WELCOME

GC0155

Clarification of Fault Ride Through Technical Requirements

Meeting 6

07 September 2022

Online Meeting via Teams

nationalgridESO

Agenda

Topics to be discussed	Lead
Welcome	Chair
Review of Actions Log	Chair
ESO Updates • FRT Temporary Overvoltage Requirement Withstand Voltage	BA
Workgroup Discussions • Technical Questions from SSE / HVRT studies	FN/PM
Review Timeline	Chair
Terms of Reference • Progress Check	Chair
AOB & Next Steps	Chair

Members / Alternates & Observers

Role	Name	Representing
Chair	Banke John-Okwesa	**Code Administrator (ESO)**
Technical Secretary	Ruth Roberts	**Code Administrator (ESO)**
Proposer	Terry Baldwin	**NGESO**
Workgroup Member	Alan Mason	**Oceanwinds**
Workgroup Member	Alan Creighton	**Northern Powergrid**
Workgroup Member	Alastair Frew	**Drax Power Station**
Observer	Andrew Larkins	**Sygensys**
Workgroup Member	Andrew Vaudin	**EDF**
Workgroup Member	Bieshoy Awad	**NGESO**
Observer	David Griffiths	**RWE Generation UK, RWE Renewables**
Observer	Fiona Williams	**NGESO**
Workgroup Member	Forooz Ghassemi	**NGET**
Workgroup Member	Frank Martin	**Siemens**
Workgroup Member	Fraser Norris	**SSE**
Workgroup Member	Garth Graham	**SSE Generation**
Workgroup Member	Isaac Gutierrez	**Scottish Power**
Observer	Mike Kay	**Independent**
Workgroup Member	Nicola Barberis Negra	**Orsted**
Observer	Owen Curran	**Siemens**
Workgroup Member	Priyanka Mohapatra	**Scottish Power**
Workgroup Member	Ryan Tumilty	**SSE**
Workgroup Member	Sean Gauton	**Uniper Energy**
Workgroup Member	Tim Ellingham	**RWE Generation UK, RWE Renewables**
Workgroup Member (Alternate)	Julie Richmond	**Scottish Power**
Workgroup Member (Alternate)	Martin Aten	**Uniper**
Workgroup Member (Alternate)	Sridhar Sahukari	**Orsted**
Workgroup Member (Alternate)	Tobias Siepker	**Siemens**
Authority Representative	Shilen Shah	**Ofgem**

Timeline

Banke John-Okwesa – ESO Code Administrator

Timeline for GC0155

Milestone	Date	Milestone	Date
Proposal Presented to Panel	16 December 2021	Workgroup 10 – Finalise solution(s) and legal text, agree that Terms of Reference have been met, Review Workgroup Report and hold Workgroup Vote	14 March 2023
Workgroup 1 – Understand / discuss proposal and solution, note the scope and identify any possible alternative solutions, agree timeline and review terms of reference, agree next steps.	10 February 2022	Workgroup Report issued to Panel	22 March 2023
Workgroup 2 – Refresher: review and agree timeline and Terms of Reference, Review/Develop solution(s) and legal text, identify/assess possible alternatives.	07 June 2022	Panel sign off that Workgroup Report has met its Terms of Reference	30 March 2023
Workgroup 3 – Develop Solution(s), review of legal text and alternatives	05 July 2022	Code Administrator Consultation	07 April 2023 – 07 May 2023
Workgroup 4 – ESO to present plan and next steps re Definition of Overvoltage Requirements following a Fault, agree on the proposed plan	25 July 2022	Draft Final Modification Report (DFMR) issued to Panel	17 May 2023
Workgroup 5 – Review / assess on-going work on Overvoltage requirements	23 August 2022	Panel undertake DFMR recommendation vote	25 May 2023
Workgroup 6 – Review / assess ongoing work on Overvoltage requirements; consider HVRT findings	07 September 2022	Final Modification Report issued to Panel to check votes recorded correctly (5 working days)	29 May 2023 – 02 June 2023
Workgroup 7 – Finalise Overvoltage requirements, consider / finalise alternatives, draft consultations questions	15 November 2022	Final Modification Report issued to Ofgem	06 June 2023
Workgroup 8 – Finalise consultation questions, review consultation report	19 January 2023	Ofgem decision	TBC
Workgroup Consultation (15 Working Days)	30 January 2023 – 17 February 2023	Implementation Date	10 working days after Ofgem decision
Workgroup 9 (Post Workgroup Consultation) – Review / assess Workgroup consultation responses and Workgroup Report.	28 February 2023		

