nationalgrid

Meeting Note

Meeting name	GC0062: Fault-ride-through
Meeting number	4
Date of meeting	15 July 2014
Time	10:00 – 14:00
Location	National Grid House, Warwick.

Attendees

Name	Initials	Company
Graham Stein	GS	National Grid (Chair)
Tony Johnson	AJ	National Grid
Paul Wakeley	PW	National Grid (Technical Secretary)
Hervé Meljac	HM	EDF Energy
Campbell McDonald	CMD	SSE Generation

Apologies

Name	Company
Dave Draper	Horizon Nuclear Power
Philip Belben	Horizon Nuclear Power
Richard Ierna	National Grid

1 Introductions

1. GS welcomed representatives to the meeting and thanked them for attending. The purpose of the workgroup meeting was to consider the further study results prepared by National Grid to support the development of fault-ride-through requirements for large synchronous generators which are consistent with the ENTSO-E Requirements for Generators (RfG) Network Code. GS advised the output was to consider the study results and identify what further study work would be required to develop a set of parameters for fault-ride-through at future meetings.

2 Minutes of previous meeting

2. The minutes of the previous meeting were discussed and agreed. The meeting note can be found under the 'Workgroup' tab on the Grid Code website[1].

3 Results of Study Work

Please refer to the presentation "Meeting 4 Presentation" on the Workgroup tab of the GC0062 Webpage[1].

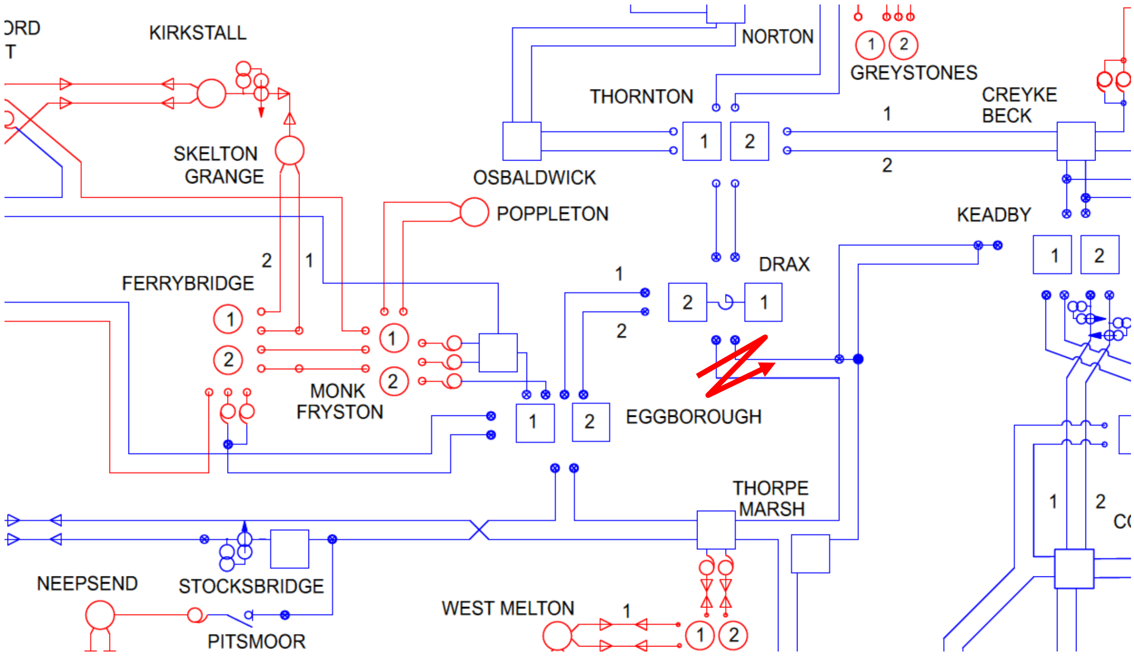
3. AJ began the presentation by summarising the key areas and actions that were agreed at the previous workgroup meeting to be considered in further study work:
    - Investigate over voltage issue identified at the Generator terminals and AVR performance. (An issue was found with the model and this has been corrected).
    - Produce System Peak Study (i.e. investigates the effect of lower voltages, and fault adjacent to the high volume of generation).
    - Record the assumptions used in the studies (detailed in the slides).
    - Investigate voltage recovery to 0.9pu.
    - Investigate the initial operation point of the Generator (i.e. full output at: for Summer minimum full lead, and Winter peak at lagging mode).
    - Effect on station auxiliaries.
4. AJ also outlined how a multi-machine study is setup under a specific operating condition to ensure compliance with the SQSS.
    - Select the full current network, with the correct type and level of demand.
    - Add the corresponding level of Generation based on the correct merit order.
    - Add in appropriate outages and substation running configurations.
    - Balance the study so that total Generation equates to the total volume of demand plus losses.
    - Adjust the controllable devices within the network (generator target voltage, reactive compensation, Quad boosters etc) so that it is compliant with the requirements of the SQSS.

