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Fast Controlled Shunt Reactor of Transformer type. Development and Application experience

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The problem of static and dynamic stability improvement becomes very important in 110-500 kV power grids when their active-power transfer achieves or exceeds the natural power. This problem can be decided successfully by using of high-speed voltage control equipment such as static VAR compensator (SVC). But the usage of SVC in high voltage networks (110 kV and more) needs either very expansive thyristor valves with the same rated voltage or dedicated step-down transformer that results in complicating of SVC configuration and extension of the required area.

The report presents the results of the fast thyristor Controlled Shunt Reactor of Transformer type (CSRT) to be developed. This CSRT can be used in high and extra high voltage power grids for the operation control and provides the voltage stability, electric power losses reduction as well as transmission lines transfer capacity increase.

CSRT consists of the special shunt reactor which susceptance can be changed very fast from zero to rated value and vice versa and thyristor valve which provides the susceptance variation.

The mechanical construction of the shunt reactor is practically the same as the one of the standard power transformer. Concentric position of the windings creates the direct electromagnetic coupling between primary (network) and secondary (control) windings and provides the corresponding changing of the current in primary winding when we change the current in the secondary one in accordance with Ampere's (circuital) law. This feature of CSRT – the possibility to change its inductivity practically instantly is the main benefit of this type reactor in comparison with another types of controlled reactors particularly during the transient and fault conditions of the network operation.

The main negative factor of the previous CSRT usage was the high level of the loss what practically stopped all developments in this direction in the world electric-power industry.

We resumed the investigations and minimized the basic and supplementary loss due to application of the original magnetic shunts and their relative disposition in the reactor core construction. All their constructive features are patented.

There was implemented the software approach of multi-functional optimization algorithm of CSRT weight and cost values. Differentiation of the obtained results in combination with the use in the construction of the reactors of a number of technical solutions aimed at ensuring real stray flux channeling, helped to create a number of reactor designs with unique technical parameters

Reactive power control of CSRT realized by the pulse-phase regulation of the thyristor valves shunted the secondary windings. Variation of the secondary winding current causes the corresponding variation of the magnetic flow in the core and provides the high speed of reactive power control in the both directions.

CSRT reactive power self-regulation system is based on the PD control of three-phase network voltage.

During last six years 10 CSRT of new generation with rated power from 25 to 60 MVA were installed at substations 110 kV and 220 kV in Russia and Angola.

Currently we produce CSRT with the split secondary winding (delta-star connection) what provides to exclude harmonics components 6n±1 sequence in the primary winding current.

The first reactors with the split secondary winding are in operation now at 220 kV substation in Russia and have the following main parameters:

- rated voltage	220 kV
- reactive power control range	0…-50 Mvar
- response time	20 мс
- max. harmonic content in network winding	1.7%

The report generalizes the field experience of CSRT which corroborates the high efficiency of the engineering solutions and technology to be accepted in presented design.