# [1246] Wed-Mo-Po3.09-02: Comparative Test Results of Fault Current Limiting Characteristics under 3-Phase Condition for the Separated and Integrated Models with Iron Cores and Coils

## Before Title : Study on the current limiting characteristics of YBCO coated conductor according to different stabilizer layer with iron core and coil


Ho Ik Du[1], Hyeon Gi Jeong[1], Sang-Jae Ban[1], Sung Chae Yang[1]

[1] Dept. of Electrical Engineering, Chonbuk National University, Jeonju, Korea (the Republic of)


CHONBUK NATIONAL UNIVERSITY

## 1. Abstract

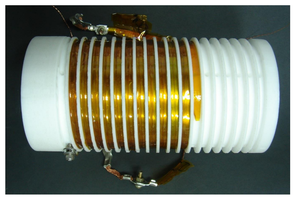

The three-phase superconducting current limiter is a future-generation power system designed to improve the power system safety. Along with the development of diverse types of superconducting current limiters, diverse measures are proposed to improve the limiters' performance. Especially, various studies are being conducted to reduce the volume and weight of superconducting current limiters using the iron core and coil. This study thus manufactured the superconducting current limiting device using the coated conductor with a high resistivity, and applied it to two models involving the iron core and coil (the model consisting of three iron cores and coils each separated and the model integrating 3 coils through one iron core) so as to compare and analyze the current limiting characteristics.

Of the two models, the separate model with additive wiring offered the higher current limiting rate, but under each wiring condition, the two models' current limiting rate was found to be not greatly different. The superconducting current limiting element's thermal strain was evaluated as smaller with the integrated model compared to the separated model, but the integrated model created the quench resistance of the superconducting current limiting element at the sound phase S phase, suggesting that the result increased the critical current of the superconducting current limiting element, but studies should continue through the structural change of the integrated model.

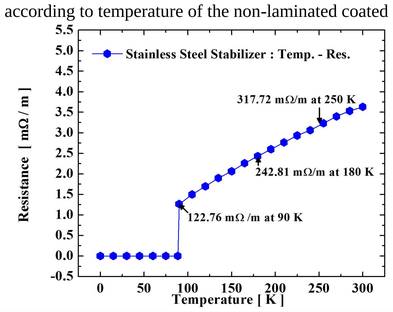

## 2. Properties of YBCO thin-film wire

- Properties of fault current limiting element.

| YBCO coated conductor(AMSC 344S) | |
|---|---|
| Stabilizer | Stainless steel |
| Length of pattern/width/thickness | 500㎝/4.4㎜/0.2㎜ |
| Layer of stabilizer/over/substrate | 20㎛/Ag2㎛/Nickel50㎛ |
| $I_c$ & $T_c$ | 70$A_{rms}$ (1㎶/㎝, @77K), 90K |
| Voltage rating | 0.6$V_{rms}$/㎝ (@300K) |
| Resistance | 3.7㏀/㎝ (@300K) |

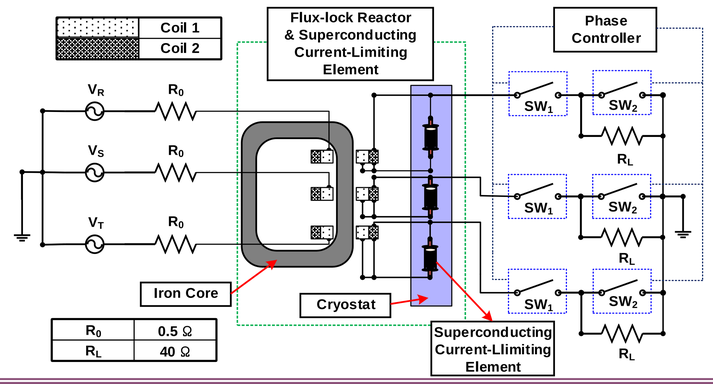


- Resistance variations according to temperature of the non-laminated coated conductor.



