nationalgrid

Minutes

Meeting name	GC0028: Constant Terminal Voltage
Meeting number	4
Date of meeting	19 September 2014
Time	10:00 – 14:00
Location	National Grid House, Warwick, CV34 6DA

Name	Initials	Company
Graham Stein	GS	National Grid (Chair)
Antony Johnson	AJ	National Grid
Bieshoy Awad	BA	National Grid
Philip Jenner	PJ	RWE
John Norbury	JN	RWE
Paul Newton	PN	EON
Herve Meljac	HM	EDF
Philip Belben	PB	Horizon
Fraser Richardson	FR	Scottish Power

Apologies

Martin Cunningham	SP	Scottish Power

1 Introductions/Apologies for Absence

112. GS welcomed everyone to the meeting and the attendants introduced themselves. GS explained that the objective of the meeting was to update the workgroup on the progress that has been made so far and to seek their views on the next steps.

2 Approval of Minutes

a) Workgroup meeting 3 minutes - 19th June 2014

113. The draft minutes were discussed. JN advised he had one comment relating to item 82 suggesting that it was rephrased to capture the point more clearly. It was noted that the working assumption was that MVAr payment was based on metered output. JN commented that they were a good set of minutes.

ACTION:- Item 82 of previous minutes to be updated to make it more explicit.

b) Update on actions

114. *AJ to update Terms of Reference.* AJ confirmed that he had forwarded this request to the Codes team for the website to be updated to include the revised terms of reference.

115. *AJ to look at the possibility of adding some clarification on BC2.A.2.6 within the Grid Code Connection Conditions.* AJ confirmed that clarification of BC2.A.2.6 (ie the ±25MVAr tolerance limit) would be included as part of the legal drafting and reference would also be included in the Connection Conditions so it was clear what obligations Generators would have to meet at the design stage. It was also queried whether the ±25MVAr limit was a step change or a steady state value. It was further advised that this would be addressed as part of this working group and reflected in the legal text.

116. AJ to discuss with the Generator Compliance team whether NGET tests generating units for compliance against the ±25MVAr tolerance. AJ advised the group that he had spoken to Generator Compliance and confirmed that testing is not undertaken to check the ±25MVAr tolerance. The only assessment undertaken is that the tap data is examined as a paper exercise but no formal testing is undertaken.

117. AJ to provide background information on existing derogations whilst respecting the issues of confidentiality. BA advised that he had looked at the derogations and from the period between 1990 – the present, it was unclear to draw exact conclusions due to the site specific nature of each derogation. He advised this had become complex due to the various changes which had been implemented over the years such as NETA, BETTA and Offshore Transmission arrangements. JN advised that the group were interested in the more recent derogation examples.

118. AJ to confirm how the voltage dependency of loads is modelled in the studies under consideration. AJ advised that voltage dependency is not explicitly modelled in the studies other than in the case of contingency studies which are modelled in the time frame between 10 seconds to 3 minutes. PB enquired as to whether the standard model used constant power or constant impedance. AJ advised that he would check.

119. Action:- AJ to establish if the standard study model uses constant power or constant impedance.

3 Constant Terminal Voltage – EDF Presentation

120. HM presented his presentation and conclusions. The following points were noted.

121. HM stated the purpose of the exercise was to observe the effect on the resilience of a synchronous machine (through observing the critical clearing time and hence the stability margin) to system faults when operating over the entire excitation range with different voltage / reactive power operating points achieved either by varying the Generator terminal voltage or by using an on load tap changer with the terminal voltage controlled to 1.0p.u.

122. The analysis was undertaken in Eurostag using a single machine model and two scenario's were investigated. The first used a small generator of 180MW (225MVA) based on an ABB 13E2 open cycle gas turbine generator with a static excitation system. The second scenario was based on a 1770MW (2082MVA) Generator with a brushless excitation system which would be typical of a unit installed in a large nuclear power plant. The same set of tests were applied to each scenario. In each case, a fault was applied to the HV side of the Generator Transformer with the Generator operating at each point on the extremity of its operating chart. The critical clearing time was examined with the Generator either operating using an onload tap changer or via generator terminal voltage control.

