PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

Design of test circuit for HVDC circuit breaker based on AC supply

PROgress on Meshed HVDC Offshore Transmission Networks

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CONTENT

- DC circuit breakers
- DC current interruption
- Test requirements
- Low frequency AC short-circuit generator test circuit

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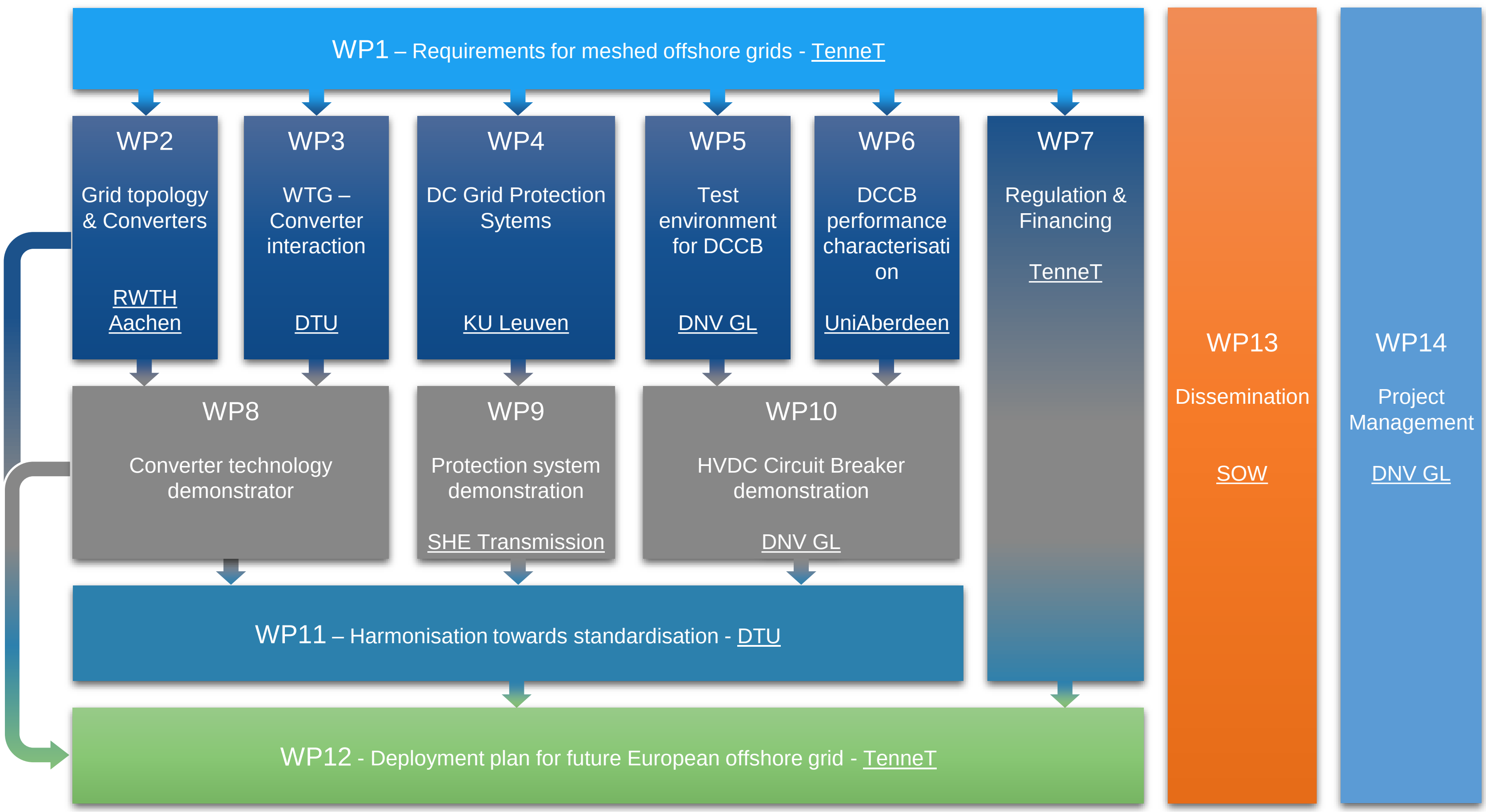
PROMOTioN – The Project

