



PROMOTiON

PROGRESS ON MESHED HVDC
OFFSHORE TRANSMISSION
NETWORKS



Mechanical Circuit Breaker with Active Current Injection

PROMOTiON Workshop: TSO Workshop on DC Circuit Breakers, 17th February 2017, Arnhem,
Mitsubishi Electric Europe



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Mitsubishi Electric Europe

History

- ↗ Mitsubishi Electric Corporation : established in 1921 from a shipbuilding company
- ↗ Mitsubishi Electric Europe: first European office opened in 1969 in London

Locations

- ↗ Head Quarter Europe: the Netherlands
- ↗ Power System Group: London UK

Products and Services:

- ↗ Energy Systems
- ↗ Semiconductor Devices
- ↗ Building Systems
- ↗ Air conditioning Systems
- ↗ Transportation Systems

Transmission & Distribution Systems



Transformers



Switchgears

Power Generation Systems



Static Var Systems



Instrumentation and Control

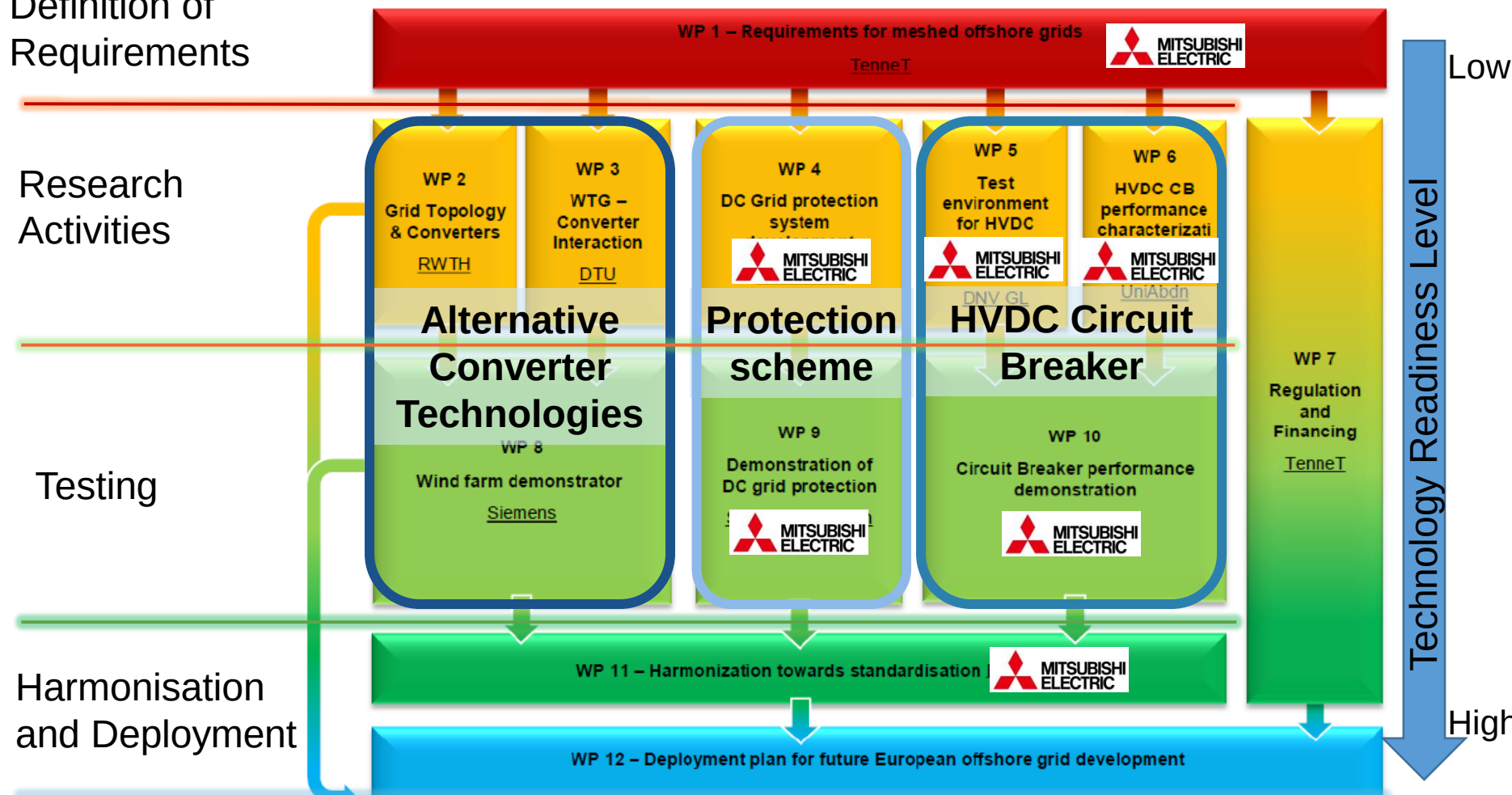
Mitsubishi Electric Europe in PROMOTiON

Definition of
Requirements

Research
Activities

Testing

Harmonisation
and Deployment



Mechanical Circuit Breaker with Active Current Injection

Introduction on HVDC Circuit Breakers

Large DC networks will have a significant impact on the AC networks during DC disturbances. DC faults can damage HVDC equipment or unacceptably influence AC network stability.



