CIGRE Study Committee B4

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

WG* N° B4-69	**Name of Convenor :** Dennis Woodford (Canada)
Technical Issues # : 3	**Strategic Directions # 1**
The WG applies to distribution networks (4):	**No**

Title of the Group: Minimizing loss of transmitted power by VSC during overhead line fault

Scope, deliverables and proposed time schedule of the Group :

Background : Existing VSC transmission is dominated by underwater and underground cable systems, generally with XLPE-DC cables. As the need for VSC transmission expands, so too will the requirement to minimize transmission costs with overhead transmission where possible. It may not always be likely that VSC transmission can stay overhead. Environmental and agricultural concerns as well as the challenge of obtaining and permitting right-of-way through built-up areas may necessitate reverting to underground and/or underwater cables for a portion of the transmission length.

The overhead transmission line portion will be exposed to adverse atmospheric impacts causing line-to-earth faults which are temporary for the most part which can be cleared and transmission resumed after a period of time. Phase-to-earth temporary faults for ac transmission may apply circuit breaker reclosing within a second or so with either three phase reclosing or single phase reclosing. HVDC LCC transmission with overhead lines has a controlled arc extinction and restart process for temporary faults that is also accomplished within a second. Fast acting HVDC circuit breakers are being developed to emulate in VSC transmission what circuit breakers accomplish in ac transmission for clearing of line faults and recovery to pre-disturbance transmitted power.

In each of these ac and dc line-to-earth temporary faults that allow reclose or restart cause power flow disruption for the second or so the reclosing or restarting sequence requires.
This WG objective is to investigate how pole-to-earth faults on overhead VSC transmission can be cleared with little or no loss of transmitted power, taking into account portion of the transmission line may be underground or underwater cable.

Scope :

1. The common symmetrical monopole will be the most likely VSC converter topology that should be considered. Other converter configurations and variations to the symmetrical monopole will be considered and evaluated to see how effective they could be to meet the objective of this WG. The pros and cons of each will be considered. For example, the symmetrical monopole with two conductors does not require firm earth connection as a conventional bipole requires with three conductors, one of which is the metallic return. A single symmetrical monopole will lose redundancy for a permanent line or cable fault unless there are two independent monopoles with four conductors.

2. A single pole-to-ground fault for the high resistance earthed symmetrical monopole results in little or no power transfer being lost during the fault while the voltage of the un-faulted pole jumps to two per-unit. Overhead line insulators can be designed to withstand a 2.0 pu overvoltage for a short period of time. With XLPE-DC cable in the transmission, the CIGRE specified type test for such cables is 1.85 per-unit How the VSC converter can be rated, configured and controlled to keep the overvoltage to the cable within the type test limits will be investigated along with methods to quickly rebalance the dc line voltages after the fault arc has extinguished.

3. The impact of using modern multilevel modular converters (MMC) with full bridge, half bridge

and other configurations will be investigated. The pros and cons of each topology will be considered. The full bridge based topology has the ability to limit or eliminate short circuit currents and reduce the need for high-speed dc side circuit breakers. The possibility of populating the valve arms with a combination of half- and full-bridge sub-modules to lower dc voltage during single line to earth faults will be investigated. Loss of power transfer during the line-to-earth fault with full bridge sub-modules in the converter will be investigated along with accommodating pole-to-pole line faults.

4. Selection of the proper values and configuration for high resistance earthing for symmetrical monopoles will be studied. For example, the high resistance earthing can be either at the unit transformer secondary winding Y point or through a zig-zag grounding transformer or a bank of MOV surge arresters. Moreover, the value of the high resistance to earth should be designed in such a way that the dc circuit is balanced during normal steady state operation.

5. Investigate the means of the VSC transmission to detect and respond to cable faults and other permanent line-to-earth faults.

6. One important means of reducing impact of dc line faults is to lower the occurrence of environmentally caused faults by lower profile of the overhead dc transmission line. This can be achieved with shorter height towers, and smaller spans. In this way lightning shadow is reduced and the transmission line is exposed to lower wind forces. These will be quantified through comparative studies of higher versus lower profile overhead transmission line examples.

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7. The results determined for minimizing power loss for line-to-earth faults on overhead point-to-point VSC transmission as studied above will be evaluated for application to DC grids. The possibilities and limitations for this extension of VSC transmission will be studied and how dc circuit breakers may be applied to segment the potion of a faulted grid so that a large grid will be minimally impacted by a dc line fault.

Deliverables : Technical brochure with summary in Electra

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

Comments from Chairmen of SCs concerned :

Approval by Technical Committee Chairman : M. Waldron
Date : 30/09/2014

(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