cigre Symposium Aalborg, Denmark
4th-7th June 2019

1200V, 200A Laboratory prototype for LC DC Circuit Breaker

Preferential subject 3.

D. Jovcic
University of Aberdeen, UK

DC Circuit Breakers are expected to play critical role in future DC transmission grids and in multiterminal HVDC lines. They will facilitate continued operation of complex DC systems, by providing fast isolation of faulted DC lines [1][2].

Very fast hybrid DC Circuit breakers have been developed [3], which are based on excellent speed of response of high-voltage electronic valves. Fully mechanical DC CBs have also been developed to high-voltage prototypes [4], and they have advantages in lower complexity, although operating speed will be slower (around 8ms opening time).

Fig 1 shows proposed topology for LC DC CB. This is a mechanical device which consists of: fast disconnector S1, AC switch S2, capacitor Cs and energy absorber SA. S1 opens firtstly and commutates current in capacitor Cs which creates a series LC with inductor Ldc. With series LC circuit inserted in DC line, DC current will have zero-current crossing and therefore S2 opens under AC circuit conditions. The period of AC variables is adjusted with CS and SA and considering opening speed of S1 and S2.

The purpose of capacitor Cs is to limit voltage rise gradient while conatcts of S1 are separating. This means that counter voltage (Cs voltage) will begin to rise as soon as contacts of S1 begin to separate. Therefore the fast operating speed is one of the advantages of the proposed topology.

A 1200V, 200A prototype has been built at university laboratory as sown in Fig 1. S1 is air-disconnector driven by Thomson coils which opens in 2ms and the design has been reported in [5].

Fig 2 shows one experimatal test for interrupting around 200A DC current. In Fig 1a) we see that 130A current is commutated from S1 to Cs in around 400µs. The current in capacitor reaches peak of 190A in 1.6ms, and then it drops to zero in around 3.7ms. Switch S2 opens at very low AC current at 3.7ms.

The voltage peaks at around 1200V in 1.6ms, as seen in Fig 2b). Fig 2c) also shows the measurement of S1 contact position x, separation z, and velocity *v*.

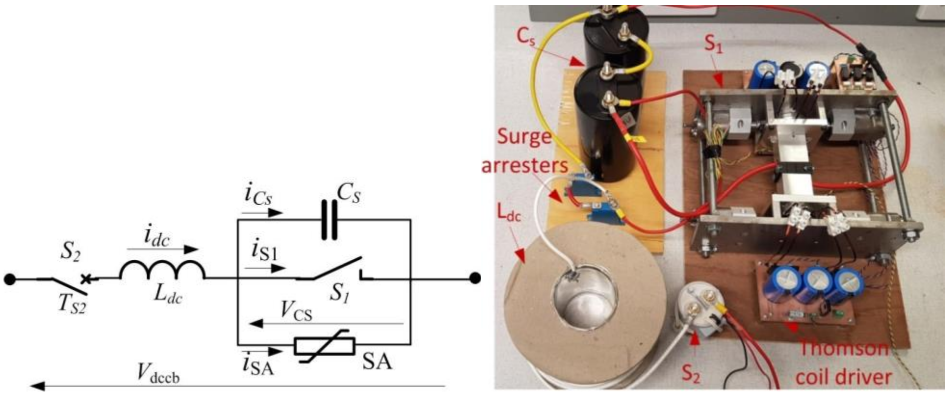

Fig.1: Schematic and experimental setup of LC DC Circuit Breaker.

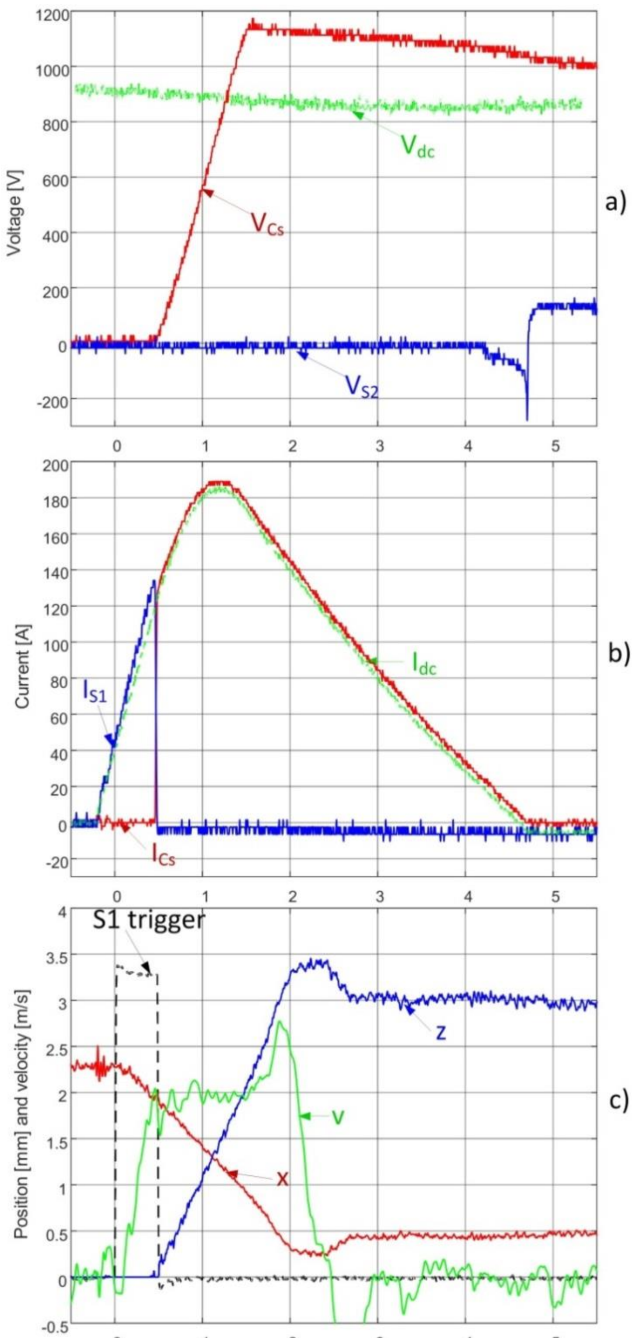

Fig.2. Experimental DC CB testing results. a) Voltages, b) currents, c) contact position and velocity.

1 ACKNOWLEDGEMENTS

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

References

[1] CIGRE joined WG A3 and B4.34 “Technical Requirements and Specifications of State of the art HVDC Switching Equipment” CIGRE brochure 683, April 2017.

[2] D Jovcic and K Ahmed "High Voltage Direct Current Transmission: Converters Systems and DC Grids", Wiley, 2015.

[3] Häfner, J., Jacobson, B.: ‘Proactive Hybrid HVDC Breakers - A key innovation for reliable HVDC grids’. Proc. CIGRE 2011 Bologna Symp., Bologna, Italy, Sep 2012, pp. 1-7.

[4] K. Tahata, S. Oukaili, K. Kamei, et al., “HVDC circuit breakers for HVDC grid applications,” Proc. IET ACDC 2015 conference, Birmingham, UK, pp. 1-9, Feb 2015.

[5] M. Hedayati, D. Jovcic “Low Voltage Prototype Design, Fabrication and Testing of Ultra-Fast Disconnector (UFD) for Hybrid DCCB” CIGRE B4 colloquium, Winnipeg October 2017