An adequate DC protection scheme is necessary

HVDC Circuit Breaker:

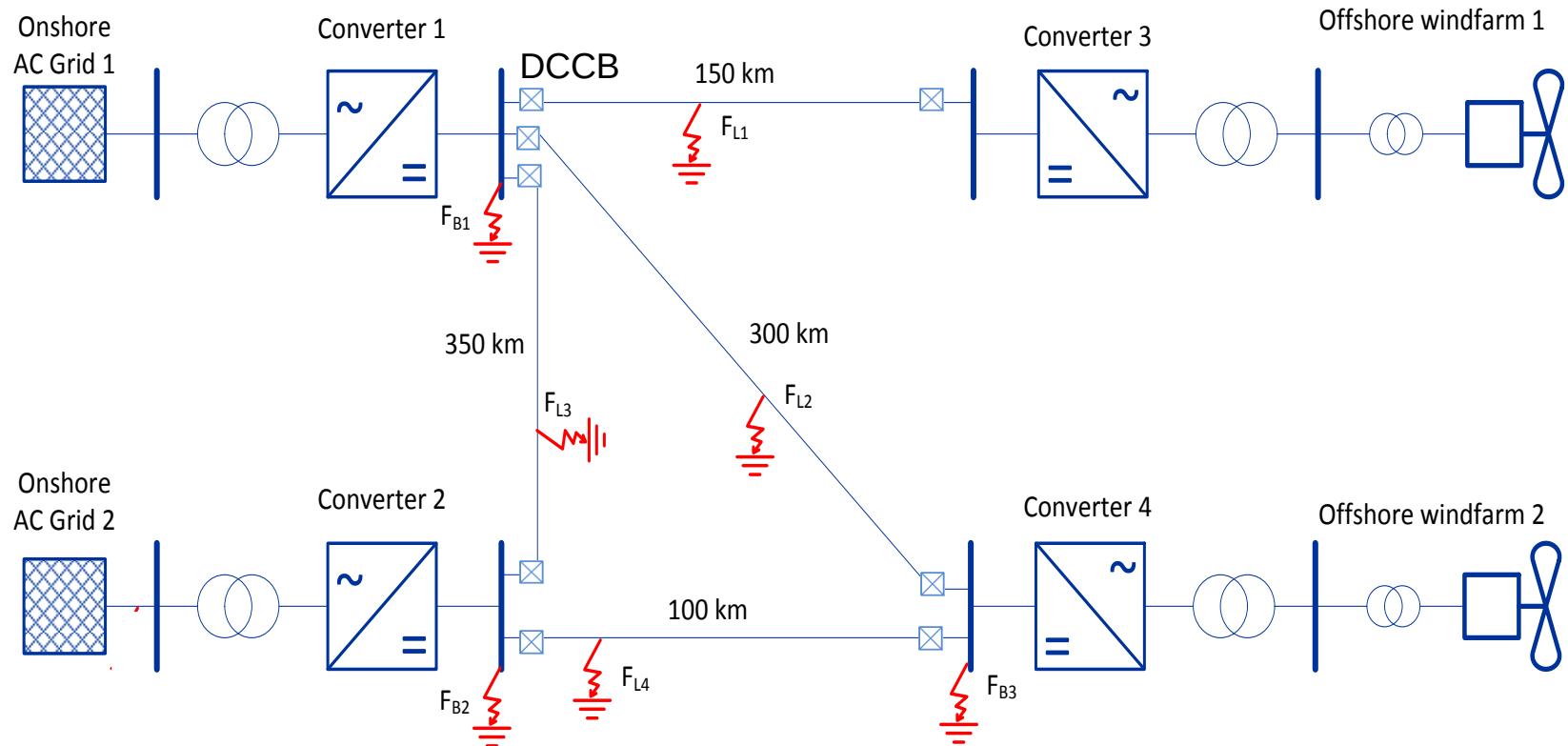
Key component of a DC protection scheme

Isolation of faulted segments so that the healthy areas of the DC network continue to operate

Foreseen Applications:

