European Association for the Development of Renewable Energies, Environment and Power Quality

International Conference on Renewable Energies and Power Quality (ICREPQ'09)

Valencia (Spain), 15th to 17th April, 2009

System Studies of DC Reactor Type Fault Current Limiter in Distribution Grid

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Abstract. The growth of the generation of electrical energy and the increased interconnection of networks lead to higher fault current levels. The short circuit current will impose high dynamical and thermal stresses on electrical equipments. All equipments have to have a short circuit rating capable of withstanding this level. Traditionally, handling these increasing fault currents often requires the costly replacement of substation equipments or the imposition of changes in the configuration that may lead to decreased operational flexibility and lower reliability. An alternative approach to reduce the fault current is the application of Fault Current Limiters (FCLs)[1]. In case of newly planned networks, fault current limiters allow the use of equipment with lower ratings which renders possible considerable cost savings. To reduce the short circuit current, the superconducting fault current (SFCL) is expected to be introduced in real power system. The application of the SFCL would not only decrease the stress on device but also offer a reliable interconnection. There are various type of SFCLs which are based on different superconducting material and designs such as, flux lock, transformer, resistive, DC reactor types and so on[2]. In this paper, a DC reactor type FCL has been studied. It has zero impedance under the normal condition and large inductive impedance under the fault condition. Its advantage is that it can limit fault current without delay and no damage because it doesn't undergo S/N transition of superconductor. The waveform of the fault current does not have a surge current waveform, because DC reactor prevents a sudden increasing of current[3]. Distribution systems have been designed and built as a passive unidirectional system to accept generation or bulk supplies from transmission grids or substations. Most of distribution structure are radial. The short circuit current is just limited by the impedance of various system components. Thus, the integration of the SFCL could offer an effective solution to controlling fault current levels in distribution grids. To achieve a successful interruption of circuit breaker, not only on interrupting current but also on Transient Recovery Voltage (TRV) appearing across the breaker contacts must be considered. In other words, depending upon the kind of the fault current and its and system's parameters, the insertion of the fault current limiter in to the power system can result in more severe interrupting problems. Therefore, it is important to study the interrupting behavior of a circuit breakers in the presence of the fault current limiter

1. Three-Phase DC Reactor Type FCL

Fig.1 shows the three-phase DC reactor type FCL, which consists of the superconducting coil (SC), series transformer bridge circuit. The diode bridge converts three-phase AC to DC current, which flows through the super- conducting coil. After charging the SC and in the steady state condition, the current of SC is approximately

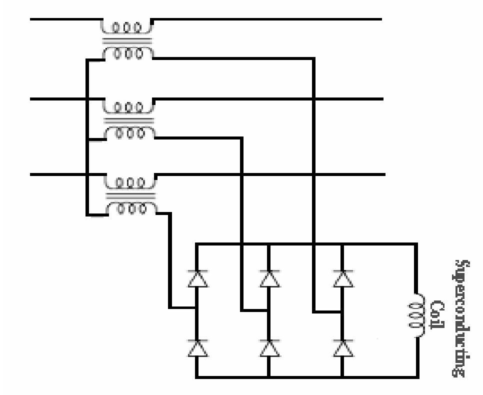


Fig. 1. DC reactor type SFCL schematic diagram

constant, so *dIsc/dt* is equal to zero and the impedance seen by the primary side of the coupling transformer is very low. Under the fault conditions, the current increases with a constant rate.

2. DC Reactor Type FCL In Distribution System

A typical distribution system is represented in Fig. 2. The source impedance includes the transformer impedance and the upstream short-circuit impedance. Parallel feeders are connected to the Point of Common Coupling

(PCC). The bus is supplied by a substation transformer from an 110 kV network. The upstream source system is modeled as an infinite bus and the source impedance consists of an equivalent resistance and inductance connected to the local distribution substation. The feeder consists of cables, FCL and a circuit breaker.

