Analysis on Current Limiting and Magnetizing Characteristics Due to Winding Locations of Superconducting Fault Current Limiter Using E-I Core

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Introduction

- This paper compared current limiting characteristics of superconducting fault current limiter (SFCL) using E-I core due to the location of windings.

- Since E-I core has three legs and two magnetic paths, the current limiting characteristics of SFCL were expected to be affected by the installation location of windings, either center leg or right/left leg.

- To analyze its characteristics, the electrical equivalent circuit of the SFCL were derived and the electromagnetic analysis for the SFCL with the designed structure were performed. From the short-circuit tests, the hysteresis curve and the voltage-current trajectory of the SFCL due to the installation location of windings were extracted and compared each other.

Introduction

- The SFCL with windings in the center leg of E-I core was shown to be larger magnetizing inductance compared to the one with windings in the right or left leg of E-I, which was analyzed from the hysteresis curve.

- In addition, larger decreased fault current right after the fault occurrence in the SFCL with windings in the center leg of E-I core was confirmed than the SFCL with windings in the right or left leg of E-I.

Schematic configuration

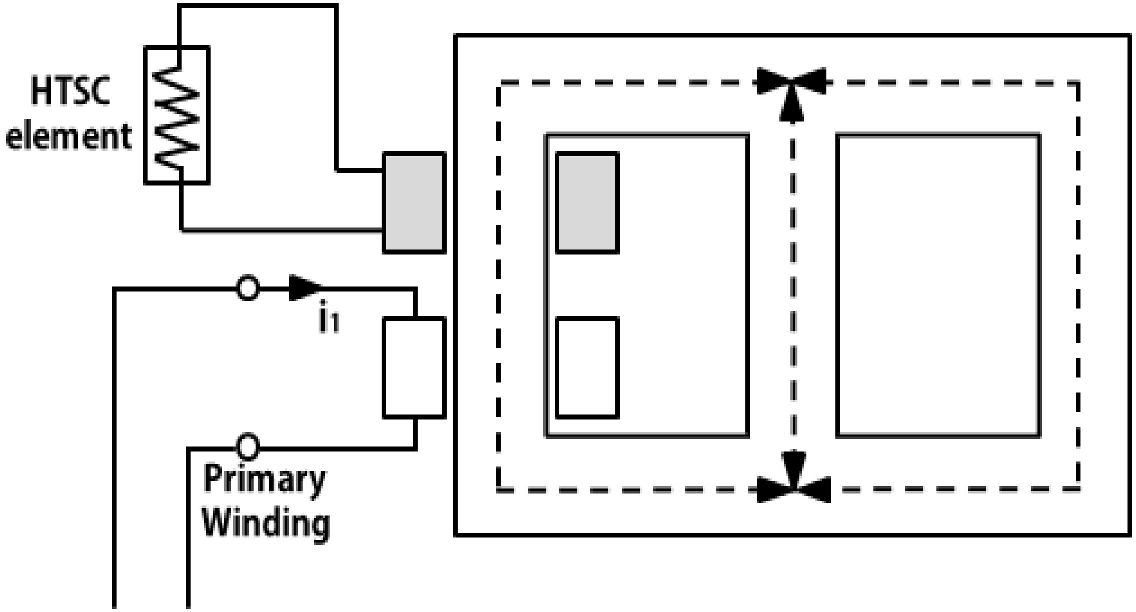

Fig. 1. Schematic configuration of SFCL using E-I Core.