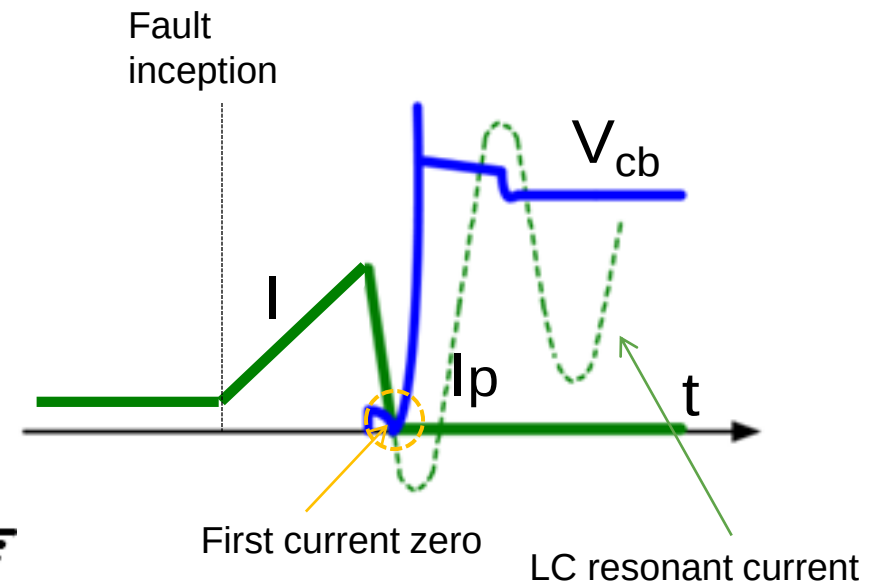
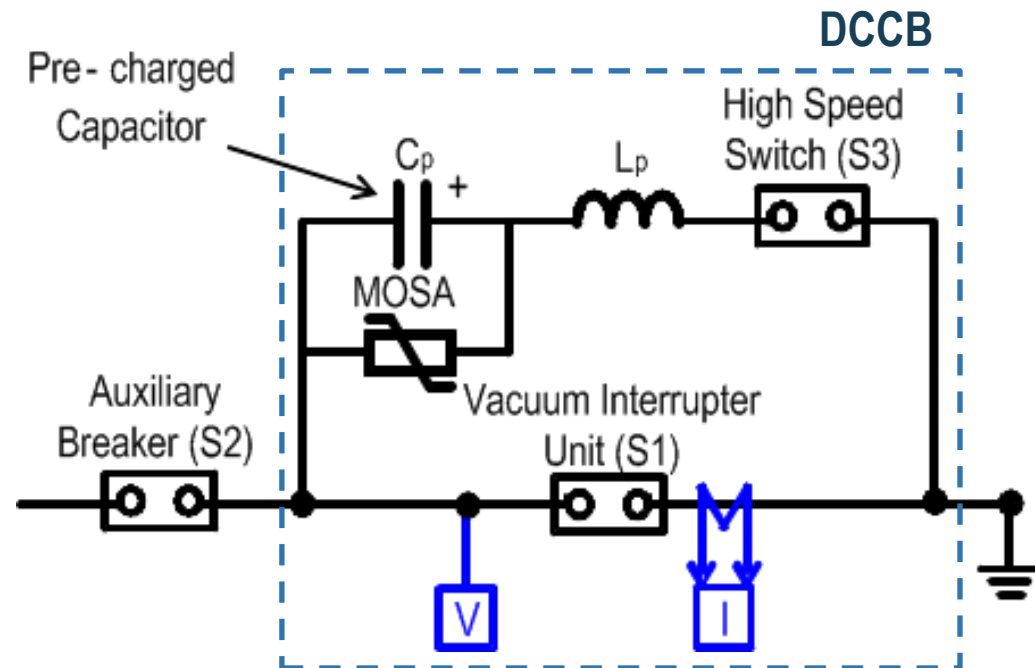
- Multi-terminal DC grids (~ 320 kV)
- Offshore DC collector networks (~ 80 kV)

