nationalgrid

Meeting Note

Meeting name	GC0062: Fault-ride-through
Meeting number	5
Date of meeting	30 September 2014
Time	10:00 – 14:00
Location	National Grid House, Warwick.

Attendees

Name	Initials	Company
Graham Stein	GS	National Grid (Chair)
Richard Ierna	RI	National Grid
Tony Johnson	AJ	National Grid
Paul Wakeley	PW	National Grid (Technical Secretary)
Philip Belben	PB	Horizon Nuclear Power
Dave Draper	DD	Horizon Nuclear Power
Hervé Meljac	HM	EDF Energy

Apologies

Name	Company
Campbell McDonald	SSE Generation
Philip Jenner	RWE

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 of the workgroup was to move towards a position of agreeing a proposed change to the GB Grid Code for large synchronous generators.

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 Update on Actions

Action 7

3. NGET confirmed that a single machine study model had been provided to industry parties in PowerFactory format so they could assess the proposed voltage against time curve with respect to their power station auxiliaries. It was noted that a number of industry parties have had trouble using the file.

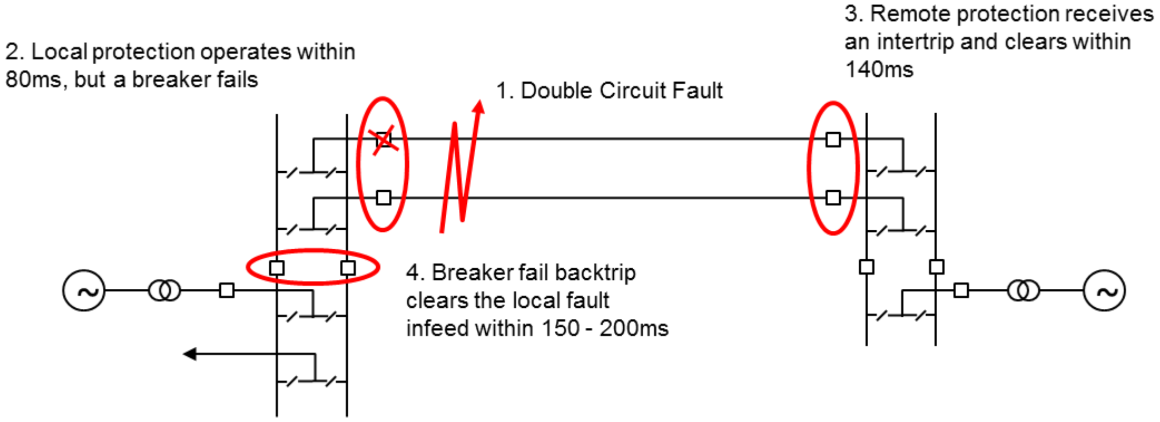
4. Industry parties are invited to request data in a different format from NGET as required.

Action 8

5. AJ reported that he had confirmed that the protection operating times that had been used in the model were representative of system conditions. He advised he had been in discussion with NGET Design Assurance at Thorpe Park that operation of the local circuit breaker would occur within 80ms at 400kV, with the remote breaker operating typically within 140ms at 400kV.

