CIGRE Study Committee B5

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP[1]

WG N° B5.65	**Name of Convenor:** Dr. Farfilho (BRAZIL)	
Strategic Directions #[2]: 6,1,3,4,10	**Technical Issues #[3]: 1**	
The WG applies to distribution networks[4]: Yes		
Potential Benefit of WG work #[6]: 1,2,3		
Title of the Group: Enhancing Protection System Performance by Optimising the Response of Inverter-Based Sources		

Scope, deliverables and proposed time schedule of the Group:

Background:

Non-synchronous sources continue to be added to power grids. The shift away from traditional generation based on large high-inertia synchronous machines, towards smaller and dispersed renewable sources based on synchronous and non-synchronous machines and inverter-based technology, will continue and accelerate. Under fault conditions these new sources do not behave in the same way as large synchronous generators. The unique response of these sources to fault conditions considerably challenges traditional protection principles developed decades ago for grids with synchronous generators driving fault currents. With the increased penetration of these non-synchronous sources, traditional grid protection principles will be stressed to the point of potentially losing dependability.

There is only slow progress in devising new protection principles more suitable for grids with predominantly non-synchronous sources. Line current differential or directional comparison schemes with weak infeed logic continue to work if there is enough strong non-synchronous generation in the grid. But even these powerful principles will face considerable performance issues once the grid is dominated by weak non-synchronous sources.

The key reason for slow progress in devising better protection principles is that the new source characteristics are not easily discoverable and universal, but they depend on design choices of manufacturers based on requirements from users and grid codes in effect at the time. A source response depends on the make and model and it may change with software upgrade to the sources controllers. It is well recognized that this non-standard fault response creates risk and adds cost when integrating these new sources into the grid. What is less known is that it discourages relay manufacturers from developing new relay technologies. The relay manufacturers do not have any fixed source characteristics to work with.

A possible solution to this challenge is to explore possibilities for identifying characteristics of large non-synchronous sources, primarily inverter-based sources, that can be standardized and thus give the relay manufacturers and application engineers a fixed reference to work with. It is given that such common characteristics cannot violate the laws of physics or drive the cost of the source up beyond a point acceptable by the users. An inverter-based source will not replicate a synchronous machine, but it can still respond in a consistent predicable way to fault conditions allowing properly re-designed relays to work dependably even if the network consist of only these new sources.

This Working Group will explore if, within the constraints of the laws of physics, cost, and typical grid codes, a large inverter-based source can universally maintain certain characteristics during fault conditions that would allow new protection principles for the grid fed from these sources. If such characteristics exist, they can be considered as a part of the future grid codes.

Scope:

1. Identify, review and explain protection issues for applications in networks containing non-synchronous sources including but not limited to: distance protection polarization, distance protection dependability, frequency measurement and tracking, phase selection for single pole tripping, directional protection elements.
2. Generate ideas for controlling non-synchronous sources, especially large inverter-based sources, with the objective to maintain predictable and useful relationships between the source terminal voltage and currents to facilitate adequate performance of those protection applications that have problems today.
3. Investigate technical feasibility, impact on cost, and impact on ability to deliver on other grid code characteristics, of the identified ways to control the sources for facilitating adequate grid protection for sources connected on the sub-transmission and transmission voltage levels.
4. Make recommendations to the industry regarding feasibility of introducing source characteristics under fault conditions to improve operation of grid protection.
5. Propose a method for translating the parameters of a source which is compliant with the suggested short circuit response for the purpose of representing the source into short circuit calculation programs.

This work is ambitious and concerns new and rapidly developing technology. Heavy involvement of power electronics and protective relay experts in a collaborative manner is critical to success. To better understand this undertaking, consider this example: a robust directional principle can be implemented if the source outputs measurable negative-sequence voltage and current. These quantities do not have to be large. Signals at the level of few percent of nominal can be measured by relays with sufficient accuracy. The source is permitted to modulate the negative-sequence current and voltage in terms of angle and magnitude at will, if the voltage and current are tied with a constant impedance. The said impedance can be relatively large, and the amount of energy associated with this negative-sequence output can be kept to a minimum. The Working Group is to evaluate ideas like this in terms of their ability to support robust grid protection on one hand, and the feasibility and cost for the source on the other hand. The Working Group shall coordinate and leverage the following CIGRE activities:

- JWG B5/B4.25 "Impact of HVDC Stations on Protection of AC Systems".
- JWG CIRED B5 C6.26 "Protection of Distribution System with Distributed Energy Resources".
- 2017 B5 Colloquium Auckland, PS2: “Protection Issues in Modern Power Systems With Renewable Generation And Storage”.

Deliverables:

☒ Technical Brochure and Executive summary in Electra

☒ Electra report

☒ Tutorial[5] (Proposal Forms and Power Point slides)

Time Schedule: start: August 2018 **Final Report**: August 2022

Approval by Technical Committee Chairman: M. Waldron

Date: 11/04/2018

Notes: [1] or Joint Working Group (JWG), [2] See attached Table 2, [3]See attached Table 1, [4] Delete as appropriate, [5] Presentation of the work done by the WG, [6] See attached table 3

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
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 (ref. 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

Table 3: Potential benefit of work

1	Commercial, business or economic benefit for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical direction
5	Guide or survey related to existing techniques. Or an update on past work or previous Technical Brochures
6	Work likely to have a safety or environmental benefit