Application of DCCB in MTDC grids

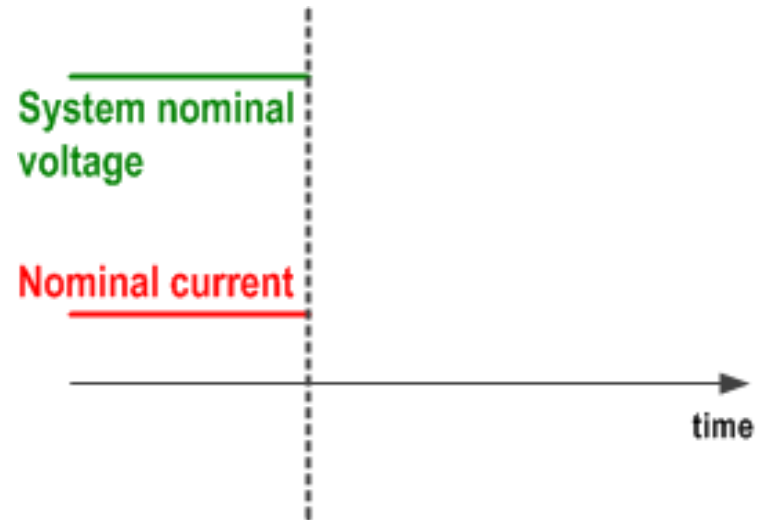
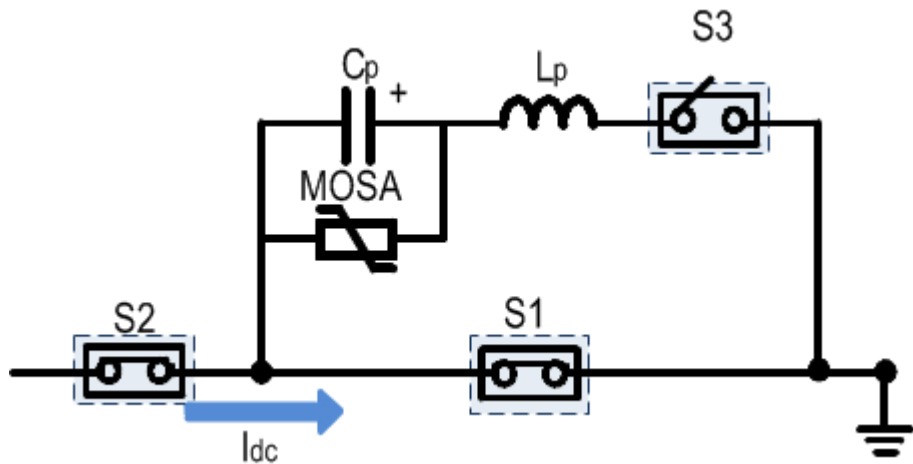


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DCCB Topology



Stage 0: Pre-fault Conditions

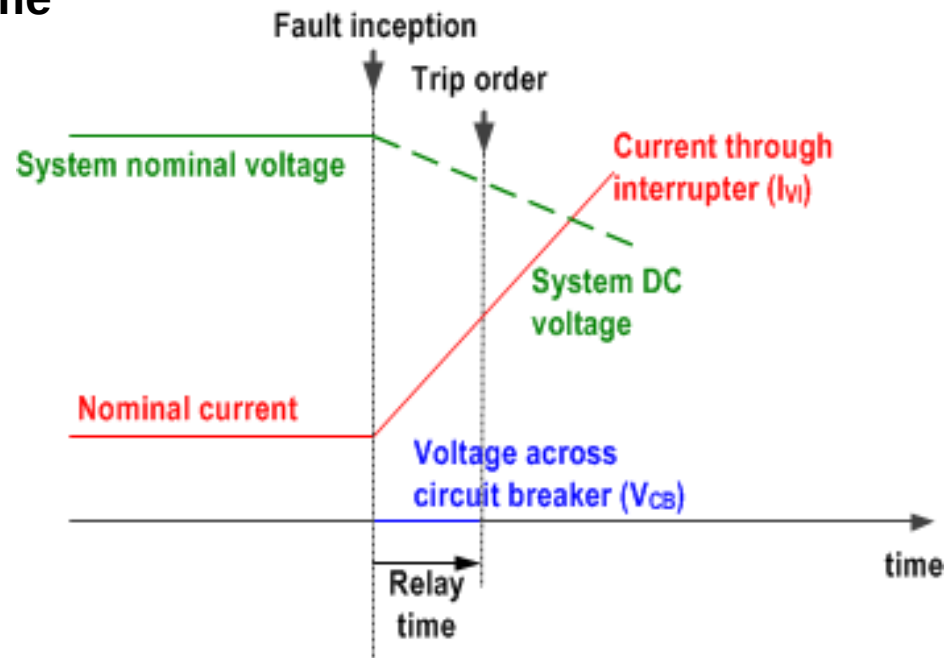
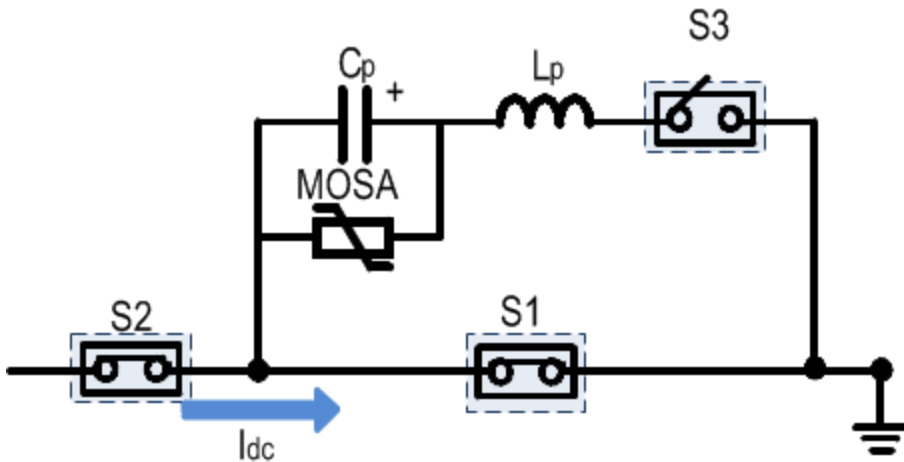


