

Effect of Superconducting Fault Current Limiter on Hybrid Circuit Breaker in Power System

Miss. K.L. Bari¹, Prof. S.M. Shembekar², Dr. P.J. Shah³

¹PG Scholar, Dept of Electrical Engineering, SSBT'S College of Engineering & Technology, Jalgaon, Maharashtra, India

²Assistant Professor, Dept of Electrical Engineering, SSBT'S College of Engineering & Technology, Jalgaon, Maharashtra, India

³Professor and HOD of Dept of Electrical Engineering, SSBT'S College of Engineering & Technology, Jalgaon, Maharashtra, India

Abstract: - HVDC transmission system is applicable for bulk power transmission over a long distance. During transmission of bulky power obviously there exists many chances of faults. These faults in HVDC system are converter station fault, DC line to line fault, DC line to ground fault. When sudden short circuit fault is happened on transmission line, it will cause sudden increase in current magnitude. Various electrical devices used for protection of such a transmission line against serious fault current. Circuit breakers, current limiting reactor are used to protect the system from fault current, superconducting fault current limiter is one of them. HVDC circuit breakers are available in various types out of them we focus on Hybrid DC (HDCCB) circuit breaker in this paper. For better results circuit breaker is consider with two cases means without applying Superconducting Fault Current Limiter and by applying Superconducting Fault Current Limiter. In this paper Resistive type Superconducting Fault Current Limiter is used with Hybrid circuit breaker. Resistive Superconducting Fault Current Limiter have an effective solution to effectively limit fault current levels by absorbing fault current during fault. The simulation results are observed for the model of HDCCB. The magnitude of the fault current in the HDCCB with and without SFCL is compared.

Introduction

The high voltage direct current (HVDC) transmission line has experienced a great development over the last decades due to the following features: 1) compact and flexible station layouts, with low space requirements and a scalable system design; 2) a high dynamic performance and stable operation with AC network; 3) supply of passive network and black-start capability; 4) an independent control of active and reactive power. HVDC circuit breakers (HVDC CB) are widely considered a key technology in the implementation of the HVDC system. Generally, fault current interruption can be easily achieved via zero-current crossing. To fulfill the zero-crossing condition of DC fault current, a forced current reduction method should be utilized, and various type of HVDC CB are summarized; some of which have revealed prototypes and successful test results. In this paper we have focusing solely on Hybrid DC circuit breaker (HDCCB) to achieve artificial current zero should be somewhat modified. As an alternative, one feasible solution is to combine fault current limiting technologies with DC breaking topologies. Current limiting technology has been getting much attention as it can efficiently limit the short-circuit faults and improve transmission system performance. Superconducting fault current limiter is an effective solution to reduce the fault current, without changing transmission line parameters.[1]

Superconducting Fault Current Limiter (SFCL) is innovative electric equipment which has the capability to reduce fault current level within the first cycle of fault current. The application of the fault current limiter (FCL) would not only decrease the stress on network devices, but also can offer a connection to improve the reliability of the transmission system. There are various types of SFCLs, which are made of different superconducting materials and have different designs. They are categorized into three broad types: the resistive type, the inductive type and bridge type SFCL. In this paper we have find outs result of resistive SFCL on performance of Hybrid DC circuit breaker. Here we discussed the operating characteristics of SFCL introduced into a simplified power transmission model system of Hybrid DC circuit breaker (HDCCB) using Matlab/Simulink.[2]

A) HVDC test bed model :

In order to analyze the impact of SFCL on Hybrid HVDC CBs, a test-bed model was designed in Matlab/Simulink as illustrated in Fig 1. Here the system model is developed by using different components of different rating. The simple, symmetrical, monopole, point-to-point, 2- level, half-bridge HVDC system was utilized to concentrate the interruption performance of the DC fault current in detail. The AC network adjacent to the HVDC link was substituted by an equivalent RL impedance, which enabled the X/R ratio of the power system to be determined. The converter transformer was a wye-delta connection. A phase

reactor, L_p , was added between the converter and transformer to filter the harmonics during conversion. Each type of HVDC CB and SFCL was located at the output of the rectifier. Detailed specifications of the HVDC link are as follows: the rated voltage = ± 100 kV, nominal current = 1 kA, nominal power flow = 100 MW, and the transmission line length = 50 km. [3]