Work Package Structure



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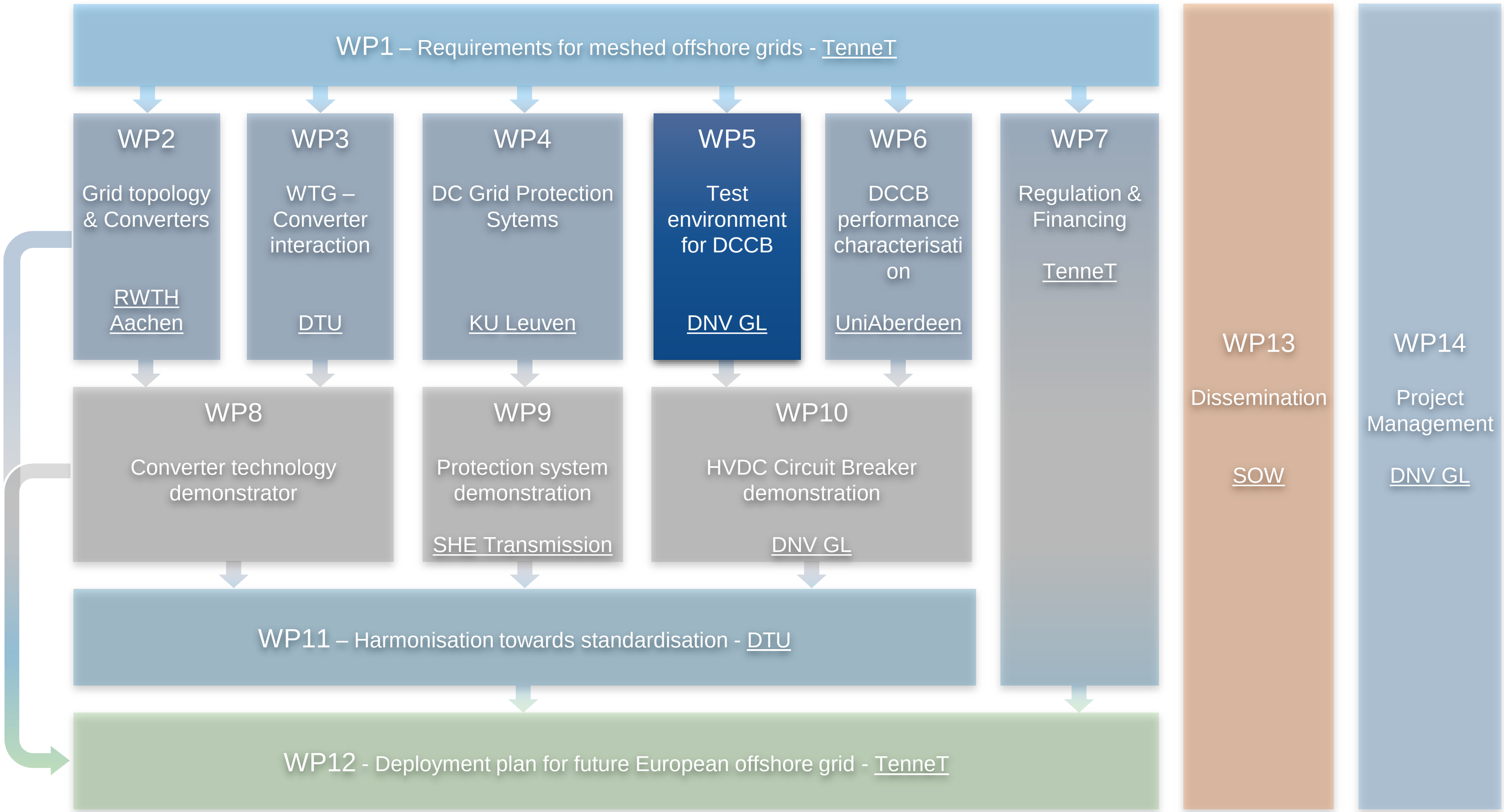
PROMOTioN – Work Package 5