Winter Peak Study – System Effects

5. In contrast to the summer minimum studies presented at the last workgroup, a series of studies were undertaken under winter peak conditions. The 2013 figures for winter peak are a demand of 54.73GW and 13997MVAr, with low-levels of non-synchronous generation connected.
6. A range of faults were simulated at Seabank and Drax / Eggborough. The Drax / Eggborough case is considered as a significant part of the network for Fault Ride Through consideration as it has a high concentration of Generation.
7. Seabank is a modern CCGT station. Drax and Eggborough are CEGB-era Coal fired stations located around 8 miles apart. Drax consists of 6 units of 660MW each, and Eggborough consist of 4 units of 500 MW each. Drax and Eggborough are connected by a 400kV double circuit.

[1] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0062/

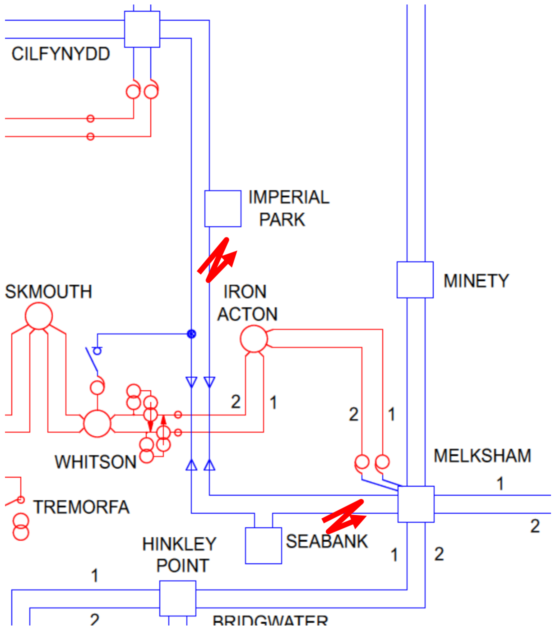
Drax – Keadby – Thorpe Marsh, Drax – Thorpe marsh double circuit



8. The first simulation was a solid three phase fault applied adjacent to Drax on the Drax – Keadby – Thorpe Marsh, Drax - Thorpe Marsh double circuit under winter peak conditions. Prior to the fault, all 6 Drax units were running in the lagging mode. It is assumed that protection cleared the circuit within 140ms, except for circuit breaker X705 at Drax which was considered to have stuck. The back up protection cleared Drax Main Bar 2 by operating circuit breakers X120, X220, X210 and X290 within 500ms. This immediately took Drax Unit 2 off the system as it was connected to Main Bar 2.

9. Due to the proximity of the fault Drax Units 1 and 3, and Eggborough Units 1 and 3 were observed to pole slip and so disconnected. Additionally Ferrybridge Units 3 and 4 were observed to pole slip, and so would have tripped off the system, due to their proximity to the fault. Other stations located remotely from the fault did not display any significant issues and would have been expected to stay connected. Under these conditions a total of 3.5GW of generation was lost, which would have resulted in activation of low frequency demand disconnection schemes, as the generation loss is outside the required 1800MW SQSS limit.

Seabank – Melksham, Melksham – Imperial Park double circuit.



10. A disturbance was applied to the Seabank-Melksham and Melksham-Imperial Park double circuit. The simulation was run at winter peak, and all Seabank units were running in the lagging mode pre-fault. As part of the model circuit breaker X205 at Seabank was assumed to stick. Within 550ms the backup protection of X120, X210 and X490 operated, disconnecting one unit at Seabank.

11. For a zero retained voltage disturbance at Seabank for 140ms and then followed by retained voltage of 0.5pu for a further 410ms (total fault clearance time of 550ms) all the other Seabank machines remained connected. For a zero retained voltage at Seabank for 140ms and a retained voltage of 0.5pu for a further 560ms (total fault clearance time of 700ms) pole slipping was observed. This indicates that for 0.5pu there is a critical total fault clearance time of between 550ms and 700ms when the onset of pole slipping is expected.

12. The fault on this circuit would leave the remaining Seabank units comprising 750MW feeding a single circuit to Cilfynydd which could result in stability issues. Other stations located remotely from the fault did not display any significant issues.

13. The results for the multi-machine models at winter peak were consistent with that observed for summer minimum in terms of the limited effect on generation remote to the fault.

Single Machine Studies

14. In order to consider the abilities of a single generator with a view to finding the range at which pole slipping is predicted to commence, a single-machine study was run simulating a single generator connected to an infinite bus with a specified impedance in between. In order to establish whether the single machine studies were an appropriate representation of the multi-machine model a number of studies where run on the Seabank and Eggborough machines and consistency between the single- and multi-machine models was found.

