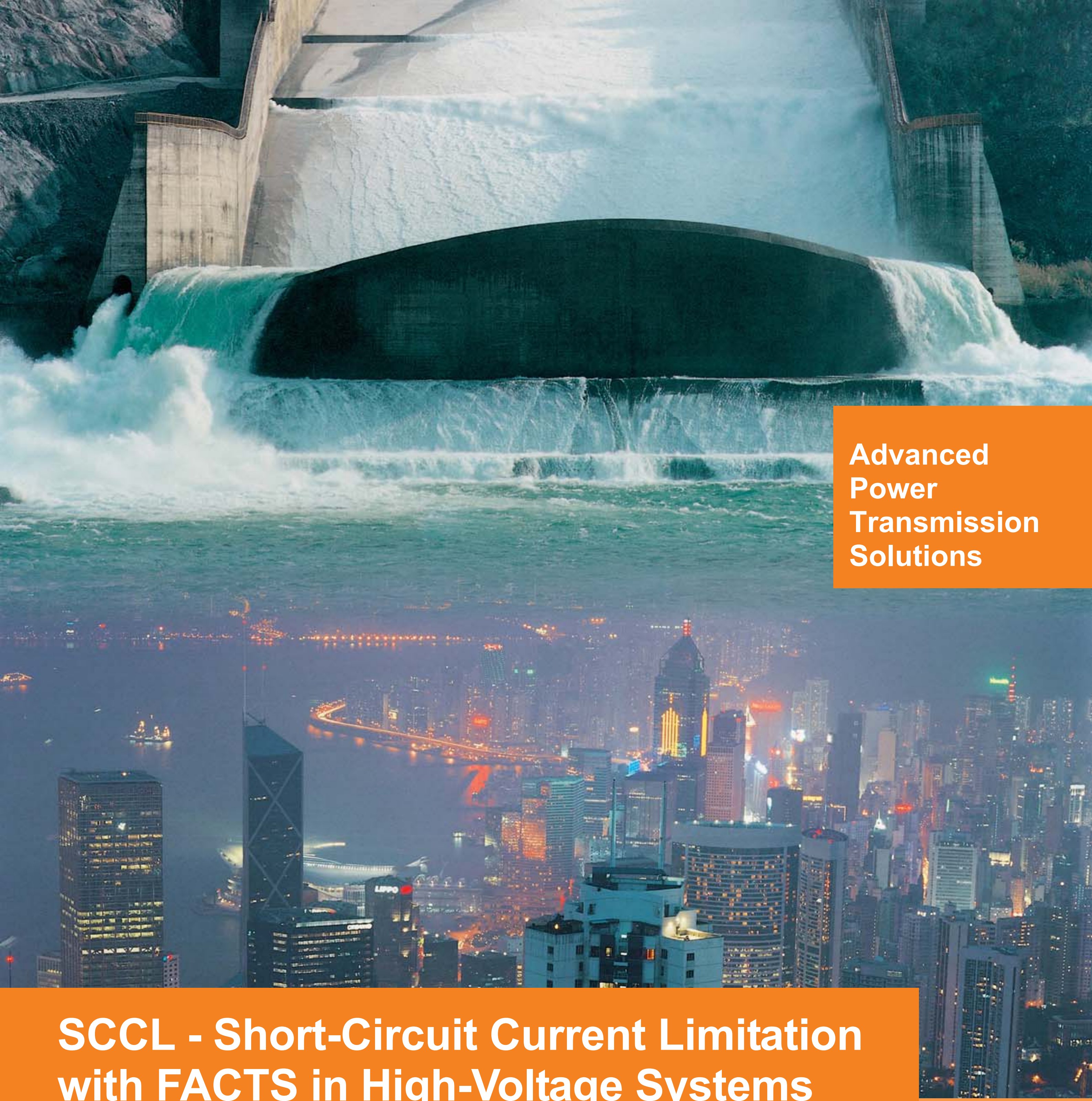

Advanced Power Transmission Solutions

SCCL - Short-Circuit Current Limitation with FACTS in High-Voltage Systems

Application & Features

SIEMENS

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SCCL - Short-Circuit Current Limitation with FACTS in High-Voltage Systems

FACTS (Flexible AC Transmission Systems) and HVDC (High Voltage DC Transmission) are powerful devices used to enhance system performance in the evolving power markets. A tendency towards an increase in generation capacity can be observed worldwide, for example the installed capacity is expected to grow from 3.560 GW (in the year 2000) up to 5.700 GW in 2020. The increasing power demand and major environmental constraints require advanced solutions for transmission systems: care must be taken to insure, that the transmission system under such dynamic market conditions is not going to produce a bottleneck, but rather be the key for a high return on investment and positive cash-flow.

Increasing generation in high load density networks on one hand and on the other hand interconnections between systems, increases the short-circuit power substantially. If the short-circuit current rating of the equipment in the system is exceeded, the equipment must be either upgraded or replaced, both of which are either very cost- or time-intensive procedures. Short-circuit current limitation offers clear benefits in such cases. Current limitation using passive elements, for example reactors, is a well known practice, however it reduces system stability and there is an impact the load-flow.

