nationalgrid

Stage 02: Workgroup Report

Joint Grid Code and Distribution Code Report

GC0110: LFSM-O compliance requirements for Type As and B PGMs

What stage is this document at?

01	Modification Proposal
02	Workgroup Report
03	Code Admin Consultation
04	Draft Self-Governance Report
05	Final self-Governance Report

Purpose of Modification: To update the Grid Code and G99 with revised text for *limited frequency sensitive mode- over-frequency* compliance so that manufacturers have clear pass/fail criteria for limited frequency sensitive mode-over-frequency compliance.

This document contains the discussion of the Workgroup which formed in June 2018 to develop and assess the proposal, the voting of the Workgroup held on 18 June 2018 and the Workgroup's final conclusions. The Workgroup concluded that GC0110 should be implemented as it better facilitates the Grid Code objectives.

High Impact: *Manufacturers, installers and owners of Type A and B power generating modules connected to both distribution and transmission systems*

Medium Impact: *DNOs*

Low Impact: *None*

Contents

Timetable

Workgroup Meeting 1	6 June 2018
Workgroup Meeting 2	18 June 2018
Workgroup Report submitted/presented to Panel	20 June/28 June 2018
Code Administration Consultation Report issued to the Industry/closes	06 July 2018/29 July 2018
Draft Modification Self-Governance Report presented to Panel/Industry	07 August 2018
Grid Code Panel Determination Vote	15 August 2018
Final Modification Self-Governance Report published	16 August 2018
Appeal window opens/closes	16 August 2018/7 September 2018
Decision implemented in Grid Code (10 WDs following closure of appeal window)	21 September 2018

Any Questions?

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1 About this document

This report contains the discussion of the Workgroup which formed in June 2018 to develop and assess the proposal.

Section 2 (Original Proposal) and Section 4 (Proposer's solution) are sourced directly from the Proposer and any statements or assertions have not been altered or substantiated/supported or refuted by the Workgroup. Section 5 of the Workgroup contains the discussion by the Workgroup on the Proposal and the potential solution.

The Grid Code Panel detailed in the Terms of Reference the scope of work for the GC0110 Workgroup and the specific areas that the Workgroup should consider.

The table below details these specific areas and where the Workgroup have covered them within the Workgroup Report.

The full Terms of Reference can be found in Annex 1.

Table 1: GC0110 Terms of Reference

Specific Area	Location in the report
a) *Implementation and costs;*	Section 10
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*	Annex 2 and 3
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*	Section 5
d) *Consider materiality of change*	Section 5
e) *Workgroup consultation and whether required*	Section 5

Table 2: Acronym Table

Acronym	Meaning
FSM	Frequency Sensitive Mode
LFSM-O	Limited frequency sensitive mode - over-frequency
PGM	Power Generating Modules
RfG	Network code on Requirements for Grid Connection of Generators - Commission Regulation (EU) 2016/631

2 Original Proposal presented to Grid Code Review Panel

Defect

The Grid Code legal text proposed to be implemented as part of GC0102 introduces new specific limited frequency sensitive mode - over-frequency requirements for all Type A and B generators. This is a new requirement for all distribution connected generation, and also a new limitation of frequency sensitive mode requirements for transmission connected smaller (ie Type A and B) generation.

What

The specification and testing requirements for Type A and B limited frequency sensitive mode- over-frequency need to be clarified – and this clarification fed into G99 which also need to be updated to reflect this.

Why

Manufacturers of Type A and B power generating modules (PGM) need clarity on the limited frequency sensitive mode- over-frequency requirements so that they can ensure compliance at the point of manufacture. For reciprocating gas engines in the Type B size range the performance requirements are onerous. Although not a mass market product, these are nevertheless turned out in significant numbers and it is not appropriate or efficient to have a dialogue in every instance when a Type B PGM is commissioned.

How

The Grid Code and EREC G99 will need to be modified post clarification of the compliance requirements.

Why Change?

In the development of GC0102 and the associated EREC G99 documentation, the existing Grid Code requirements were identified as being RfG compliant and appropriate to retain in GB. However the application of limited frequency sensitive mode- over-frequency to distribution connected generation as small as Type A & B is completely new. Also, as well as being new, it has not been the practice that limited frequency sensitive mode- over-frequency is provided in isolation from frequency sensitive mode. Hence the historic approach to assessing limited frequency sensitive mode- over-frequency has been as part of a wider assessment of frequency sensitive mode.

The current Grid Code drafting includes phrases such as “as much as possible” and only indicative performance requirements. The proposer accepts that such drafting prompts appropriate discussions regarding performance with Generators on a case by case basis for Large Power Stations. However it is not appropriate for manufacturers making many-off common products such as Type A & B power generating modules, where a prescriptive pass/fail criterion for compliance is required.

Code Specific Matters

- Familiarity with current Grid Code requirement.
- Understanding of the practical issues associated with frequency following performance of generating modules, particularly synchronous, in the Type A & B size range.
- Familiarity with the performance characteristics of smaller asynchronous generating units.

Reference Documents

GC0102 Grid Code modification
EREC G99

3 Governance

Proposed Governance:

Joint work with the DCRP

As many of the PGMs affected by these requirements will be connected to the Distribution Network it is appropriate that this is a joint Workgroup, carrying on the approach taken in drafting EREC G99, whereby it is National Grid’s responsibility under the RfG to specify these parameters, but their implementation needs to be jointly agreed between transmission and distribution.

Although this is unlikely to be a contentious modification as the intent is only to clarify the exact requirements, it is expected that there will be high degree of interest in ensuring that the proposed revised text is both clear and does not inadvertently impose new requirements on Users.