Equivalent Circuit

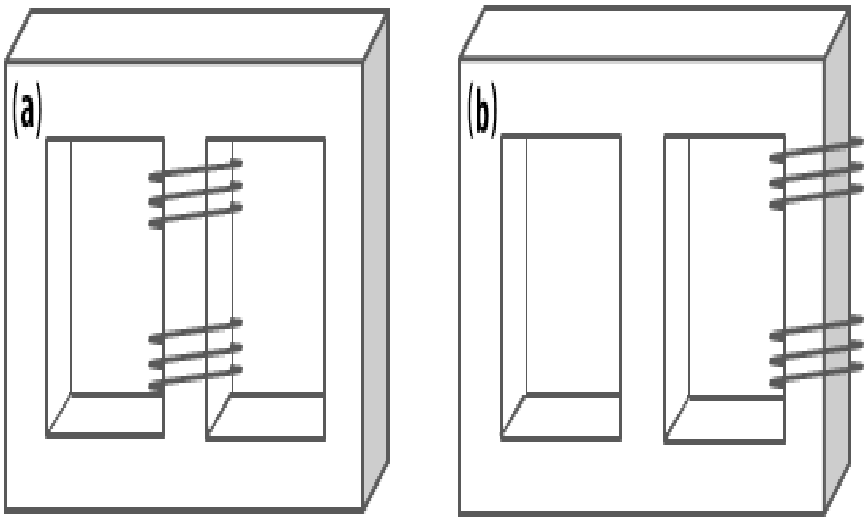

Fig. 2. E-I core Conneted Windings on Each Leg

(a) Middle Leg of E-I Core Connected with Primary and Secondary Windings

(b) Right Leg of E-I Core Connected with Primary and Secondary Windings

Experimental Circuit

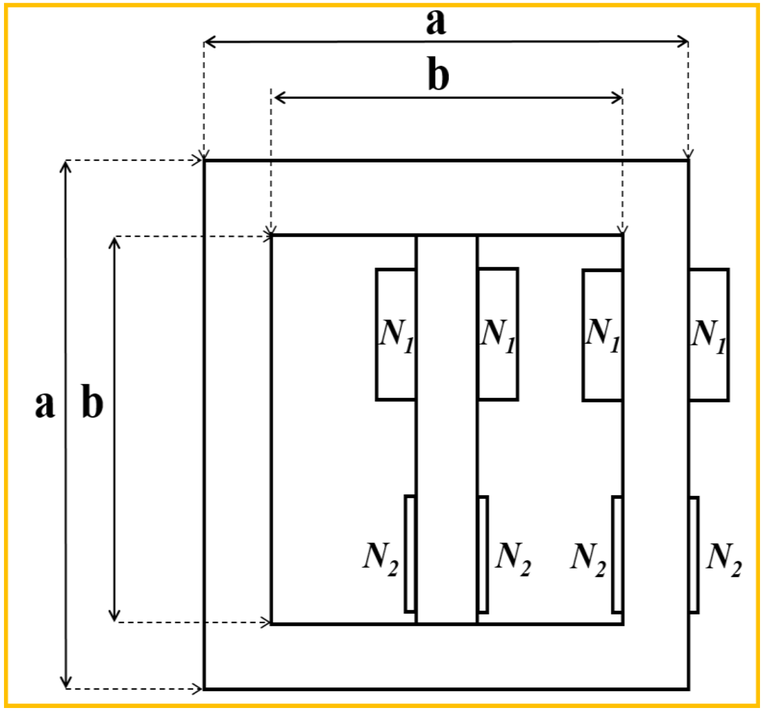

Fig. 3. Analysis model of E-I Core.

Specifications of the transformer type SFCL

Table 1. Parameters of Analysis Model

Parameters	Mean	Value [Unit]
l_a	Total length of flux path (a)	845.8450 [mm]
l_b	Total length of flux path (b)	845.1172 [mm]
A_C	Cross Section Area of Core	2,500 [mm^2]
T_{N1}	Turn number of Coil 1	176 [Turns]
T_{N2}	Turn number of Coil 2	66 [Turns]
A_W	Cross Section Area of Coil	8 [mm^2]
R_{N1}	Resistance of Coil 1	2.1 [Ω]
R_{N2}	Resistance of Coil 2	0.5 [Ω]
a	Length of a	248 [mm]
b	Length of b	152 [mm]
I_C	Critical Current of Superconductor	21 [A]

