Study Committee A3

Transmission and Distribution Equipment

Paper 10545_2022

Recent HVDC Circuit Breaker Development and Testing

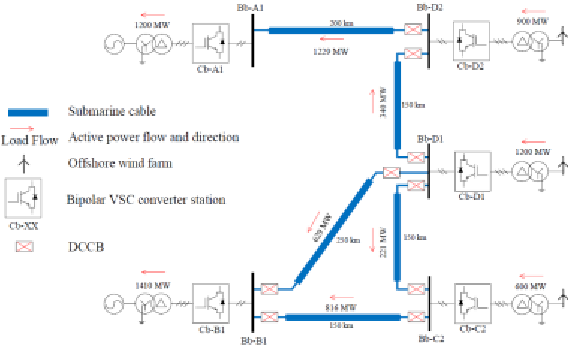
N. A. Belda[1], R. P. P. Smeets[1], H. Ito[2], S. Tokoyoda[2], T. Inagaki[2], S. Nee[3], T. Modeer[3], M. Semere[4], A. Hassanpoor[4], C. A. Plet[5]

[1]KEMA Labs, [2]Mitsubishi Electric, [3]SciBreak AB, [4]Hitachi Energy, [5]DNV

Motivation

- Increase technology readiness level (TRL) of HVDC CBs, define and develop test methods and test procedures
- Field and practical experiences are unavailable → provide lab experience as inputs to ongoing standardization activities
- Increase confidence of end users HVDC CBs through demonstration
- Challenges of testing and develop alternative testing methods

Method/Approach

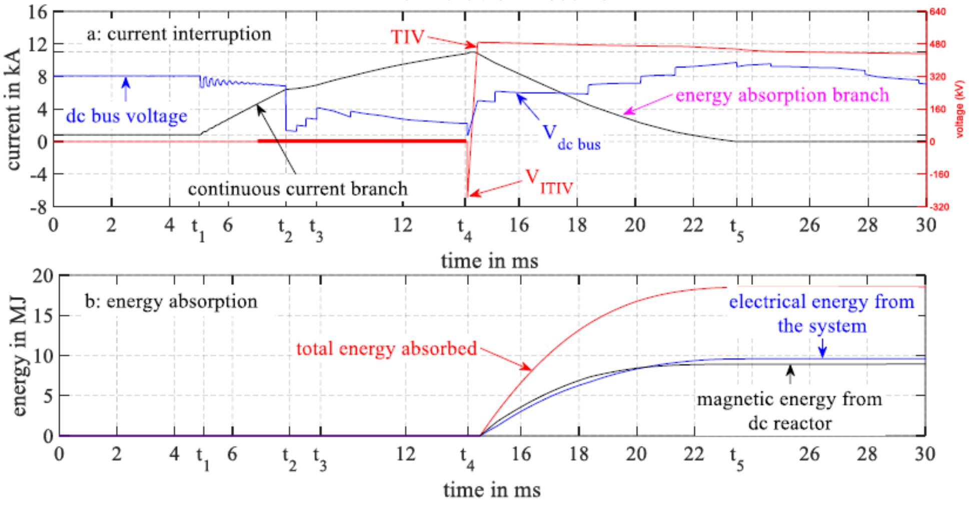


Objectives

- Qualify HVDC CBs for short-circuit current breaking
- Define requirements of HVDC CBs → Perform (conceptual) system simulation studies
- Evaluate and compare test circuits, develop test method and setup test procedure, define test duties
- Experimental investigation of HVDC CB setup → Determine and quantify the electrical and thermal stresses (on internal (sub-)components)
- Full-power testing (demonstration) of three different technologies of HVDC CBs
- Submit HVDC CBs to complete stress as would be in service in one go

- Fault current interruption process and critical stresses
  - Internal current commutation
  - Generation of TIV
  - Energy absorption
  - DC recovery voltage withstand
- Electrical stresses
  - Short-circuit current
  - Voltage stresses
- Non-electrical stresses
  - Thermal energy stresses
  - Mechanical stresses