Test environment for HVDC circuit breakers



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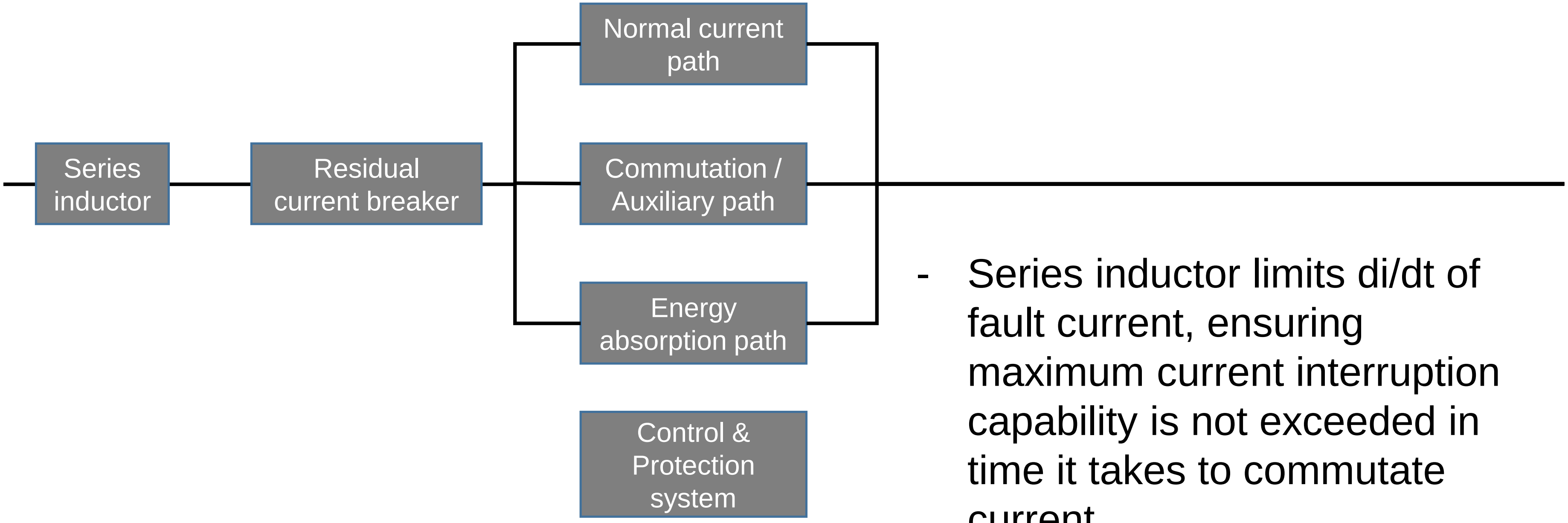
HVDC circuit breaker principle

- Normal current path provides low loss normal operation
- During fault, commutation path creates artifical current zero
- Current is commutated into energy absorption path (surge arrestor)
- Energy absorption path applies large reverse series voltage, suppressing current



- Series inductor limits di/dt of fault current, ensuring maximum current interruption capability is not exceeded in time it takes to commutate current

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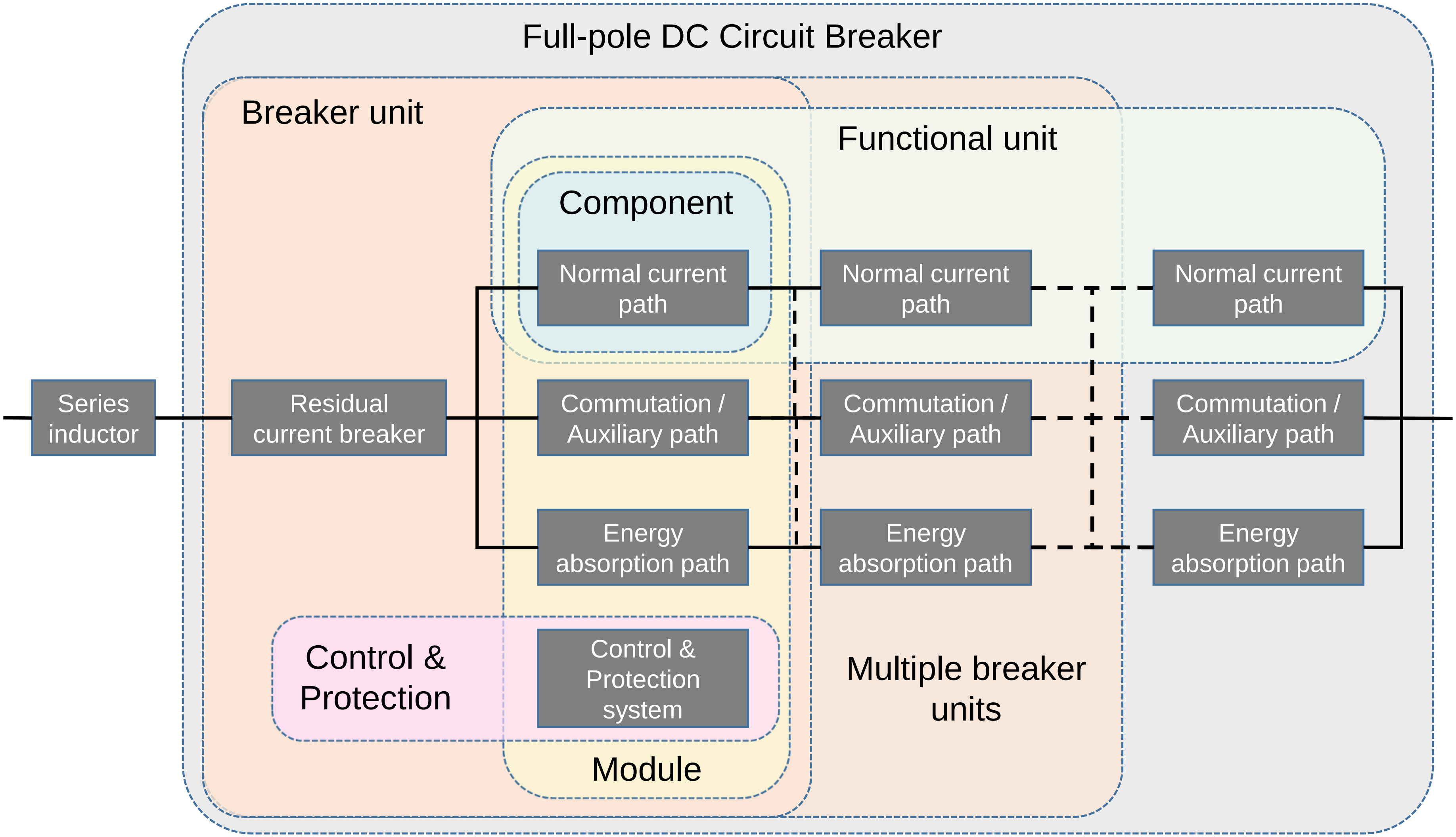
PROMOTioN – Work Package 5