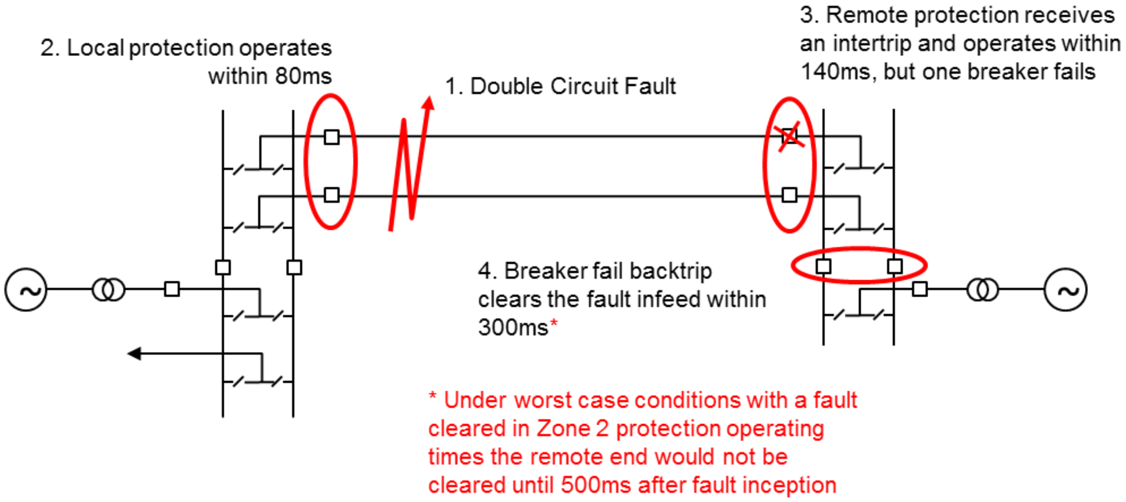
6. Furthermore, should the local breaker fail to open, as illustrated in case 1 (below), the breaker fail protection would operate typically within 150ms of fault inception with remote clearance within 300ms. Should the remote breaker fail to operate, as illustrated in case 2, the remote breaker fail protection would, in the worst case, typically operate within 500ms of fault inception but this would be based on a protection system operating in Zone 2 time. The diagrams below are representative of a typical system layout, rather than being an example of any particular location.

A double circuit fault, with a failure of a local breaker



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

A double circuit fault, with a failure of a remote breaker



7. It was noted by workgroup members that in the final workgroup report, it should be clear about what the purpose of fault-ride-through is. It was noted that currently terminology in the Grid Code refers to Mode A and Mode B faults. Mode A faults (less than 140ms) are designed to secure against credible faults against the criteria defined under the SQSS. On the other hand Mode B faults (longer than 140ms), are unsecured and outside the SQSS, but are required to prevent overall system collapse to non credible faults. In particular, it is desired that generation which is remote from a severe Transmission fault remains connected to the system, even though some generation local to the fault would be excepted to trip as a result of a fault and associated voltage dip.

Action 9

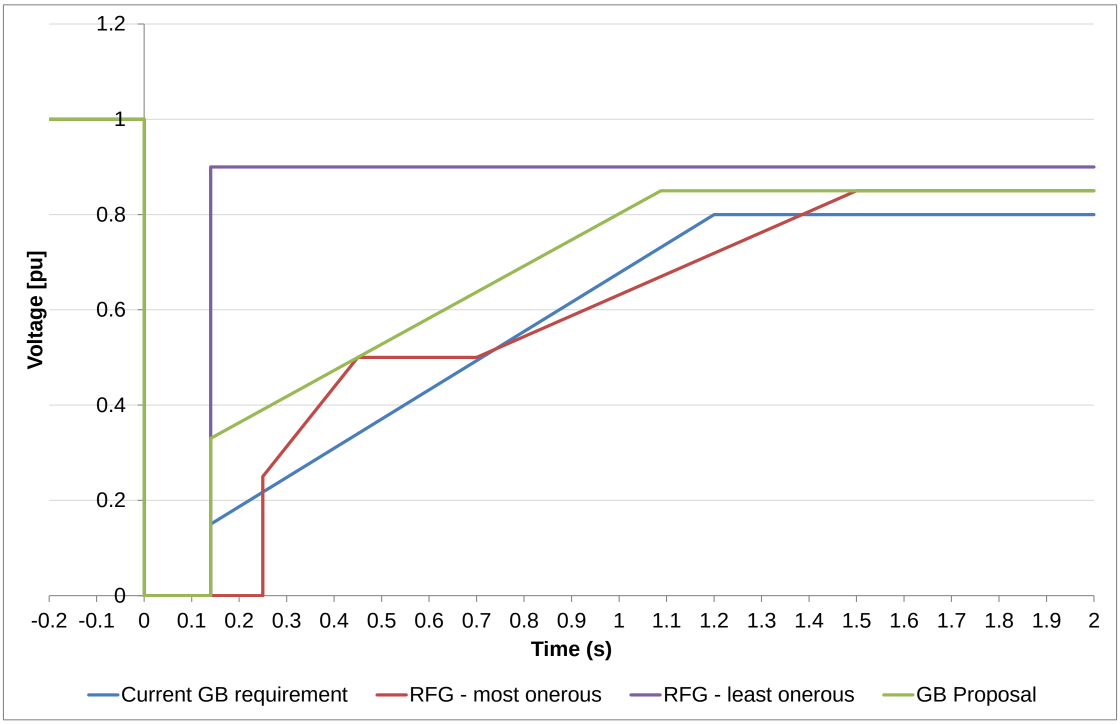
8. The presentation and discussion at the workgroup discharged this action.

