Chapter-8

CONCLUSION AND FUTURE SCOPE

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.

The parameters of TRV defined by IEC standards (IEC 62271-100) 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.

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.

The TRV envelopes and parameters obtained for testing 36kV rating circuit-breakers are shown for both terminal and short line fault test duties. The results are compared with the required results according to IEC standards and are almost the same.

In order to find the possible combinations of circuit components of 4-parameters TRV parallel current injection method synthetic test circuit and to optimize the values of capacitance of capacitor banks for the desired frequencies of a particular rating of circuit-breaker, program has been developed by using MATLAB M-file. Program/software is also developed with the help of VISUAL BASIC 6 software to find all possible combinations of the circuit components and also to optimize the circuit components for the desired frequencies for a particular rating of circuit-breaker. This software is user friendly and speed is very fast, just by one click it will show all the possible combinations of circuit components for the desired frequencies.

After finding optimal circuit components for a particular rating of circuit-breaker by using software, the 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 which are developed by many researchers. In order to compare and find better and economical 4-parameters TRV control circuit for the same test conditions, the design and simulation of other 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. 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.

The comparison of TRV control circuits shown in Figures 6.1, 6.19 and 6.20 is made on aspects of equivalence, operation, required capacitive energy and applicability. The energy requirement for each capacitor bank used in different control circuits is given in the Table 6.16 and Table 6.20 for comparison purpose.

As discussed in chapter 6, it is seen that in control circuit–II, the transformation from a 2 - Parameters to 4 - Parameters TRV circuit is simpler. But this circuit needs the highest capacitive energy and permits the testing of circuit-breakers at lower voltage compared to other two circuits.

TRV waveform of control circuit – I is good and needs only 53 to 57% capacitive energy of circuit – II for the same test conditions. The voltage rating of circuit breaker which can be tested is higher than with circuit – II. The voltage on C_2, however is higher and special attention should be paid to the insulating level of this bank.

Circuit – III is the most economical test circuit in terms of capacitive energy necessary and needs only 35 to 40 % capacitive energy of circuit – II for the same test conditions. Voltage rating which can be tested is highest with circuit – III. But circuit – III is the most complex to operate due the use of two spark gaps and more number of circuit components.

The results obtained by using different circuits have been discussed and compared with the required results according to IEC standards. The results shown are almost the same according to IEC standards. The results shows that although each circuit has its own merits, the control circuit-I appears to be very effective and is better than other circuits.

In order to verify the designed and simulated results, a laboratory model (Prototype) of 4-parameters TRV control circuit has been developed and fabricated. The values of components are taken the same as obtained by computer aided design and simulation. Only thing the main capacitor bank Cn is charged in volts instead of kV. The experiment results show a good agreement with the predictions and according to the desired one as per IEC.

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. Program has been developed by using BASCOM-AVR software version 1.11.8.3 from MCS Electronics to generate the pulses at the desired moment by using timers, one for denergization of master breaker (MB) and test breaker (TB), and the second for firing triggered spark gap at the desired moment. The program is down loaded and tested on ATmega8 Micro-controller. The developed automatic controller was tested and Oscillographs were recorded for pulses, one for interruption of MB and TB, and the second high pulse generated for firing triggered spark gap. The control circuit has been setup. The experiment results show a good agreement with the desired test criterion.

Summary

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 parallel current injection method 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.

In order to verify the designed and simulated results, the laboratory model of 4-paramters TRV synthetic test circuits has been developed and fabricated for the same circuit components. In the laboratory model, the values of circuit components are taken the same as obtained by computer aided design and simulation, however the main capacitor bank was charged in volts instead of kV.

In the future work , the actual development and fabrication of synthetic test circuit for testing High voltage and Extra high voltage circuit-breakers with proposed optimized circuit components (to reduce the energy required by the various capacitor banks and hence reduce the size, cost and space requirement) is suggested, if financially it is feasible.

Also, the design and simulation of synthetic test circuit for testing ultra high voltage circuit-breakers (1200kV rating circuit-breakers), which is likely to come in India by 2012 is suggested.

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