Terminology and Design



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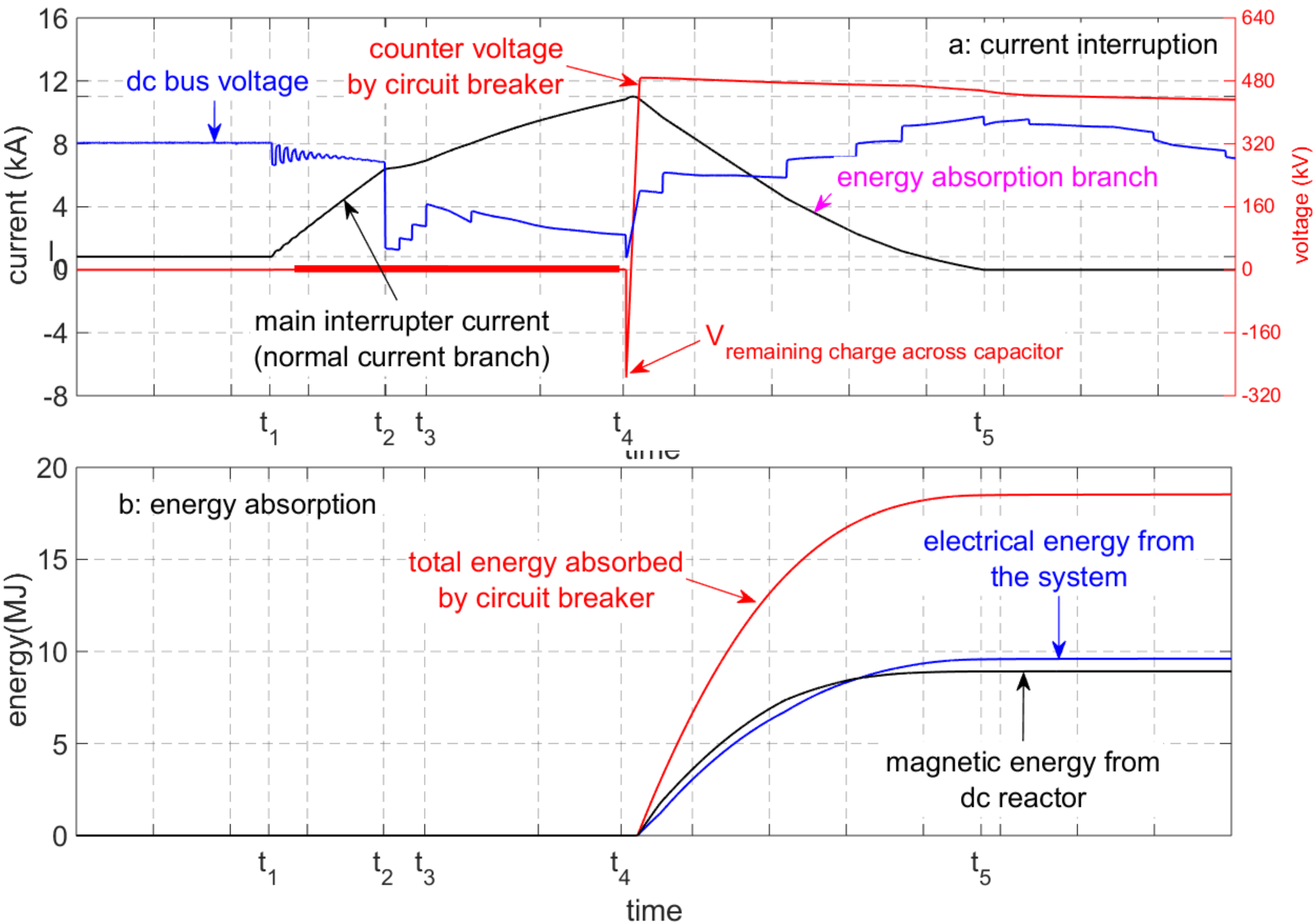
Electrical stresses on DC circuit breaker