123. In conclusion, HM noted that both scenarios produced consistent results. The results indicated that if the Generator terminal voltage is increased, a higher stability margin is obtained. It was observed that, with the Generator operating in the leading mode (ie underexcited), a better stability margin was achieved when the reactive power is controlled through adjusting the onload tap changer at 1.0pu terminal voltage than when it was controlled through reducing the generator terminal voltage at nominal tap ratio. Whereas, with the Generator operating in the lagging mode (ie overexcited), a better stability margin was achieved when the reactive power is controlled through increasing the generator terminal voltage at nominal tap ratio than when it was controlled through adjusting the onload tap changer at 1.0pu terminal voltage. HM also noted that both methods of controlling reactive power give broadly comparable results but he re-iterated that as a minimum there would be a requirement for an on-load tap changer although the range and size would require further evaluation.

124. To finalise, HM noted that one solution may be have an offset tap changer. In other words the tap changer should be used when the Generator is operating in the underexcited mode and the generator terminal voltage could be used when operating in the overexcited mode.

125. The slides are available at:-

http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0028/

4 Options and Study Work – NGET Presentation

126. BA re-capped the options under consideration these being (Option 1) – Full range of taps to achieve the required reactive capability range at the HV side of the generator transformer for system voltage variations of ±5% with the Generator terminal voltage controlled to 1.0 p.u and the tap range set to limit the MVAr range to ±25MVAr, (Option 2) – Satisfaction of the Grid Code requirement using a combination of Generator transformer taps and variations to terminal voltage or (Option 3) – Fixing the Generator Terminal voltage to 1.0p.u and using a restricted number of taps.

127. BA advised that he had re-examined all three options using a large nuclear Generator (such as a European Pressurised Water Reactor (EPR)) in which to run the studies. BA also advised that following the previous meeting held on the 20th June, that he had re-checked his theoretical analysis and compared these against simulation results in Digsilent Powerfactory. He advised that good agreement had been obtained between both sets of analysis.

128. On slide 5, HM noted that the second equation only assumes an infinite busbar advising that when Qg is derived in relation to the transformer ratio (a) the results are dependant upon Vg and Vs, with Vs being fixed to 1.0p.u. BA agreed that this gave pessimistic results and agreed to re-check.

129. ACTION:- BA to re-check simulations and examine the effect of varying the system strength.

130. It was also noted on slide 5 – second bullet that the term 1:0.912 to absorb 582MVAr at 0.95 p.u should be 1:0.92. BA advised that he would check and confirm.

131. ACTION:- BA to check transformer ratio 1.0.912 should be 1.0.92 on slide 5.

132. With regard to Option 1, BA advised that from the calculations undertaken, in order to achieve a tolerance of ±25MVAr for a 1770MW (2082MVA) Generator and 2100MVA Generator Transformer connected to an infinite system, then a range of +60 to – 44 taps would be required to achieve the full reactive range. The workgroup discussed this issue and it was noted that this was an excessive number of taps. It was suggested that the ±25MVAr step change should be reviewed with the possibility of increasing this to match up with the 1% step voltage criteria. It was noted that the step change in voltage on the System was affected by the System strength not the number of MVAr's delivered and therefore any future change would need to be a function of the minimum fault level at the connection point. It was also noted that with a large number of taps and a mechanical tap changer, it could take a significant amount of time to reach the desired tap not to mention the complexity in the design of the winding arrangement. HM suggested that the requirement for 100 taps, based on the generator connected to an infinite system, is unreasonable. He also noted that his initial assessment and internal discussions within EDF suggested that the requirements can be met using a much lower number of taps. As a final point BA advised that if the MVAr tolerance was reduced ±80MVAr this would result in -19/+24 taps

133. BA then presented option 2. He advised that the full current Grid Code range could be achieved with a restricted number of taps but the terminal voltage may need to vary by as much as ±6.3% instead of the previously suggested ±3%. He advised that a marginal gain in reactive power at the Grid Entry Point was achievable. BA also advised that he had completed studies to assess the impact on the post fault response. In summary he advised that with the Generator operating in the lagging mode, the generator response to a voltage step at the Grid Entry Point improves for both operation at a low tap position and at a high terminal voltage. Whereas, the change in Reactive Power delivered to the system improves for operation at a low tap position deteriorates for operation at a higher terminal voltage. It was noted that the

combination of the operation at a low tap position and high terminal voltage in the study cases considered resulted in an overall improvement of the response to a step change in voltage. On the other hand if the Generator was operating in a leading VAr condition, the Generator response deteriorated for operation at a higher tap and a reduction in Generator terminal voltage. Whereas, the change in Reactive Power delivered to the system deteriorates for operation at a low tap position and improves for operation at a higher terminal voltage. It was noted that the combination of the operation at a higher tap position and lower terminal voltage in the study cases considered resulted in an overall deterioration of the response to a step change in voltage

134. BA then summarised option 3 which effectively requires the terminal voltage to be controlled to 1.0p.u with a restricted tap range. BA advised that with a transformer tapping range of +23 / -19 taps it was not possible to provide the full reactive range even at 1.0pu voltage at the Grid Entry Point.. If the tap step was widened to ±80MVAr then this requirement could be achieved with a tap range between of -19/24 taps.