15. The test cases used were:

    i. Zero pu retained voltage at the HV Generator terminals for 140ms with the Generator in the full leading mode and pre / post fault voltage set to 1.0pu

    ii. 0.4pu retained voltage at the HV Generator terminals for 270ms with the Generator in the full leading mode and pre / post fault voltage set to 1.0pu

    iii. 0.5pu retained voltage at the HV Generator terminals for 700ms with the Generator in the full leading mode and pre / post fault voltage set to 1.0pu

    iv. 0.68pu retained voltage at the HV Generator terminals for 1000ms with the Generator in the full leading mode and pre / post fault voltage set to 1.0pu

v. 0.85pu retained voltage at the HV Generator terminals for 10s with the Generator in the full leading mode and pre / post fault voltage set to 1.0pu

16. Further tests were done with scenarios (i) to (iv) with the post fault voltage returning to 0.9pu. In all these cases, the generators under test remained connected. Tests (ii) to (v) were then repeated but in this case an additional constraint of 0pu for the first 140ms was added. It was found that all tests passed except test (iii) where pole slipping was observed.

17. Additional studies were then run to establish the point at which pole slipping occurred. In this case the fault impedance was halved to further reduce the retained voltage. (Due to the iterative nature of this study work the recorded voltages are indicative only) The following results were observed:-

- 10s at 0.58pu volts (Seabank) and 0.69pu (Eggborough)
- 1 second at 0.48 pu (Seabank)
- 270ms at 0.23pu (Seabank) and 0.22pu (Eggborough)

18. Three tests resulted in pole slipping so additional impedance was added until a stable result was achieved:

- 1s at 0.42 to 0.51pu (Eggborough)
- 700ms at 0.42 to 0.47 (Seabank) and 0.39 to 0.45 pu (Eggborough)

19. As a result of these studies, it has been possible to identify a further option for the voltage against -time curve (see slide 31). It was noted that some further consideration needs to be given to the period between 550ms – 700ms for a retained voltage of 0.5pu.

4 Discussion

20. A discussion was held on station auxiliaries, and it was noted that there are different types of auxiliaries at different types and age of power stations. AJ noted that as part of the 2005 fault ride through development work, rough studies had been completed to understand the impact on auxiliaries but no significant issues for station auxiliaries had been noted. CMD noted that the effect on station auxiliaries was at least in part associated with how the plant operator configures their station board, which is not known to the system operator. HM noted that EDF has a model for the auxiliaries on their nuclear power stations which may be of interest.

21. There was a query over the timings for the operation of the backup protection in different areas of GB. NGET indicated they would confirm the timings of backup protection on the Transmission System.

22. HM noted we should be working towards defining the process by which generators demonstrate compliance with the fault-ride-through requirements. In particular it was noted that in other grid codes in Europe in demonstrating fault-ride-through compliance a zero reactive power output is considered.

23. HM summarised the set of information that the generators are likely to want to know in order to demonstrate compliance with the fault-ride-through requirements:

- A single-machine model,
- The pre-fault active power *P* and reactive power *Q* of the generator,
- The grid impedance *Z*,
- The desired voltage-time curve,
- Information about stability and power recovery.

5 Actions and Next Steps

24. Building on the studies presented at the workgroup, further studies will be necessary to consider additional factors to gather further data to allow the workgroup to proceed with discussions on changes to the GB fault-ride-through requirements. These further studies will cover the following issues and will clearly state any assumptions / parameters:

- NGET to perform further studies to investigate the period between 550ms – 700ms for a retained voltage of 0.5pu;
- NGET to consider the effect of a fault on transmission at 400kV, on lower voltage networks including distribution.
- For single machine studies, NGET to provide:
  - a plot of voltage at the connection point for each simulation;
  - the grid impedance used for the simulation.
- HM to consider the effect on auxiliaries, based on the NGET single-machine model. NGET will make a single machine model available for Work Group Members to assess the impact on their auxiliaries.
- NGET to consider some future studies of large nuclear sets, such as Hinckley Point C or Moorside. These studies would include the resilience of these large sets to a remote fault, for example a fault at Seabank and the effect on Hinckley Point.
- NGET to consider further the initial operating point of the plant. Is it realistic to assume that, for example, Hinckley Point C would ever run in the full lead, due to the quantity of MVARr that would be being produced locally?

25. The next meeting is scheduled for held on Tuesday September 30 2014 at which these further study results will be considered, with a view to formulating an initial proposal for the NGET parameters position.

ID	Actions	Captured	Owner	Status
1	Circulate Grid Code Panel Paper pp12/14 on fault-ride-through	WG 1	NGET	Closed
2	Setup meetings for 2014 (Next meeting in early February, then at 8 to 10 week intervals)	WG 1	NGET	Closed
3	Prepare an initial review of fault-ride-through compliance in GB	WG 1	NGET	Closed
4	Prepare preliminary analysis of voltage recovery profiles and a proposal for analysis required to demonstrate the need case.	WG 1	NGET	Closed.
5	Full range of study assumptions to be provided	WG 3	NGET	Closed
6	NGET to prepare undertake further study work as identified in paragraph 26.	WG 3	NGET	Closed
7	NGET to provide details of the single-machine model to workgroup members, to allow them to run their own studies	WG 4	NGET	Open
8	Confirm protection operating times with NGET protection specialist and ensure that studies are representative of actual operating points.	WG 4	NGET	Open
9	NGET and industry parties to consider further study work as outlined in paragraph 24.	WG 4	NGET / Industry	Open