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Analysis and reduction of TRV effect on circuit breaker and MOV in a real power system with TCSC

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Abstract. A thyristor-controlled series capacitor (TCSC) is an effective device that adjusts impedance through thyristor control to increase power transfer capability in a transmission line. It has so many advantages such as system reliability and power transmission capability improvement. However the application of series compensator in power system can affect other devices such as circuit breakers. In this paper, we analyze the transient recovery voltage (TRV) effect of a line circuit breaker in the cases with and without TCSC via simulation, and suggest an effective method to overcome the increase of TRV due to the TCSC installation. Also, the effectiveness of the bypass method on a metal oxide varistor (MOV) was demonstrated.

A 345 kV transmission line in Korea was selected as a study case. Grid system including transmission lines, detailed TCSC models, circuit breakers, and nearby power stations were modelled using PSCAD/EMTDC. The TRV was analyzed by implementing a short circuit fault along the transmission line and at the breaker terminal. The energy of the MOV was measured during the protection operation. In the case of applying the proposed protection scheme, TRV satisfies the standard. However, the MOV energy capacity increased as delay time increased. This result can solve the TRV problem due to the expected transmission line fault in a practical TCSC design.

Keywords; component; Transient recovery voltage, TCSC protection, MOV protection, Thyristor bypass

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1. Introduction

A Thyristor-controlled series capacitor (TCSC) is an effective device that adjusts impedance through thyristor control to increase power transfer in a transmission line. KEPCO plans to install TCSCs in the ShinYeongju-Hanul and the ShinJecheon-Donghae 345kV transmission line as part of the metropolitan power transmission project. Before installation of TCSCs, it is necessary to study the effect of the TCSC application on power systems. One of these studies is transient recovery voltage (TRV) of a line circuit breaker (LCB) according to series capacitor compensation of the line when a fault occurs in the transmission line. This paper deals with the change of TRV, rate of rise of recovery voltage (RRRV) and MOV energy capacity due to two types thyristor valve bypass operation methods when the fault occurs in the transmission line including TCSCs. The 345 kV ShinJecheon-Donghae transmission line was selected for this study. Grid systems were modelled using PSCAD / EMTDC, it includes transmission lines, detailed TCSC models, LCB, and nearby power stations. Fault simulations for TRV and MOV energy analysis were simulated on faults occurring at terminal and transmission line. A three - phase ground fault was selected according to IEC standard for TRV. The difference of TRV according to the TCSC protection method was compared. As the results of this study, using the thyristor bypass strategy can be confirmed that the conventional LCB can be used without increasing capacity when installing TCSC and it helps to reduce TRV when the LCB is operated due to the fault during the TCSC operation.

2. Methods

In this study, a new method for TRV reduction was proposed and compared with the conventional method. Conventional basic methods bypass the thyristor as fast as possible to protect the TCSC when detecting faults in the MOV and current transformer. The proposed method is to bypass the thyristor by delaying until the voltage across the capacitor of each phase is 0 V. The voltage across the capacitor in the event of a fault is shown in Fig.1.

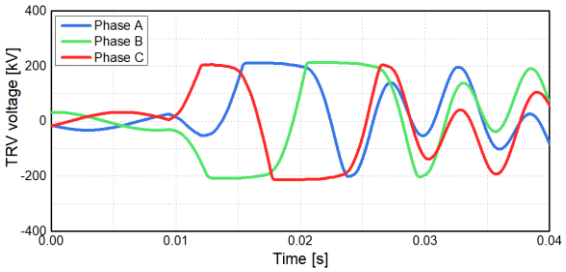


Fig. 1. Voltage across the capacitor during fault

For accurate simulation, PSSE data based on actual system were converted into PSCAD. As shown in Fig. 2, the circuit for the analysis is a steady state equivalent model. The thyristor was replaced by a switch. The type of fault is a three-phase ground fault, the fault inception time is every 10 degrees, and the fault location varies from the terminal to the line divided into 10 parts. And the two types of protection schemes were compared.

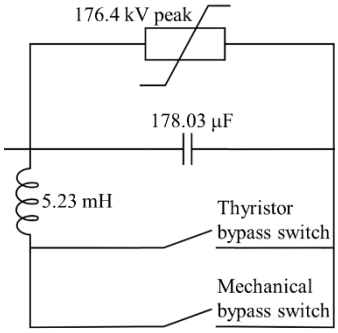


Fig. 2. TCSC equivalent model for simulation

3. Results

To verify the TRV reduction, the existing TCSC protection scheme and the proposed TCSC protection scheme were compared. Fig. 3 shows the most severe case of TRV analysis. When a basic protection scheme is applied, the TRV exceeds the standard envelope. However, TRV decreases when the proposed method is applied.

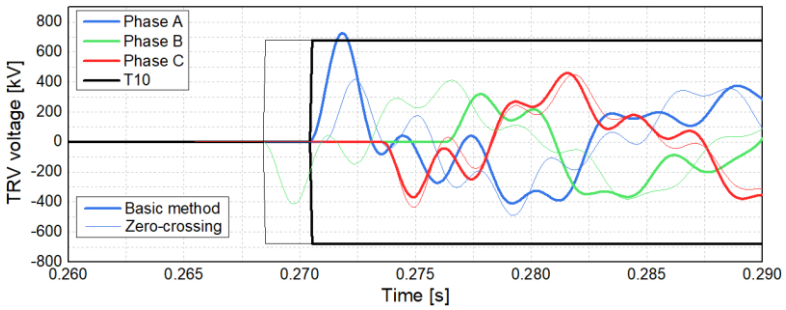
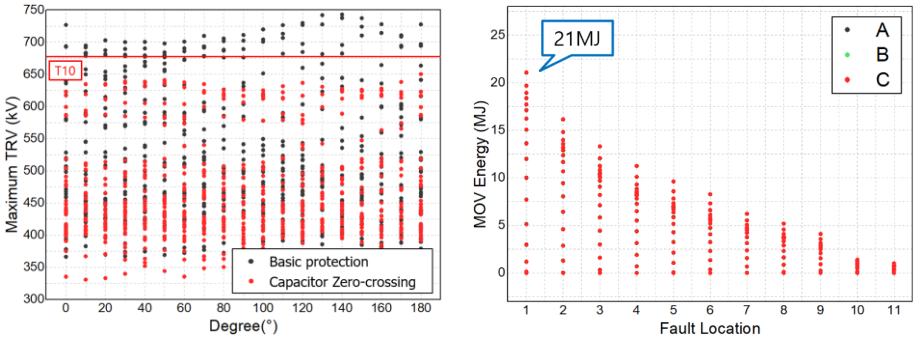


Fig. 3. TCSC equivalent model for simulation

The overall simulation results are shown in Fig. 4. When the conventional protection scheme expressed by the black dot is applied, it can be confirmed that the simulation result of many cases exceeds the applied standard. However, when the proposed TCSC protection method is applied, the TRV standard is satisfied in all cases.

However, the MOV energy is increased by bypass delay time and the MOV capacity needs to be increased.



(a) Overall Max. TRV result, (b) the energy consumed in MOV with proposed method

Fig. 4. Overall Max. TRV results

4. Conclusion

This paper deals with TRV and MOV energy changes according to the TCSC protection method. When the proposed method is used, it is confirmed that TRV can be reduced compared with the conventional method. However, the proposed method requires a delay time before bypassing the thyristor, which requires an increase in MOV capacity. This result is useful for TRV reduction and MOV capacity design of the line where the actual TCSC is installed.

Acknowledgment

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