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GROUP REF. : SC-B4
PREF. SUBJECT :PS1
QUESTION N° : Q1.4

Q1.4 With the large number of HVDC converters being integrated to the power system what challenges are foreseen with lack of harmonized grid codes? What impact would a harmonized grid code have on the project development cost and time?

Considerations on resonances in low order harmonic range

- Different frequencies are used in Japan, 50 Hz in the eastern region and 60 Hz in the western region, two regions are interconnected via frequency converters.
- As more and more RES (Renewable Energy Sources) such as photo voltaic or wind power plants are introduced into the grid, more inter regional power transmission is needed. The Hida-Shinano HVDC link (bipole LCC-HVDC 900 MW) was recently installed to increase the interconnection capacity between east and west region transmission networks.
- As the converter on 50 Hz side is connected to the core 500 kV network through almost 100 km long 2 circuit overhead line and the converter station has a lot of reactive power equipment and AC harmonic filters for existing BTB FC (frequency converter) systems (Figure 1), possibility of resonances in low order harmonic range had been considered.

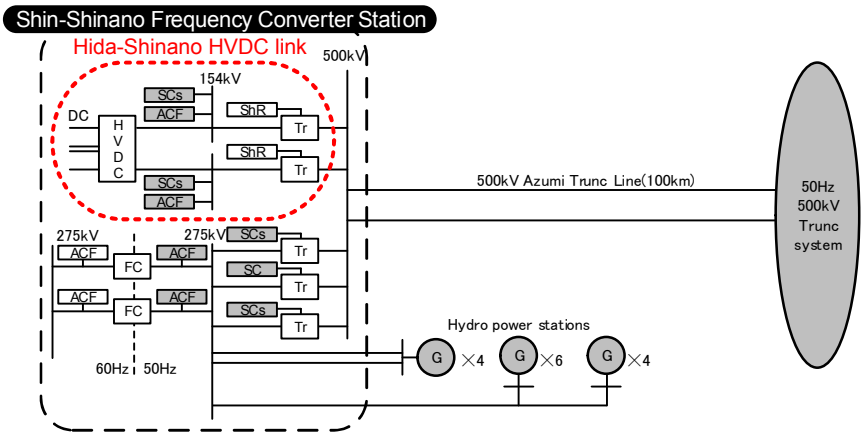

Figure 1. Shin-Shinano Converter station and adjacent AC network

- It was found that the network can be resonant at small integer harmonic order such as 2nd, 3rd or 4th in several particular network conditions (Figure 2).
- Transient studies such as transformer energisation cases or line fault cases, in such conditions as the network is resonant at low integer orders, were done.
- We found that the transiently injected harmonic current generates significant voltage distortion with very high network impedance at the low resonant frequency.

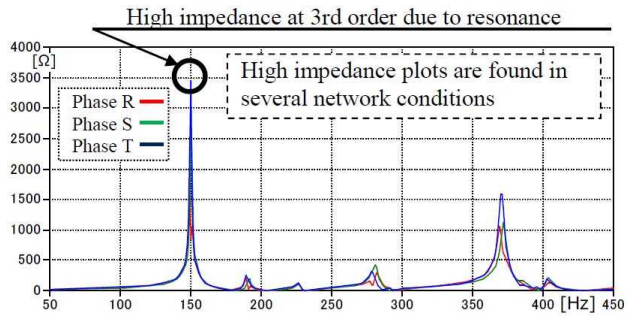

Figure 2. F-Z characteristic at Shin-Shinano converter station 500kVac bus-bar (Example of 3rd order resonance)

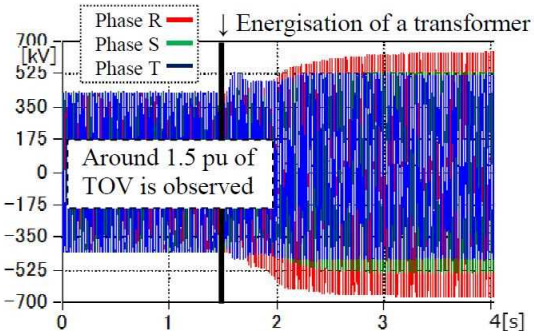

Figure 3. 500 kV bus-bar voltage on a transformer energisation network of F-Z characteristic in Figure 2

・Lowering the network impedance at resonant frequency was considered as a radical countermeasure and we decided to introduce damping resisters to AC harmonic filters.

・The network impedance at the resonant frequencies would be decreased to around one tenth as before and problems for TOVs and instable converter operation would be solved (Figure4, Figure5).

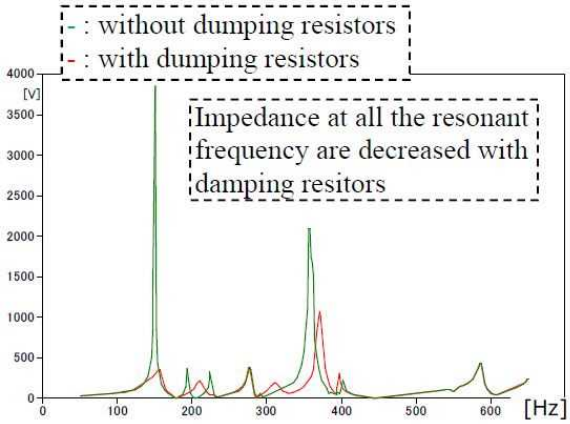

Figure 4. F-Z characteristics with and without damping resistor for filter banks

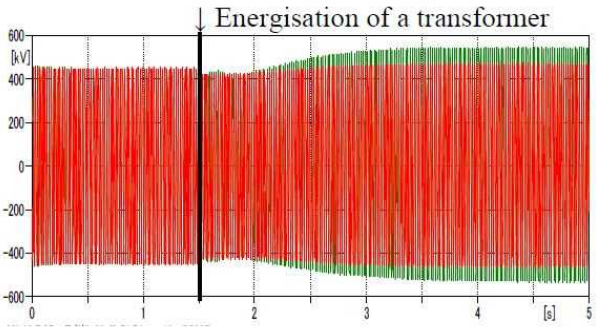

Figure 5. 500 kV bus-bar voltage on a transformer energisation with the network of F-Z characteristic with and without damping resistor

・It was found that countermeasures are necessary to avoid TOVs and low-order harmonic resonance for installing LCC-HVDC system in the Shin-Shinano Converter station.

・To avoid this concern, the introduction of damping resistors in the AC harmonic filter was effective.