3 Further study work

Please refer to the presentation "Meeting 5 Presentation" on the Workgroup tab of the GC0062 Webpage*1*.

Voltage-against-time Curve

9. AJ reported that it has been necessary to slightly alter the voltage against time curve (green curve – slide 6) presented at the previous workgroup meeting, as it was not compliant with the RFG requirements. DD requested if the green curve presented in error at the last meeting had been sent to Generator manufacturers. The new curve (green) presented below is latest proposed voltage against time-curve based on the most recent study work.. For comparison, the current GB requirement (blue) and the permitted envelope from RFG (maximum – red, minimum - purple) are also plotted.



10. The parameters of the proposed GB Fault Ride Through curve are:

- Pre-fault voltage: 1pu.
- For faults of 0 to 140ms seconds generators must be capable of riding through 0pu retained volts at the point of connection.
- Faults of greater than 140ms but less than 1.088s duration will have a minimum varying linearly from 0.33pu (at 140ms) to 0.85pu (at 1.088s). Note that it passes through the point 0.5pu at 0.45s as required by RFG.
- For faults of 1.088s to 180s, generators must be capable must be capable of remaining connected with 0.85pu at the point of connection.

11. Note that the proposed voltage-against-time curve as an option suggested for the voltage against time curve is less onerous that the current GB requirement specified in the Grid Code.

12. The proposed option is an evolution of what has been presented in previous workgroups, based on the study work undertaken by National Grid based on the withstand capability of a typical 600MW Generator..

Fault-Level

13. RI advised that he had undertaken some analysis under summer minimum conditions (i.e. when fault levels are at their lowest) to demonstrate how the fault infeed varied across the system for different Generator connections. He also summarised the results by providing the maximum, minimum, mean and median values.

14. Workgroup members noted that fault infeed levels were provided to generators from National Grid for a number of different purposes, and it would need to be clear what any new value was based on, and the circumstances under what conditions the value should be used. It was noted that RfG requires the TSO to provide the fault ride through conditions for the Generator such as pre and post fault short circuit capacity, at the Connection Point together with the Generator Operating conditions.

15. By considering the system at summer minimum, when fault-levels are at their lowest, it was noted that on average the machine rating divided by system fault infeed was 3.52% whilst the the worst individual machine to fault infeed ratio was 8.42%.

Large generator simulations

16. In order to consider the effect of the new expected nuclear fleet, a number of studies were run to test a large 1700MW, 2000MVA generator under a range of different fault levels. In this situation, the generator in a single machine study was found to be unstable with leading

conditions with 0.5pu for 500ms and a fault level of 25GVA . For the same machine at unity power factor, the machine was stable. In both cases the Generator was fitted with a rotating exciter (300ms ride time) and a Power System Stabiliser (PSS).The following points are noted in relation to large Generating Units (2000MVA).:-

- Grid Code change for machines above 1600MVA which allows them to have a reduced Short Circuit Ratio of 0.4;
- Low fault level i.e. high impedance and weak system;
- Slow excitation system using rotary exciters.

17. The above issues contribute to a reduced level of stability when the power system is subjected to a fault.

18. It has been observed in the previous studies that due to the effect of the generating set being connected, the recorded voltage continued to fall after fault inception.