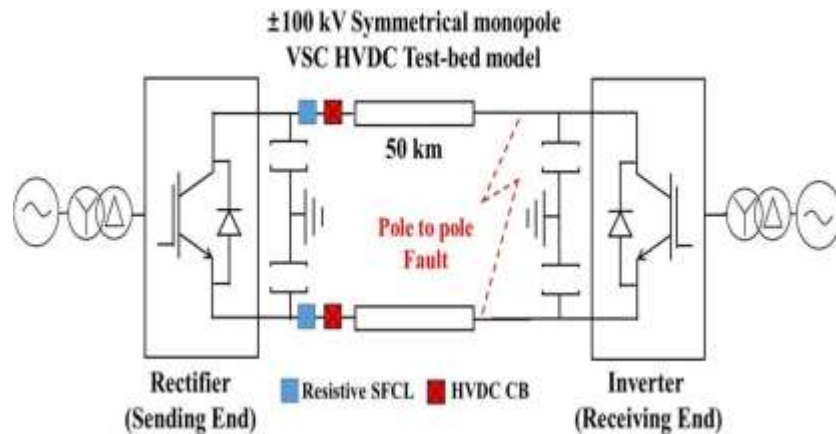


Fig. 1. Two-level point-to-point HVDC test bed model

In this model Hybrid DC circuit breaker (HDDCB) is used in series with Resistive Superconducting Fault Current Limiter (SFCL).

B) Hybrid DC circuit breaker (HDDCB):

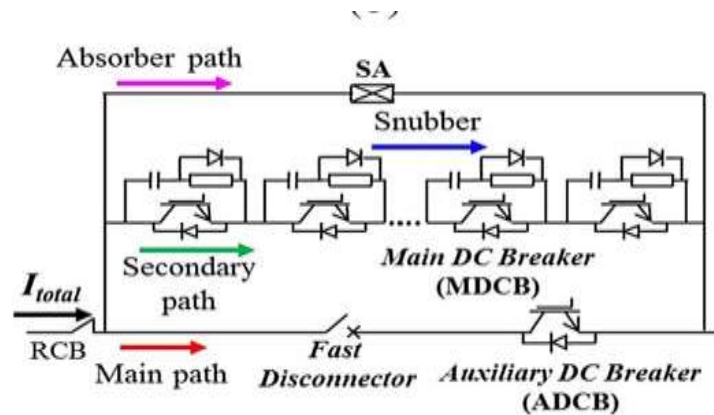


Fig.2. Hybrid DC circuit breaker

It is based on fast mechanical switches and power electronics switches and combines the merits of resonant and solid state breakers. The low loss branch consists of an ultrafast disconnector and a load commutation switch. In the main breaker, IGBTs are connected in series and surge arrester is used to exhaust the fault current. The delay times of IGBT was assumed as $\Delta t_{IGBT} = 6 \mu s$ in simulation. During normal operation, current flows through the main path, when a DC fault occurs, the auxiliary DC breakers (ADCB) and fast disconnector are opened sequentially, and then the current starts to commute from the main path to secondary path. After commutation, main DC circuit breakers (MDCB) in secondary path are opened, and total current is reduced because the current flows to the snubber circuit of MDCB until the parallel-connected SA trips. When the voltage across the HDDCB terminals exceed to knee voltage, the SA ignites and forces the DC fault current to zero by absorbing remaining fault energy. Rating of HDDCB:

Current – 5 kA, Voltage – 100 kV, Power – 100 MW. The results of simulation models are shown in fig.3 [4].

C) Simulation results of HDCCB without SFCL:

Fig.3. shows main current of HDCCB without applying SFCL Main current value of HDCCB without SFCL is 3.5 kA. In this case of HDCCB without using SFCL, the fault current interruption time is 7.8 ms.

