Coordination Strategy of Magneto-biased Superconducting Fault Current Limiter and Relay Protection in 10 kV Urban Power Grid

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1. INTRODUCTION

Superconducting fault current limiter (SFCL)can limit the increasing fault current in the power system with renewables and protect devices in renewable energy system. This paper investigates the influence of the SFCL parameter on its performance in a 10 kV urban power grid. This paper analyzes the SFCL's two-stage operating mechanism and establishes the SFCL model and 10 kV urban power grid model. This paper finally figures out a set of economically recommended reference value. When the YBCO quench resistance is 3.19 Ohm and the single branch reactance of double-split reactor is 4.99 Ohm, the current limiting rate is 48% at the first peak and 76% at the second peak in this 10 kV urban power grid.

2. STRUCTURE

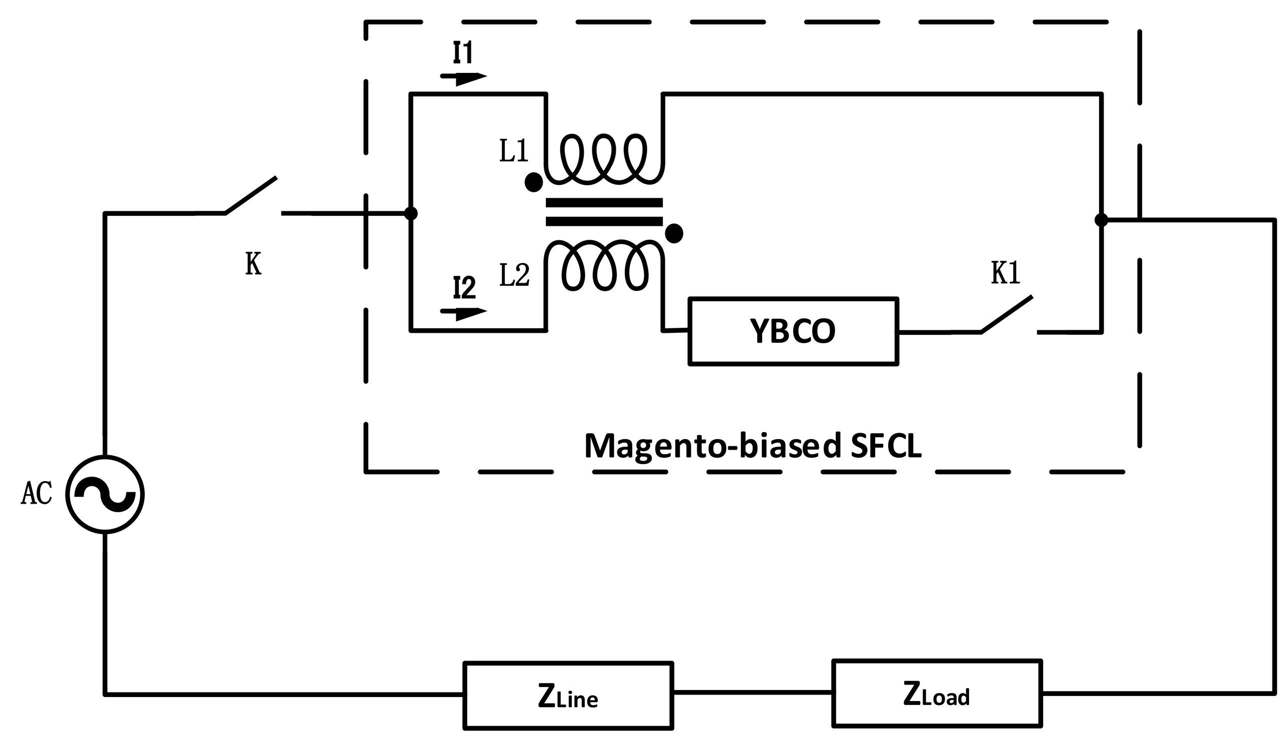
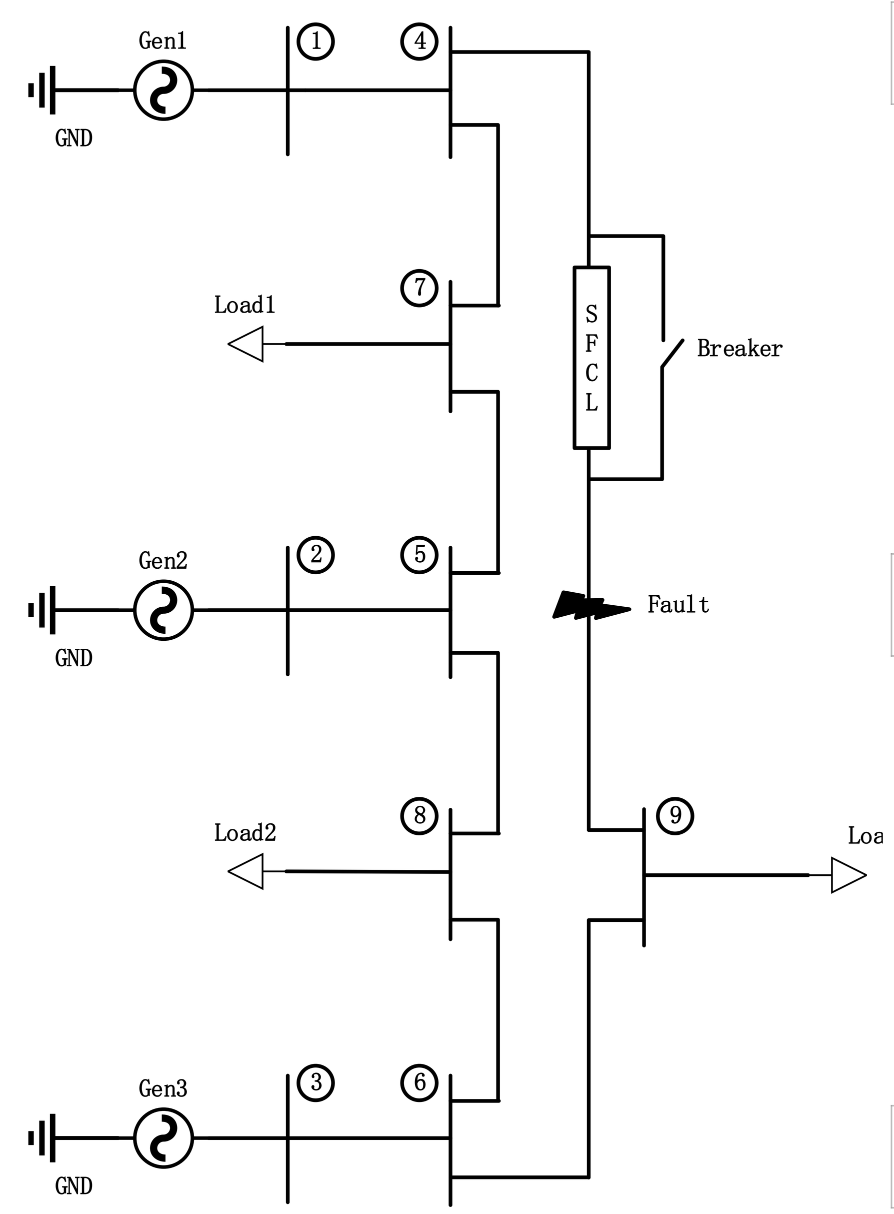


