Fault Current Limiting Operations of Three-Phase Transformer Type SFCL using Secondary Windings with Closed Loop

ID# 1055

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1. Introduction

- Three-phase transformer type superconducting fault current limiter (SFCL) using secondary windings with closed loop, which consisted of three-phase transformer windings wound on three legs of E-I iron core and three superconducting modules (SCMs), were suggested and its fault current limiting operations according to ground-fault types were analyzed.
- To verify the effective operation of the three-phase transformer type SFCL using secondary windings with closed loop, the unsymmetrical ground and the symmetrical ground faults were applied into three-phase power simulated system with the suggested SFCL.

2. Configuration

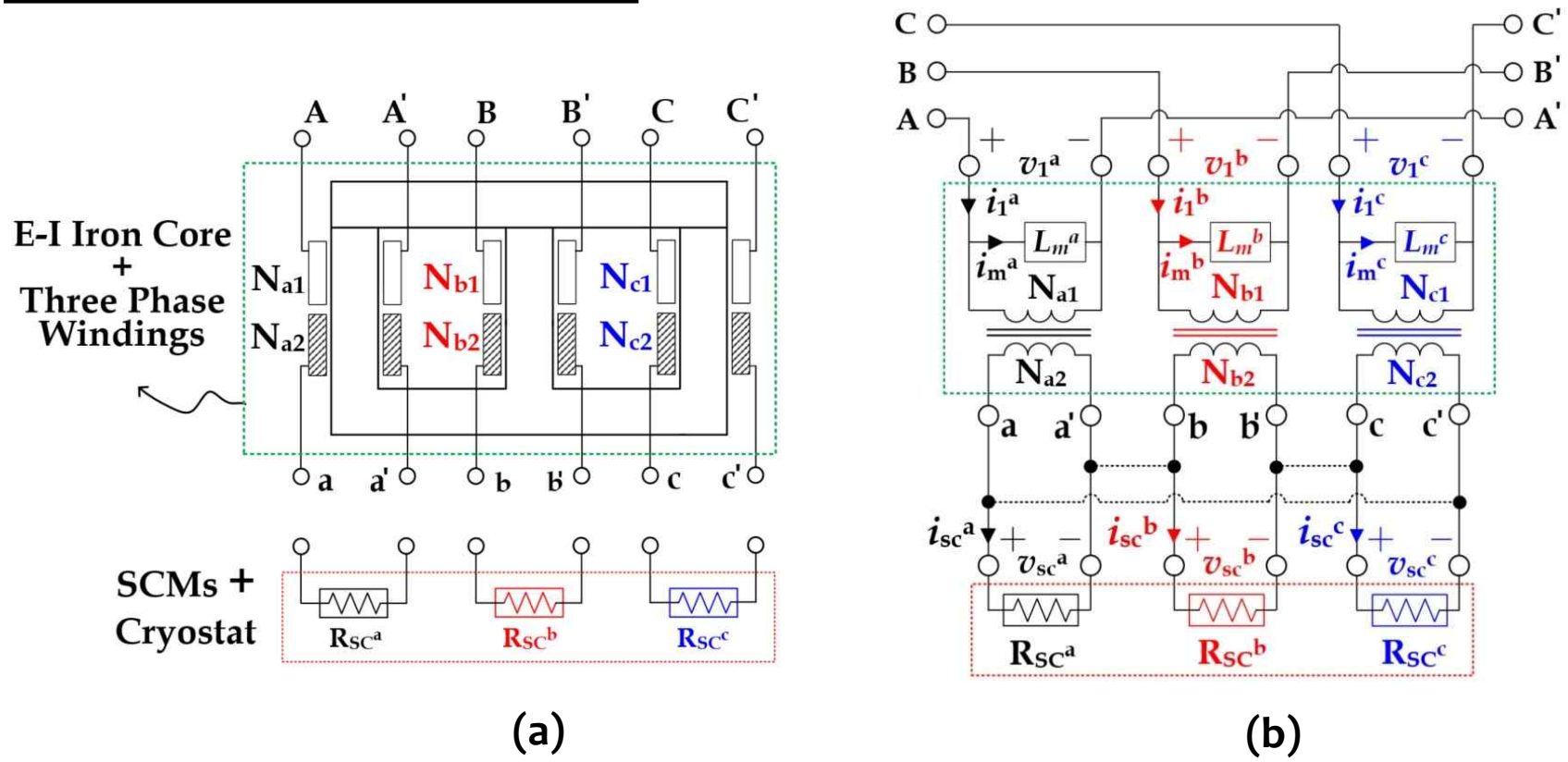

Fig. 1. Schematic diagram of the three-phase transformer type SFCL

(a) Isolated structure of three SCMs between secondary windings

(b) Closed loop structure of three SCMs between secondary windings

