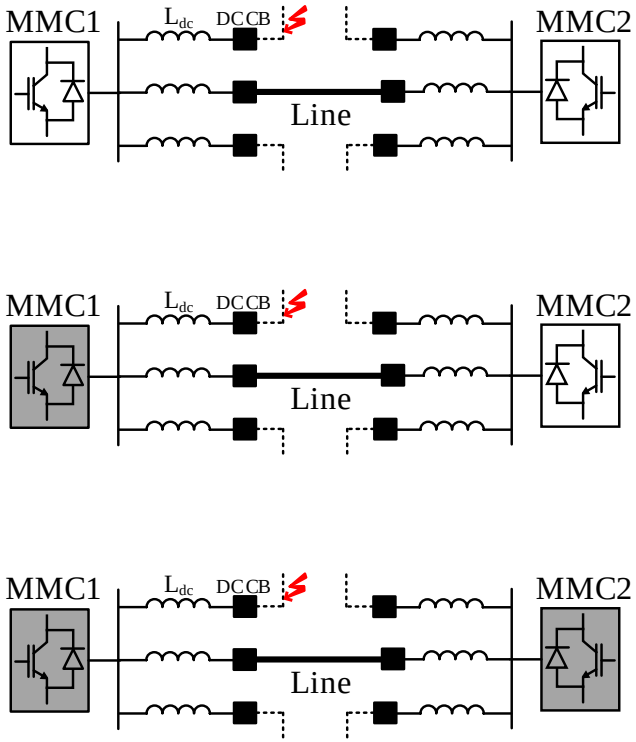
Remaining needs for grid codes

- Grid side expectations on various equipment parameters
- Fault current levels
- Voltage and current requirements
- Converter behavior
- What data should be exchanged?
- Which models should be exchanged?
- HVDC Grid Fault Ride Through Scenarios:
  - Fault Ride Through Scenario 1 (DC-FRTS1)
    - All converters are prohibited from blocking.
  - Fault Ride Through Scenario 2 (DC-FRTS2)
    - Remote converters are prohibited from blocking.
  - Fault Ride Through Scenario 3 (DC-FRTS3)
    - All converters can be blocked temporarily.



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Remaining needs wrt to measurement equipment

- Voltage measurements:
  - Location (respective to the busbar, inductance, poles,…)
  - Amount
  - Accuracy, bandwidth, delay
- Current measurements:
  - Location (respective to the busbar, inductance,…)
  - Amount
  - Accuracy, bandwidth, delay

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Remaining needs wrt to modeling and simulations for protection studies

- DC converters are still hard to simulate
  - Level of detail shared for protection studies?
- Behavior during the fault needs to be fully understood, in terms of default behavior and the degree of freedom available
  - Did we consider actual fault waveforms
- Different converter types/implementations/topologies might have different behavior
- DC choppers and their interaction with the grid
- Interaction of protection equipment (including inductors) with the system can cause instabilities, and require the right models and simulation tools

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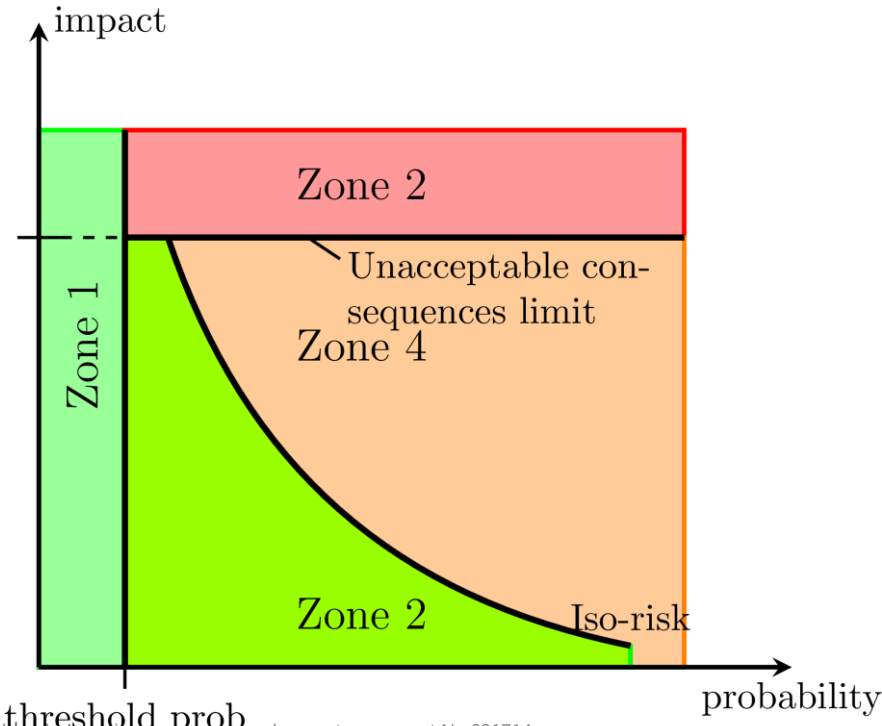
Remaining needs wrt to topology development

- AC system developments are largely rule based
- Significant learning based on probability and impact
- Same approach to be used for DC grids
  - Busbar topologies
  - Nr of connections, redundant paths
  - …



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Conclusions

- DC grid protection has reached the stage that a solution is found
- This solution might need refinement
- Further developments are expected
- Two main lines of thought:
  - Industrialization
  - Agreements on the expected behavior will require adaptations
- End solution should be:
  - “multi-vendor”
  - Integrated in the existing substation infrastructure (including IEC 61850,…)
  - Future ready (grid extensions)

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