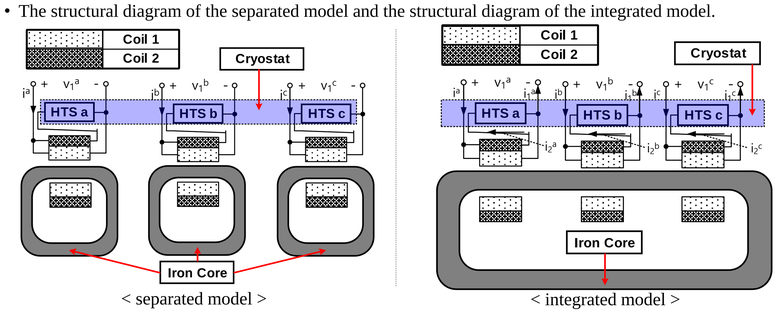

## 3. Experimental Set up

- Test system diagram of the experimental circuit.



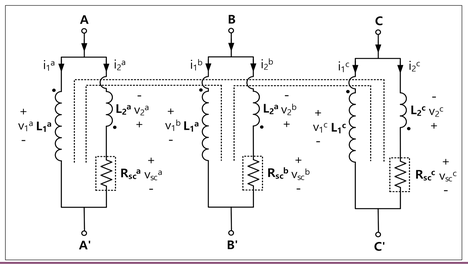

## 4. Structure and principle of operation of the model with the iron core and coil separated into three phase and the integrated model

- The structural diagram of the separated model and the structural diagram of the integrated model.



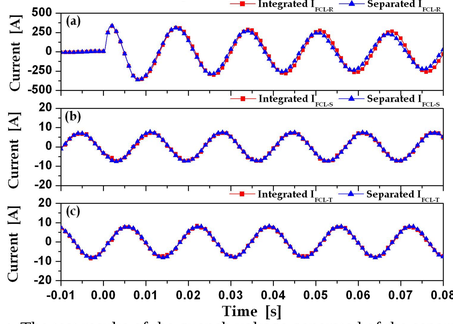

< separated model > < integrated model >

- Equivalent circuit of the separated model and integrated model.



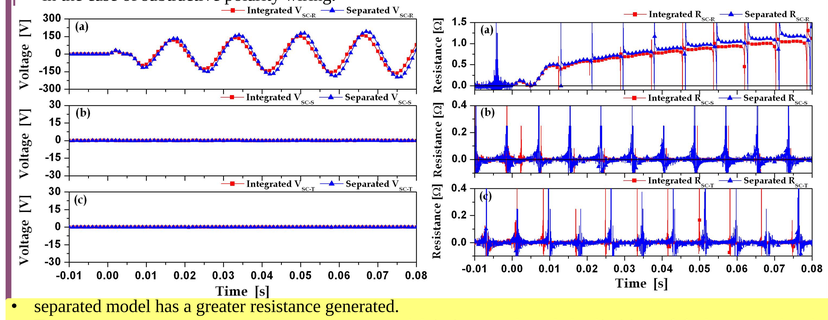

## 5. Analysis of current limiting characteristics of the integrated model of iron core and coil and of the model with separation thereof

- . The test results of the current limiting characteristics of the separated model and the integrated model in the case of subtractive polarity wiring




- In Figure (a) the limited current
- separated model : 332.18 $A_{peak}$ (equivalent to being limited to 43.49% of the fault current)
- integrated model : 340.72 $A_{peak}$ (equivalent to being limited to 42.04% of fault current)
- in the subtractive polarity wiring, the current limiting characteristics of the separated model were evaluated as superior to those of the integrated model.

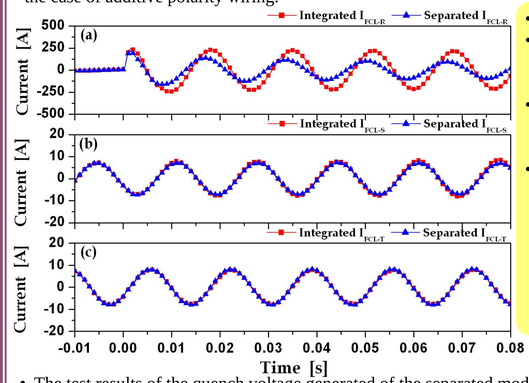
- The test results of the quench voltage generated of the separated model and the integrated model in the case of subtractive polarity wiring
- The test results of the quench resistance occurrence trend of the separated model and the integrated model in the case of subtractive polarity wiring.