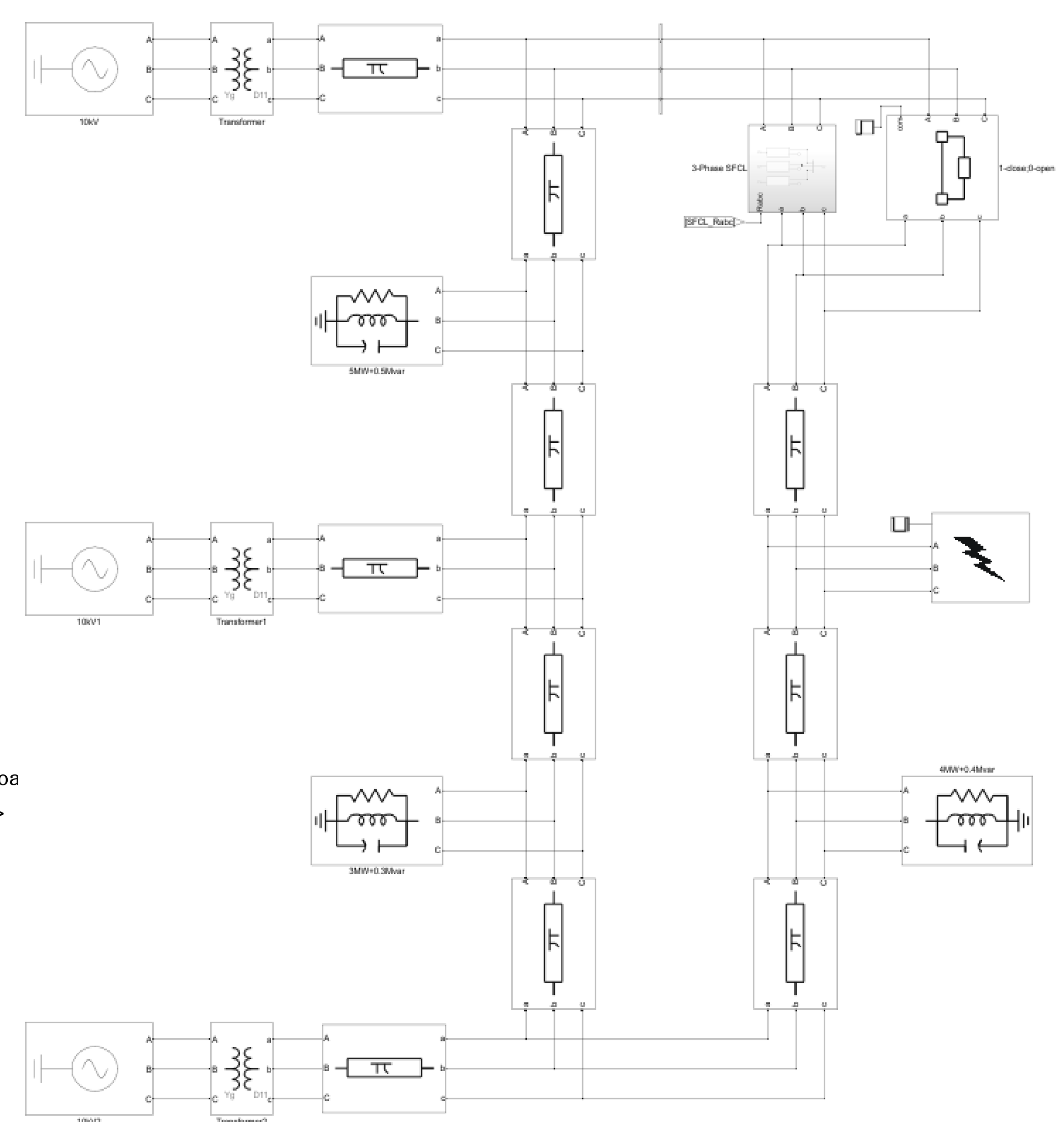
Fig. 1 The diagram structure of the magneto-biased SFCL