3. Experimental Circuit

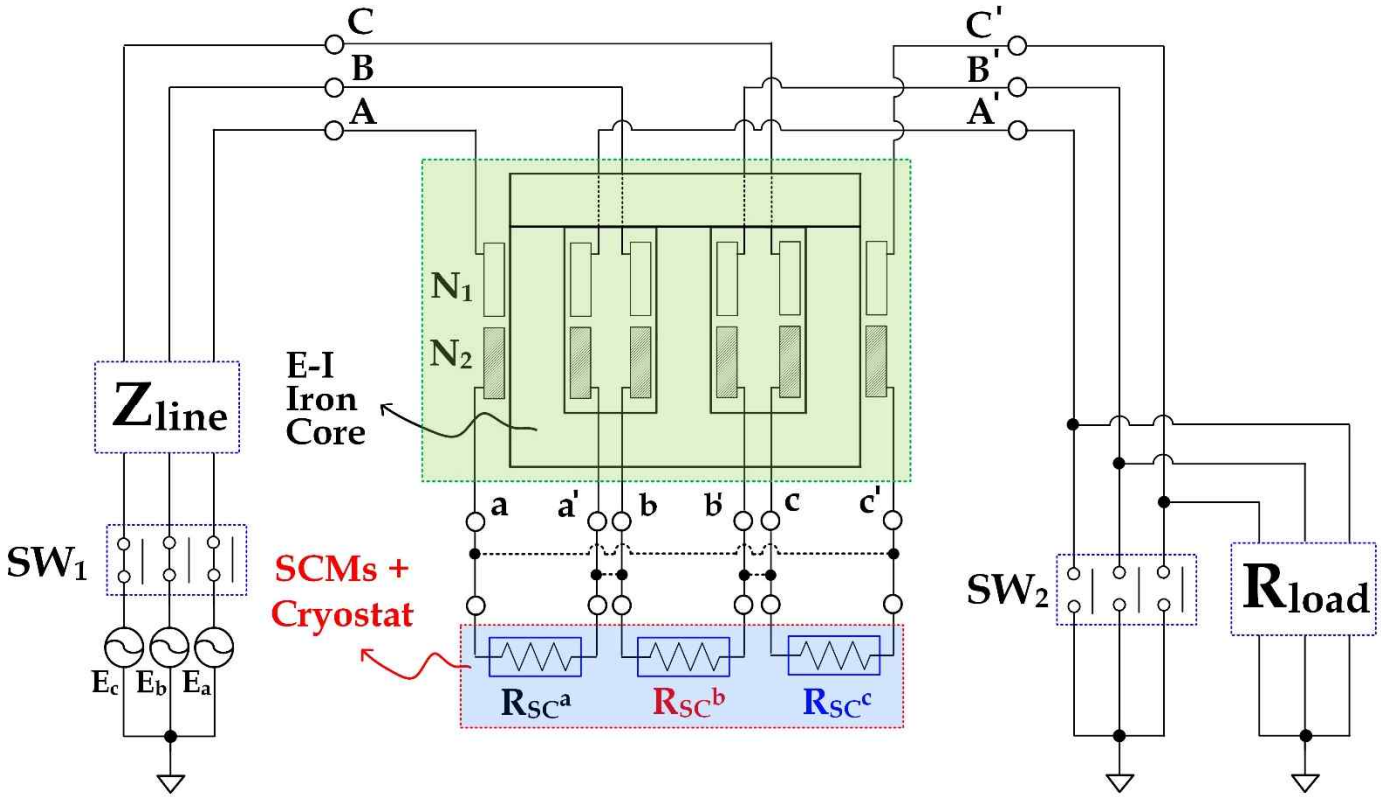

Fig. 2. Experimental test circuit of three-phase transformer type SFCL

4. Experimental Results and Analysis

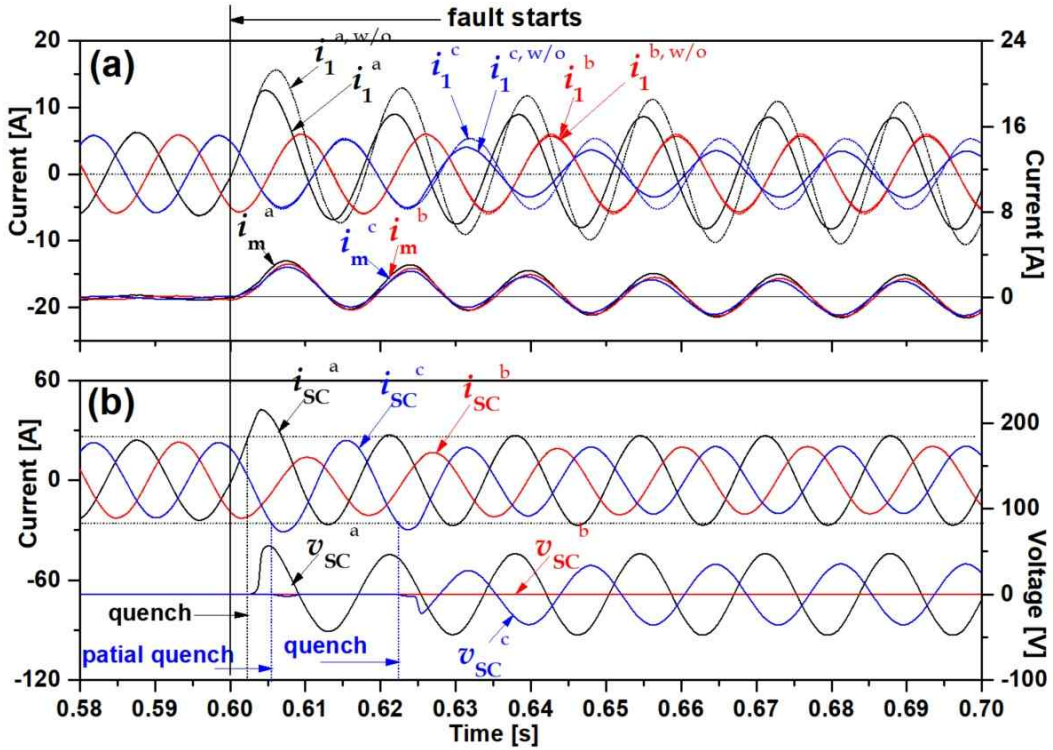

Fig. 3. Fault current limiting operational waveforms of three-phase transformer type SFCL with isolated structure in case that single (phase-a) line ground fault happens. (a) Current waveforms flowing into the primary windings. (b) Current and voltage waveforms in three SCMs.

