

# Current Limiting Characteristics of Transformer Type SFCL due to Winding Direction of Additional Circuit

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## Abstract

In this paper, the transformer type superconducting fault current limiter (SFCL) with additional secondary winding, which could limit the fault current through twice quench operations, was suggested. The suggested SFCL includes one primary winding, two non-isolated secondary windings wound on the same iron core, and two high- $T_c$  superconducting (HTSC) elements connected with each secondary winding. The advantage of the suggested SFCL is that it can perform the twice current limiting operations due to the transient amplitude of the fault current. Among its designed parameters, the winding direction of two non-isolated secondary windings is expected to affect the current limiting characteristics of the SFCL with twice quench operations.

To analyze the dependence of the current limiting operation on the winding direction of the two non-isolated secondary windings, the fault current limiting tests were performed with the suggested SFCL and the current limiting characteristics of the SFCL were discussed.

## Conclusion

In the present study, an additional circuit was connected to the secondary winding of a transformer type SFCL. The double quench-based fault current limiting characteristics were also analyzed depending on the winding direction of the secondary winding. When an additional circuit was connected to the secondary winding and the number of windings of the secondary winding was designed to be three times as great as that of the original winding, a quench occurred in both the superconducting elements almost simultaneously in the case of an additive polarity winding. However, a quench first occurred in the second superconducting element and then in the first superconducting element to limit the fault current.

In conclusion, in contrast to the prediction that a quench would occur in the first superconducting element by the generation of a fault current when an additional circuit was connected to the secondary winding ( $N_2$ ), a quench first occurred in the second superconducting element to limit the fault current. In addition, the results of the present study showed that the fault current may be limited by varying the design conditions regarding the number of windings of the additional circuit. The analyzed excess current limiting characteristics verified the practicality of the superconducting fault current limiter proposed in this paper.

