CIGRE Study Committee C4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP (1)

JWG* C4/B5.41	**Name of Convenor :** Liisa Haarla (Finland) **E-mail address**: Liisa.Haarla@fingrid.fi
Technical Issues # (2): 8	**Strategic Directions # (3): 1**
The WG applies to distribution networks (4): No	
Title of the Group: Challenges with series compensation application in power systems when overcompensating lines	

Scope, deliverables and proposed time schedule of the Group :

Background :

So far, virtually all series compensated lines worldwide have a maximum degree of line impedance compensation of about 75 to 80%. As transmission systems have developed, it has become more frequent that new intermediate substations are built somewhere in the middle of existing long transmission lines. If these lines are already series compensated, there is a need also to divide the existing series capacitor (SC) station into two SC stations of half the original size (to keep the compensation degree as before), which is an expensive extra task due to the need to build one totally new SC station. It would then be very economic if it was possible to just add the new intermediate substation and not divide the series capacitor station at all. By dividing and sub-dividing the line segments in such a way that the original large series capacitor was split and several new ones were built on each of the line segments, this would cost more than replacing the series capacitors with other devices to enhance the system dynamic performance, such as an SVC. Thus, there are some challenges of what would be the best approach both in the short-term and long-term perspective.

Furthermore, in a few cases there have been proposals for compensating existing transmission lines at levels of 90% or higher although only one actual case is known from Sweden where no relay mis-operations or other problems have been reported during its 15 years in operation. Therefore, it is of interest to check the impact of overcompensation in the application of SCs. The subjects of interest are both system technical performance (i.e. steady-state voltage profiles, transient recovery voltage on breakers, subsynchronous resonance, etc.) and protection issues (i.e. fault detection on overcompensated lines; for example, distance protection would become impossible).

Scope :

The scope of the WG would be to

1. Study the following possible consequences of the overcompensation:
    - abnormal voltages during grid faults (overvoltages);
    - significant steady-state high voltages due to the changing voltage profile along the line and thus a need for shunt compensation;
    - SSR (Sub-Synchronous Resonance);
    - large transient torques on nearby generators during fault conditions;
    - TRV (Transient Recovery Voltage) withstand concerns on existing line circuit-breakers;
    - stability and dynamic behaviour of synchronous generators operating near overcompensated lines;

- resonances
- Also, to consider the interaction between series compensation and wind turbine generators

These, and other concerns, are well known phenomena and are studied typically in all applications of SC. However, it would be prudent to briefly review these subjects, with due reference to previous work, to identify if particular challenges exist with regard to very high or overcompensation levels of SC application. The work would focus on the lines of a meshed grid, which means that the analyses of radial lines (such as load aspects and flicker) are excluded. Consideration will be given to well established study techniques looking at SSR and whether improvements are needed and whether other possibilities, such as on-line monitoring for SSR issues, have been or need to be developed.

2. Review possible protection strategies for overcompensation and how these might be evaluated
   Overcompensation will mean that distance relays on transmission lines will not operate properly. With typical series capacitor applications, during the design stages, detailed electromagnetic transient simulations studies are often done to create the observed current waveforms that would be seen by protective relays for various faults. The results of the simulations are then fed into the relay equipment using COMTRADE format files to evaluate the function of the line protective relays. With overcompensated lines, the distance relays will not be able to function properly, and so consideration has to be given to other possible protection strategies and how these can be evaluated through similar simulation studies. For example, can current inversion phenomenon lead to mal-operation of current differential protection, too?

This is a joint working group between SCs C4 and B5, led by SC C4 who will take responsibility for the final submission of the technical brochure to the CIGRE central office after it has been reviewed and approved by both SCs. The primary role of B5 is to contribute to the aspects related to protection. SC A3 is also interested in the aspects of the work related to circuit breaker TRV issues, and thus will nominate two or three experts to participate in this WG and identify whether additional related work in necessary.

Deliverables: The WG will prepare a Technical Brochure an Electra summary of the work, as well as a tutorial summary presentation of the work.

Time Schedule : 2015 **Final report** : 2017

Comments from Chairmen of SCs concerned :

Approval by Technical Committee Chairman : M. Waldron
Date : 08/01/2015

(1) Joint Working Group (JWG) - (2) See attached table 1 – (3) See attached table 2
(4) Delete as appropriate

Table 1: Technical Issues of the TC project "Network of the Future" (cf. Electra 256 June 2011)

1	Active Distribution Networks resulting in bidirectional flows within distribution level and to the upstream network.
2	The application of advanced metering and resulting massive need for exchange of information.
3	The growth in the application of HVDC and power electronics at all voltage levels and its impact on power quality, system control, and system security, and standardisation.
4	The need for the development and massive installation of energy storage systems, and the impact this can have on the power system development and operation.
5	New concepts for system operation and control to take account of active customer interactions and different generation types.
6	New concepts for protection to respond to the developing grid and different characteristics of generation.
7	New concepts in planning to take into account increasing environmental constraints, and new technology solutions for active and reactive power flow control.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics.
9	Increase of right of way capacity and use of overhead, underground and subsea infrastructure, and its consequence on the technical performance and reliability of the network.
10	An increasing need for keeping Stakeholders aware of the technical and commercial consequences and keeping them engaged during the development of the network of the future.

Table 2: Strategic directions of the TC (cf. Electra 249 April 2010)

1	The electrical power system of the future
2	Making the best use of the existing system
3	Focus on the environment and sustainability
4	Preparation of material readable for non technical audience