This SFCL mainly consists of a double-split reactor, a YBCO superconductor, and a fast circuit breaker. The double-split reactor is made of two inductors in parallel, L_1 and L_2 ($L_1 = L_2 = L$). The Dotted Terminals of L_1 and L_2 are connected reversely. The coupling coefficient of L_1 and L_2 is k, and the mutual inductance is $M = kL$. The YBCO coated conductor is connected in series to L_2 and the fast circuit breaker K_1. K_1 aims at protecting the YBCO superconductor from overcurrent damage.

3. 10 KV URBAN POWER GRID SIMULATION PLATFORM

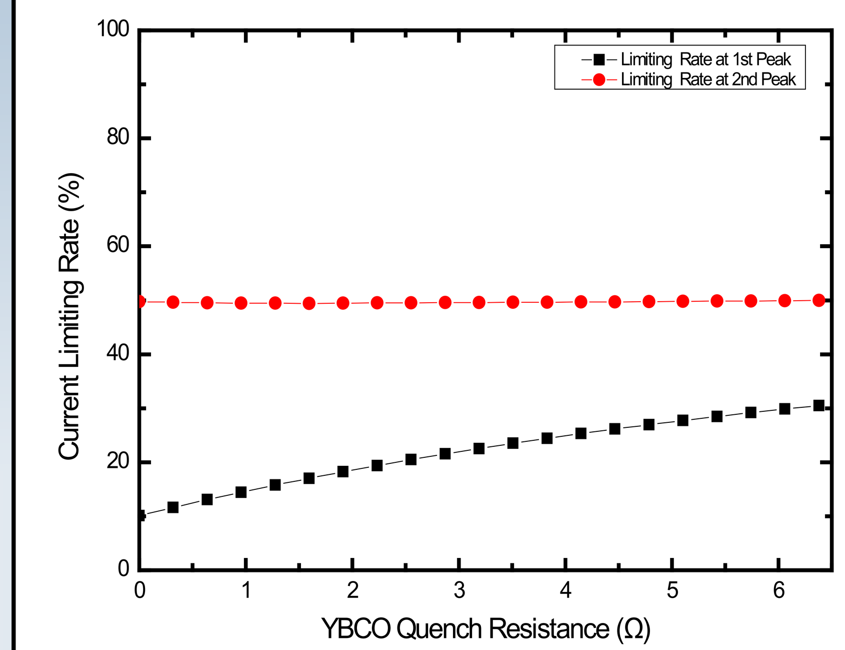


(a) topology diagram

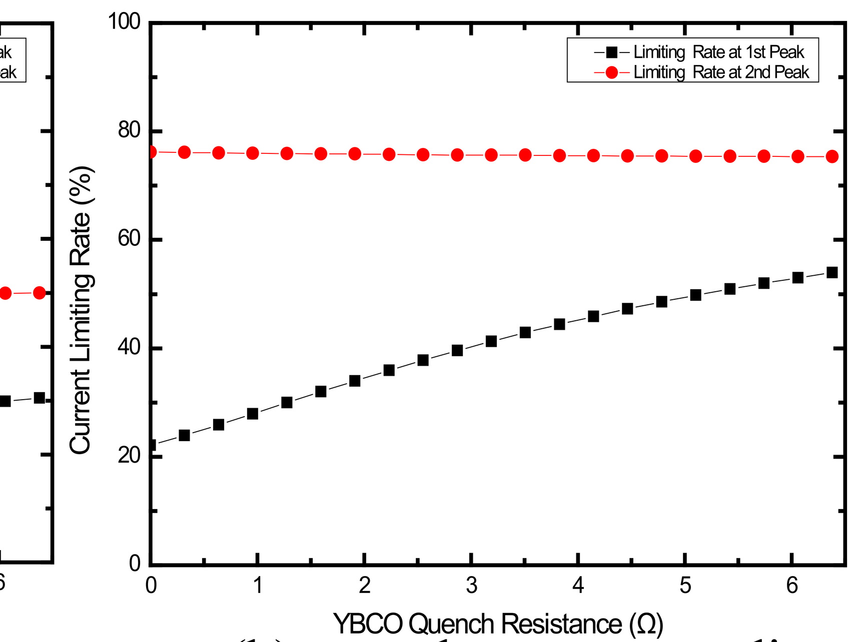


(b) SIMULINK diagram

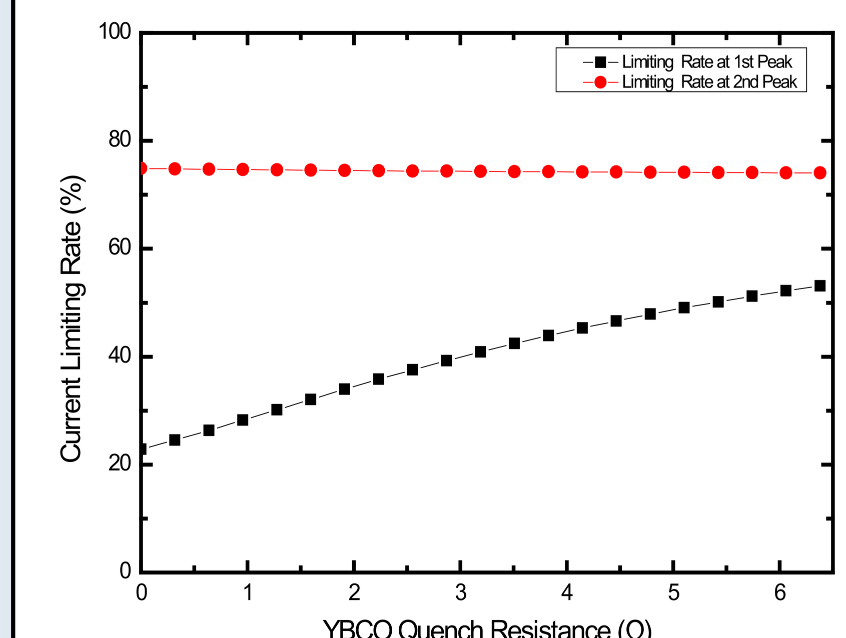
Fig. 2 The topology and the SIMULINK diagram of the 10 kV urban power grid simulation platform



