Grid Code Review Panel

Information Required to Evaluate Subsynchrononous Resonance on the Transmission System

A paper by National Grid
Contact: Graham Stein

Summary of Issue

1. All electrical and electromechanical power systems have resonant oscillatory modes at a range of frequencies. These resonances can be excited by disturbances to a system, including routine switching events. Most oscillations are harmless and short lived because of the effective damping inherent in a system. However, under exceptional circumstances an oscillation can grow and be maintained at a sufficient magnitude, and for a sufficient period of time, to cause plant damage or system instability.

2. The rotating shaft system of a turbine generating unit has inherent torsional oscillation frequencies which are determined by its large inertia masses and the interconnected shaft system. If the associated frequencies reflected at the terminals of the generator are close to characteristic frequencies of the connected electrical power system and is insufficiently damped, there will be unfavourable interaction between the two systems. The problem generally lies in the sub-synchronous frequency range (frequencies below 50Hz) as those at the super-synchronous range are well-damped.

3. The high speed active controls deployed in a number of power system technologies, including High Voltage Direct Current (HVDC) equipment, have the potential to exacerbate sub-synchronous oscillations (by providing negative damping). Equally, if explicitly designed to do so, they can provide positive damping and mitigate any risks of adverse oscillatory effects occurring. In order to do so effectively, it can be necessary to evaluate the frequency dependent characteristic of all local power system components, including the mechanical shaft system of synchronous generating units.

4. Changes to the electricity network configurations change the resonant modes of the overall power system. Series compensation has a significant impact on these characteristics and has been identified as a key tool in maximising the transfer capability of the current overhead line network across Great Britain.

5. The application of HVDC technology to the transmission system will grow significantly over the next few years alongside the deployment of series compensation solutions. There is therefore now a need to consider sub-synchronous resonance on a regular and ongoing basis.

6. The Grid Code does not specifically provide for the information exchange required in order to assess sub-synchronous resonance fully. National Grid has recently requested this information from a number of users under the provisions of PC.A.7 which allow for additional data to be requested. The information is required in order to assess the risk of sub-synchronous resonance phenomenon over a range of future system configurations and if necessary to develop control system solutions to mitigate these.

7. Given that there is a need to consider sub-synchronous resonance issues on an ongoing basis, there is a need to specify the information required from Generators clearly within the Grid Code such that generating companies can obtain this from manufacturers at an appropriate stage. There would also be a benefit in specifying what might be asked of an existing Generator should local system changes result in the need to evaluate or re-evaluate sub-synchronous resonance issues.

Current Provisions

8. The obligation to manage sub-synchronous resonance stems from National Grid's obligation to facilitate access to the transmission system safely and securely, with a specific obligation under the SQSS to avoid system instability.

9. As highlighted above, HVDC equipment can exacerbate sub-synchronous resonance. Hence, the Grid Code places a requirement on transmission users who own DC Convertors not to cause a sub-synchronous resonance problem and to provide damping control facilities in CC.6.3.16 (a).

10. First pass studies of the electrical system can show whether there may be a likelihood of a sub-synchronous frequency that could affect one of more generators. However, in order to fulfil the obligations of CC.6.3.16 (a), it can be necessary to cater for the combined effects of the detailed mechanical shaft systems together with the electrical parameters of the generating units and the connected electrical power system.

11. There is no specific provision within the Grid Code which sets out the information needed to represent the relevant mechanical components of generators.

12. PC.A.7 does however provide for National Grid to request additional data where meaningful studies cannot be performed by the relevant parties using the data submitted under current specific provisions.

13. The relevant existing Grid Code drafting is shown in Attachment 1.

Proposed New Provisions

14. It is proposed that new provisions should be incorporated into the Grid Code to specify the information required from synchronous generators to allow sub-synchronous resonance to be assessed. These would comprise a new paragraph in PC.A.5.3.2 and a complementary entry in the DRC, Schedule 1 with the information classified as DPD II.

15. The additional data items required to represent the turbine-generator shaft model for each synchronous generating unit are detailed in the draft text in Attachment 2.

GCRP Recommendation

16. National Grid intends to bring forward a consultation setting out the modifications required to the Grid Code to enable the information exchange required to facilitate the future assessment of sub-synchronous resonance. The Panel are invited to raise any additional issues for consideration.