- S1, S2 close
- S3 open, Cp pre-charged

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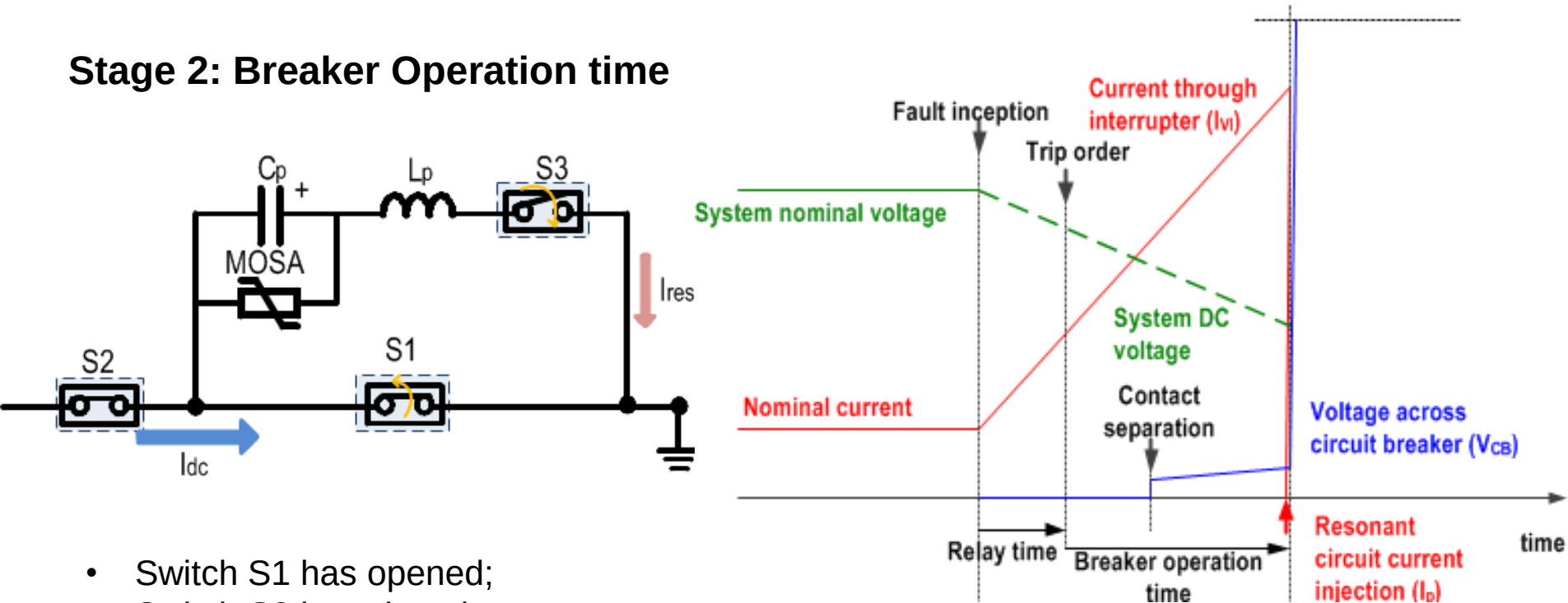
Principles of Operation

Stage 1: Fault Inception and Relay Time



- Fault inception
- DC side voltage starts to decay and current increase.
- Fault detection and discrimination (current and voltage wave fronts detected by relay)
- Breaker receives trip signal sent from relay