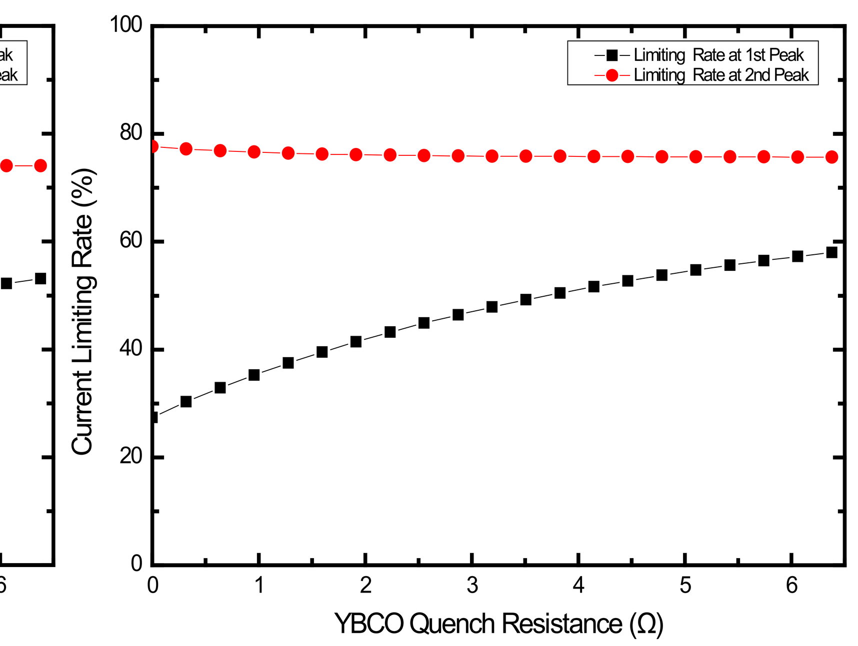
(a) single-phase short-circuit fault



(b) two-phase ungrounding short-circuit fault



(c) two-phase grounding short-circuit fault



(d) three-phase short-circuit fault

Fig. 5 Curves of the fault current limiting rate changing with the YBCO quench resistance

