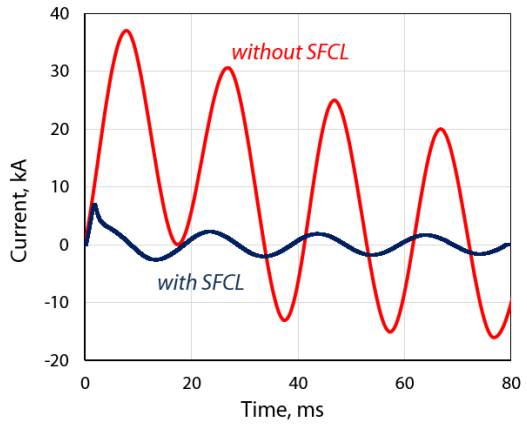
HV SFCL Superconducting Fault Current Limiter

APPLICATION

SFCL helps to improve reliability of electrical grid operation due to its effective and ultrafast limitation of short circuit fault currents. Distinctive features of SFCL technology include:

- protecting grid from short circuit currents and decreasing overcurrent exposure of grid equipment. As a result, switchgears, cables and transformers would have longer lifetime
- enabling safe connection of otherwise disconnected busbars, thus increasing grid connectivity and redundancy
- reducing voltage sags at busbars of large production plants during short circuit events in adjacent grid. As a result, downtime of production equipment would be reduced
- ensuring higher generator stability due to high active resistance of SFCL during short circuit events



Ultrafast and efficient current limitation by SFCL

GENERAL DESCRIPTION

SFCL is a non-linear smart device, which active resistance is triggered by a grid overcurrent. When the passing current is less than a certain switching value, SFCL has virtually zero resistance. The device does not alter any aspect of grid operation while in this normal operation mode. Short circuit currents cause a nearly instant transition of SFCL into a highly resistive current-limiting mode. After the short circuit current event is over and a current limitation is not anymore needed, SFCL starts to self-recover.

220 kV SFCL at HV substation

During such self-recovering, its resistance gradually decreases back to zero, restoring the normal operation mode.

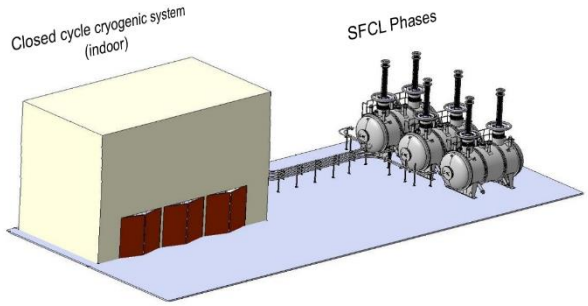
SFCL transition from the normal to the current-limiting mode occurs only when the switching current value is exceeded. This is made possible by unique properties of superconductor material, which constitutes the main operating element of the device.

SPECIFICATIONS

The table below gives approximate values for guidance purposes only. These technical parameters can be tailored in order to fit specific requirements of your particular application.

Nominal voltage	110 - 220 kV
Nominal frequency	50 or 60 Hz
Nominal current	630 - 1200 A (rms)
Switching current	up to 3000 A (rms)
Switching time	< 4 ms
Normal operation mode resistance	< 0,1 Ohm
Current-limitation mode reactive resistance	< 0,1 Ohm
Current-limitation mode active resistance	10-30 Ohm @ 110 kV 20-40 Ohm @ 220 kV
Dimensions per phase (LxWxH)	6 × 3 × 7 m @ 110 kV 9 × 3 × 7 m @ 220 kV
Phase location	Outdoor
Climatic category	from -45°C to +50°C

INSTALLATION FEATURES



Proposed installation plan of HV SFCL device

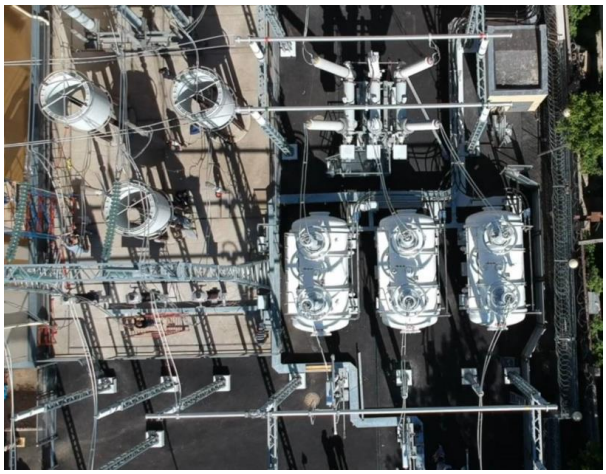
High voltage SFCL installation typically includes:

- 3 single-phase SFCL units
- cryogenic cooling system
- cryogenic control system
- integral relay protection system

Each SFCL phase is built as a separate outdoor dead-tank device, equipped with a pair of solid-state bushings.

The indoor cryogenic cooling system provides an automatic temperature control of the superconducting active part of SFCL. It can be installed up to 50 m apart from SFCL phases.

The device is designed to operate in a fully automatic fashion while requiring very moderate maintenance effort.



220 kV SFCL at HV substation (ACR and switchgear are visible on the left and top of the picture)

QUALITY AND RELIABILITY

Acceptance tests (IEEE C37.302 test guide)

- AC short-circuit current test
- Lightning impulse test
- AC high voltage withstand test
- Partial discharge test
- Heating test at nominal current

Onsite tests

- Cooling system performance test
- Control system test
- High voltage test

Grid compatibility tests

- Electromagnetic compatibility test
- Relay protection simulation (RTDS)

220 kV SFCL at the KERI high voltage test facility

EXPERIENCE AND REFERENCES

Since 2006, SuperOx team designs and builds superconducting power equipment for efficient use of energy resources.

The company has commissioned its first commercial 220 kV SFCL in 2019. The device is permanently installed at 220/20 kV substation of UNECO grid company in Moscow, Russia and has proved its characteristics in 2020 while limiting real fault current in grid. This device is the most powerful SFCL in the world today with a rated power of 450 MW.

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