4. Experimental Results and Analysis

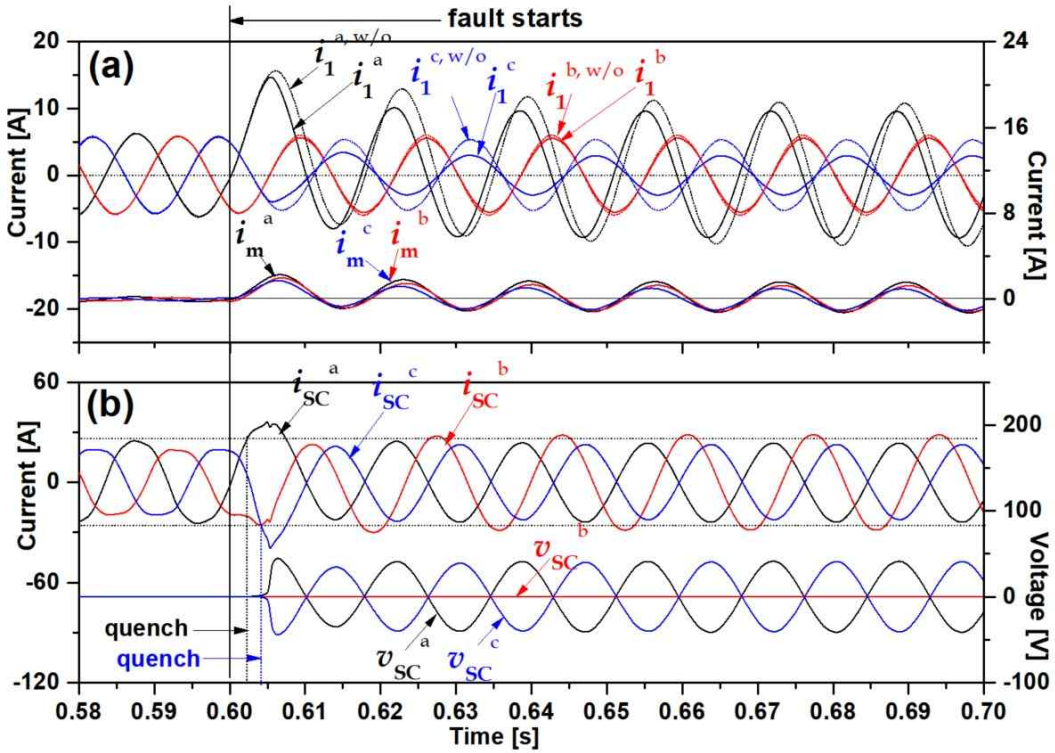

Fig. 4. Fault current limiting operational waveforms of three-phase transformer type SFCL with closed loop structure in case that single (phase-a) line ground fault happens. (a) Current waveforms flowing into the primary windings. (b) Current and voltage waveforms in three SCMs.

4. Experimental Results and Analysis

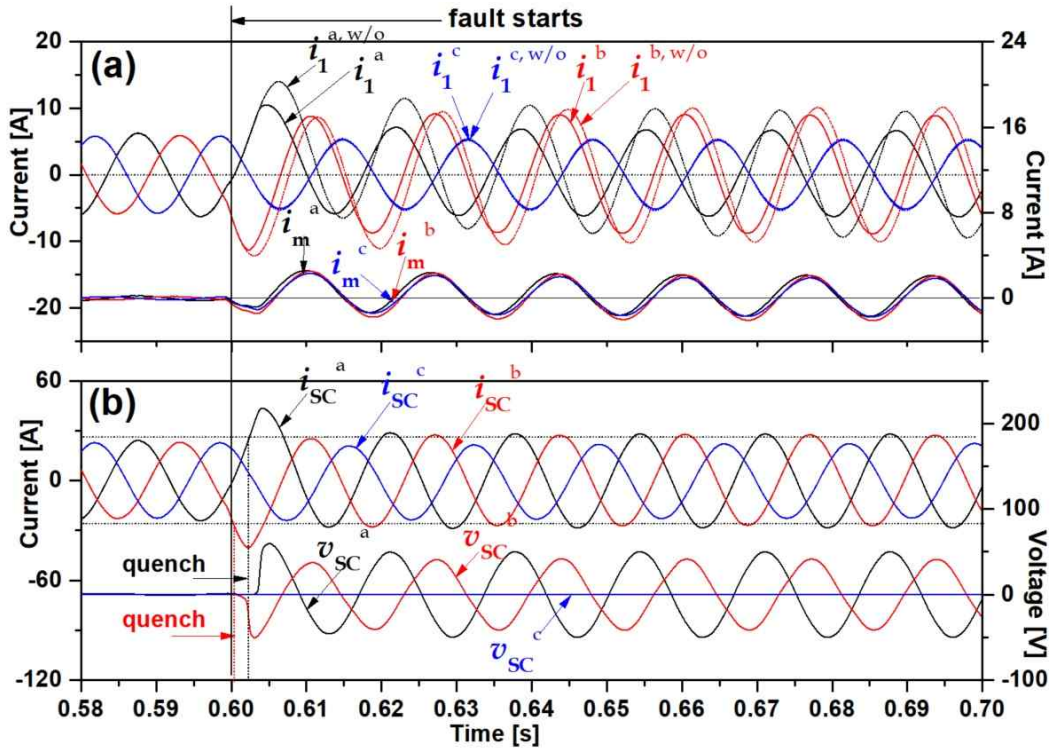

Fig. 5. Fault current limiting operational waveforms of three-phase transformer type SFCL with isolated structure of three SCMs in case that double (phase-a, phase-b) line ground fault happens.

(a) Current waveforms flowing into the primary windings. (b) Current and voltage waveforms in three SCMs.

