

Paris Session 2022



Possible approach to make harmonic performance studies of large inverter-based generation parks less conservative for low harmonic orders

SC C4

PS-1 Question 1

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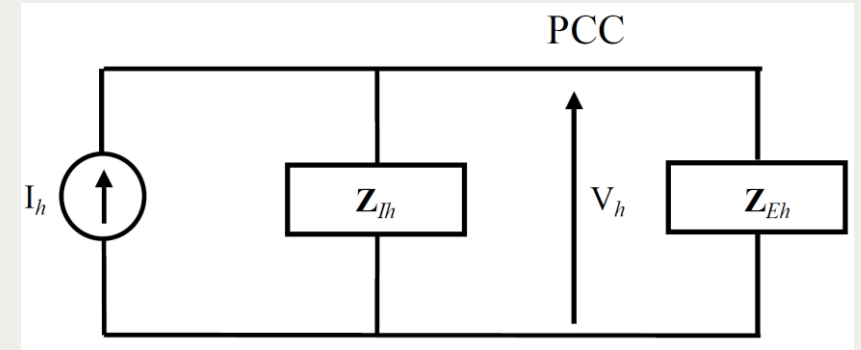
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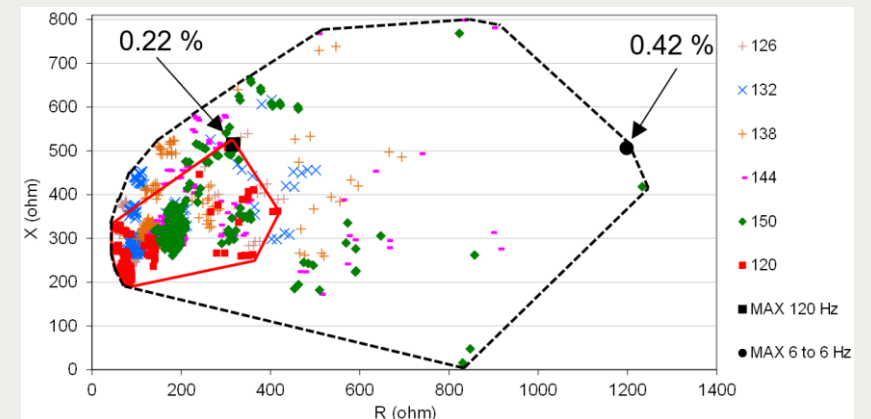
Introduction

- Harmonic performance studies are carried out to verify the need for mitigation solutions when connecting a disturbing installation
- In many cases, they are performed to capture the worst-case operating condition
- This approach may lead to overrated harmonic emissions and oversized mitigation solutions
- Flexible approaches or more detailed studies are necessary to avoid installing unnecessary filter equipment
- This contribution presents an example of divergence between study results and long-term measurements and proposes a possible solution to make the study results less conservative and more realistic

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Circuit for Overall Assessment



Example of discrete polygon used to represent the utility impedance (Z_{Eh})

Divergences between studies and measurements

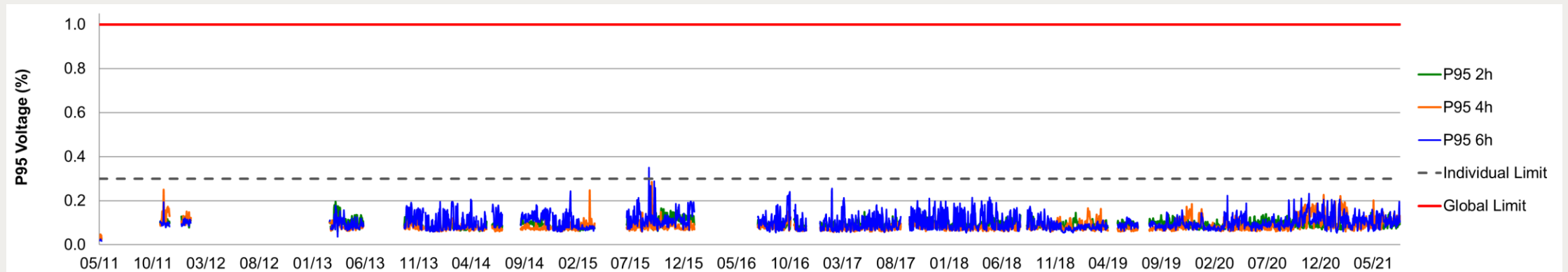
Wind farm with an installed capacity of 163,2 MW

- Results of the harmonic performance study presented to the ISO to request access to the grid

h	2	3	4	5	6	7	THD
Limits (%)	0.30	0.60	0.30	0.60	0.30	0.60	1.50
V(%)	0.98	1.54	1.29	4.14	0.13	0.60	4.77

The harmonic impedance envelopes were defined considering scenarios of complete network topology and contingency (n-1) of various equipment beyond the 3rd neighborhood of the PCC. Each envelope is composed by the harmonic frequency in study and inter-harmonic frequencies until $h \pm 0,5$ with a frequency step resolution of 6 Hz.

- 95th daily percentile (P95) from the even harmonics measured at the PCC in periods of 10 minutes over 10 years

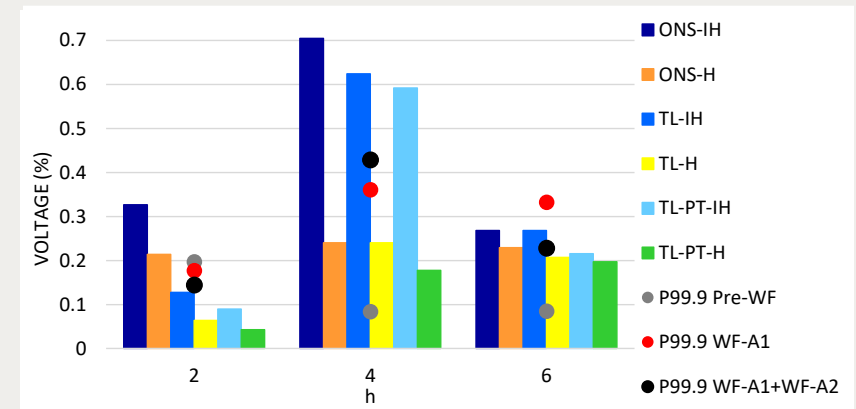


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Possible approach to make the study results more accurate

- Two studies were performed for two WFs comparing long-term measurements with simulation results using different criteria to define the harmonic impedance loci, i.e., considering or not inter-harmonics and equipment outages to compose the impedance envelopes
- Based on this assessment, some relevant conclusions were possible:
 - the inclusion of inter-harmonic impedances in the loci of 2nd to 4th harmonic can generate study results quite higher than the total harmonic voltage measured at the PCC
 - the consideration of TL and PT outages to define the loci of low order harmonics can generate harmonic voltages in studies that diverge significantly from the measurement values when considering the daily 95th percentile
- For performance assessment the loci should not include inter-harmonics and impedances calculated for occasional operating conditions (situations that statistical likelihood does not exceed 2-5% over one year)
 - with this approach simulation results and long-term measurements are more convergent
- When the study criteria are stringent and inflexible, decisions about the need to install filters should be based on evaluations combining results from studies and measurements.

Comparison of study results with long-term measurements of harmonic voltage



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