Methods

### Structure and Mechanism

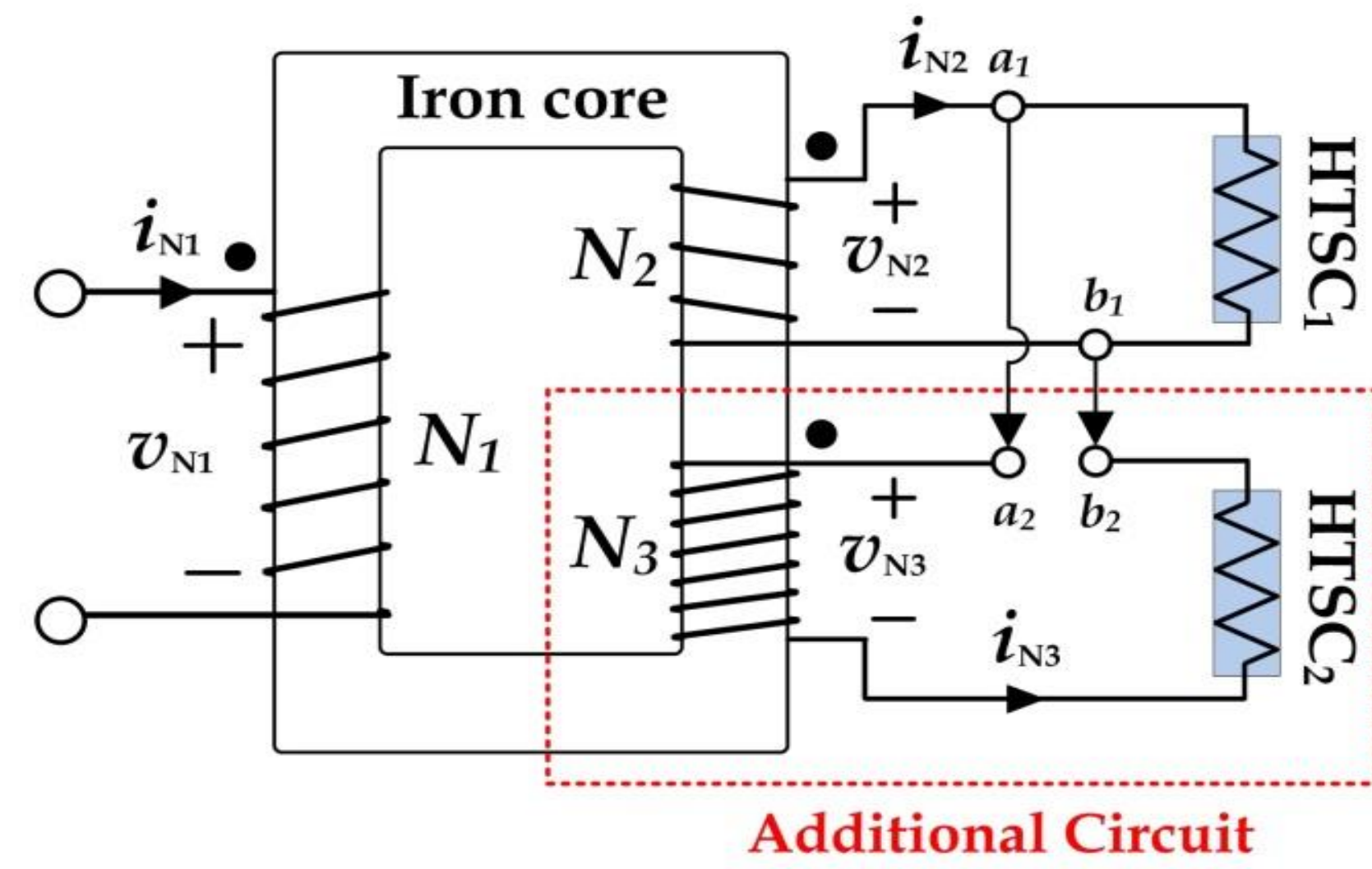


Fig. 1. Schematic configuration of the transformer type SFCL with additional circuit.