Using innovations in FACTS technology, an electronic dynamic short-circuit current limiting device, the SCCL (Short-Circuit Current Limiter), is now available. This new device operates with zero impedance in steady-state conditions (Fig. 1) and in case of a short circuit is switched to the limiting-reactor impedance within a few milliseconds.

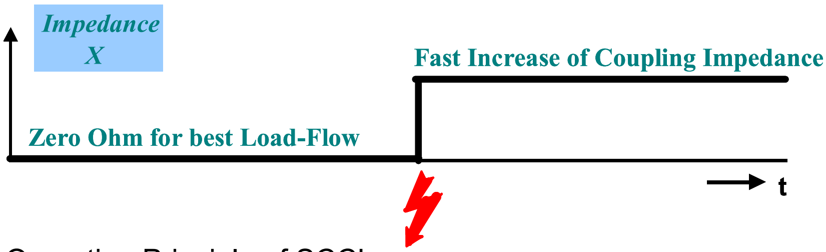

Fig. 1 - Operating Principle of SCCL

The SCCL is based on developments in series compensation. The TPSC (Thyristor Protected Series Compensation) has been successfully put into service in 3 projects in a 500 kV transmission system at the Vincent substation in the Southern Californian Grid (USA). Fig. 2 shows a photo of a Vincent TPSC.

Fig. 2 – View of a TPSC Vincent, USA

In series compensation, a capacitor is used to compensate the line's impedance, thus the line is "virtually" shortened and the transmission angle decreased which improves system stability. However, during transient conditions, short-circuit currents cause high voltages across the capacitor, which must be limited to specified values. In the past, the limitation was accomplished by using arresters (MOV), by a spark gap, or using a combination of both. The (mechanical) gap function can now be replaced by an innovative solution using high power thyristors, which are designed and tested for a 110 kA peak current capability for a sufficiently long time.

The combination of a TPSC with an external reactor, whose design is determined by the short-circuit current level which is allowed, can now be used as a Short-Circuit Current Limiter (SCCL), see Fig. 3.

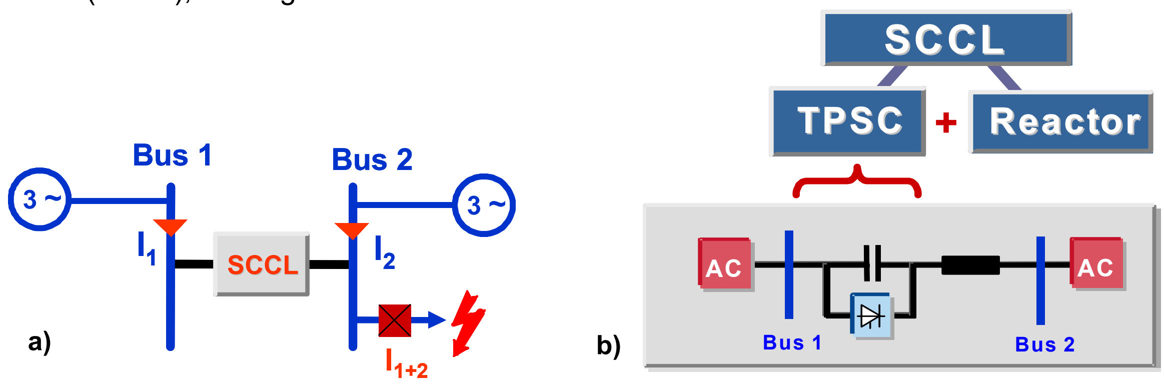

Fig. 3: SCCL - Short-Circuit Current Limitation with FACTS
a) Application b) Use of TPSC for SCCL

Recordings from site measurements of real faults and simulations show that this new type of SCCL achieves a high speed limiting function very similar to the superconducting HTS Fault Current Limiter element; however, a major difference is current limitation on the allowed (pre-calculated) values instead of current interruption on HTS FCL and other electronic current limiting devices.

Fig. 4 shows an example of an SSCL application in a system according to Fig 3 a) above. The system is designed for a fault current level of 63 kA. Due to power plant expansions, the fault current would reach 80 kA without an SCCL (Fig. 4 b), this would require a complete substation upgrade (breakers, disconnectors, busbars etc.). Using an SCCL, the fault current can be limited to 50 kA (Fig. 4 a), therefore not requiring a substation upgrade.