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Test Requirements

HVDC Circuit breaker tests

Dielectric Tests

- Lightning impulse
- DC voltage withstand

Operational tests

- Temperature rise test
- Short-time current withstand
- Current let-through

Breaking

- Breaking current
- Interruption time
- Maximum TIV withstand
- Energy absorption

Endurance tests

- Electrical Endurance
- Mechanical Endurance

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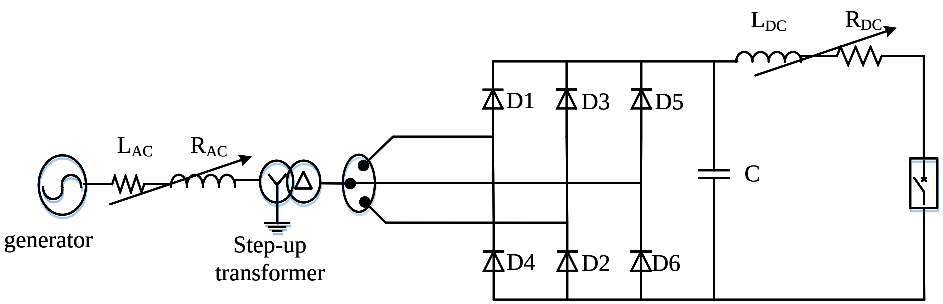
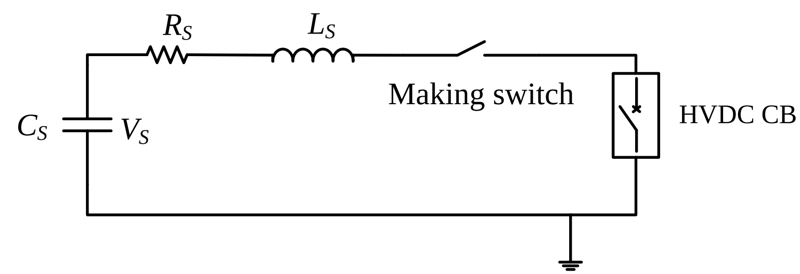
DC circuit breaker potential test circuits for current interruption tests

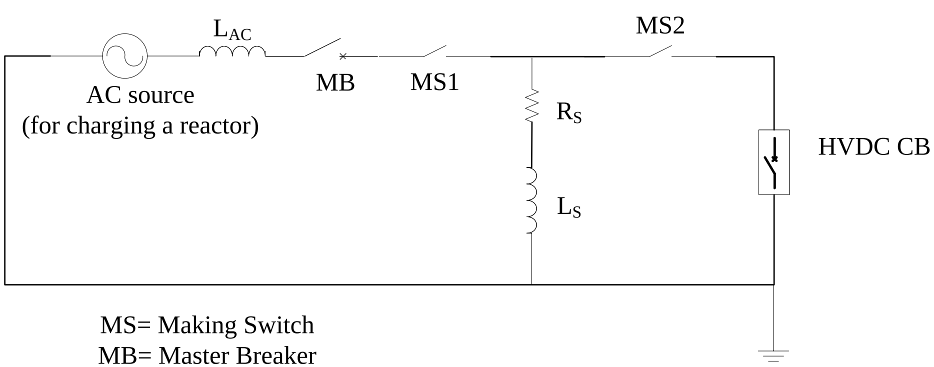
- Rectifier with controllable parameters



