Modeling of Series Capacitors in Power System Studies.

During planning and design phases of a Series Capacitor (SC) project, it is recommended that SC configurations be studied with respect to steady state and dynamic performance. The most common application studies involve power flow, transient stability, voltage stability, short circuit and transient analysis. Both conventional power system analysis software as well as EMTP-type software is typically used for these studies.

In performing system planning studies, an essential first step is to define performance objectives. Once the performance goals are established, analysis typically progresses to power flow and stability studies, in that order. For some applications, short circuit, small signal analysis and/or transient analysis is also required. The recommendations given in this document apply to Fixed Series Capacitors (FSC).

Power flow analysis

Conventional power system analysis software, e.g. PSS/E or SIMPOW [1] is used for these studies. Typical studies involve analysis of active/reactive power flow and voltage profile.

The SC is modeled as a fixed negative reactance which is connected in series with the transmission line(s).

Power system stability analysis

Conventional (PSS/E) and/or advanced power system analysis software, e.g. SIMPOW [1] is used for these studies. Typical studies involve analysis of First swing stability and Voltage stability.

The SC is modeled as a fixed negative reactance which is connected in series with the transmission line(s).

Note. In some cases it may be necessary to model the SC together with its bypass circuit. See “Short circuit analysis” below. This is especially required if the MOV is conducting significantly during the system swing.

Short circuit analysis

Advanced power system analysis software, e.g. SIMPOW [1] is used for these studies. Typical studies involve analysis of Fault currents and Through fault currents for different stages.

The SC needs to be modeled together with its bypass circuit. For MOV-protected SCs, a linear MOV-model i.e. according to Goldsworthy [2] can be used. In addition to calculation of the “conventional fault currents”, efforts should be focused on calculation of “through fault currents”, since these currents are flowing through the SC(s) and are decisive for the design of the SC main circuit components

Note. Representation of the SC as a fixed negative reactance in a conventional short circuit program is not recommended, since the results produced may deviate from the correct values by as much as 2-10 times.

Transient analysis

Advanced power system analysis software including a transient analysis module, e.g. SIMPOW [1] or EMTP type software (DCG-EMTP [3], ATP or PSCAD/EMTDC) is used for these studies. Typical studies involve analysis of MOV-size, sizing of Damping circuit components and analysis of Transient recovery voltages across line circuit breakers.

Detailed modeling of the SC including bypass circuit components and MOV-overload relay protection is required.

Remark. In some cases Subsynchronous resonance (SSR) analysis is required, especially when turbogenerators are connected in the vicinity of the SCs.
SSR studies can be grouped into self-excitation studies, i.e. Induction generator effect and Torsional interaction, and Transient torque amplification studies. The former is generally studied by means of Frequency scanning technique and also Eigenvalue analysis. The latter requires more sophisticated modeling and, therefore, EMTP-type programs are used. SIMPOW [1] is also capable of performing these studies.

References.