Stage 2: Breaker Operation time

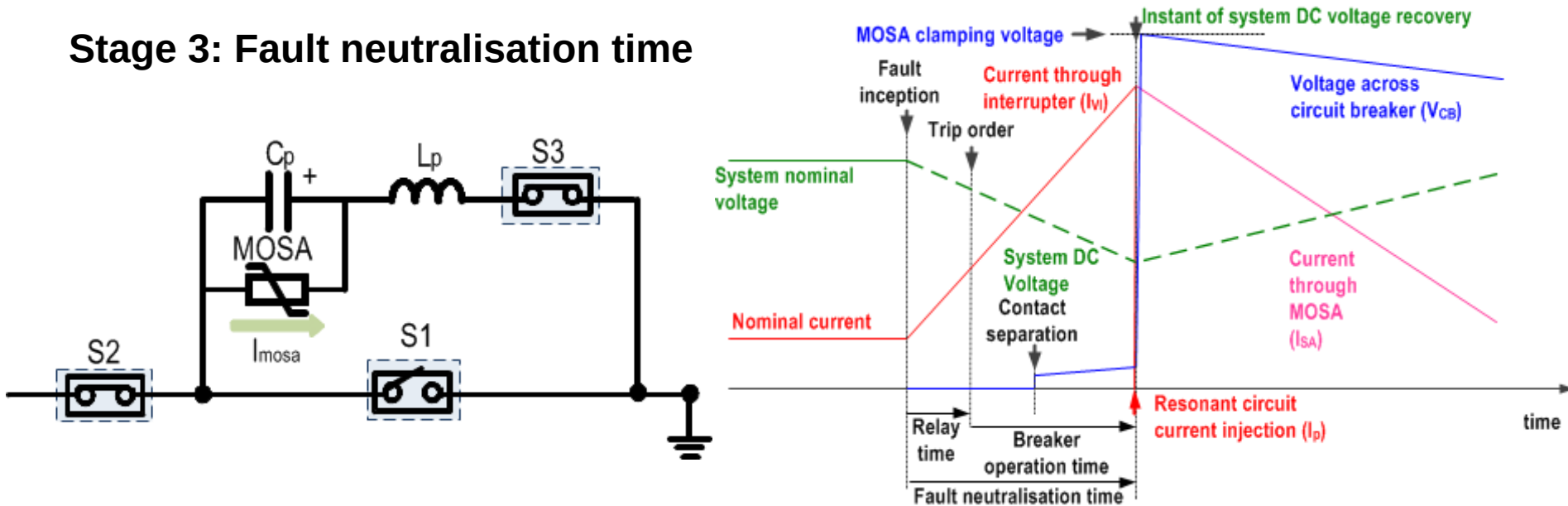


- Switch S1 has opened;
- Switch S3 has closed;
- Delays associated with physical movement of circuit breaker components.
- Current zero is generated in S1 from the resonant circuit (8ms);

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Principles of Operation - Sequence

Stage 3: Fault neutralisation time

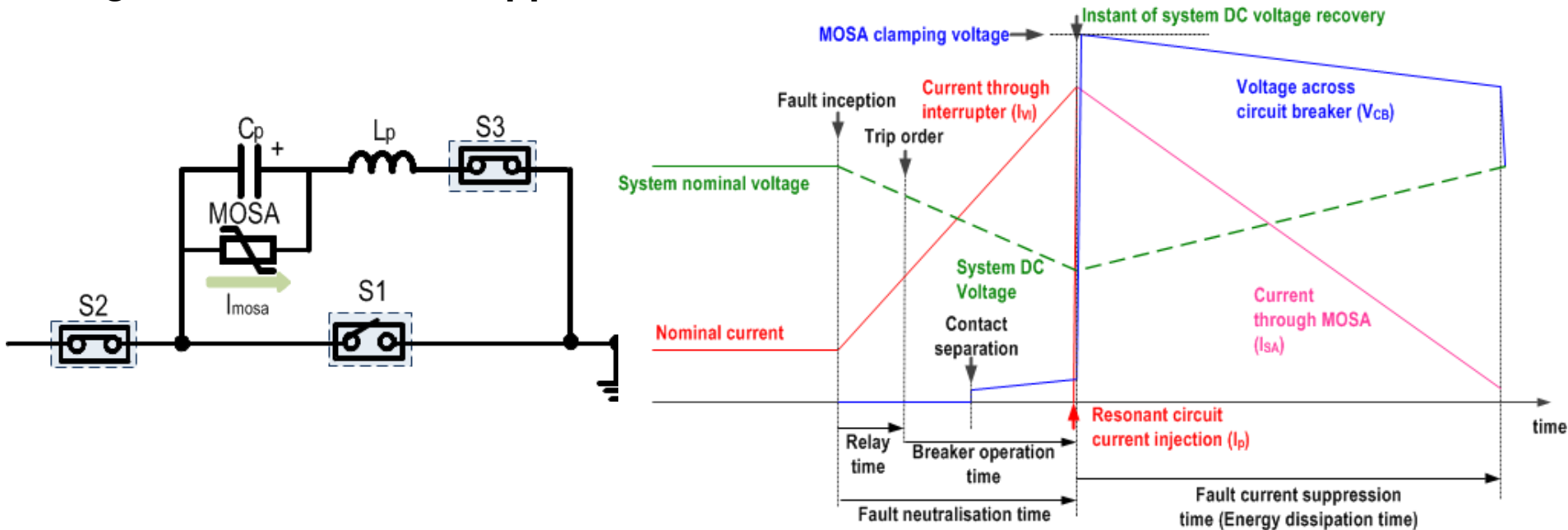


- Capacitor voltage rises until the MOSA clamping voltage is reached.
- Current is then commutated into the MOSA;
- Circuit breaker voltage is equal to MOSA clamping voltage
- At the end of Fault neutralization time (Relay time + breaker operation time):
 - Breaker has been tripped;
 - Internal current zero and counter voltage generated.