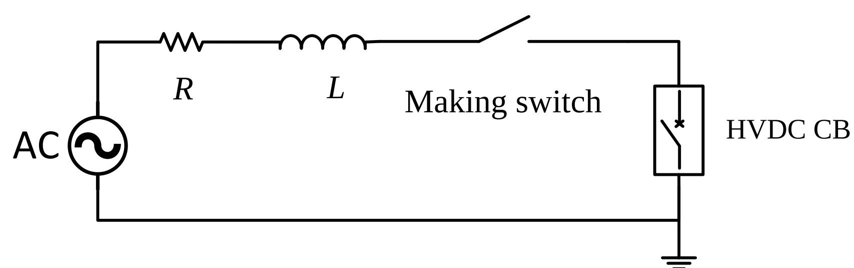
- Charged Capacitor



- Charged reactor method



- Variable Frequency AC generator



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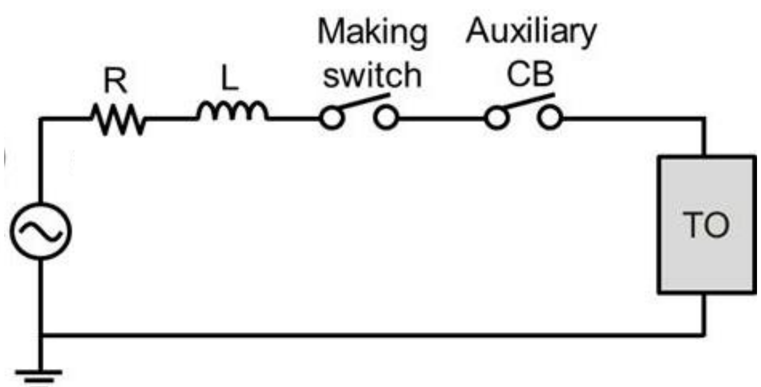
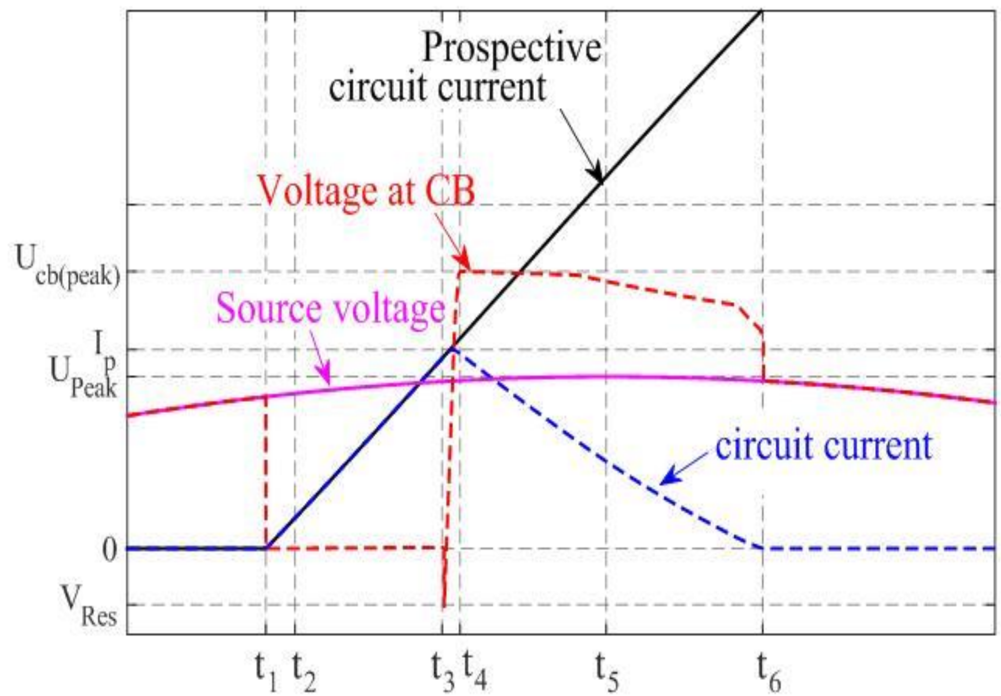
Low frequency AC short circuit generator current interruption test method