4. Experimental Results and Analysis

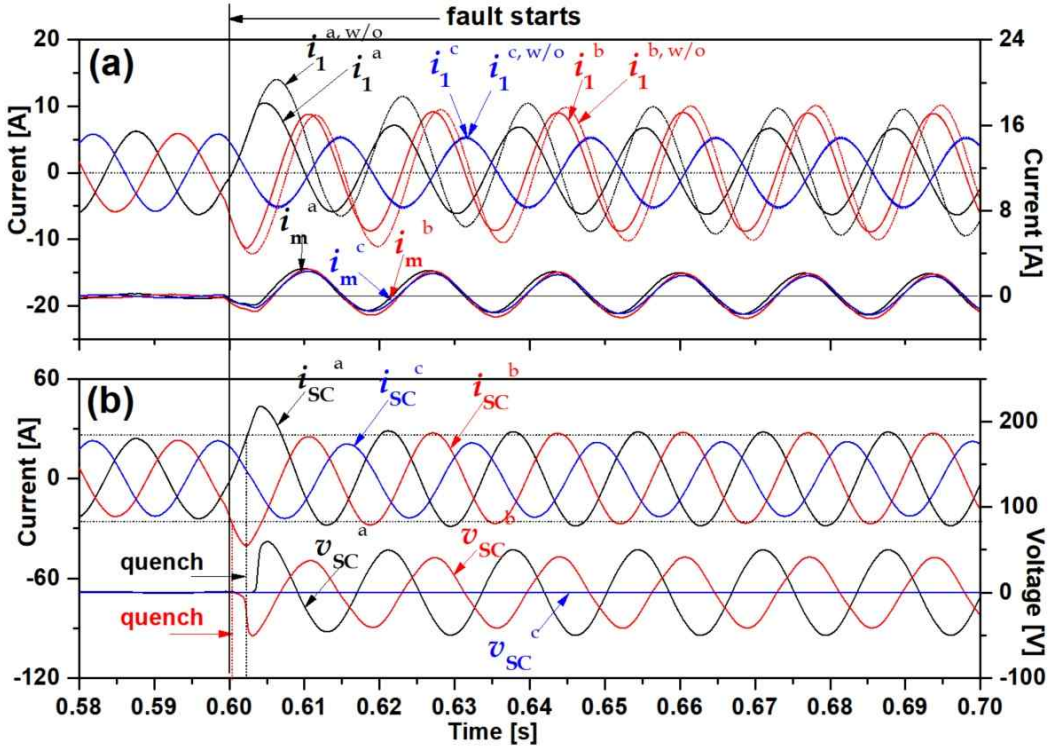

Fig. 6. Fault current limiting operational waveforms of three-phase transformer type SFCL with closed loop structure of three SCMs in case that double (phase-a, phase-b) line ground fault happens.

(a) Current waveforms flowing into the primary windings. (b) Current and voltage waveforms in three SCMs.

