Two Static Var Compensators (SVC), supplied by ABB, have been operated since 2006 in the national power transmission grid of RTE (Réseau Transmission d’Electricité) in France. One SVC, Poteau Rouge, situated close to the town of Lorient, is rated at 225 kV, -100/+200 Mvar (100 Mvar inductive to 200 Mvar capacitive). The other SVC, Plaine Haute, close to the town of Saint Brieuc, is rated at 225 kV, -50/+100 Mvar (50 Mvar inductive to 100 Mvar capacitive). Both are located in the province of Brittany in north-western France.

For years, the power transmission capacity has been unable to keep up with the rapidly increasing power demand in the region. Furthermore, Brittany has very little generation facilities of its own, with only about 5% of the power consumption generated within the province. Its power supply mainly relies on remote power plants, connected through long and heavily loaded 400 kV and 225 kV lines. These things have made voltage stability a major issue, necessitating efficient remedial measures.

The traditional measure for voltage support has been the installing of Mechanically Switched Capacitors (MSC) at 63 kV and 90 kV levels. This, however, has not been sufficient, and it was decided to install two SVCs at power transmission level plus additionally a number of MSCs.

The SVCs have the following tasks:
- Allow fast supply of reactive power upon the appearing of faults in the grid.
- Absorb reactive power to control the grid voltage during low load or high level of distributed generation.
- Add flexibility and smoothness to grid voltage control.
- Prevent tripping of wind farms located in the region.

The SVCs furthermore make up for the following shortcomings of pure MSC solutions:
- Limited or insufficient switching dynamics.
- Only stepwise voltage control possible.
- Too many MSCs would give rise to danger of harmonic amplification in the sub-transmission grid, due to high levels of 3rd and 5th harmonics present in the grid. The SVCs are connected at a higher voltage level, and therefore do not contribute to this problem.

Main circuit design
The main design is a 6-pulse configuration with one TCR branch (Thyristor Controlled Reactor), one TSC branch (Thyristor Switched Capacitor), and a harmonic filter tuned to the 5th harmonic frequency.

In Poteau Rouge, the TCR and TSC are rated at 150 Mvar each. The harmonic filter is rated at 50 Mvar. This gives the SVC a dynamic range from 100 Mvar inductive to 200 Mvar capacitive.
capacitive (-100/+200 Mvar). In Plaine Haute, the TCR and TSC are rated at 75 Mvar each. The harmonic filter is rated at 25 Mvar. This gives the SVC a dynamic range from 50 Mvar inductive to 100 Mvar capacitive (-50/+100 Mvar).

Control and protection system
The SVC is controlled by a microprocessor based control system. The control system is based on the ABB MACH 2 concept, built around an industrial PC with add-in circuit boards and I/O racks connected via standard type field buses. Dedicated voltage and current transformers provide the control system with information of the network parameters, employed in the SVC control.

The control system provides facilities for SVC control either from an Operator Work Station (OWS) in the SVC control room or remotely from the RTE control system. In order to achieve the highest possible availability of the SVC the control system is structured in Automatic Voltage Control mode as well as Manual Control mode.

The normal mode of operation is Automatic Voltage Control. The voltage control system is a closed loop system with control of the positive-sequence voltage. The voltage regulator is required to be fast enough to counteract voltage variations and disturbances, but also retain an adequate stability margin.

Standby state
The SVCs are mainly utilized as dynamic reserve. This implies that for normal grid situations, the controllable parts of the SVC (TCR and TSC) are kept in standby, and only the harmonic filter supplies reactive power. The SVC continuously monitors the grid voltage and, when needed, goes into dynamic operation to counteract grid disturbances.

Thyristor valves
The Poteau Rouge SVC utilizes thyristors of PCT (Phase Control Thyristor) type. Each three-phase thyristor valve consists of three single-phase units with PCTs stacked vertically in two anti-parallel stacks per phase. The Plaine Haute SVC uses thyristors of BCT (Bi-Directional Control Thyristor) type. In such a device, two anti-parallel thyristors are integrated into one wafer with separate gate contacts, allowing conduction in both directions. The thyristor valves comprise only one thyristor stack in each phase instead of two, enabling a more compact design. The thyristors are liquid cooled using de-ionized water with low conductivity as coolant.

Over-voltage strategy
The SVCs are designed to be fully controllable up to a system voltage of 1.3 p.u. During over-voltage, the SVCs are run in inductive mode. For voltages exceeding 1.3 p.u. as well as for voltages below 1.3 p.u. lasting for more than 5 seconds, the SVCs will be tripped.

Under-voltage strategy
If the system voltage, due to some fault in the 225 kV grid, drops to a low value, the SVCs are controlled to full capacitive output. The SVCs are designed to operate at 0.8 p.u. voltage for 90 minutes and at 0.5 p.u. voltage for 10 seconds. For voltages below 0.5 p.u. the thyristor valves are blocked, resulting in an SVC output equal to the harmonic filter output.

Environment
As both SVCs are located close to residential areas, audible noise is an issue of importance. As a precaution, soundproof walls have been erected on both sites. Furthermore, in the case of Poteau Rouge, the TCR reactor has been placed in a dedicated building.

Operational experience
The SVCs have proved their usefulness in the Brittany power grid. They have sustained the network during situations with low grid voltage and all available MSCs connected. They have also brought increased flexibility into network management, and have increased the voltage stability due to TCR fine adjustment.

Main technical data

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