### Structure and Mechanism

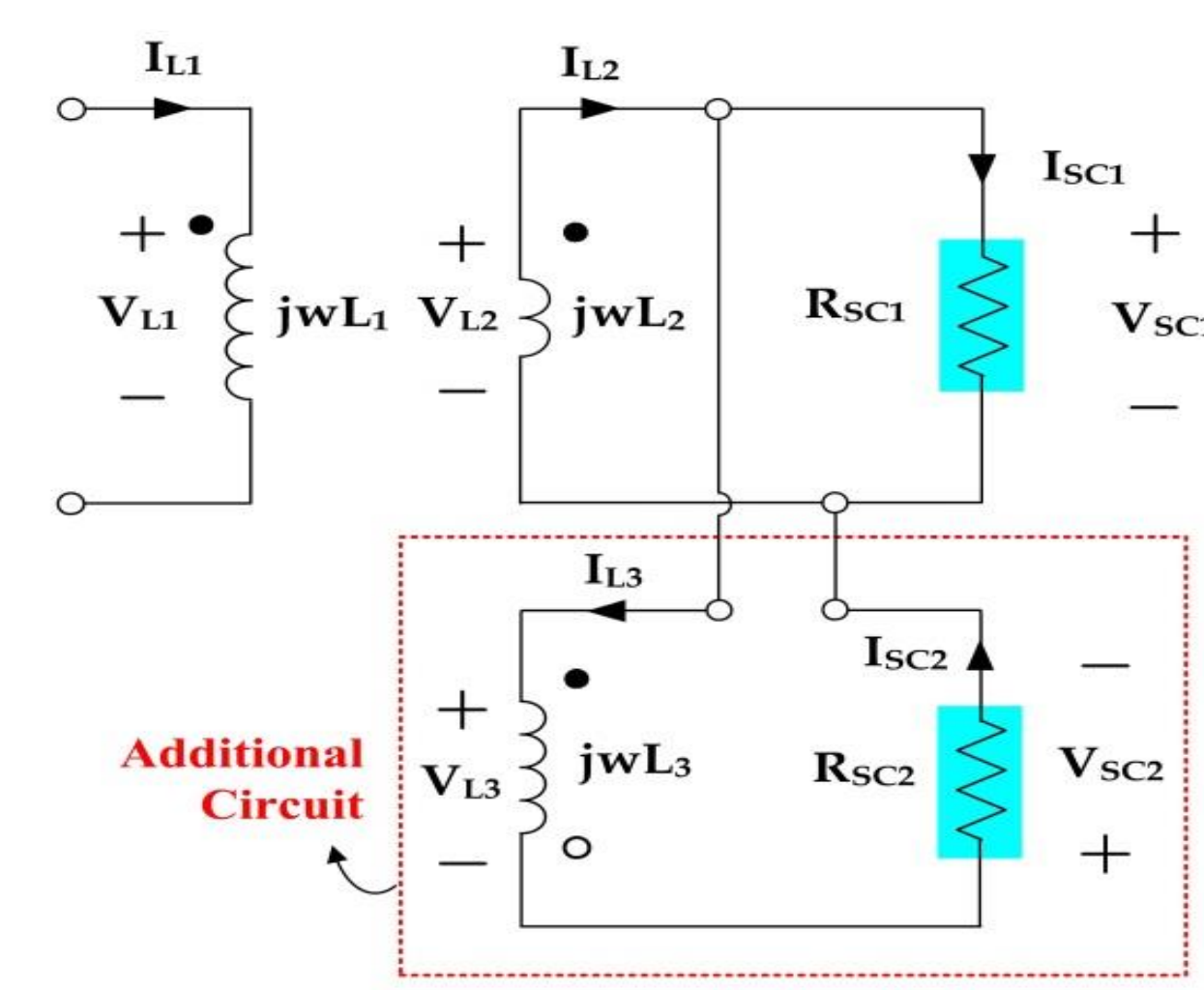


Fig. 2. Equivalent circuit of the transformer type SFCL with additional circuit