Review of Actions Log

Banke John-Okwesa – ESO Code Administrator

Actions Log

Action Number	Workgroup raised	Owner	Action	Comment	Due by	Status
16	WG	All	Workgroup members to respond to NGESO Questionnaire to determine plan for additional requirements		5th August	Closed
17	WG4	BA/FW	Consolidate comments received, check those requirements that can/cannot be included and provide update.		15th August 2022	Closed
18	WG4	BA	Reach out to manufacturers to get their views	Remained open and an ask for WG members to reach out to manufacturers also		Open
19	WG5	FG	To share updated slides with the workgroup from the presentation today			Complete
20	WG5	PM	To send the material to NGESO providing details on convertor manufacturer specifications		ASAP	Complete
21	WG5	IG/BA	To meet offline to support with providing contacts of convertor manufacturers		ASAP	Open
22	WG5	All	To provide NGESO with clear articulation with examples of the TOV issues		ASAP	Open
23	WG5	All	For the workgroup to share with BJO to collate any evidence or examples they have on research work on TOVs to help support NGESO work and develop the modification solution		ASAP	Open
24	WG5	FN	To share some technical questions for the Workgroup to deliberate and discuss		7th Sept	Complete
25	WG4	AL	Creation of Strawman on vector shift requirements for the workgroup to review			Open

ESO Updates

FRT Temporary Overvoltage Requirement Withstand Voltage

Bieshoy Awad - NGESO

nationalgridESO

FRT Temporary Overvoltage Requirement
Withstand Voltage

Topics for discussion

- Two main topics for consideration when setting requirement for fault ride through (FTR)
  - Temporary overvoltage withstand capability of equipment
  - Power electronic (PE) equipment performance during and after an event
- In relation to FTR, event here is defined as balance and unbalance faults

Withstand capability for equipment

- GB Grid Code CC.6.2.1.1 defines earth fault factor for 132 kV and above
  - For England and Wales, EFF is 1.4 or less
  - For Scotland, EFF is 1.5 or less
- The above means the voltage on healthy phases during single and double phase to earth faults may reach 1.4 pu and 1.5 pu respectively in E&W and Scotland
- TS 1 and other equipment technical specifications require withstand capability at 1.5 pu or higher voltage levels for certain time, e.g. 60 s

Proposal for setting the expected TOV level

- For 400 kV and 275 kV, TOVs (rms level) are expected to reach 1.4 pu based on 420 kV and 300 kV respectively for 400 and 275 kV
- TGN 288 envelope for rms of voltage is proposed to be considered
- Users may expect this voltage from the system and users shall not cause the system voltage to exceed it

Questions please

Fault Ride Through Requirements

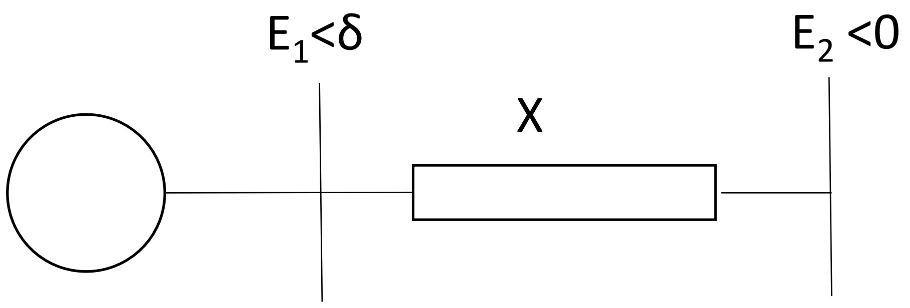
Why Low Voltage Limits

- Ability of a Generating Unit to inject active power into a system is dependent on the voltage of that system.

