

Paris Session 2022



Harmonic modelling of IBR and impact on harmonic stability

C4 – Power System Technical Performance

PS1 – 1 Modelling, measurement and assessment of PQ phenomena including emerging areas such as supra-harmonics, harmonic instability, geo-magnetically induced currents and other similar phenomena

Question 2: What are the experiences on harmonic instability associated with IBRs in AC power systems? Can the phenomena be reliably predicted using the existing modelling and analysis methodologies, paying attention to data requirements and possible improvements for the future?

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Question 2 (part 1): What are the experiences on harmonic instability associated with IBRs in AC power systems?

- Low damping characterizes weak networks with high density of IBRs:
 - large amount of power electronics and cables,
 - low amount of conventional generation and loads.
- IBR controls can present negative resistance seen at their connection with the AC power system. This is due to the nature of their control system and it can vary based on the vendor's design.
- In the event of a resonance, the negative resistance can amplify the resulting oscillations, with possible damage to the equipment and interruption of operation.

- Paper no. 10928 [1] highlights that a common problem faced by HVDC transmission systems connected to converter-based networks, as wind and solar power plants, is the occurrence of harmonic currents and voltages or harmonic oscillations caused by system resonances and low damping [2].

[1] G. Tremouille, K. Carvalho, J.C. Urrego, A. Kumar, "Equivalent Impedance of Wind and Solar Power Plants for AC Harmonic Performance Assessment of VSC-HVDC Systems", CIGRE Session Paris 2022

[2] C. Buchhagen, C. Rauscher, A. Menze, J. Jung, "BorWin1 – First Experiences with harmonic interactions in converter dominated grids," in International ETG Congress 2015, Bonn, 2015

Question 2 (part 2): Can the phenomena be reliably predicted using the existing modelling and analysis methodologies, paying attention to data requirements and possible improvements for the future?

- Paper no. 10928 [1]: importance of including controls in modelling of IBRs and impact on accuracy of harmonic performance assessment, especially for HVDC design.
- Traditionally, power system elements are modelled by passive circuit conventional elements.
- However, for IBRs, more detailed data representing the harmonic behaviour of their control systems is essential.
- Models available in literature [3], CIGRE WG C4.49 [4] CIGRE WG B4.81 enable IBR manufacturers to provide impedance-based models which describe their devices with a fair degree of accuracy without giving away proprietary information about their control algorithm.
- Way forward: coordinated effort to make such models available to all the parties involved in the engineering of the AC power system.
- Clear data requirement is key; this level of information is expected to become standard practice in the power industry.

[1] G. Tremouille, K. Carvalho, J.C. Urrego, A. Kumar, “Equivalent Impedance of Wind and Solar Power Plants for AC Harmonic Performance Assessment of VSC-HVDC Systems”, CIGRE Session Paris 2022

[3] M. Cespedes, J. Sun, “Impedance Modeling and Analysis of Grid-Connected Voltage-Source Converters,” IEEE Transactions on Power Electronics, vol. 29, n° 3, pp. 1254-1261, March 2014.

[4] L. Kocewiak, R. Blasco-Gimenez, C. Buchhagen, J. B. Kwon, “Overview, Status and Outline of Stability Analysis in Converter-based Power Systems”, 19th International Wind Integration Workshop, 11-12 November 2020.

Group Discussion Meeting