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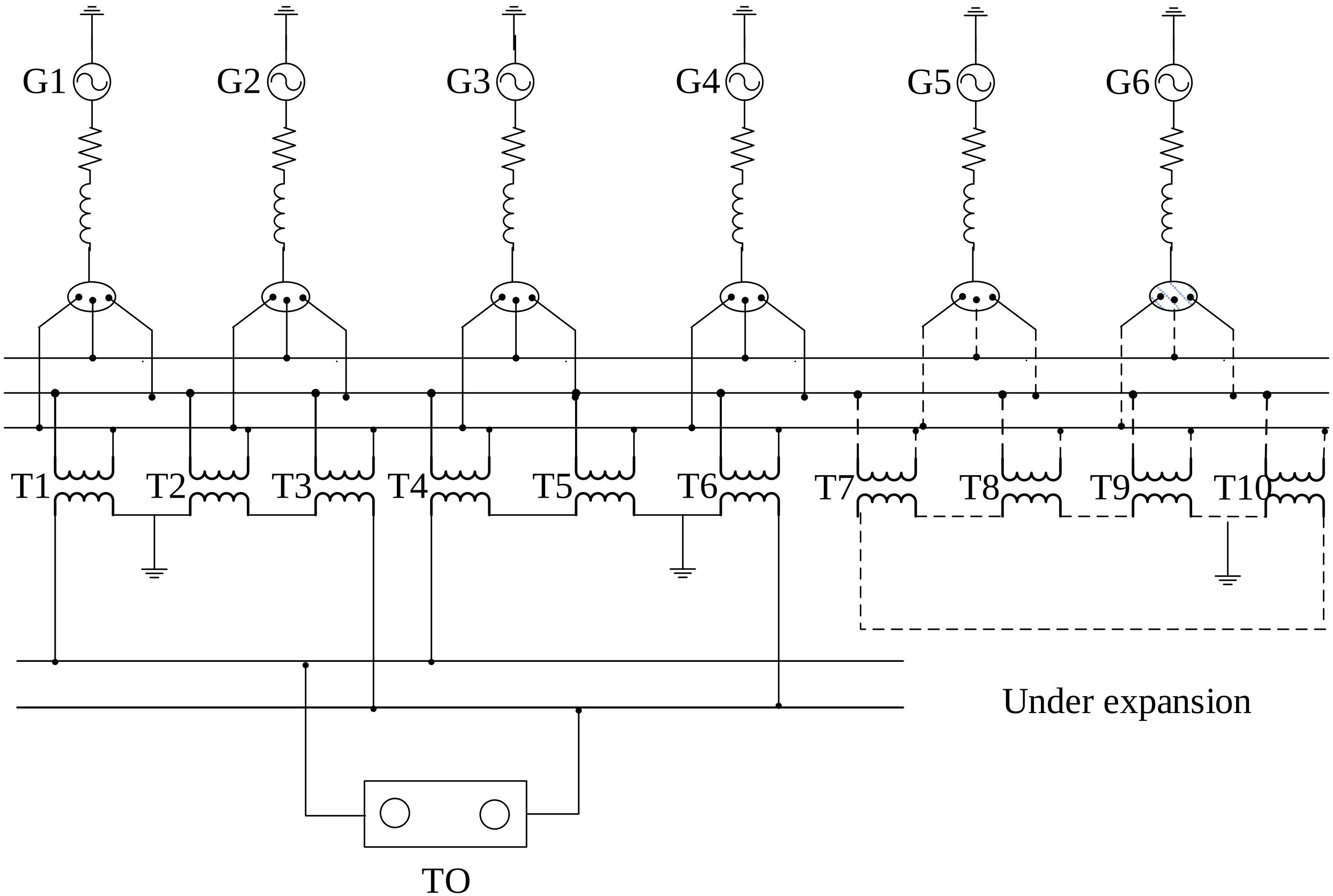
KEMA Laboratories test set-up