- A significant drop in voltage means that a Generating Unit will not be able to deliver its full output for that period.

- As the mechanical input for the Generating Unit is unlikely to change fast enough, the power imbalance will
  - Cause the rotor of a synchronous machine to accelerate
  - Cause a rise in the DC link voltage in a wind turbine to rise

- If persists for a long period of time, a low voltage is likely to cause
  - Pole slipping for synchronous machines
  - Excessive heating for the DC link chopper resistor



$$P = \frac{E_1 E_2}{X} \sin \delta$$

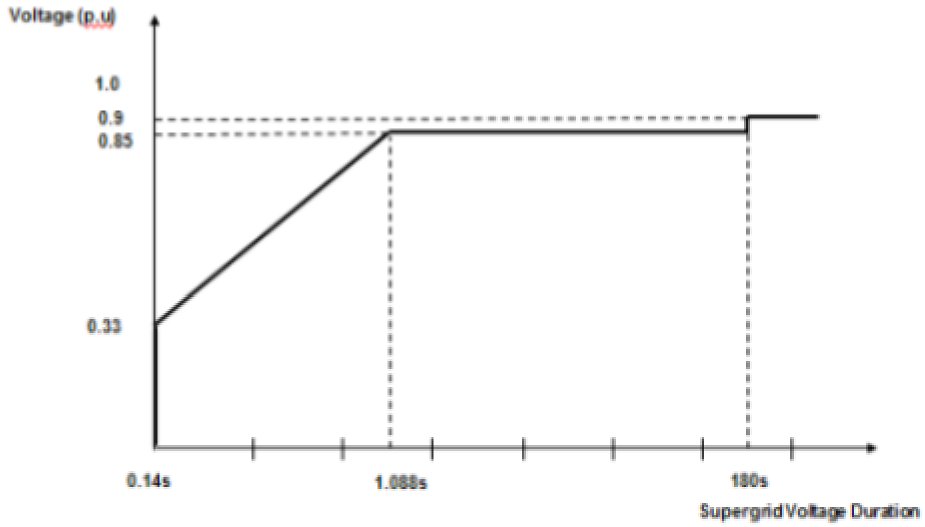


Figure 5a

Fault Ride Through Requirements

The requirements apply for all voltages above 1pu.

CC.6.3.15.1 1b) i) remain transiently stable and connected to the System without tripping of any Synchronous Generating Unit for balanced Supergrid Voltage dips and associated durations on the Onshore Transmission System (which could be at the Interface Point) anywhere on or above the heavy black line shown in Figure 5a. Appendix 4A and Figures CC.A.4A.3.2 (a), (b) and (c) provide an explanation and illustrations of Figure 5a; and,

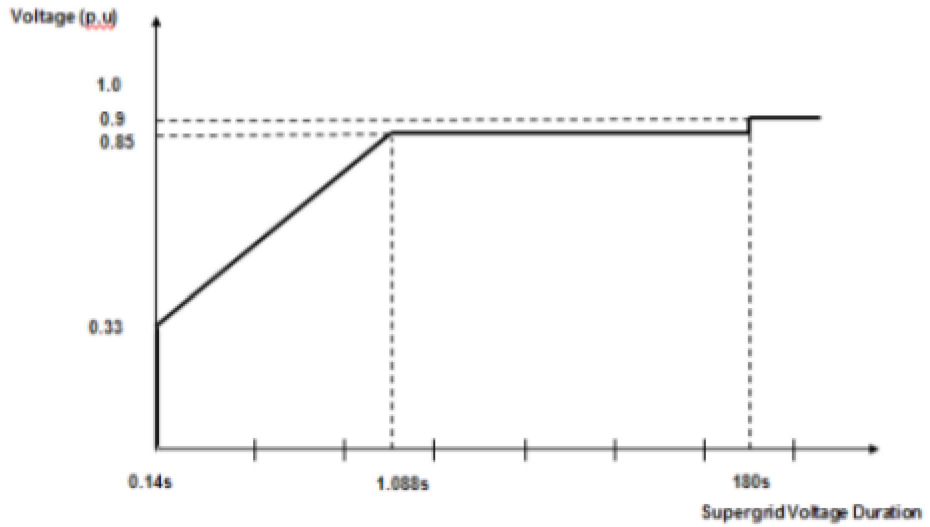


Figure 5a

Fault Ride Through Requirements

Why No High Voltage Limits (yet)