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Principles of Operation - Sequence

Stage 4: Fault current suppression time

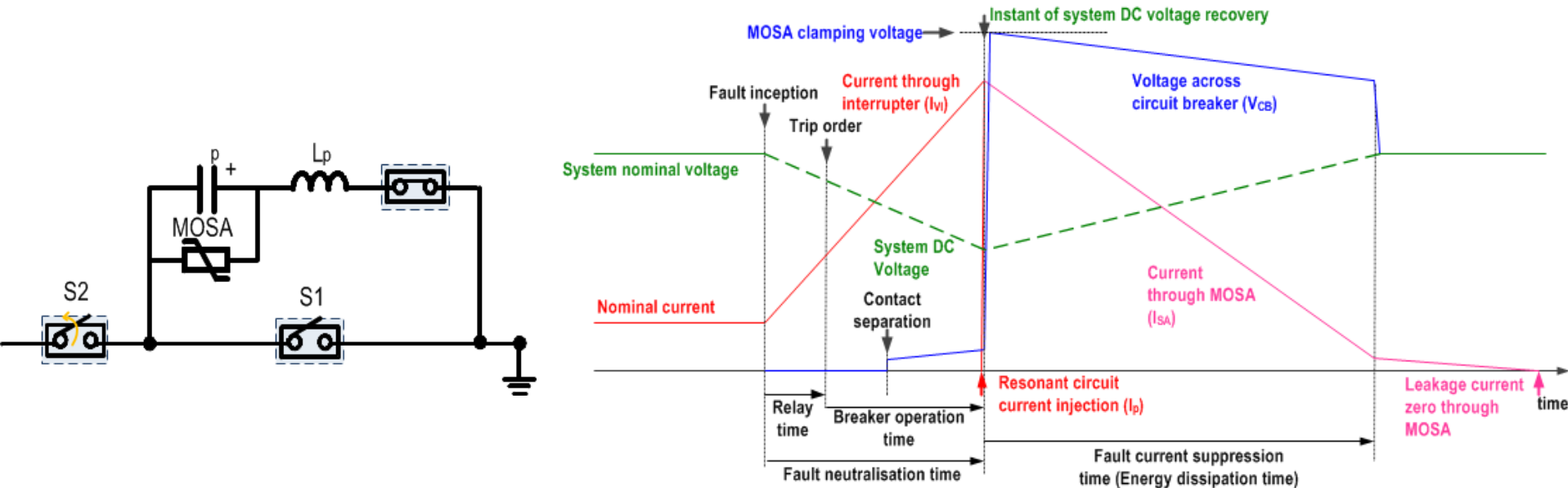


- Time for stored magnetic energy to be dissipated in the MOSA determined by the system configuration (cable length, MOSA characteristic, etc)

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Principles of Operation - Sequence