- separated model has a greater resistance generated.
- Thus, the overall impedance of the separated model is increased, and the limiting of fault current by the increased impedance is found to be greater than the integrated model.

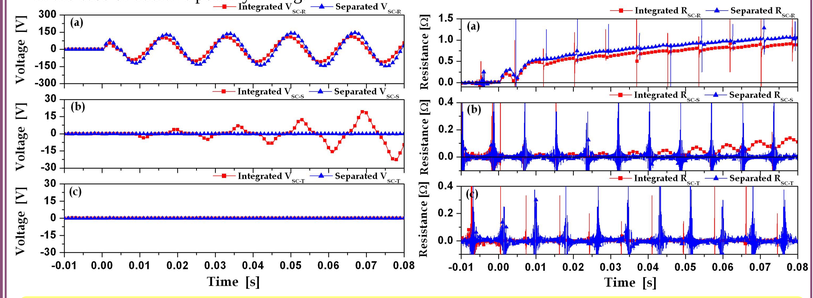
## 5. Analysis of current limiting characteristics of the integrated model of iron core and coil and of the model with separation thereof

- The test results of the current limiting characteristics of the separated model and the integrated model in the case of additive polarity wiring.




- In Figure (a) the limited current
- separated model : 211.43 $A_{peak}$ (equivalent to being limited to 64.04% of the fault current)
- integrated model : 540.11 $A_{peak}$ (equivalent to being limited to 59.16% of fault current)
- the separate model where the current limitation in the fault phase was caused, and the integrated model caused a phase difference of the line current, because the integrated model has R, S, and T-phase reactors connected to one iron core.

- The test results of the quench voltage generated of the separated model and the integrated model in the case of additive polarity wiring.
- The test results of the quench resistance occurrence trend of the separated model and the integrated model in the case of additive polarity wiring.




- Like in the additive polarity wiring, the generated voltage of the device offers a greater level with the separate model, because the superconducting current limiting element of the separated model
- Meanwhile, Left Figure (b) confirms that, in the sound phase S phase, voltage is generated in the superconducting current limiting element of the integrated model, and this can be confirmed at the generated resistance of the superconducting current limiting element.
- The reason that, in the sound phase, the resistance of the superconducting current limiting element is generated is that it is attributable to the structure of the integrated model.

## 6. Conclusion

The three-phase superconducting current limiter, made up of the iron core and coil, is one of the diverse types of superconducting current limiters. In order to compare and analyze the current limiting characteristics of the two models, this study manufactured and tested the model wherein the three-phase superconducting current limiter consists of three coils and three superconducting current limiting elements via a single iron core, and the model wherein iron core and coil, and the superconducting current limiting element are divided into three units each.

Based on the current limiting rate, the current limiting performance of the two models was compared, revealing that, in both subtractive polarity and additive polarity wiring modes, the separated model offers superior current limiting performance compared to the integrated model. However, in terms of the current limiting rate, the two models have no big difference. Further, the reason that the two models showed a different current limiting rate under subtractive polarity and additive polarity wiring is that the magnetic flux was generated more in the case of additive polarity wiring than the subtractive polarity wiring. Meanwhile, the integrated model generated quench resistance even in the sounds phase, because it was attributable to the structure of integrated model.

Considering the above test results, the integrated model has the advantage of reducing the thermal strain compared to the separated model, but has the problem of generating quench resistance even in the sound phase. If the quench resistance of the sound phase generated can be reduced through the analysis of the integrated model structure (measures to increase the critical current of the superconducting current limiting element along with the analysis of structure), it will offer the measures designed to reduce the volume and weight of the superconducting current limiter using the iron core and coil.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