4. Experimental Results and Analysis

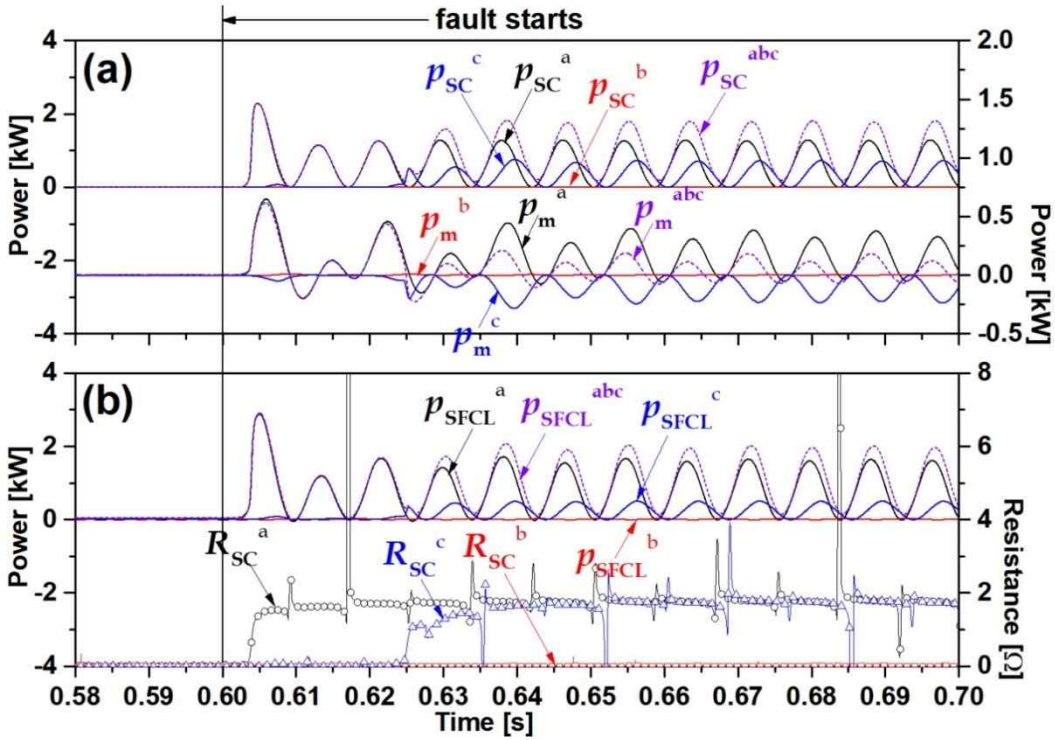

Fig. 7. Total instantaneous power comprising three-phase transformer type SFCL with isolated structure in case that single (phase-a) line ground fault happens.

(a) Power consumption and magnetization loss waveforms in three SCMs. (b) Power and Resistance waveforms in SFCL.

4. Experimental Results and Analysis

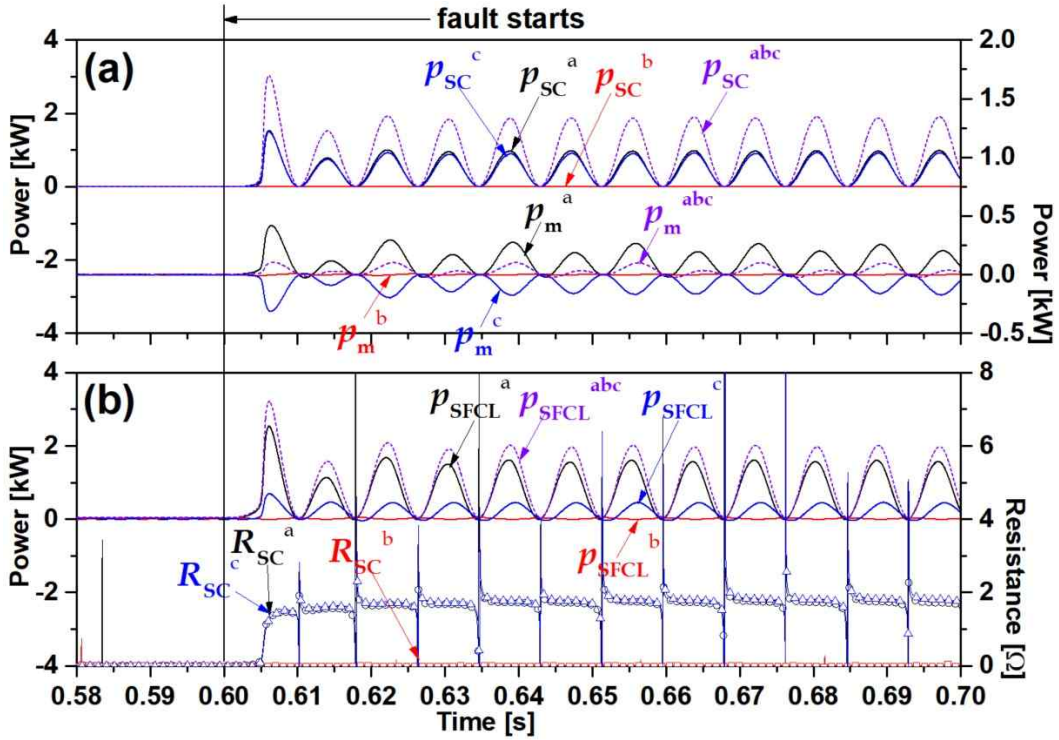

Fig. 8. Total instantaneous power comprising three-phase transformer type SFCL with closed loop structure in case that single (phase-a) line ground fault happens.

(a) Power consumption and magnetization loss waveforms in three SCMs. (b) Power and Resistance waveforms in SFCL.

