

# Paris Session 2022



## Harmonic Interactions – Observations and Mitigations

B4: DC systems and Power Electronics  
PS1: HVDC Systems and their Applications  
Q1.17

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Group Discussion Meeting

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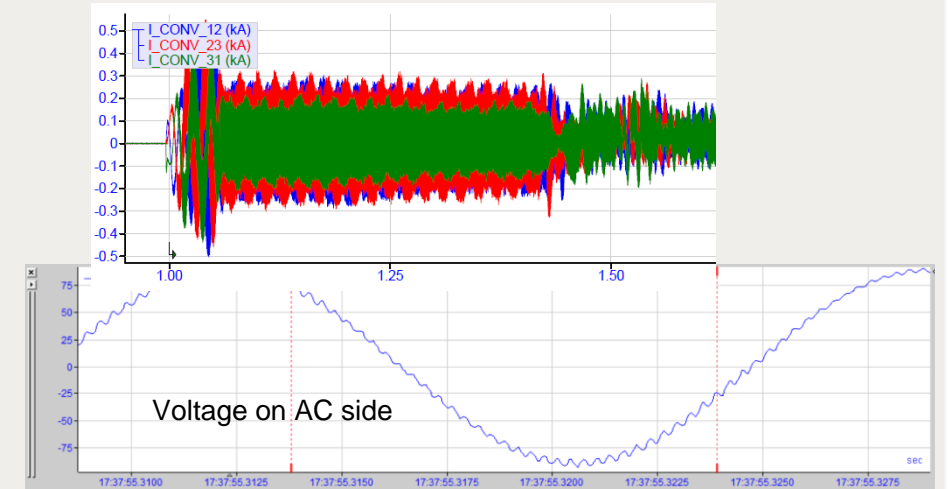
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# Harmonic Interactions - Observations and influence factors

Higher risk for Harmonic Interactions have been observed in case of:

- Long **AC cables** at converter side
- **Cable dominated AC grids** (e.g. offshore grids)
- Stray capacitances in **OHL** with high grid impedance
- **Unfavorable HF filter designs** (e.g. tuned at or near effective switching frequency of converter)



Undesired harmonic interactions between converter and AC side are mainly influenced by limited bandwidths and delays in:

- Measuring
- Communication
- Signal processing
- Actuators



Negative damping effects possible in some frequency ranges (typ. 1kHz ... 4kHz)



Requires protection mechanisms to avoid equipment damage (AC harmonic protection)

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# Harmonic Interactions - Approach to avoid or mitigate interactions

## Analysis and modelling requires

- Accurate modelling of connected AC system, primary components (incl. parasitic elements), control algorithms
- Harmonic impedance analysis based on the whole modelled system

## Mitigations and preventive measures

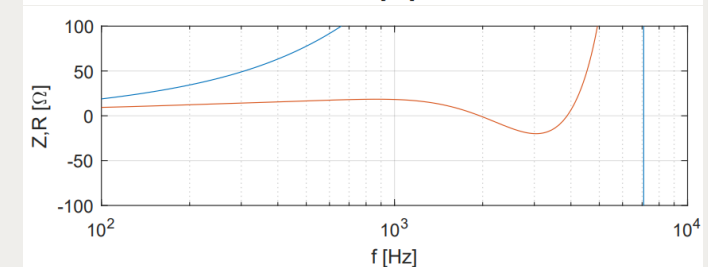
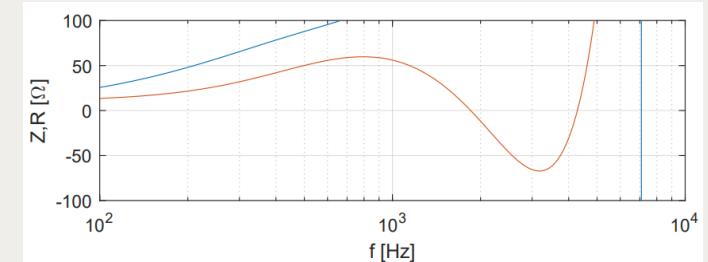
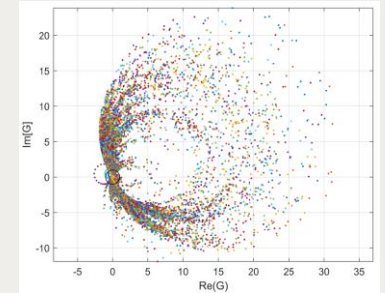
### Station and AC grid (if feasible):

- Reduce or avoid cables
- Damping circuits / HF filters
- Exclude critical system configurations

Appropriate converter control design (including short delays) is mandatory, given harmonic content from grid (and other relevant effects) needs to be considered

Structural and parameter optimizations of converter control necessary to achieve optimum trade-off between transient response and robustness

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Harmonic Impedance of converter control only.

**Positive damping over whole frequency range if transformer and arm inductance is considered!**