Experimental Results

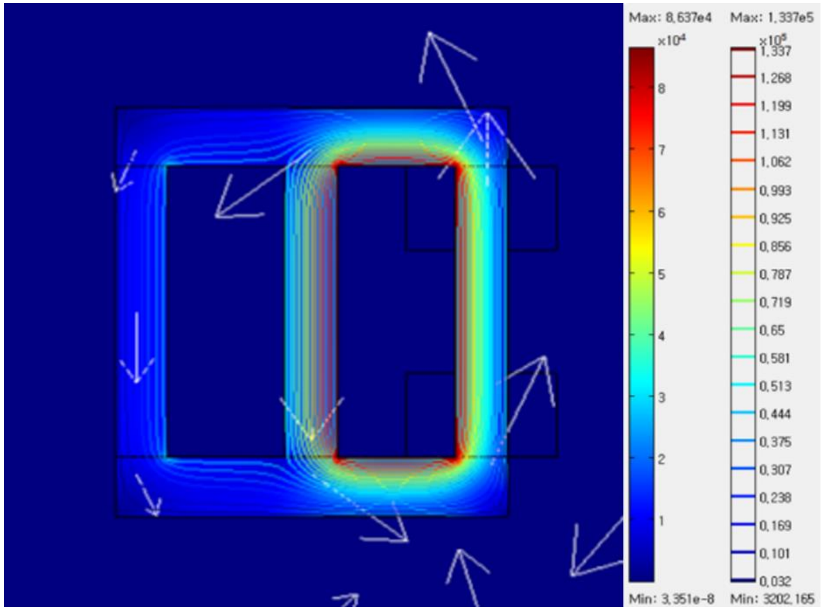

Fig. 4. Distribution of Magnetic Flux for Right Leg Core

Experimental Results

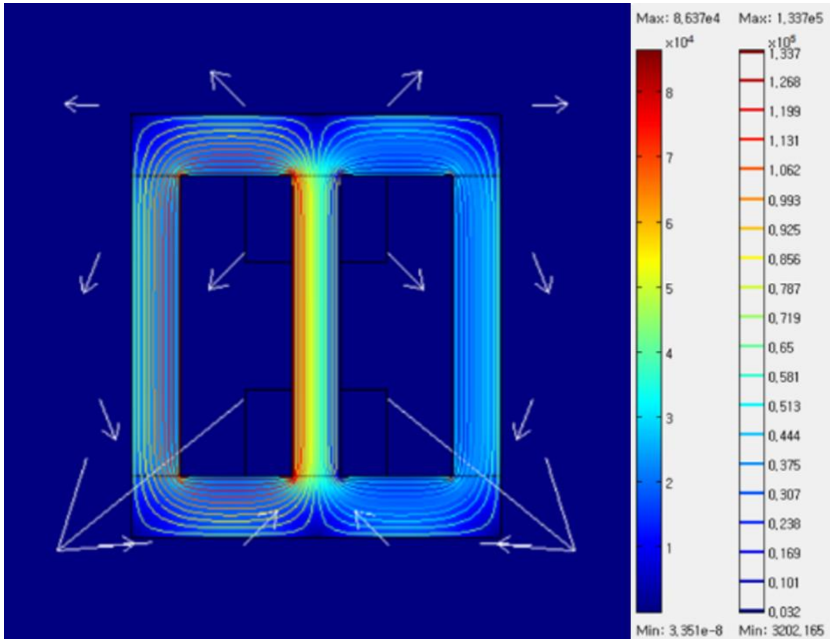

Fig. 5. Distribution of Magnetic Flux for Middle Leg Core

Experimental Results

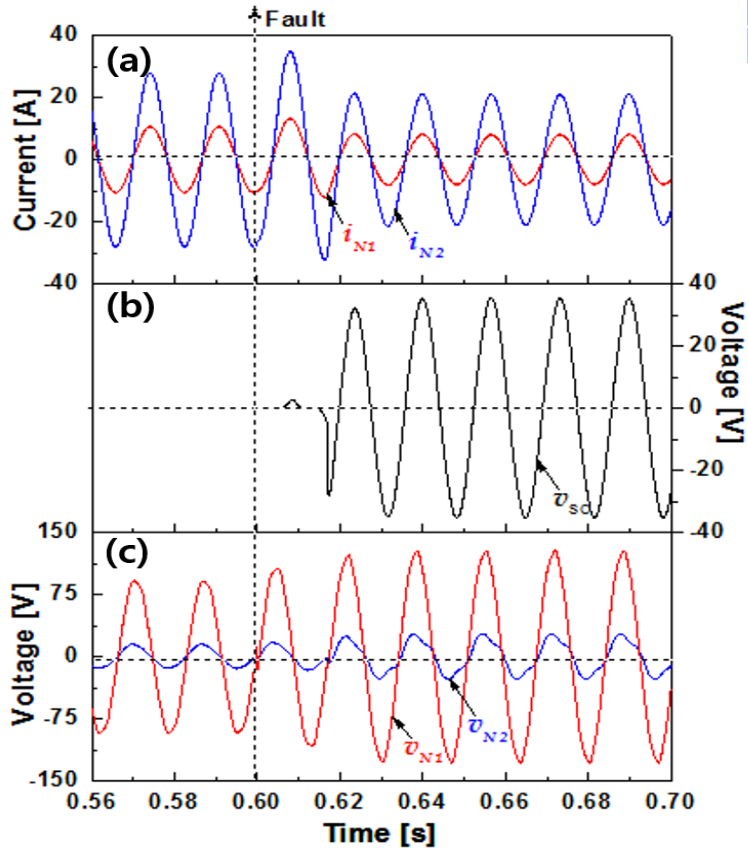

Fig. 6. Graphs of Voltage and Current for Right Leg