19. In order to effectively simulate this, a different setup was proposed for the single machine study in PowerFactory. The setup is as follows:

    - Fault infeed from the Grid set to maximum (10TVA)
    - A fault impedance of 15GVA
    - In parallel to the impedance, a 1TVA 1% 2:1 transformer (i.e. 400kV to 200kV)
    - To initialise the voltage drop, the circuit break was closed on the 2:1 transformer for a period of time.

20. HM cautioned against using very large and very small parameters, such as fault infeed, in numberical modelling as these tended to lead to convergence problems.. DD noted that an alternative situation would be to switch between two infinite bus bars with different voltages.

21. The excitation system was also considered. In particular, what effect the excitation type, ceiling voltage and rise time had on the stability performance of the machine.. For a 2000MVA machine with 15GVA fault infeed (modelled as described in section 17 above, it was found that the machine was stable under importing MVAr conditions, with the following excitation systems:

    - -130MVAr for 300ms 2pu Rotating Excitation System
    - -300MVAr for 300ms 3pu Rotating Excitation System
    - -475MVAr for 50ms 3pu Static Excitation System

22. HM noted that although these large generators may have the capability to operate fully in the lead, it was less clear if that capability would ever be required. Although there may be a system need for MVAr to support the voltage, the requirement is location specific and a large quantity or reactive power from a single station may not be appropriate. It was however noted that in general the system was more stable under this scenario rather than when specific faults were modelled..

4 Effect on Auxillaries

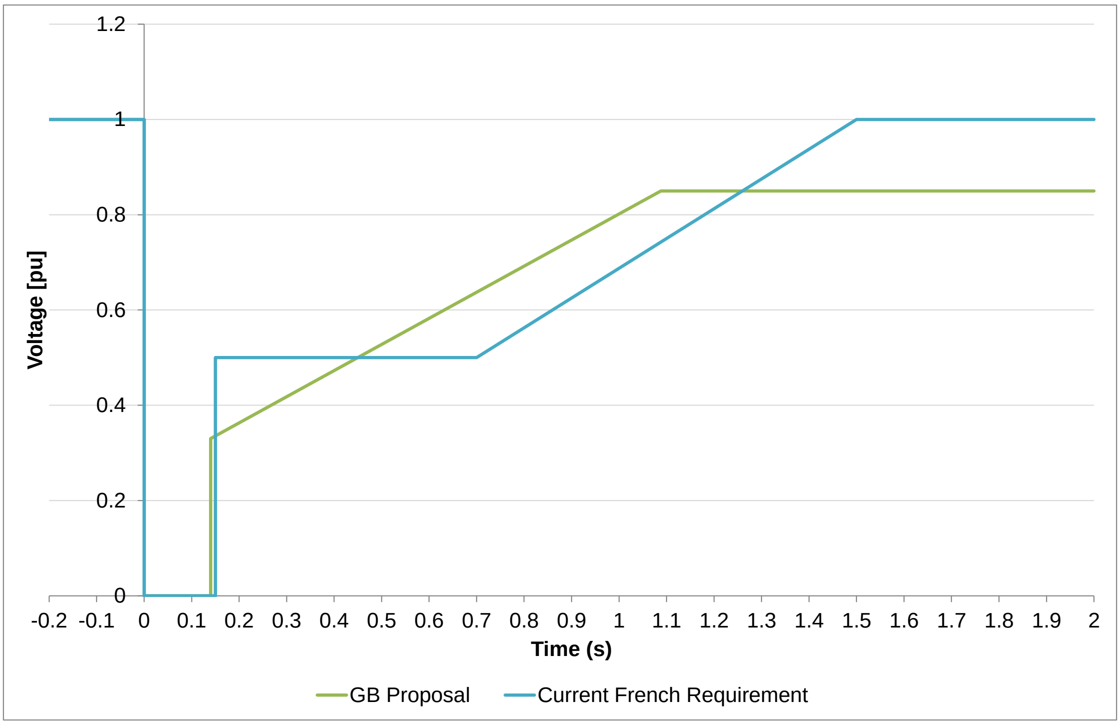
23. HM reported on the expected impact on station auxiliaries, based on studies and knowledge of the French system.

