

## Study Committee A3 Transmission & Distribution Equipment

Paper 10626\_2022

### Development of a 22.9 kV/2,000 A Compact R-SFCL

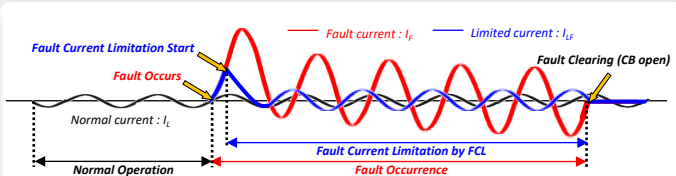
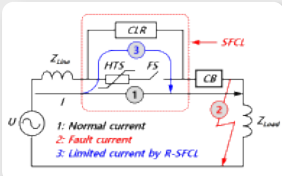
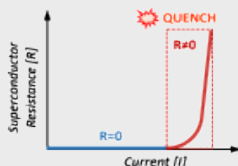
Min Jee KIM, Sung Joon KIM, Gyeong Ho LEE, Chae Yoon BAE, Young-Geun KIM  
LS ELECTRIC Co., Ltd.

#### SUMMARY

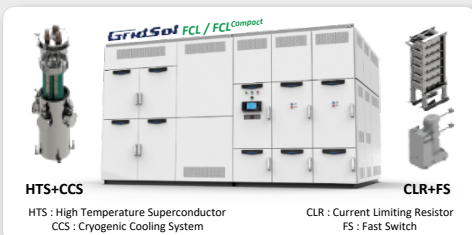
A 22.9 kV/2.0 kA resistive superconducting fault current limiter (R-SFCL) was designed and fabricated focused on compact size, modular design, and the efficiency of cryo-cooling system (CCS) operation. And Moreover, performance tests, including an electrical insulation test, a temperature-rise test, an impedance test and a fault current limitation test, were successfully passed at LS ELECTRIC's PT&T and KERI, the official certification institute. The R-SFCL is scheduled to be installed on the 22.9kV bus section between two 154/22.9 kV transformers in the Seogochang substation of KEPCO in 2022. In order to prevent the spread of fault current between the interconnected system, the R-SFCL plays a role in limiting the fault current as soon as the fault current occurs.

#### What is the Superconducting Fault Current Limiter (SFCL) ?

- A SFCL is an electrical power equipment with novel concept **utilizing changes in physical properties of the superconductor**.
- In usual time, the SFCL doesn't give any impacts on power system, **but when fault occurs, the SFCL fastly limits the initial fault current** that cannot be blocked by a circuit breaker.
- Effect of SFCL Application
  - **Prevention of damage and prolongation of life of expensive major facilities** such as power equipment, transformers, and superconducting cables
  - **Improvement of renewable energy acceptability and energy efficiency** in power grid



#### 22.9kV / 2,000A R-SFCL developed by LS ELECTRIC

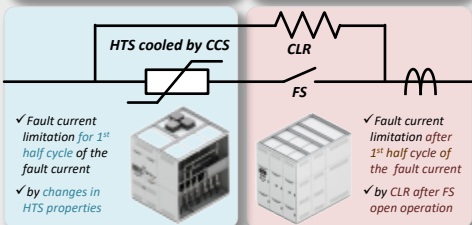


#### Specifications

- Ratings 22.9kV / 2,000A / 60Hz
- Electrical insulation AC 60kV/min, LI 150kV<sub>BIL</sub>
- Operating current 2kA
- Impedance 6Ω (Resistance)
- Max. Limitation time 0.4s
- Limited current ~10 kA<sub>peak</sub> (1<sup>st</sup> peak) / ~2.2 kA<sub>rms</sub> (after 1<sup>st</sup> peak)
- Size (m) W1.7 X D3.0 X H3.2 (Superconducting Unit)  
W2.6 X D3.0 X H3.2 (High Speed Impedance Unit)
- Installation site KEPCO's Seogochang S/S for power system interconnection

#### Superconducting Unit

#### High Speed Impedance Unit



#### Characteristics

- **Maximum capacity & Minimum Size** in distribution voltage levels
- **Resilient response** to various fields and rated power with **modular design**
- **Lengthen the life cycle & reduce exchange cost** of electrical power equipment
- **Increase safety & efficiency** with **interconnection operation** of electrical power system without fault cascading

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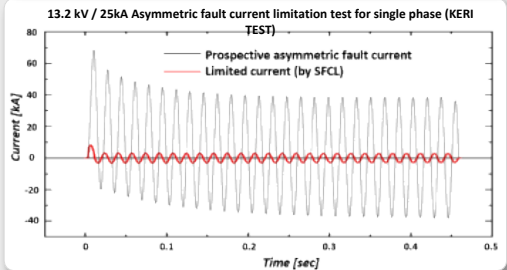
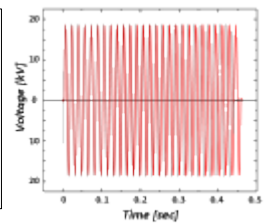
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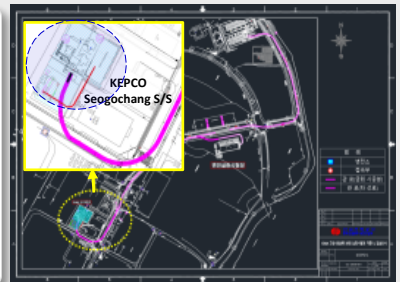
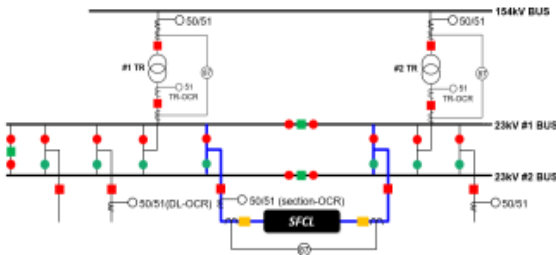
#### KERI TEST

Electrical insulation test, Temperature-rise test, Fault current limitation test ...



- The first peak current of the fault current was reduced by more than 80% by the superconductor unit. ( $68 \text{ kA}_{\text{peak}} \rightarrow 8 \text{ kA}_{\text{peak}}$ )
- The fault current after the first peak was reduced by more than 90% by the high speed impedance unit. ( $25 \text{ kA}_{\text{rms}} \rightarrow 2 \text{ kA}_{\text{rms}}$ )

#### Future Activities : Pilot project for power system interconnection by the R-SFCL



- **Infrastructure construction** for the installation and operation of SFCL began at KEPCO Seogochang substation in mid 2022.
- **An artificial fault current (AFG) test in the real-system** to ensure that protection coordination between conventional relays is performed appropriately when the SFCL limits the fault current in the real power grid.
- **A long-term simulated load test** that applies a current varying from 100A to 2,000A to SFCL using power supply for 3 months to evaluate the long-term operational reliability of the CCS.
- **A pilot operation - 22.9kV power grid interconnection with the installation of SFCL on the 22.9kV bus section between two 154/22.9 kV transformers** - will begin at the KEPCO's Seogochang substation in mid 2023.