135. BA then advised that he had investigated a number of scenarios under option 3 using a multi machine study. He also drew on some examples which had been observed at the National Grid Control Centre in which there have been cases of Generating Units at Drax operating in the full lead, even though the voltage at Drax 400kV busbars was low, in order to ensure voltages in the North East are managed to within acceptable limits. He also presented some multi machine simulation studies to demonstrate this effect. In response PB wondered if de-loading the Drax machine would solve the high voltage issue. JN noted that constraining a generator to maximise reactive capability was not ideal

136. To finalise the presentation, BA noted that if the ±25MVAr tolerance was relaxed a number of issues could result which included i) complexity in setting up a voltage profile, especially under minimum demand conditions, ii) tap hunting, iii) larger voltage excursions, iv) restrictions due to step change (1%), v) potential additional investment and vi) possible need to instruct additional reactive plant to achieve the voltage profile required. It was noted that further analysis needs to be undertaken in this area, in particular the impact on fault levels. Notwithstanding this, it was agreed that the ±25MVAr tolerance as currently detailed in BC2.A.2.6 should ideally be specified in the Connection Conditions to make it clear what obligations apply to Generators at the design stage.

ACTION:- BA to undertake further analysis on considering relaxing the ±25MVAr tolerance, in particular the impact on fault levels.

137. The Slides are available at:

http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0028/

5 Effect of Grid Strength on Tap Changing

138. HM then presented an additional presentation which demonstrated the effect of Grid Strength on tap changing. He advised that all studies had been run in Eurostag v4.3 in which a single machine study had been established with a variable impedance of between 5 – 20% on a machine base of 2082.3MVA. He summarised the results as follows:-

i) 5% Grid Impedance , 1 tap step caused a 0.75kV voltage step / 75MVAr change
ii) 10% Grid Impedance, 1 tap step caused a 1.2kV voltage step / 57MVAr change
iii) 20% Grid Impedance, 1 tap step caused a 1.7kV voltage step / 38 MVAr

6 Review of advantages and disadvantages of each Option

139. BA reviewed the advantages and disadvantages of each option. The slides are available at:-

http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0028/

140. The following points were noted:-

141. With regard to Option 1, PB noted that -19 to +24 taps was twice as many as we have today even with a relaxation to ±80MVArs. Concern was noted the current legal text as originally suggested was not transparent as it referred to the Bilateral Agreement. PN advised that derogations may still need to remain in place. HM also noted concern over the number of taps if the ±25MVAr limit is retained. He also expressed concern over the time it could take to achieve the new target if a large number of taps were required. The final point raised potential implications of outstanding derogations not yet granted by Ofgem.

ACTION:- Identify the likely implications of Option 1 on any derogations not yet granted by Ofgem.

142. With regard to Option 2, PB advised that there were essentially two variants, these being 2a) where there are a restricted number of taps and the Generator terminal voltage is adjusted at the extreme ends of the range to achieve the required reactive capability level for system voltage variations or 2b) where the generator transformer tap range covers the entire operating range but each tap has a wider step (ie a coarse control) and the exact HV target voltage is obtained by adjusting the Generator Terminal voltage (ie a fine control). It was noted that with option 2, the difficulty would be in defining the boundary between the tap range and point at which constant terminal voltage control would then be used (option 2a) or the tap change step size and ability of the generator to provide a fine control adjustment over the entire tap change step size (option 2b). It was agreed that these two variants would require further investigation.

ACTION:- NGET to further investigate options 2a and 2b in particular the boundary between the transformer tap range and the point at which Generator Terminal Voltage is used to control the HV Voltage.

143. With regard to Option 3, it was re-confirmed that the full reactive capability could not be delivered using this method. Following a discussion, it was agreed that Option 3 did not fulfil the Grid Code objectives and therefore should be discounted.

7 Discussion / Next steps

144. The main issues discussed at the meeting are reflected above. JN however advised that a draft working group report should be prepared.

ACTION:- NGET to start preparing a draft working group report.

145. It was agreed that the next working group meeting should be held in early / mid-November.

ACTION:- NGET to circulate a doodle poll for meeting dates in early / mid-November.