(a) Primary and Secondary Current (b) Applied Voltage to HTSC
(c) Primary and Secondary Voltage

Experimental Results

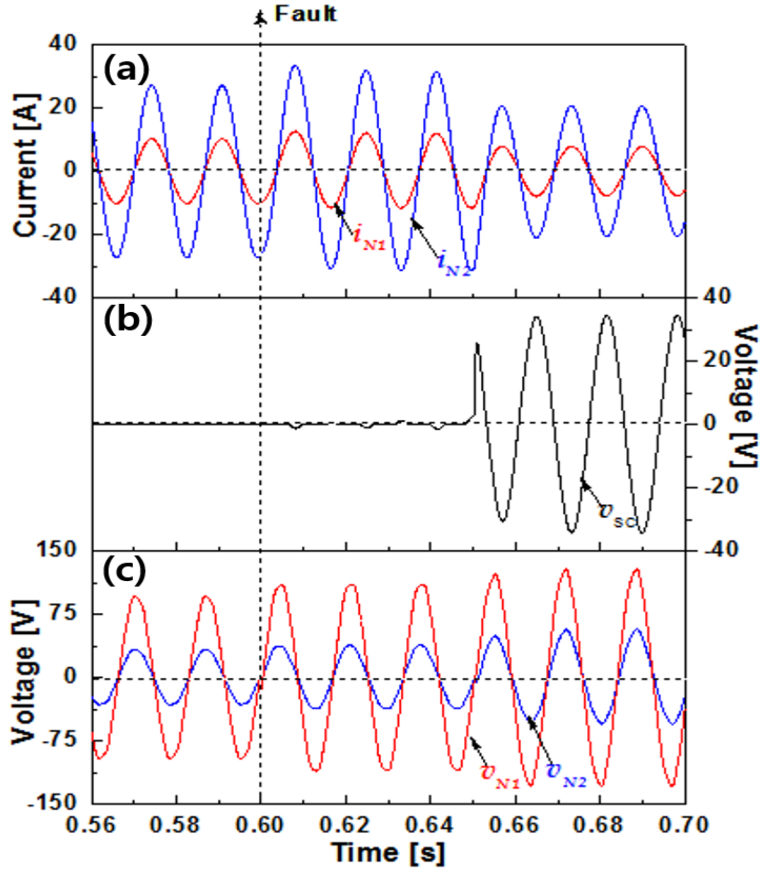

Fig. 7. Graphs of Voltage and Current for Middle Leg
(a) Primary and Secondary Current (b) Applied Voltage to HTSC
(c) Primary and Secondary Voltage