- For synchronous machines,
  - increased voltage enhances the synchronising torque coefficient and makes the machine less likely to pole-slip.
  - The PSS is likely to deal with issues associated with the reduced damping torque coefficient

- For wind turbines
  - There has been no clear articulation of what the issues that they will encounter are due to a high and extended Temporary Overvoltage.
  - Papers shared so far do not explain the risks but offer solutions to the issue through windfarm control systems.

- Transmission plant are rated to a much higher voltage

- User's Plant are rated to deal with an earth fault factor of 1.4pu (E&W) and 1.5pu (Scotland)
- User's Plant are also expected to ride through earth faults where voltages could rise as high as 1.4pu.

Fault Ride Through Requirements

Interactions with Frequency Management

- Any Generating Unit/Power Park Module should only trip if its disconnection is required to clear a fault.
- Reactive current injection during a fault supports the system voltage and contributes towards voltage recovery. This reduces the risk of further generation tripping.
- If additional generation is likely to trip, and provided that this additional loss increased the unbalance beyond the frequency response available on the system, is likely to trigger Low Frequency Demand Disconnection.
- For this risk to be managed, NGESO will have to
    - Identify the risk in real time

      ➔ The resource and timescales required to allow for EMT simulations for all secured events are prohibitive
    - Procure frequency response to manage it.

      ➔ The costs associated with securing simultaneous events were found to be prohibitive (FRCR 2021 for BMU+VS events and FRCR 2022 for 2 simultaneous BMU events)

Temporary Overvoltage

Step 1- Agree ceiling

A limit on TOV will need to be defined – potentially as new clause CC.6.1.11.

This limit will need to be guaranteed by design.
The limits used in TGN 288 are

- consistent with that used by other TOs
- consistent with what we think the minimum capabilities of the Users' plant are

NGESO proposes to use TGN 288 limits

Users will be required to ensure they don't increase TOV beyond the limit.

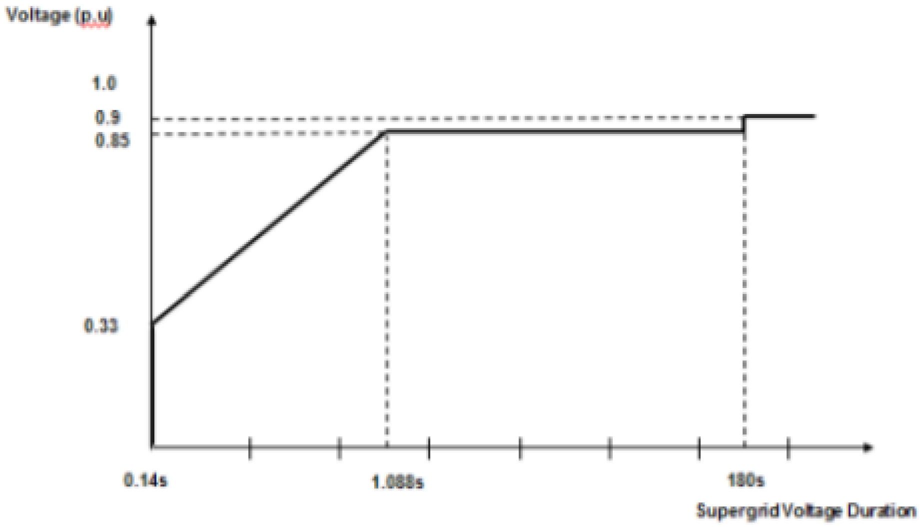


Figure 5a

Temporary Overvoltage

Step 2- Review other related plant performance requirements and fault ride through the requirements.