### Experimental Configurations and Methods

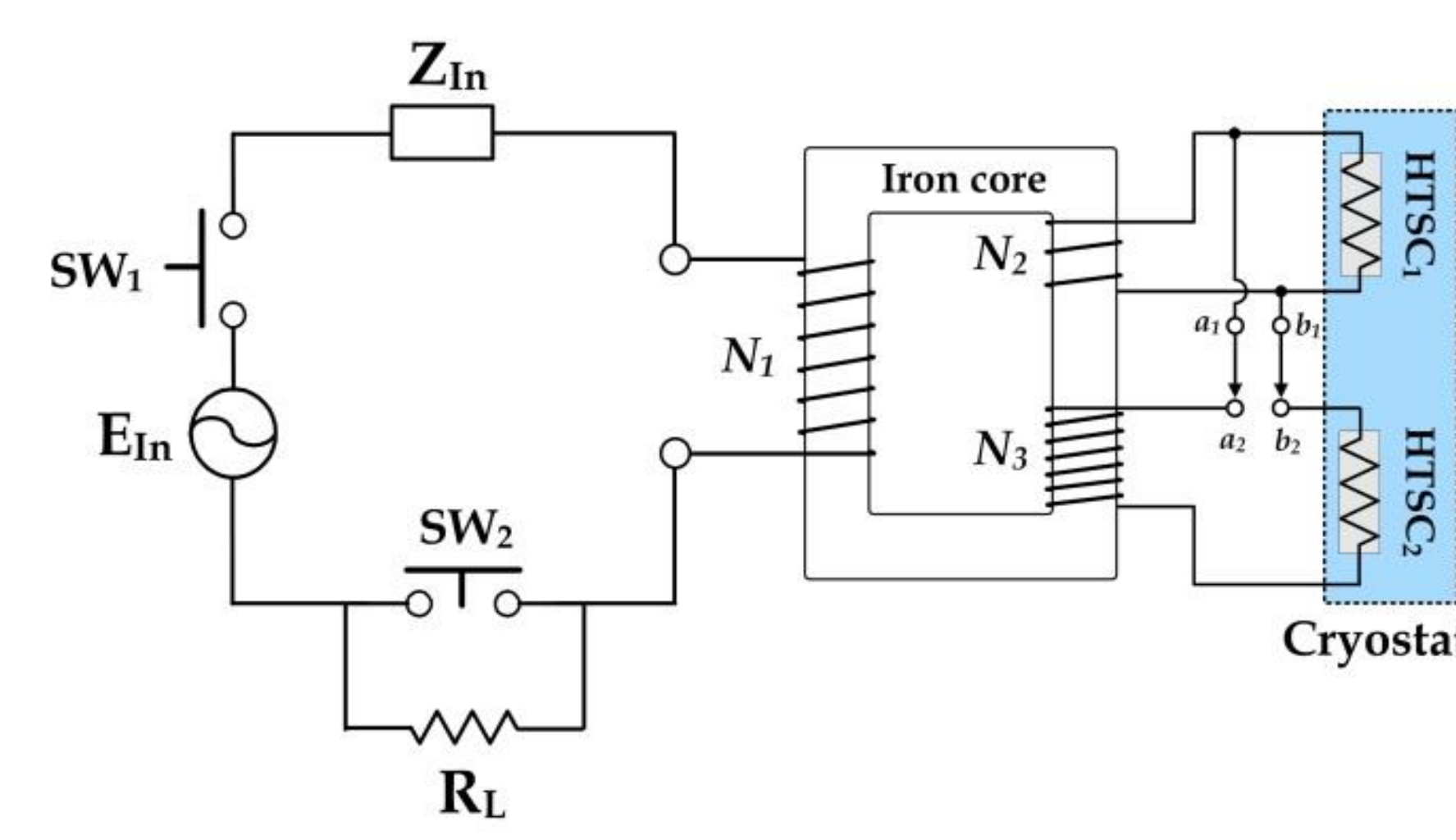


Fig. 3. Experimental Circuit for the short-circuit test of the transformer type SFCL with additional circuit