Attachment 1

Current Grid Code Text relevant to sub-synchronous resonance

Additional Damping Control Facilities for **DC Converters**

CC.6.3.16 (a) **DC Converte**r owners, or Generators in respect of **OTSDUW DC Converters** or **Network Operators** in the case of an **Embedded DC Converter Station** not subject to a **Bilateral Agreement** must ensure that any of their **Onshore DC Converters** or **OTSDUW DC Converters** will not cause a subsynchronous resonance problem on the **Total System**. Each **DC Converter** or **OTSDUW DC Converter** is required to be provided with sub-synchronous resonance damping control facilities.

PC.A.7 ADDITIONAL DATA FOR NEW TYPES OF **POWER STATIONS**, **DC CONVERTER STATIONS**, **OTSUA** AND CONFIGURATIONS

Notwithstanding the **Standard Planning Data** and **Detailed Planning Data** set out in this Appendix, as new types of configurations and operating arrangements of **Power Stations**, **DC Converter Stations** and **OTSUA** emerge in future, **NGET** may reasonably require additional data to represent correctly the performance of such **Plant** and **Apparatus** on the **System**, where the present data submissions would prove insufficient for the purpose of producing meaningful **System** studies for the relevant parties.

Attachment 2

Proposed Draft Text

(New Text in Red)

PC.A.5.3 **Synchronous Generating Unit** and Associated Control System Data

PC.A.5.3.1 The data submitted below are not intended to constrain any **Ancillary Services Agreement**

PC.A.5.3.2 The following **Synchronous Generating Unit** and **Power Station** data should be supplied:

…

(g) Generating Unit Mechanical Parameters

It is occasionally necessary for **NGET** to assess the possible interaction between **NETS** and **User's Systems** including the torsional characteristic of the rotating components of **Generating Units**. For **Generating Units** with a **Completion Date** after *dd mmm yyyy*, and the following data items should be supplied:

The number of turbine generator masses
Inertia for each turbine generator mass (kgm^2)
Stiffness constants between each turbine generator mass (Nm/rad)
Number of poles
Relative power applied to different parts of the turbine
Mechanical mode frequencies (Hz)
Modal damping decrement factors for the different mechanical modes

DRC Schedule 1

DATA DESCRIPTION	UNITS	DATA to RTL CUSC Contract	DATA to RTL CUSC App. Form	DATA CAT.	G1	G2	G3	G4	G5	G6	STN
TIME CONSTANTS (Short-circuit and Unsaturated)											
Direct axis transient time constant *(PC.A.5.3.2(a))*	S	□		**DPD I**							
Direct axis sub-transient time constant *(PC.A.5.3.2(a))*	S	□		**DPD I**							
Quadrature axis sub-transient time constant *(PC.A.5.3.2(a))*	S	□		**DPD I**							
Stator time constant *(PC.A.5.3.2(a))*	S	□		**DPD I**							
MECHANICAL PARAMETERS *(PC.A.5.3.2(a))*											
The number of turbine generator masses		□		**DPD II**							
Inertia for each turbine generator mass	Kgm^2	□		**DPD II**							
Stiffness constants between each turbine generator mass	Nm/rad	□		**DPD II**							
Number of poles		□		**DPD II**							
Relative power applied to different parts of the turbine	%	□		**DPD II**							
Mechanical mode frequencies	Hz	□		**DPD II**							
Modal damping decrement factors for the different mechanical modes		□		**DPD II**							
GENERATING UNIT STEP-UP TRANSFORMER											
Rated MVA *(PC.A.3.3.1 & PC.A.5.3.2)*	MVA	□	■	**SPD+**							
Voltage Ratio *(PC.A.5.3.2)*	-	□		**DPD I**							
Positive sequence reactance: *(PC.A.5.3.2)*											
Max tap	% on MVA	□	■	**SPD+**							
Min tap	% on MVA	□	■	**SPD+**							
Nominal tap	% on MVA	□	■	**SPD+**							
Positive sequence resistance: *(PC.A.5.3.2)*											
Max tap	% on MVA	□		**DPD II**							
Min tap	% on MVA	□		**DPD II**							
Nominal tap	% on MVA	□		**DPD II**							
Zero phase sequence reactance *(PC.A.5.3.2)*	% on MVA	□		**DPD II**							
Tap change range *(PC.A.5.3.2)*	+% / -%	□		**DPD II**							
Tap change step size *(PC.A.5.3.2)*	%	□		**DPD II**							
Tap changer type: on-load or off-circuit *(PC.A.5.3.2)*	On/Off	□		**DPD II**							