Experimental Results

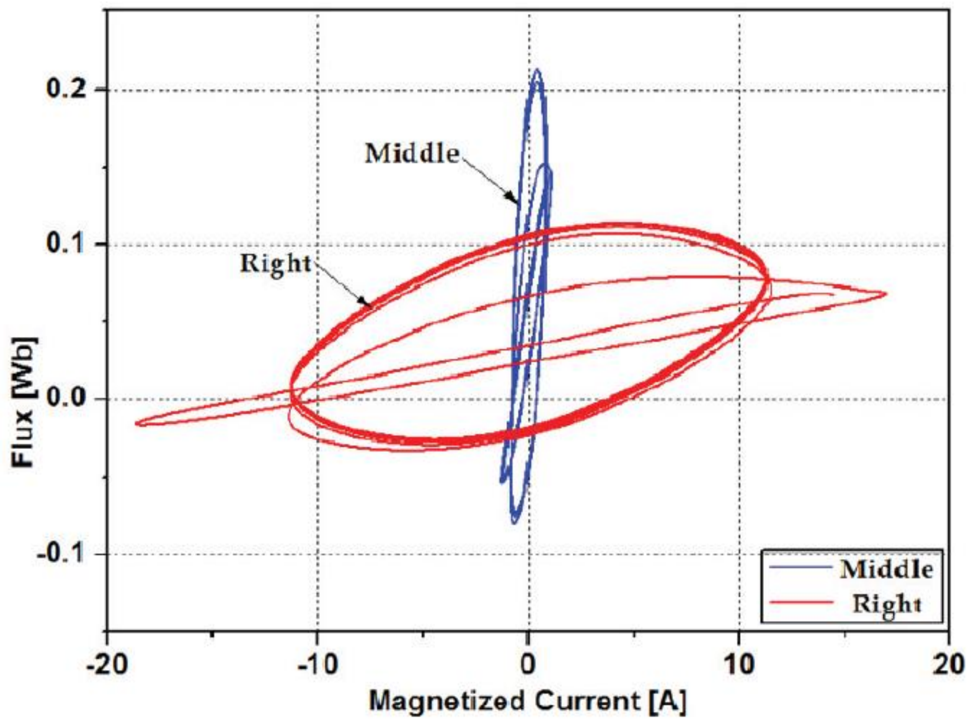

Fig. 8. Experimental Hysteresis Curve of Middle and Right Leg

Experimental Results

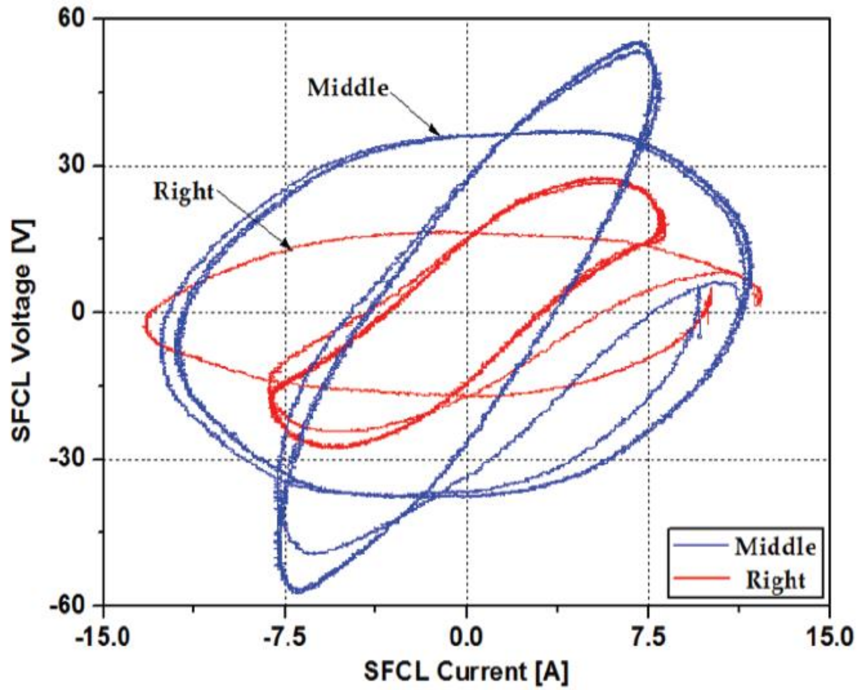

Fig. 9. V_{SFCL}-I_{SFCL} Curve During Fault

IV. Conclusions

1. In this paper, we investigated the saturation characteristics and limiting characteristics of the transformer-type superconducting fault current limiter through the E-I core. In each case, the magnetization inductance can be deduced from the Multi-Physics simulation and theoretically confirmed..

2. In case of connecting to the middle iron core, the magnetization inductance was larger than that of the right core due to the length of the short iron core. This large magnetizing inductance also has a large saturation potential and can be confirmed to have an adverse effect. On the other hand, in the case of the limiting impedance, it became larger due to the influence of the large magnetization inductance.

IV. Conclusions

3. In the case of the intermediate iron core, the initial fault current was low due to the low initial impedance. This quickly exceeded the critical current of the superconductor, and the operation of the current limiter was quick.