Results

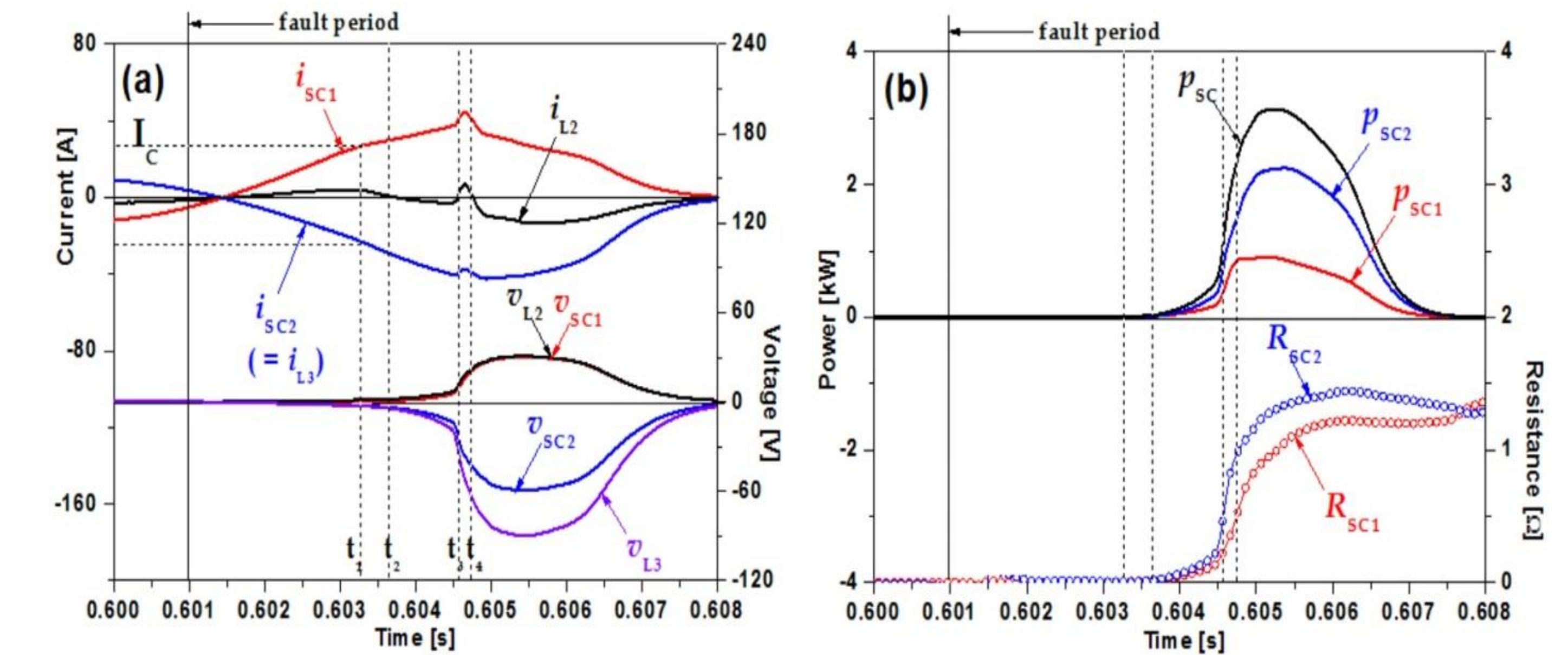


Fig. 4. Transient fault current limiting characteristics of the transformer type SFCL with additional circuit in case of the additive polarity winding. (a) Current and voltage waveforms. (b) Power burdens and resistance characteristics