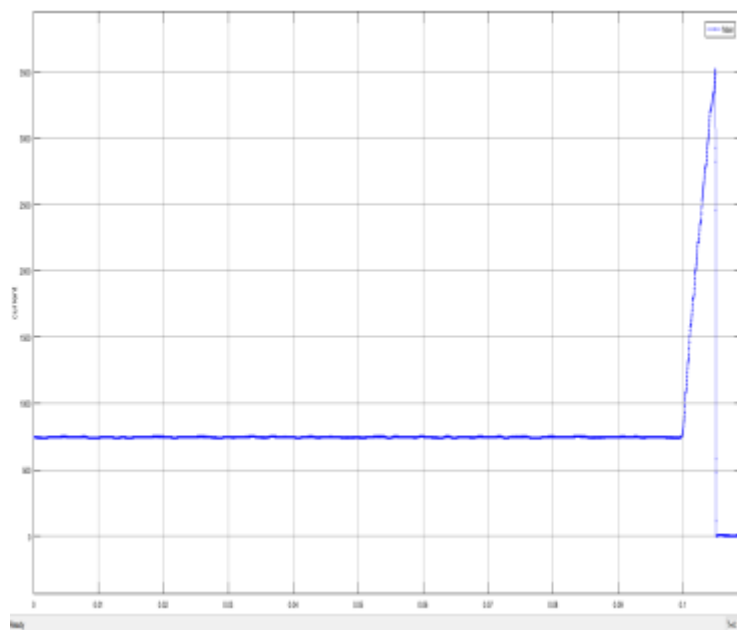


Fig.3. Main current of Hybrid circuit breaker

Secondary path current of HDCCB without SFCL is 3.5 kA. Shown in fig.4

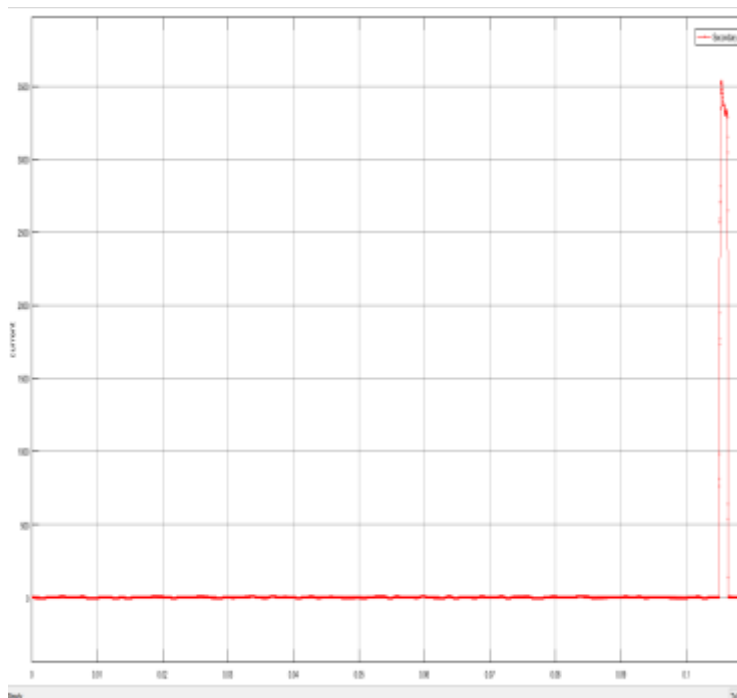


Fig. 4 Secondary current for HDCCB without SFCL

Current through absorber path having value 3.1 kA. Shown in given fig. 5

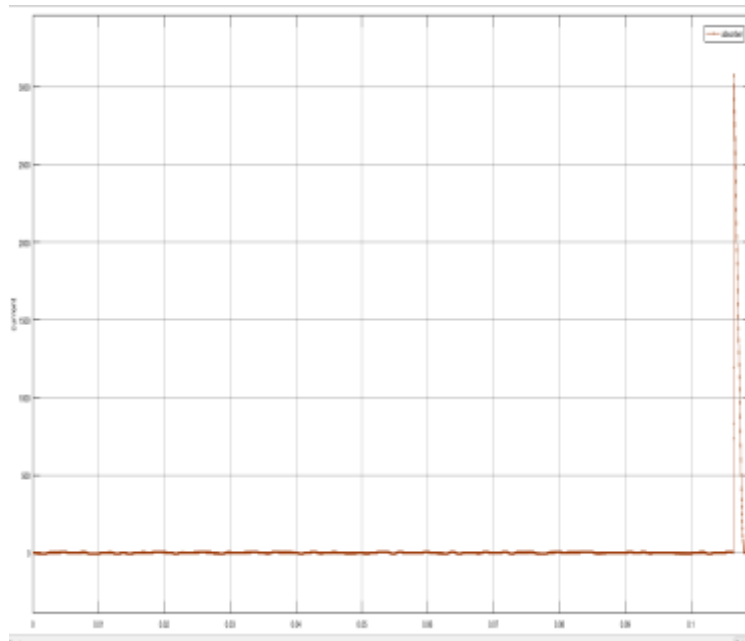


Fig.5 Absorber path current for HDCCB without SFCL

Now we have to find simulation results of Hybrid DC circuit breaker when SFCL is used. Simulation model of this system is similar with above case only difference is SFCL is added here in series with HDCCB.

