Study Committee B4

HVDC AND POWER ELECTRONICS

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Harmonic Performance Requirements and Mitigation for Back-to-Back HVDC in Turkish Transmission System

E. Partal

ELTEM-TEK Co. Inc. and Consultant to TEIAŞ Ankara-Turkey

H. F. Bilgin, E. Altintas, T. Avci, E. B. Ozmen, O. Tanidir

TUBITAK MAM Energy Institute-Gebze-Turkey

Motivation

- This research work is carried out within the scope of the research and development of back- to- back connected MMC type VSC HVDC system which is funded by *Scientific and Technological Research Council of Turkey (TUBITAK)* Public Research Grant Committee (KAMAG), customized by *Transmission System Authority of Turkey (TEIAS)* and being directed by *TUBITAK Marmara Research Center (MAM)* Energy Institute.
- MMC type VSC HVDC system for back- to- back connection of Turkey and Iran will be developed and installed by TÜBITAK and Adularya Energy.
- To ensure compliance with the Turkish Grid Code, TEIAS requires the assessment of expected impacts on the existing harmonic distortion levels of the non-linear and resonant loads in transmission system.
- By this way, available margin between the existing harmonic voltage distortion levels on the network and the Grid Code limits is determined.

Harmonic Performance Requirements

- The harmonic performance requirements of 100MVA MMC type VSC HVDC BTB which will be installed at Gürbulak SS are evaluated in three stages.

Stage A

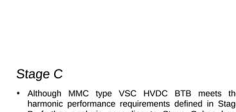
- Connection is allowed without further evaluation as long as and some other conditions are satisfied.
- As the condition above is not satisfied, other conditions for Stage A are not considered.

Stage C

- Although MMC type VSC HVDC BTB meets the harmonic performance requirements defined in Stage B, further analysis according to Stage C has been carried out.
- This analysis has been performed by considering the complete model of Turkish Electricity Network in DIgSILENT, the power system analysis software.

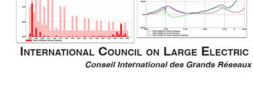
Single line diagram

- A part of the complete model by illustrating MMC type VSC HVDC BTB at Gürbulak and the neighbour buses.



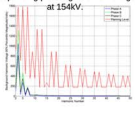
- HVDC system is modelled as current source whose harmonics are determined from the simulation results in PSCAD when the HVDC BTB is generating 100MW at 154kV.
- Although HVDC BTB injects negligibly small in magnitude of current harmonics around the 50th harmonic, voltage harmonics seem to approach planning limits cause of system resonance at around 50th harmonic.
- Having adequate damping in the transmission system, this doesn't cause any problem for compatibility of the HVDC BTB since it is the planning level of voltage harmonic limits at Gürbulak SS where HVDC BTB is to be connected.

Voltage harmonics at 154kV bus of Gürbulak SS with corresponding planning level and the planning level of harmonic impedance at Gürbulak HVDC BTB SS w.r.t. harmonic orders.



Background

Background harmonics at 154kV bus of Doğubeyazıt SS and the corresponding planning level for voltage harmonics at 154kV:

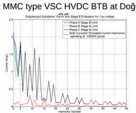


- Headroom available to the connection is calculated by

ii) Calculation of Connection Limits

- Available connection headroom is used in combination with a linear harmonic impedance approximation to determine the current emission limits according to Ohm's law.
- Harmonic limits are compared with current harmonics injected by MMC type VSC HVDC BTB.
- Injected current harmonics are obtained from simulation results of MMC type VSC HVDC BTB in PSCAD when it is generating 100MW at 154kV voltage level.

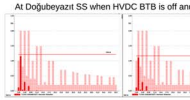
Limits of current harmonics and current harmonics injected by MMC type VSC HVDC BTB at Doğubeyazıt



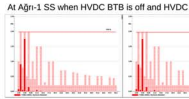
Voltage Harmonics

- Voltage harmonics at adjacent busbars are analyzed for the cases, with / without HVDC.

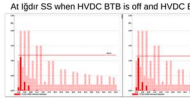
At Doğubeyazıt SS when HVDC BTB is off and HVDC



At Ağrı-1 SS when HVDC BTB is off and HVDC BTB is on



At Iğdır SS when HVDC BTB is off and HVDC BTB is on



Conclusion

- Harmonic performance requirements of MMC type VSC HVDC BTB system which is in development and will be installed at Gürbulak to 154kV transmission line between Turkey and Iran has been determined.
- The compliance of the HVDC BTB system to these requirements has been shown.
- Resonant characteristic of transmission lines at PCC has been emphasized although it doesn't result any problem for the HVDC BTB system in satisfying planning limits of Grid Code because MMC type VSC HVDC can produce multi- level output voltage waveform, close to sinusoidal waveform.