24. The equivalent ‘fault-ride-through’ requirement in France (see below) is for auxiliaries to be capable of riding through any voltage-time curve above the specific curve. Compliance requires a simple statement of compliance. It is acknowledged that the requirement or how to demonstrate compliance is not as clear as it could be.

25. HM noted that in France providing that the Generator can ride through the defined voltage against time curve then the auxiliaries will also satisfy this requirement. The proposed GB curve

is similar to French curve[2] therefore it was expected to not cause a significant issue for auxiliaries in GB.

The following diagram illustrates the proposed curve for GB, and the current French curve for transmission connections.



26. Critically, there is the area between 150ms and 450ms where the current French requirement is less onerous than the proposed GB requirement. There is a need to ensure that this area does not cause concern for GB station auxiliaries.

5 Actions and Next Steps

27. Building on the studies presented at this and previous workgroup meetings, it was agreed that the workgroup is getting closer to the point at which a conclusion can be drawn for the work on large directly connected synchronous generation. This conclusion needs to include a voltage-against time curve, and the pre-fault conditions.

28. In order to facilitate the conclusion of this work, for the next meeting NGET are to prepare:

- A summary of the workgroup finding and proposal, as a slide pack, for discussion.
- Consider the impact of the proposals on the new large nuclear fleet of Generators.
- Consider further the requirement of specifying the fault-level at either a local or global level.
- Superimpose the orange voltage against time curve on top of the RfG requirement.
- Change the date in the terms of Reference to March 2015 instead of March 2014.

29. Industry parties are asked to consider:

- The stability of their station auxiliaries against the proposed curve.
- Where possible, to do some further analysis – particularly of large plant – against the proposed GB curve.

30. The next meeting will also consider the terms of reference in more detail, to highlight where further work may be required and to plan for future workgroups. The group also mentioned the

2 RTE Documentation technique de reference, Article 4.3 – Stabilité, Installation raccordée au réseau d'interconnexion: http://clients.rte-france.com/htm/fr/mediatheque/telecharge/reftech/01-09-14_complet.pdf

impact on Embedded Synchronous plant. This requires further analysis but one suggestion was to require Embedded Generators to satisfy the requirement for Transmission System faults only.

31. The next meeting is scheduled for held on Friday November 21 2014 at which agreement on the GB proposal will be sought.

ID	Actions	Captured	Owner	Status
7	NGET to provide details of the single-machine model to workgroup members, to allow them to run their own studies	WG 4	NGET	Closed
8	Confirm protection operating times with NGET protection specialist and ensure that studies are representative of actual operating points.	WG 4	NGET	Closed
9	NGET and industry parties to consider further study work as outlined in paragraph 27.	WG 4	NGET / Industry	Closed
10	NGET to identify if green voltage against time curve has presented in meeting No 4 had been forwarded to Generator manufacturers	WG5	NGET	Open
11	Industry parties to request further parameters / details from NGET if they are unable to access the PowerFactory single machine model.	WG 5	Industry	Open
12	For the next meeting, NGET to prepare: • A summary of the workgroup findings and proposal, as a slide pack, for discussion. • Consider the impact of the proposals on the large nuclear Generating fleet • Consider further the requirement of specifying the fault-level at either a local or global level.	WG 5	NGET	Open
13	Superimpose the orange voltage against time curve on top of the RfG requirement	WG 5	NGET	Open
14	Change the date in the terms of Reference to March 2015 instead of March 2014.	WG 5	NGET	Open
15	For the next meeting, Industry parties are asked to consider: • The stability of their station auxiliaries against the proposed curve • Where possible, to undertake some further analysis – particularly of large plant – against the proposed GB curve.	WG 5	Industry	Open
16	Industry are invite to engage with NGET to ensure National Grid are appropriately modelling the new large nuclear fleet in System studies.	WG 5	Industry / NGET	Open