Results

### Transient fault current limiting Characteristics

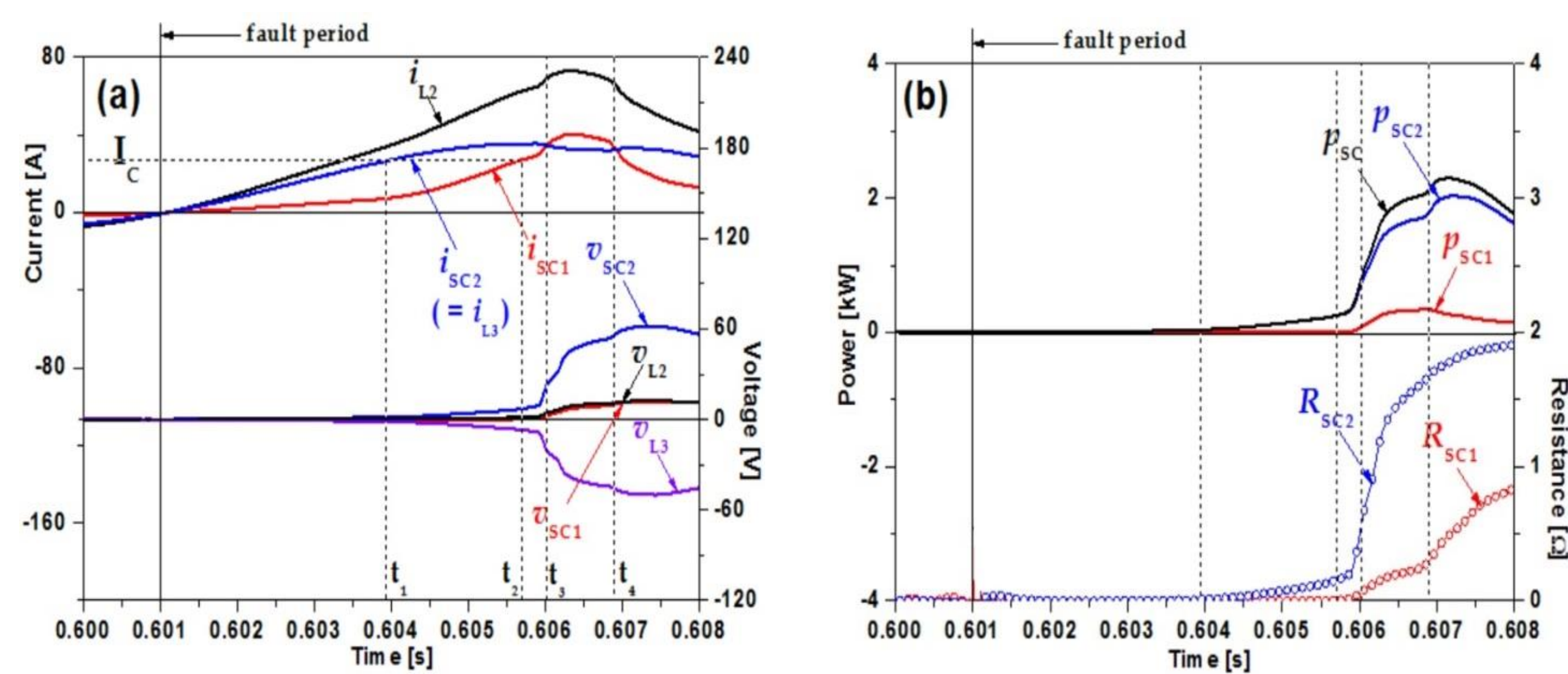


Fig. 5. Transient fault current limiting characteristics of the transformer type SFCL with additional circuit in case of the subtractive polarity winding. (a) Current and voltage waveforms. (b) Power burdens and resistance characteristics