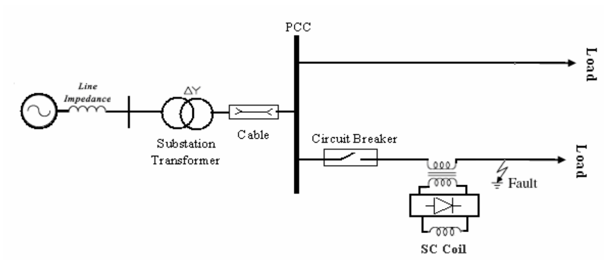
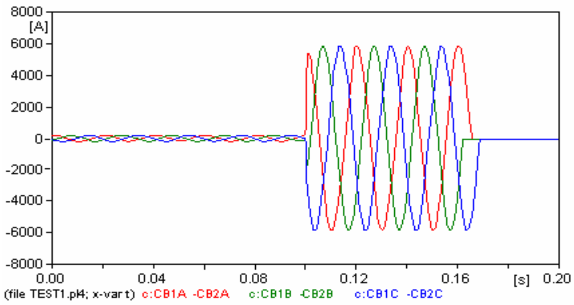


Fig. 2. Schematic diagram of the study system

3. Simulation Results

The total simulation time was 200ms and the simulation time step is 1μs. Fig.3 and Fig.4 show the line current, voltages of PCC and circuit breaker TRV without and with using FCL, respectively. It can be seen in Fig.3 and Fig.4 that a DC reactor type FCL can limit the fault current, can mitigate the voltage sag and can reduce the TRV and RRRV of circuit breaker.



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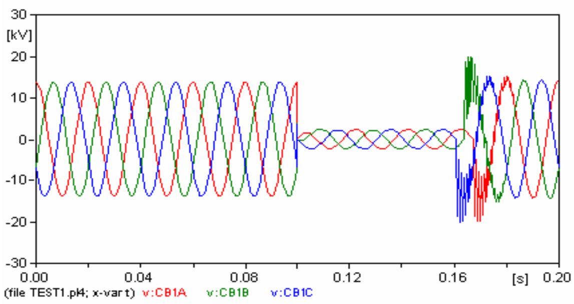

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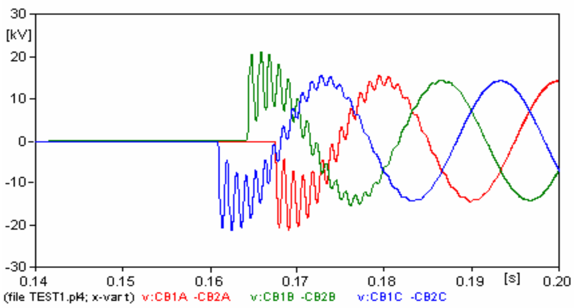

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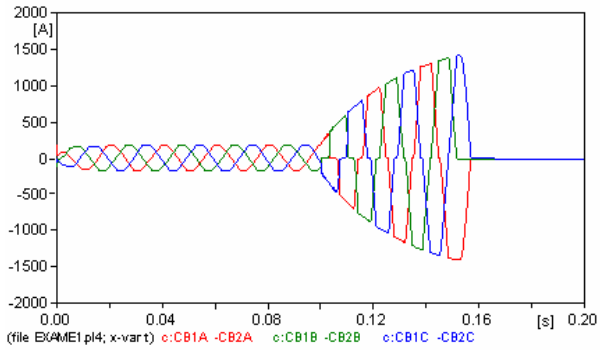
Fig .3: a-Fault Current
b-Voltage of PCC and c-Circuit breaker TRV
Without FCL



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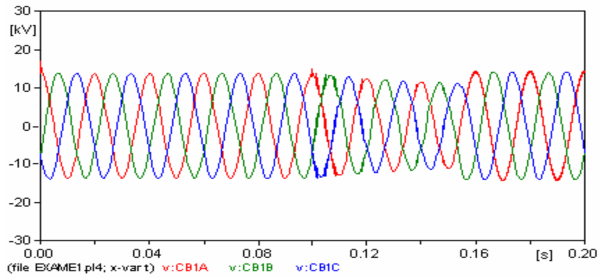

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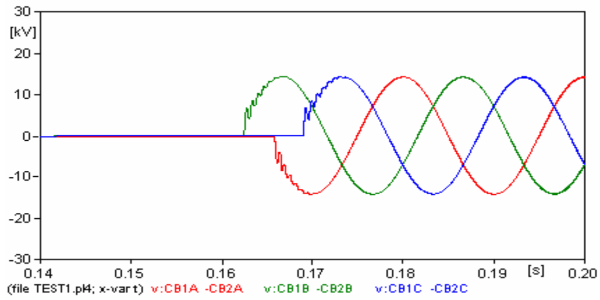

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Fig .4: a-Fault Current
b-Voltage of PCC and c-Circuit breaker TRV
With Using FCL

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