To understand how the plant is

- going to respond to Temporary Overvoltage events
- Will not exacerbate any such an event

Workgroup Discussions

All

HVRT Studies

There are 5 key points highlighted through the work done by wider industry

1. The converters do not inherently have HVRT capability, this needs to be built in to them which comes at a cost. Even with that, there is a overvoltage limit that converters can sustain it comes down to their reactive power capability.
2. Converters can be tuned over time to better sustain overvoltage and phase jumps. However, they need to be designed at the 1st place do so, and also then because of point 1 there is an upper limit to what it can sustain. Currently from market review, most converters can do 1.2-1.3 pu HVRT and 30-40 degrees in phase jump capability.
3. Phase jump is dangerous to stable operation of PLLs. Where possible, these should be avoided altogether on the grid.
4. It is important for industry to be proactive about Grid Code changes as what we install today needs to be fit for purpose for next 15-20 years. I.e. Study of system interactions and dynamic modelling is key in identifying key grid characteristics that generators will need to ride through in future.
5. Incentivising Grid Forming converters at right nodes will contribute to voltage stiffness at various parts of the network. Developers who install Grid Forming technologies should be incentivised for improving the overall stability of the grid.

Technical Questions for OEMs

1) What are they main steps taken by converter OEMs when designing a converter to connect at a particular location? In particular how do the pre-fault and post-fault fault levels feed into the design process?
2) When a converter is designed for a particular set of network fault levels (pre-fault and post-fault), is an assumption being made that this fault current is being provided by a certain proportion of grid-forming voltage sources (rather than other grid-following converters acting as current sources)?
3) If the above is yes, when NGESO operates the network in such a manner which invalidates the above assumption (i.e. allows the network fault levels to go below that which fed into the original design process for many users, either in terms of absolute fault level MVA, or in terms of the proportion supplied by grid forming voltage sources), how does this affect the converter's fault ride through capability (both low-voltage and high-voltage)? And VS-withstand capability?
4) Under what set of conditions, typically, is the converter FRT capability affected to the point that disconnection / de-loading becomes much more likely?
5) In terms of retrospective modifications, what steps would have to be taken to reinstate frt performance for a much lower fault level? What defines the limit of what is possible with existing hardware/software?
6) Presumably any proposed modification to the fast fault current injection requirement (in order to counteract voltage rise on fault recovery caused by the existing ffc injection requirement) would apply on a forward-looking basis only.
   a. Does this introduce a risk of control system interactions between ‘original’ and ‘modified’ controllers?
   b. What steps would OEMs have to take in order to retrofit this modified control strategy onto existing sites?

Terms of Reference

Banke John-Okwesa – ESO Code Administrator

GC0155 – Terms of Reference

Workgroup Term of Reference	Location in Workgroup Report
a) Implementation and costs;	
b) Review draft legal text should it have been provided. If legal text is not submitted within the Grid Code Modification Proposal the Workgroup should be instructed to assist in the developing of the legal text; and	
c) Consider whether any further Industry experts or stakeholders should be invited to participate within the Workgroup to ensure that all potentially affected stakeholders have the opportunity to be represented in the Workgroup. Demonstrate what has been done to cover this clearly in the report	
d) Consider Electricity Balancing Regulation (EBR) implications	
e) Minor changes and clarifications to the existing Grid Code Fault Ride Through (FRT) requirements specifically but not limited to consideration of the following areas: i. Clarify instances where User plant is required to trip in order to clear transmission system faults ii. Amending requirements for generating maximum reactive current during faults where these may be unachievable for some generators iii. Amending post-fault active power requirements to consider whether generators at low load may have greater levels of oscillation than permitted iv. To consider clarifying and or defining requirements for over-voltage following a fault	
f) Identify and address any cross code impacts on other codes especially Distribution Code (e.g. G99 requirements)	**TBC**

AOB & Next Steps

Banke John-Okwesa – ESO Code Administrator