### Transient fault current limiting Characteristics

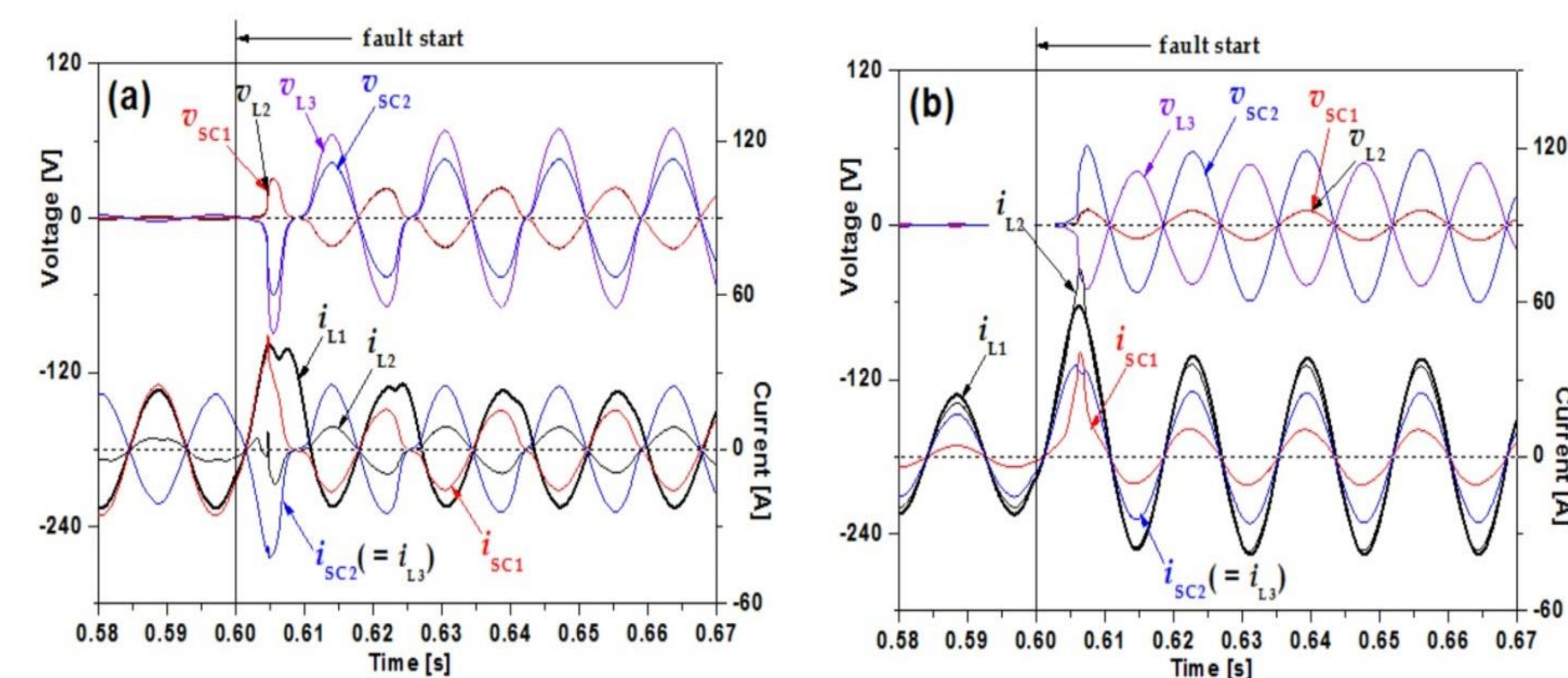


Fig. 6. Fault current limiting characteristics of the transformer SFCL with additional circuit using double quench in case of the winding direction. (a) In case of the additive polarity winding. (b) In case of the subtractive polarity winding.

### Resistances and Power burdens

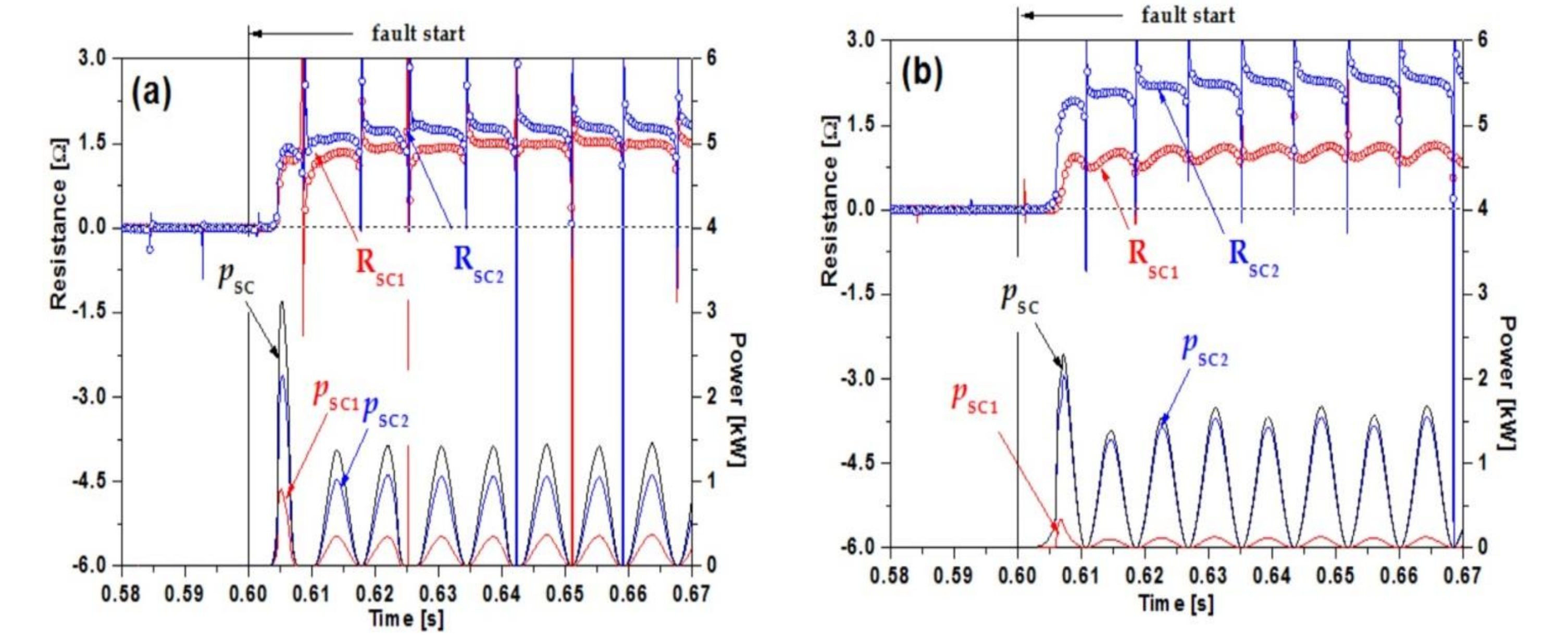


Fig. 7. Resistances and Power burdens of two HTSC elements comprising the transformer type SFCL with additional circuit. (a) In case of the additive polarity winding. (b) In case of the subtractive polarity winding.