CIGRE Study Committee B4

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

WG* N° B4.74	**Name of Convenor: Qi Guo** (CHINA) **E-mail address**: guoqi@csg.cn
Technical Issues # (2): 3	**Strategic Directions # (3): 2**
The WG applies to distribution networks (4): No	
Guide to Develop Real-Time Simulation Models (RTSM) for HVDC Operational Studies	

Scope, deliverables and proposed time schedule of the Group:

Background:

Over the last 10 years, the total number of High Voltage Direct Current (HVDC) transmission projects in operation around the world has surpassed 66 projects with a total capacity of about 150 GW.

Cigre Technical Brochure 563 provides an overview of simulation models typically required at different stages of an HVDC system. Simulation models of converters including Real-time simulation models (RTSM) have been covered in Technical Brochure 604 (B4.57).

Both of these brochures provide some general guidelines for simulation of HVDC systems. However, with the increased number of HVDC projects either in operation or being planned in the power grids, the networks are becoming more complex with multi-infeed of HVDC systems and AC&DC parallel systems formed and embedded in the existing AC system network. This is the case in many systems in Europe, India, Brazil and China. Therefore, simulation models need to consider specific HVDC operational issues such as multi-infeed of HVDC or parallel AC and DC systems interactions. For example, DC protection could be triggered inappropriately by an AC system fault if the protections of AC and DC system are not properly coordinated. Furthermore, HVDC commutation failures on several HVDC stations in a multi-infeed network may lead to unacceptable system oscillations, extremely low voltage during the recovery period or even instability issues.

Real-time simulation (RTS) is one of the most important simulation platforms and has been widely used for the HVDC system dynamic performance studies, control and protection testing and verification, examining the performance of an HVDC link and providing mitigation of any issues prior to or during commissioning. Real time simulation provides many advantages such as accurate modelling of nonlinear components and the ability of being interfaced directly with the actual hardware of the control and protection in real time.

Scope:

The objective of this WG is to provide general guidelines for development of real time simulation models for HVDC operational and specification studies. The scope will be limited to the development of HVDC real time simulation models and their applications including the following the tasks.

1. Methodology and considerations for development of simulation models and guidelines for the minimum level of detail needed for real-time HVDC operational studies. This task will cover the modelling of:
    - HVDC power system components such as converter transformers, converters, AC filters and HVDC lines and cables required for operational studies for both LCC and VSC HVDC systems.
    - High level architecture of HVDC control and protection systems including the behavior of protections which provide feedback into or modify the behavior of

control systems, and which may incorporate redundancy (with switchover to redundant systems) and backup protections utilizing different algorithms and diversity of protective actions or tripping times.

- Models for HVDC control and protection instrument transformers, such as DCVT and DCCT including input signal filtering or processing and bandwidth requirements or limitations.
- Representation and testing of ac system models for different categories of ac network connected to the converter stations. Three types of models will be addressed based upon the objectives of studies and characteristics of the actual systems.
    - Simplified static voltage source models which may be applicable in the case of large strong systems with little frequency variation and which are often used in factory acceptance testing (FAT) of HVDC projects
    - Dynamic equivalent models for ac systems where the frequency of the system may change or where there may be a significant power angle swing during the disturbance and system recovery.
    - Detailed frequency dependent network equivalent (FDNE) models, which may be applicable during HVDC islanded operation where large frequency excursions and possibly low order resonances may occur.
    - Combinations of the above models in in the same case to represent special conditions such as islanding of a portion of the network.
- Slow acting control systems such as JVC (joint var control) and AGC for post disturbance voltage stability study. The requirement to include such features and the appropriate level of detail and high level logic for implementation of these features will be reviewed.
- DC commutation switch model and arc model
- Models of renewable generation such as wind and solar operating isolated with single HVDC connection into the Ac network for interaction and integration studies and studies of the isolated section of the network containing the renewable generation.

2. Methodology for validation and testing of the models to verify the effectiveness and accuracy of HVDC RTSM, which includes comparisons of the real-time simulation results with the Transient Fault Records (TFR) or other records such as protection tripping records. Comparison of models against load flows or real system flows and voltage profiles. Comparison of model short circuit levels against actual levels or level determined in other software.
3. Selected applications of RTSM for HVDC studies.
    - Post-disturbance analysis study of HVDC operation to optimize strategy and parameter of HVDC C&P system and mitigate performance concerns.
    - Real-time simulation models of the overall AC and DC system to support the validation and mitigation of system transient stability issues in network planning of new or refurbished HVDC project.
    - LCC HVDC and VSC HVDC interaction studies including different cases like commutation failures, frequency controller or frequency stabilizer operation, POD (power oscillation damping)
    - Operation of VSC HVDC in STATCOM mode and possible dynamic prioritization between ac voltage control and dc power transfer depending on system conditions, etc.
    - Level of detail needed in models of Control and Protection systems for the study of coordination between FACTS devices such as STATCOM, SVC, and

synchronous condensers and HVDC converter stations.

- In cases where new FACTS devices are planned near an existing HVDC, the level of detail that needs to be modelled in the RTS system for the new and existing C&P systems to ensure adequate simulation of dynamic performance and protection coordination will be evaluated.
- Benchmark models for SSR studies between HVDC systems and synchronous generators will be developed.

The outputs from the activities listed above will be summarized into a set of guidelines for development practical simulation models to be used in operational studies and specification studies for new or refurbished HVDC projects.

Deliverables: Technical brochure with summary in Electra

Time Schedule: Start : October 2016 **Final report** : October 2018

Comments from Chairmen of SCs concerned:

Approval by Technical Committee Chairman:

Date : 09/10/2016