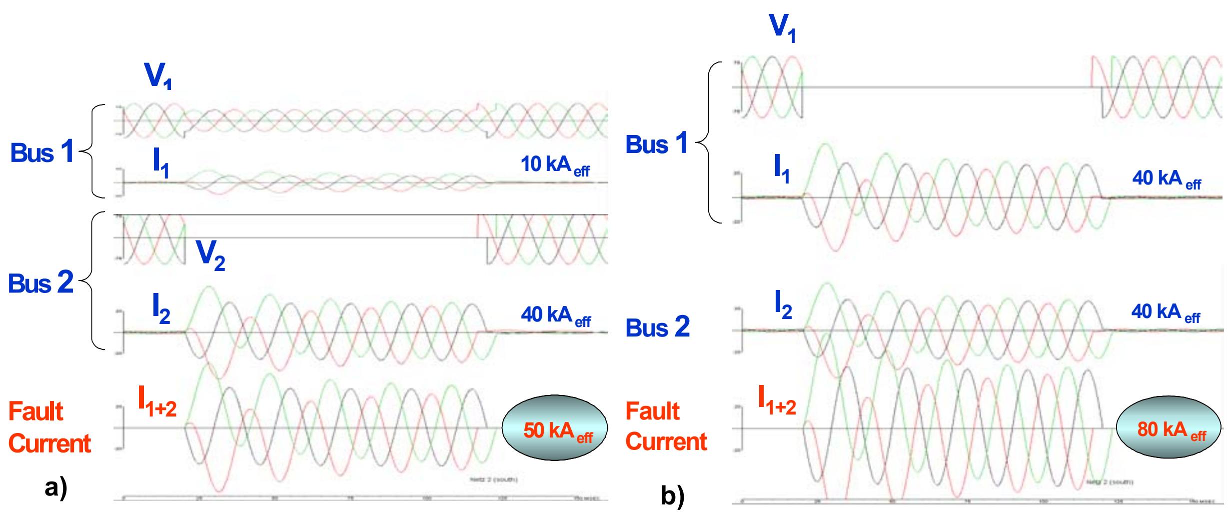

Fig. 4: Comparison of Fault Currents with (Fig. a) and without an SCCL (Fig. b)

Fig. 5 shows a 3-D view of the new SSCL. Comparing this layout with the site-view of the Vincent TPSC (Fig. 2), it can be seen, that the components of the proven TPSC are just complemented by an additional series reactor.

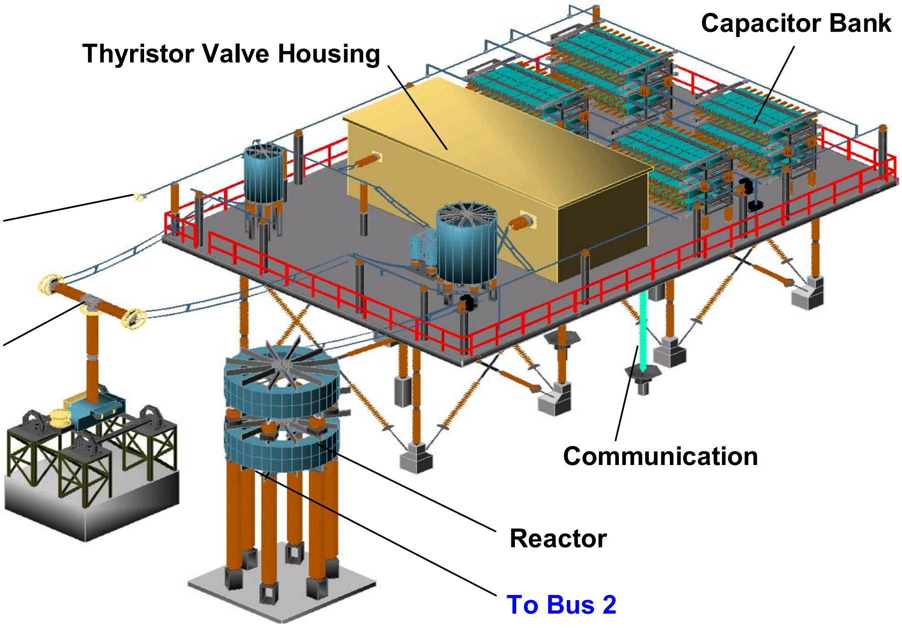

Fig. 5: 3-D View of SCCL

The design of the SCCL focuses on maximum reliability and availability.

Highlights of the SCCL are as follows:

- High power, light-triggered thyristor - 110 kA peak, self cooling
- Protection with a standard multiprocessor system widely used for HVDC, FACTS and Drive Systems
- Redundant measurement of system currents using optically powered transducers
- No auxiliary power supplies needed on the platform
- Fail-safe design - thyristor will be shorted in case of malfunction
- Backup protection provided by wafer-integrated over-voltage protection (BOD)
- Fast switch-on, instead of switch-off in other electronic solutions
- Redundant thyristors in the thyristor modules
- Minimal steady state losses (reactor only)
- Minimal maintenance - 10 h per year (0.1 %)

Additional features of the SCCL are:

- Fail-safe current limitation using a conventional reactor
- Fast current limiting function by use of high-power thyristors
- No modification of existing protection schemes required
- No impact on stability and load flow
- Operates on a single-phase basis
- Designed for multiple fault contingencies
- Dynamic add-on functions available - for POD and SSR

Using the add-on control functions, for mitigation of Subsynchronous Resonance (SSR) and for Power Oscillation Damping (POD), additional value can be created for the user.

In conclusion, with the FACTS based SCCL, a break-through in fault-current limitation for high-voltage systems has been achieved.