4. RESULTS

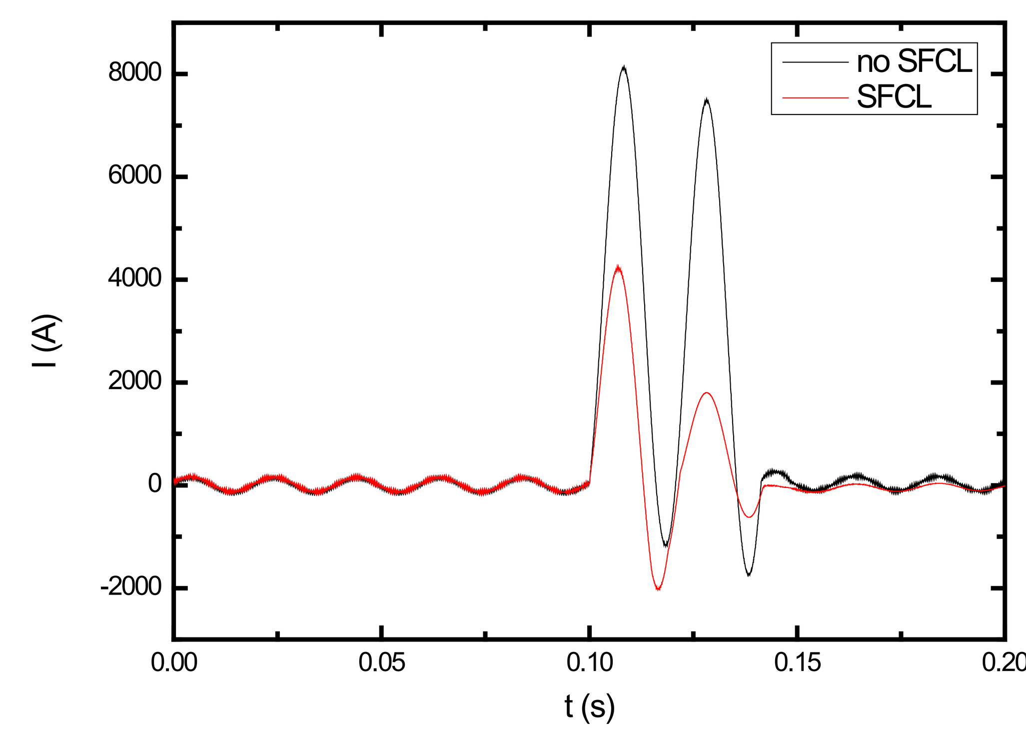


Fig. 3 The sample fault current waveforms at A phase during three phase short-circuit fault

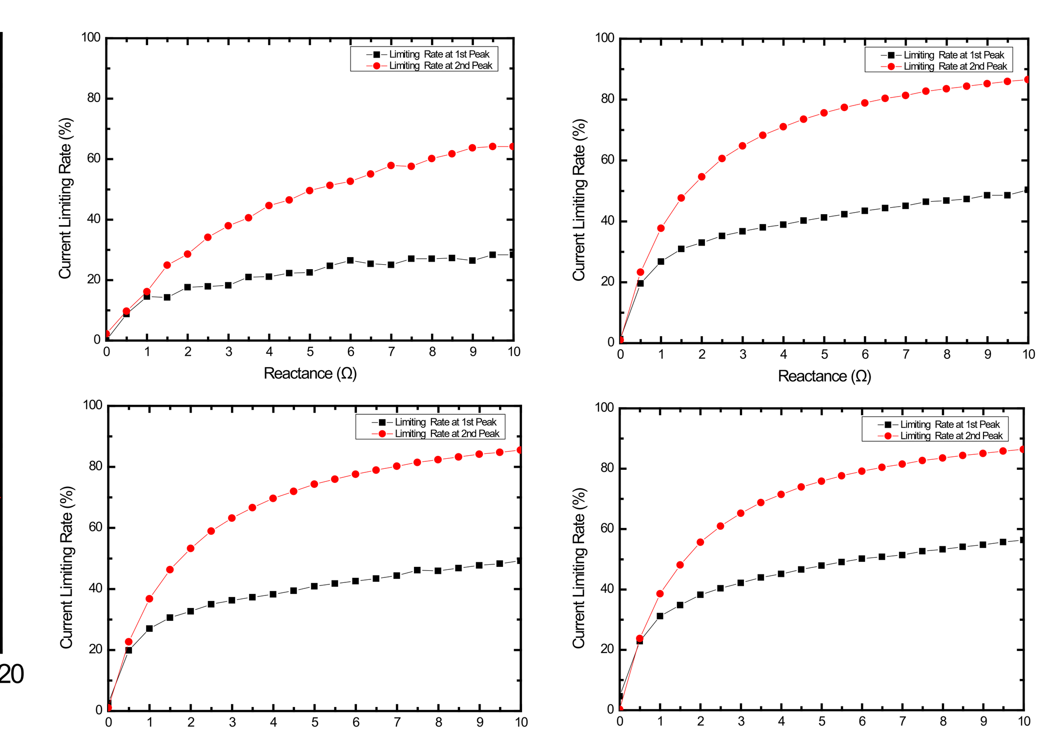


Fig. 4 Curves of the fault current limiting rate changing with the single branch reactance of the double-split reactor

5. CONCLUSIONS

The single branch reactance of the double-split reactor can influence both the current limiting rate of fault current at the first peak and that at the second peak. The current limiting rate increases with the single branch reactance of the double-split reactor but the derivative decreases. However, the influence on the current limiting rate at the second peak is significantly larger than that at the first peak.

The reference value($R_{YBCO} = 3.19\Omega$, $X = 4.99\Omega$) is economically cost-effective. It has the current limiting rate of 48% at the first peak and 76% at the second peak. When the SFCL parameters exceed the reference values, the current limiting rate increases slowly. If necessary, we recommend to increase the single branch reactance of the double-split reactor rather than the YBCO quench resistance for better effect and saving money. For example, if the single branch reactance of the double-split reactor doubles, the current limiting rate can achieve 56% at the first peak and 87% at the second peak.