Simulation Results



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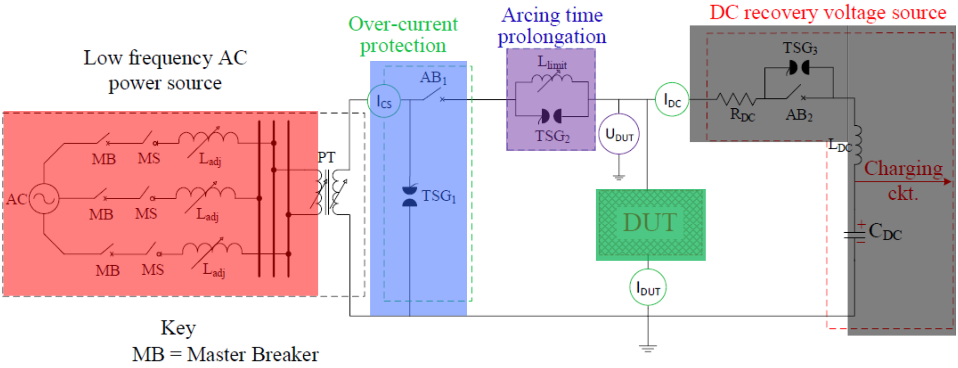
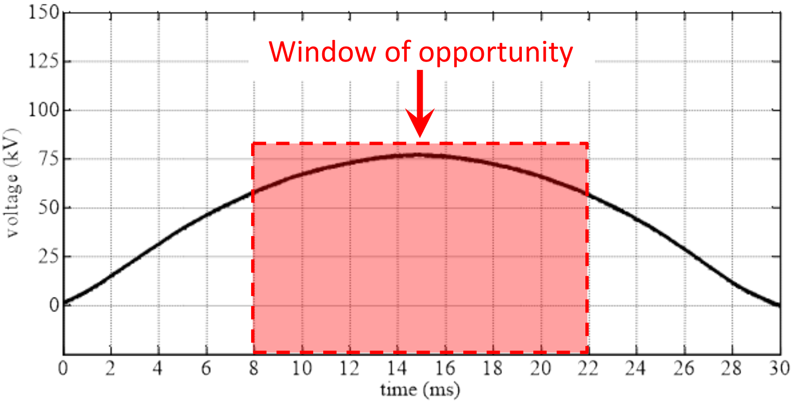
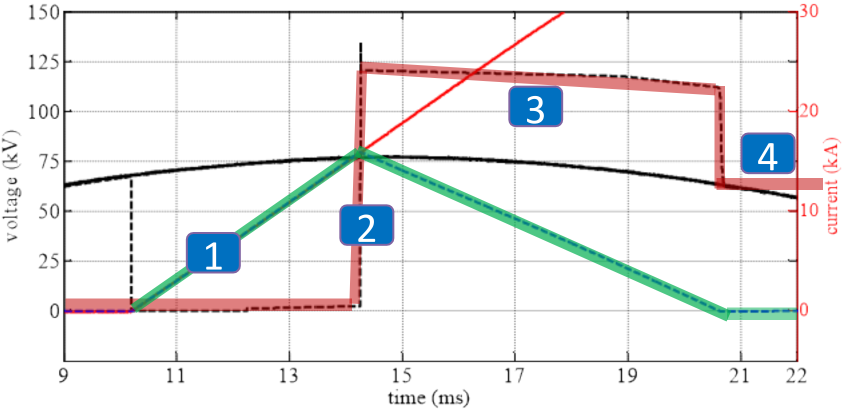
Test Circuit: AC Short-circuit generator based



Test Method : AC Short-circuit generator based



Test Parameters : Critical stresses and stages of current interruption



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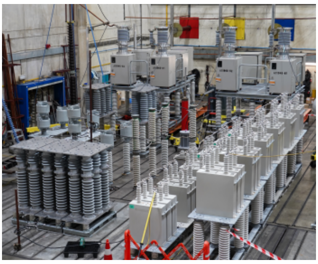
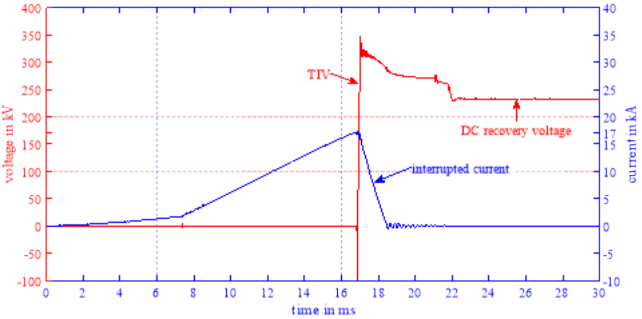
Active current injection HVDC CB



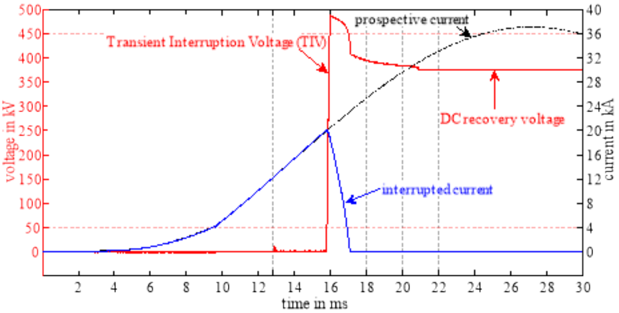
Hybrid HVDC CB

VARC HVDC CB

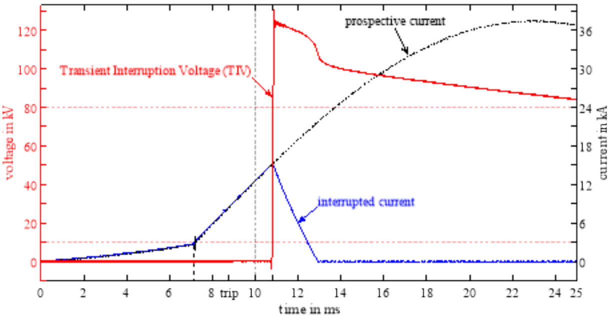
Test Result: 160/200 kV, 16 kA, 5 MJ, 7 ms



Test Result: 320 kV, 20kA, 10 MJ, 3 ms,



Test Result: 80kV, 12/15kA, 3 MJ, 2 ms,



Conclusion

- ✓ System simulation studies → Critical stresses and current breaking stages have been identified
- ✓ Current breaking test requirements of HVDC CBs have been defined → translated from simulation studies
- ✓ Adequate test method has been developed and demonstrated
- ✓ Three technologies of HVDC CBs have been tested up to 320 kV, 20KA
- ✓ TRL of 6-7 has been achieved

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