Given fig.6 shows main current of HDCCB. The main current value is about 2.9 kA. Fault current interruption time is 7.6 ms and achieve nearly 17 % reduction in fault current level.

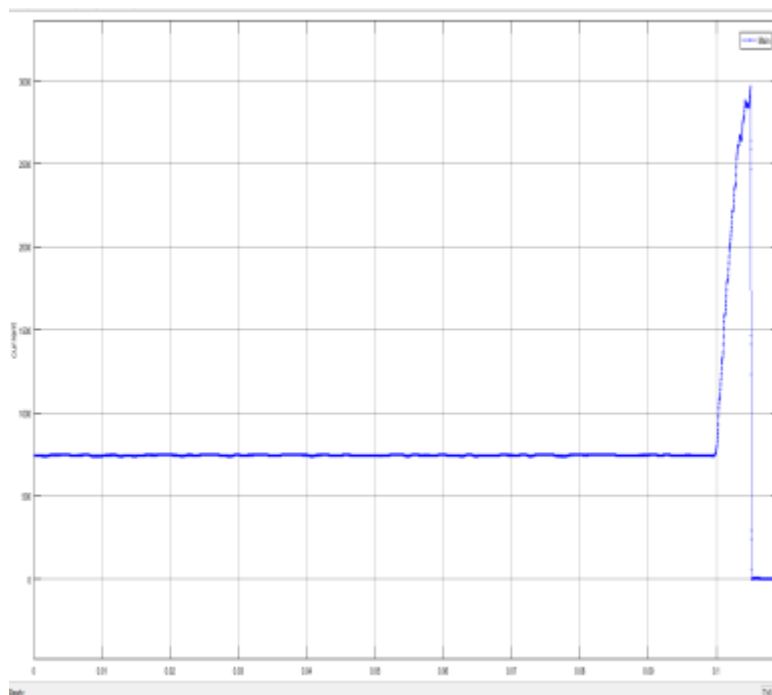


Fig. 6 Main current for HDCCB with SFCL

The secondary path i.e current through snubber circuit is 2.8 kA

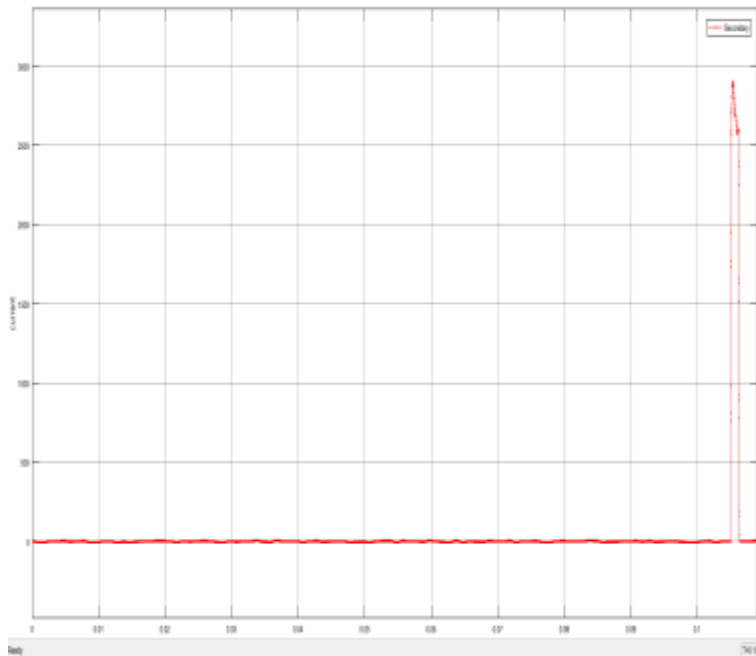


Fig. 7 Secondary path current for HDCCB with SFCL

Fig.8 shows absorber path current of HDCCB. The value of absorber current is 2.3 kA