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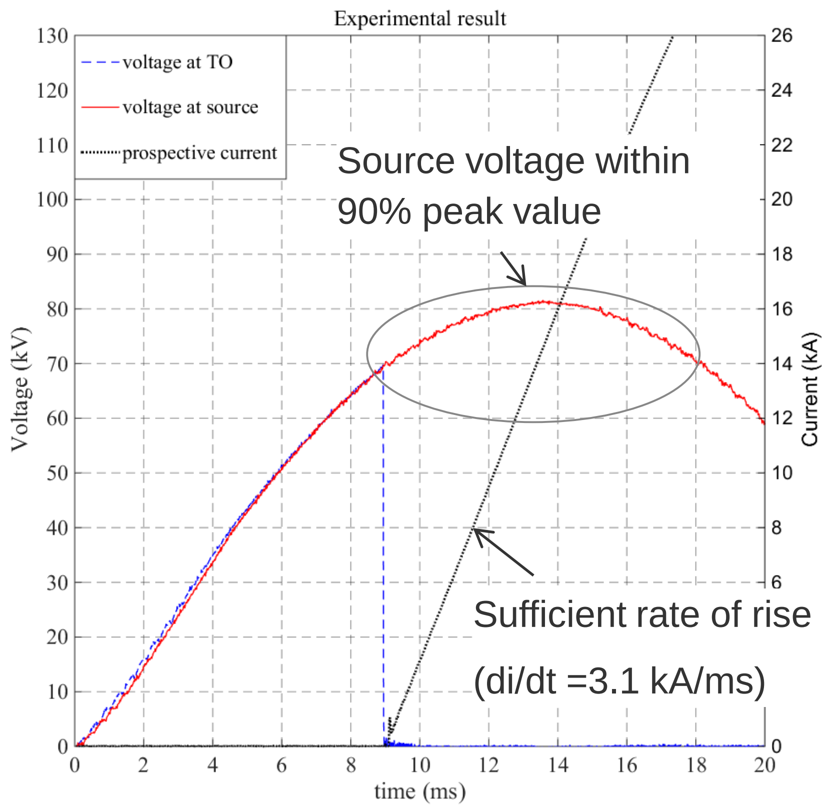
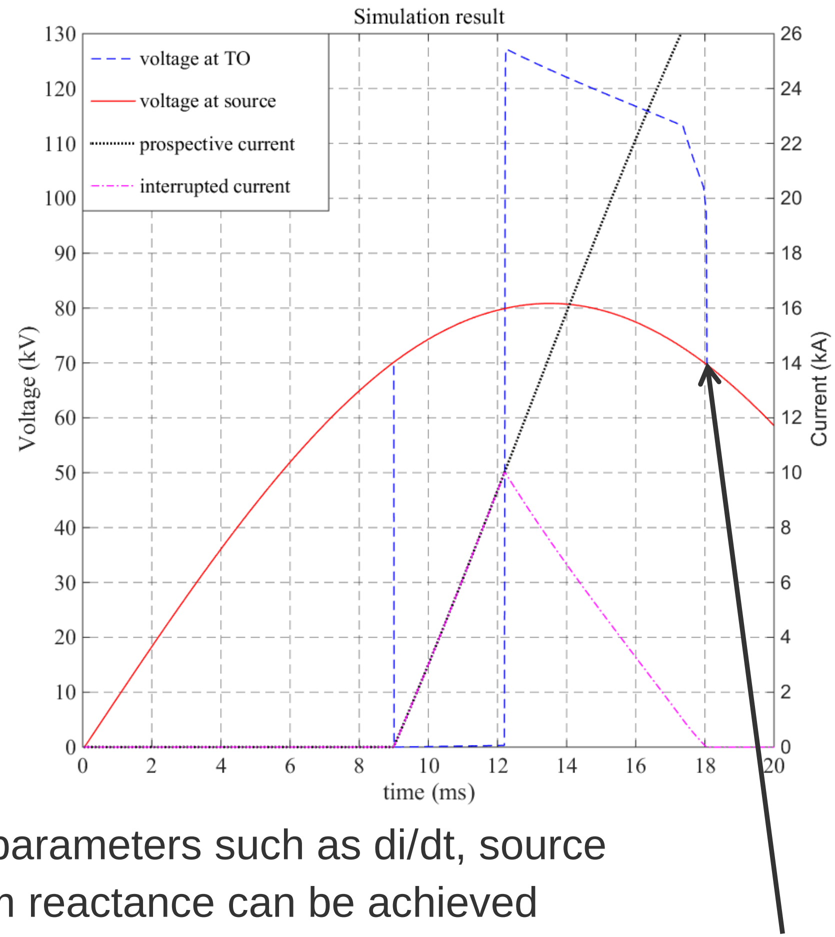
Experimental verification





- Using low frequency sufficient test parameters such as di/dt, source voltage and energy stored in system reactance can be achieved
- Prospective tests at 120 kV was also conducted

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Practical limitations of using AC short-circuit generators

- By-pass test current in case test object fails to clear
  - Fast making switch by-pass can be realised
- Application of di-electric stress after current suppression
  - Necessary for mechanical interrupters, can be applied by remnant internal capacitor voltage
- Impact of TIV imposed onto test circuit
  - Full-pole configuration cannot be tested
- Transient voltage distribution across modules in full-pole configuration
- Reclosing tests: testing of open-close-open sequence
  - Use parallel combination of timed short-circuit generators
  - Test of line charging equipment
- Control & protection system real-time simulator test

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Conclusions

- DC circuit breakers are fundamentally different from AC circuit breakers
- Testing full-pole breaker at full ratings is uneconomical and unnecessary
- DC circuit breaker testing is likely to resemble testing of converter valves
- Full DC circuit breaker test likely to consist of:
  - Operational, interrupting and endurance tests of a breaker unit
  - Dielectric tests on each type of support structure and across terminals
  - Functional tests of control and protection system
- AC short circuit generators running at low frequency can be used for current interruption testing

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Thank you!

Any questions?

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APPENDIX

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