4. Experimental Results and Analysis

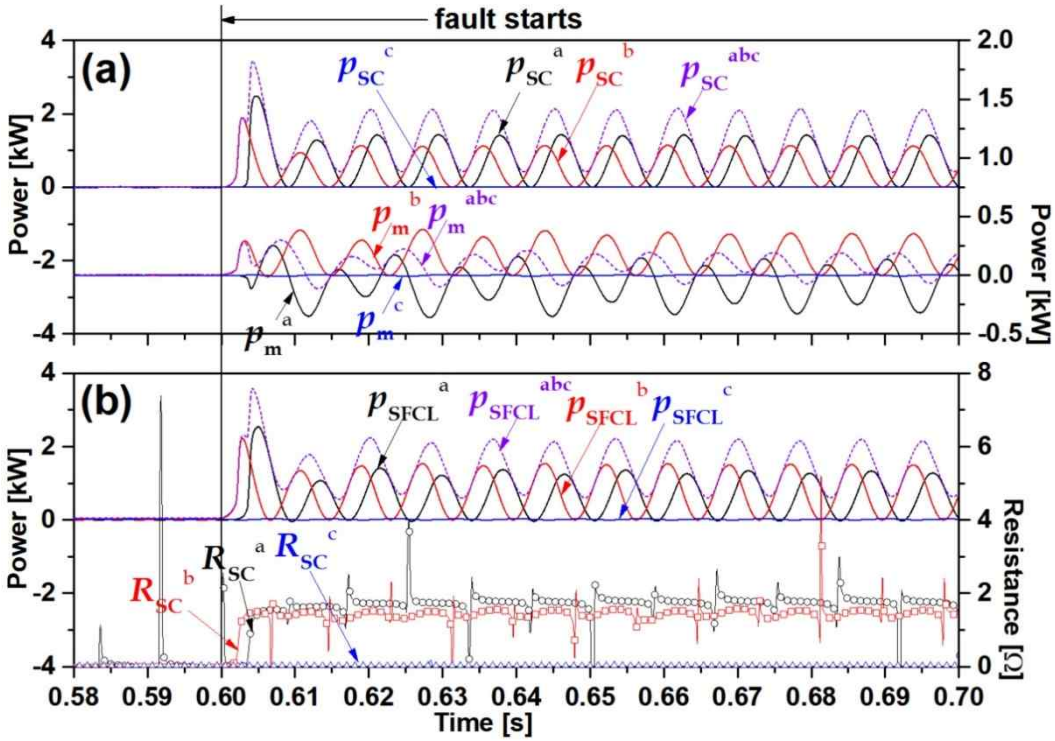

Fig. 9. Total instantaneous power comprising three-phase transformer type SFCL with isolated structure in case that double (phase-a, phase-b) line ground fault happens.

(a) Power consumption and magnetization loss waveforms in three SCMs. (b) Power and Resistance waveforms in SFCL.