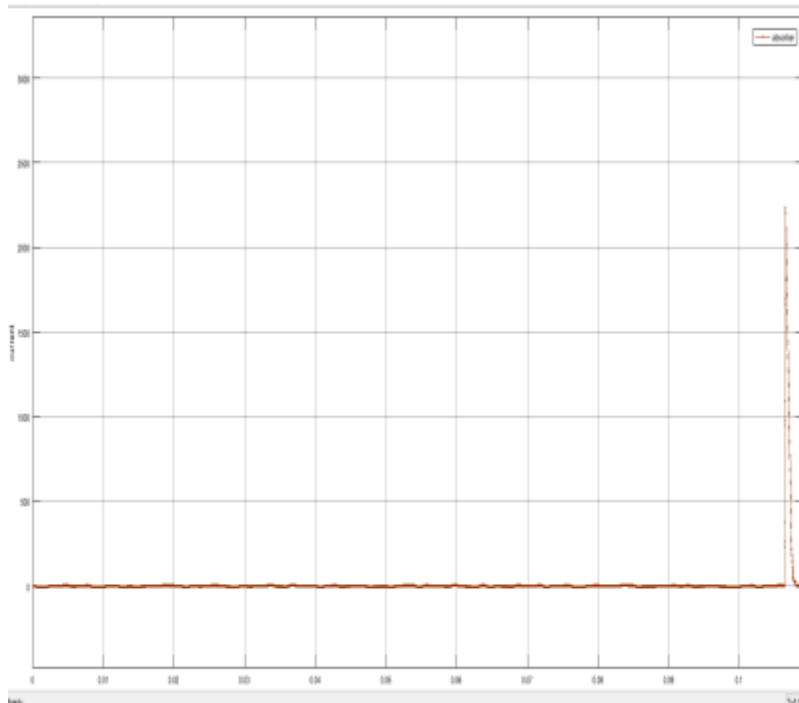


Fig. 8 Absorber path current for HDCCB with SFCL

Where, main current is current through mail path, absorber current is current through absorber path via surge arrester and last is secondary current i.e current through secondary path which consist snubbers. [5]

Table I: Current values of HDCCB without and with SFCL

Parameters	HDCCB Without SFCL	HDCCB with SFCL
Total current	3.6 kA	2.9 kA
Main current	3.5 kA	2.9 kA
Secondary current	3.5 kA	2.8 kA
Absorber current	3.1 kA	2.3 kA
Snubber current	3.3 kA	2.6 kA

Conclusion:

The high current during fault is difficult to handle by circuit breakers and every time it is not possible to use high rating circuit breakers. Considering this point in addition to HVDC circuit breaker a fault current limiting device named as Superconducting Fault Current Limiter is used in studied in this paper. The Resistive Superconducting Fault Current Limiter considers quenching characteristics and a simple HVDC test-bed were designed using Matlab/Simulink.

References:

- 1) Matthias K. Bucher, M. Frank, "Fault Current Interruption in Multi terminal HVDC Networks" IEEE Transaction on Power Delivery, vol. X, 2015.
- 2) G Swetha, R. Sathish Kumar & B. Venkata Prasanth "Performance of Superconducting Fault Current Limiter in Power System" International Journal of Research vol. 03 Issue 10 June 2016.
- 3) Jong-Geon Lee, Umer Amir Khan, Ho-Yun Lee, and Bang-Wook Lee, "Impact of SFCL on the Four Types of HVDC Circuit Breakers by Simulation" IEEE Transactions on Applied Superconductivity, Vol. 26, No. 4, June 2016.
- 4) Gen Li, Jun Liang, Carlos E Ugalde- Loo, "Impact of DC Circuit Breakers on AC/DC System Stability Subject to DC Faults" 2016 International High Voltage Direct Current Conference (HVDC 2016).
- 5) MD. Afser khan, Mr. V. Ganesh Kumar, "Fault Current Limiting Technologies of HVDC Circuit Breakers With Impact Of SFCL" International Journal of Technology and Engineering Science [IJTES] vol. 5, Oct. 2017.