ABSTRACT

Development in Electrical power transmission system requires the use of circuit-breakers with increasing breaking capacity. At present circuit-breakers are to be installed on 245kV to 1100kV power system with short-circuit ratings up to 120kA. To test high voltage circuit-breakers, direct testing using the power system or short-circuit alternators are not feasible. The testing of high voltage circuit-breakers of larger capacity requires very large capacity of testing station. To increase testing plant power is neither an economical nor a very practical solution. Even a single pole of EHV circuit-breaker can not be tested by direct means.

The largest test facility in the world, KEMA high power laboratory, with a maximum short-circuit power of 8400MVA and a 145kV, 31.5kA, 3-phase direct test capability, is limited in its power to perform the direct tests. At the present time a complete pole of SF_6 circuit-breaker can consist of a single interrupting chamber with an interrupting power above the 10GVA level. Even KEMA'S high power laboratory can not verify the short-circuit interrupting capability by direct test methods. Direct testing facility available at CPRI high power laboratory in India is of 2500MVA capacity at 36/72.5kV in three phase and 1400MVA capacity, up to 245kV in single phase for testing of circuit-breakers.

Synthetic testing is an alternative equivalent method for testing of high voltage circuit-breakers and is accepted by the various standards. Short circuit tests require circuit with response specified by IEC standards for 2-parameters and 4-parameters TRV envelopes. The parameters of TRV defined by IEC standards are quite impossible to analytically link with the values of the components of the test circuit. So computer aided design and simulation of synthetic testing circuits (TRV shaping circuits) is first necessary in order to determine the parameters of the TRV corresponding to a given test circuit.

An attempt in this research work has been made to analyze, design, simulate and develop both 2 - parameters and 4- parameters TRV control synthetic testing circuits with automatic controller and triggering circuit for testing medium , high voltage and extra high voltage circuit breakers according to IEC standards.

This research work has been mainly divided into four parts.

In the first part, Analysis and design of 2-parameters TRV synthetic testing circuit is done by using MATLAB. Computer simulation is performed to verify the validity and effectiveness of the circuit by means of PSIM simulator. Design examples and simulation results are shown for a medium voltage Circuit breakers i.e. for 36kV rating circuit breakers.

In the second part, Analysis and mathematical modelling of multi-frequency or 4 -Parameters TRV synthetic test circuit is done. In order to find circuit components and to optimize the values of capacitance of capacitor banks for the desired frequencies for a particular rating of circuit-breakers, program/software has been developed by using MATLAB and Visual Basic 6.

After finding optimal circuit components for a particular rating of circuit-breaker, design and simulation of 4-parameters TRV parallel current injection method synthetic testing circuit (Weil Dobke type) is done by using PSIM simulator for testing high voltage and Extra high voltage circuit breakers according to new TRV requirements given in IEC62271-100(2008). The circuit is designed and simulated for both terminal fault as well as short line fault test duty for testing 245kV, 420kV and 800kV rating circuit-breakers. Design optimization is done to reduce the energy required by the capacitor banks and hence reduce the size and cost of capacitor banks.

Again several synthetic test circuits based on parallel current injection method have been studied and developed by many researchers. In order to compare and find better and economical TRV control circuit for the same test conditions, the design and simulation of two more commonly used circuits based on parallel current injection method is done by using PSIM simulator to test 245 kV and 420 kV rating circuit-breakers according to new TRV requirements given in IEC 62271-100 for terminal fault test duty. The comparison of these circuits is made on aspects of equivalence, operation, required capacitive energy and applicability. After comparison, the better circuit is also simulated for 800 kV rating circuit breakers. The results obtained by using different circuits have been discussed and compared with the required results according to standards.

In the third part of this research work, the development and fabrication of laboratory model for 4-parameters TRV control circuits is done to verify the simulated results.

In the forth part of this research work, an automatic controller to interrupt short circuit current and to fire the triggered spark gap at the desired moment is presented. The automatic controller is used for the automatic closing and opening operation of circuit breakers and to fire triggered spark gap at the desired moment.

At present, synthetic testing facility for testing high voltage circuit breakers at CPRI high power laboratory, Bangalore is only up to 245kV, 63kA rating circuit breakers. In this research work, 4-parameters TRV synthetic testing circuit has been proposed for testing circuit breakers of ratings up to 800kV for both terminal fault and short-line fault test conditions with optimized circuit components according to new TRV descriptions or parameters given in IEC 62271-100. Simulated results obtained have been presented and analyzed. A laboratory model for 4 -Parameters TRV control circuits has been built. A comparison of simulated and experimental results reveals a very good agreement.

In the end of thesis, the main conclusions and future scope of the further research work is suggested. It is hoped that theoretical as well as experimental investigations as reported in this research work will help in establishing new synthetic test circuit with optimized circuit components to reduce the energy required by the various capacitor banks and hence reduce the size, cost and space requirement.