4. Experimental Results and Analysis

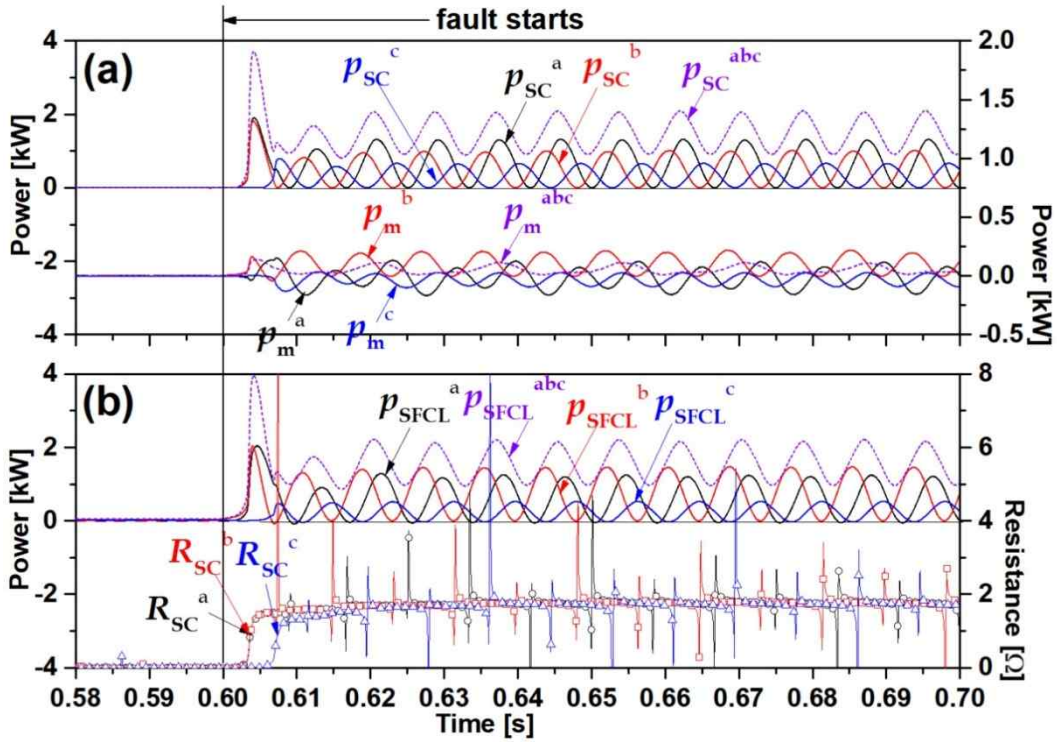

Fig. 10. Total instantaneous power comprising three-phase transformer type SFCL with closed loop structure in case that double (phase-a, phase-b) line ground fault happens.

(a) Power consumption and magnetization loss waveforms in three SCMs. (b) Power and Resistance waveforms in SFCL.

4. Experimental Results and Analysis

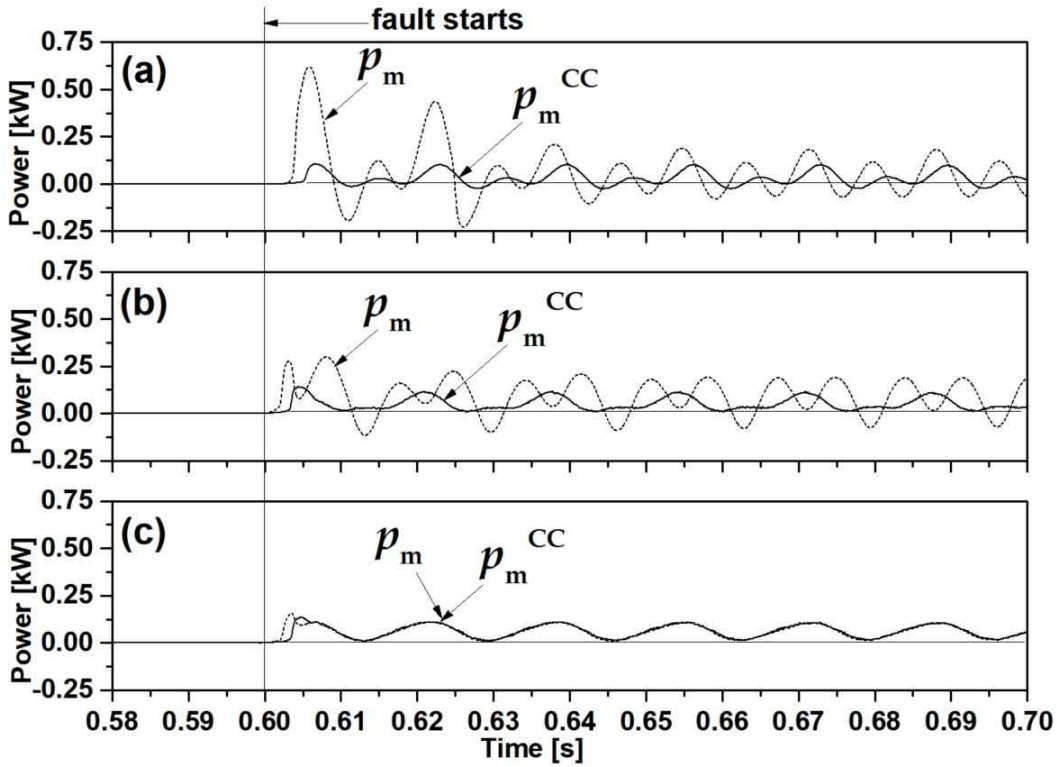

Fig. 11. Magnetization loss comprising three-phase transformer type SFCL with isolated and closed loop structure according to ground fault happens.

(a) single line ground fault (b) double line ground fault (c) triple line ground fault

5. Conclusion

- In this paper, the model SFCL in which three superconducting module modules have a closed loop on the E-I iron core is limited, and the case of the isolated structure SFCL with three SCMs and the fault current limiting characteristics are analyzed.
- In case of symmetrical ground fault, the SFCL of both models showed the same magnetizing loss power during the fault period except for the fault moment.
- In the case of asymmetrical fault, the magnetization loss power and power consumption of the SFCL were smaller than those of the isolated structure SFCL in the proposed model, and there was an effect of reducing the power burden.