Stage 5: Auxiliary circuit breaker open

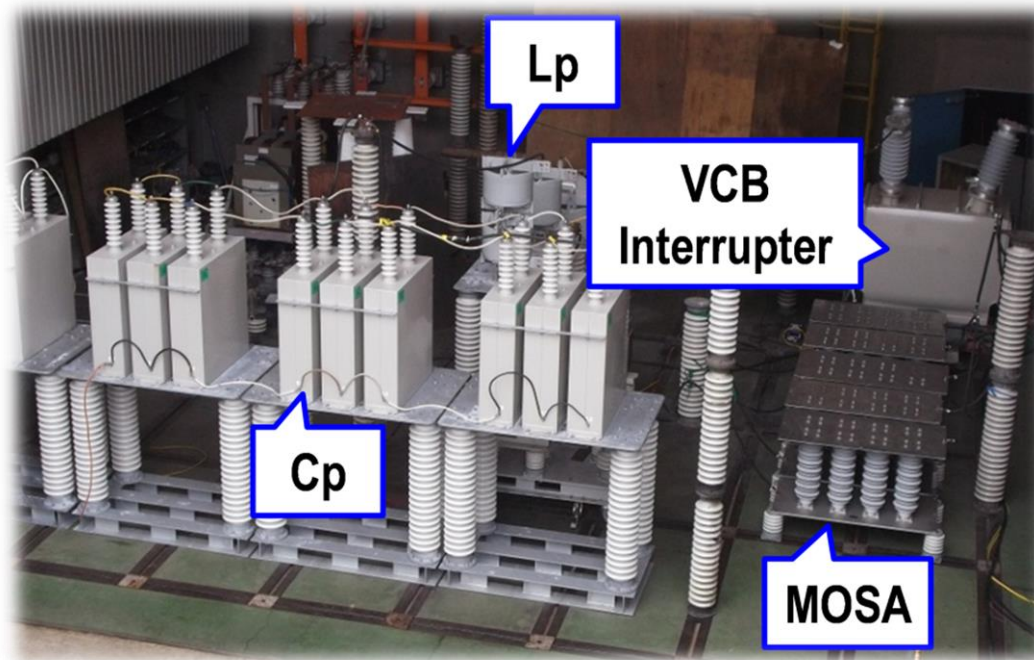


- Auxiliary circuit breaker (S2) opens
- Galvanic isolation is provided

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Testing set-up

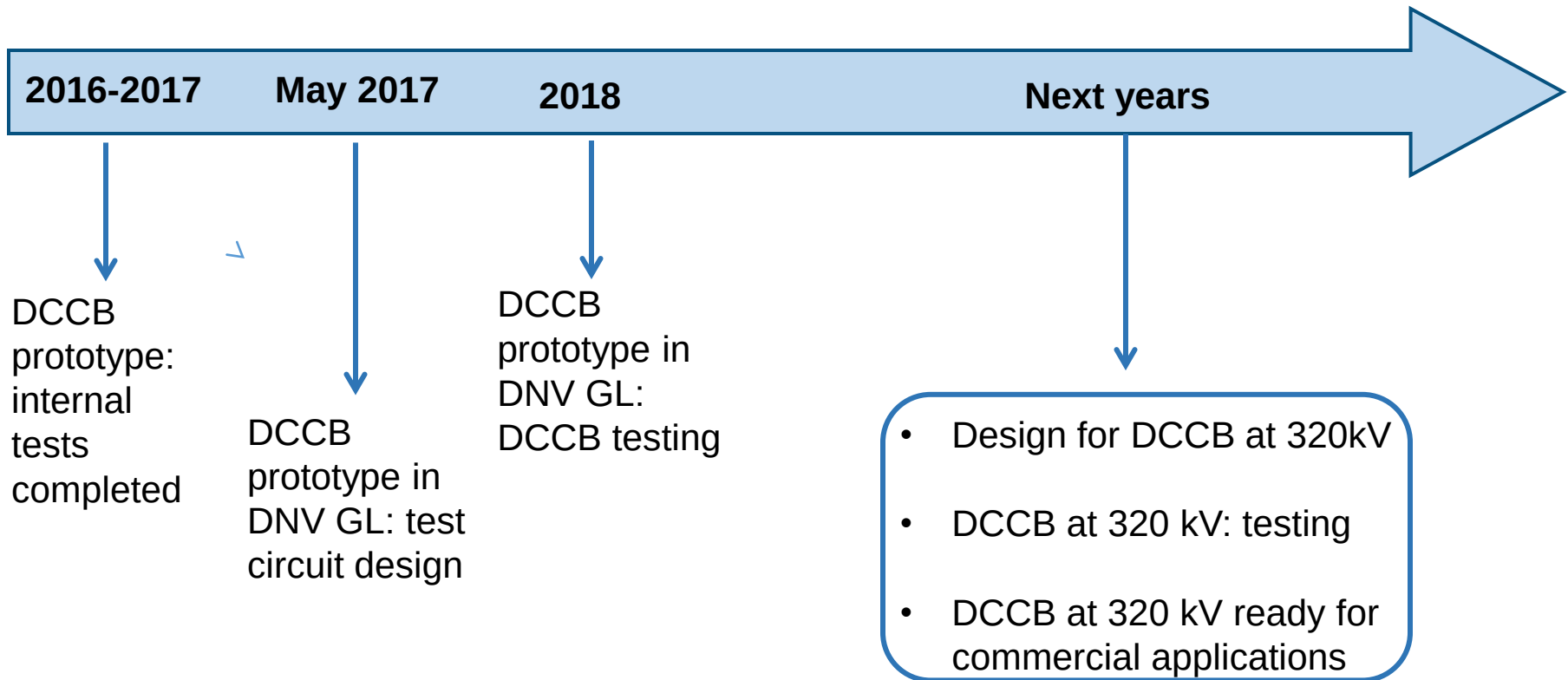
DCCB Prototype Rating: 80 kV, 16 kA



Mechanical DCCB prototype with active resonant current zero formation composed of HV vacuum interrupter was tested to interrupt DC current up to 16 kA.

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Product Time Line



[illegible]

APPENDIX

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