Requested Next Steps

This modification should:

- Progress as Self-Governance
- be assessed quickly by a Workgroup with a view to an imminent Code Administrator consultation ahead of Panel Determination

Self-Governance - This modification *is unlikely to discriminate between different classes of Grid Code Parties and is unlikely to have a material effect on:*

i) Existing or future electricity customers;

ii) Competition in the generation, distribution, or supply of electricity or any commercial activities connected with the generation, distribution or supply of electricity,

iii) The operation of the National Electricity Transmission System

iv) Matters relating to sustainable development, safety or security of supply, or the management of market or network emergencies

v) The Grid Code's governance procedures or the Grid Code's modification procedures

Panel decision on Governance following presentation of Proposal on 26 April 2018

GC0110 was presented to the Grid Code Panel on the 26 April 2018. The Panel determined that the modification met the Self-Governance Criteria and that the modification should be assessed by a Joint Workgroup with the Distribution Code.

4 Proposers Solution

Currently in GB Article 13.2 of the Requirements for Generators sets out the requirement for Limited Frequency Sensitive Mode – Over (LFSM-O) which in GB has been detailed the Grid Code section ECC.6.3.7.1.

The LFSM-O trigger frequency has been set at 50.4Hz across the GB synchronous area in ECC.6.3.7.1.1. This requirement applies to all Type A-D Power Generating Modules regardless of their connection point and so applies equally to transmission and distribution connected plant.

Within GB the maximum permissible frequency ahead of Generators being permitted to take independent action is 52Hz, which gives maximum controllable frequency deviation of 52.0 – 50.4 = 1.6Hz.

For LFSM-O the minimum steady state frequency response requirement is set in ECC.6.3.7.1.2(i) at 2% / 0.1Hz (ie 10% droop) with table 1 column 3 showing the minimum steady state response values for incremental deviations in frequency over the frequency range. This also shows for the maximum frequency deviation of 1.6Hz, a 10% droop would represent a 32% steady state output reduction. Any controlled steady state response in excess of the 32% minimum reduction is acceptable.

Frequency (Hz)	**Frequency Deviation above 50.4Hz**	**Minimum acceptable steady state response as a % of maximum generation**	**50% of steady state response in 10s capped at 5% as a % of maximum generation**
50.4	0	0%	0
50.5	0.1	2%	1%
50.6	0.2	4%	2%
50.7	0.3	6%	3%
50.8	0.4	8%	4%
50.9	0.5	10%	5%
51.0	0.6	12%	5%
51.1	0.7	14%	5%
51.2	0.8	16%	5%
51.3	0.9	18%	5%
51.4	1.0	20%	5%
51.5	1.1	22%	5%
51.6	1.2	24%	5%
51.7	1.3	26%	5%
51.8	1.4	28%	5%
51.9	1.5	30%	5%
52.0	1.6	32%	5%

Table 1 – Detailing the minimum responses for different frequency deviations

Whilst it might appear that the requirement is clearly defined the difficulty occurs in that it is not clear how quickly the steady state response needs to be delivered and the current Grid Code requirement in ECC.6.3.7.1.2.(iii) has the vague statement “of as much as possible of the reduction in 10 seconds”, hence further consideration is required as follows.

The current GB Grid Code requires as much as possible of the steady state deviation to be achieved in 10 seconds but offers no further guidance on what represents an acceptable level for this. In addition, there is no indication of an acceptable delivery time for the full droop response. In lay terms, “as much as possible”, could sensibly be interpreted as a delivery at least in excess of 50% of the total.

Automatic frequency control is managed by the operation of a governor or frequency control device. In GB, FSM plant is required to achieve a minimum response standard of 10% of its maximum output capability delivered in 10 seconds in response to falling or rising frequency of +/-0.5Hz.

The LFSM-O requirement also seeks automatic action in response to high frequency in excess of 50.4Hz. In managing a high frequency event, it therefore makes sense that in this mode, a similar response capability should be sought as a measure of “as much as possible” for the largest deviations in frequency. However as the minimum acceptable droop is 10% and therefore the steady state response expectation is half that of FSM mode (frequency response droop is between 3-5%) it makes some sense to seek a minimum standard of 5% response in 10 seconds for the LFSM-O plant.

Therefore interpreting “as much as possible” of the change in 10 seconds National Grid, suggests a value of 50% of the steady state change is achieved in 10 seconds but noting that the requirement continues for larger frequency this should be capped at a maximum of 5% of maximum output as an acceptable level of a fast acting contribution. The proposed values of the minimum response to a frequency change in 10 second are given in the fourth column of table 1.

There is one other requirement in the Grid Code relating to LFSM-O which is in ECC6.3.7.1.2(ii) – where the response requires to be continuous and linear unless it can be reasonably demonstrated to not be technically possible.

Applying the linear and proportional principle to the proposed minimum response to frequency change in 10 seconds to active deviations of 0.2Hz, 0.5Hz & 1.6Hz for LFSM-O gives a view of minimum acceptable responses as follows in table 2:

Time	Frequency Deviation		
	ΔF = 0.2Hz (50.6Hz)	ΔF = 0.5Hz (50.9Hz)	ΔF = 1.6Hz (52Hz)
10s	2% of max output	5% of max output	5% of max output
20s	4% of max output	10% of max output	10% of max output
30s	4% of max output	10% of max output	15% of max output
40s	4% of max output	10% of max output	20% of max output
50s	4% of max output	10% of max output	25% of max output
60s	4% of max output	10% of max output	30% of max output
64s	4% of max output	10% of max output	32% of max output

Table 2 – Detailing the minimum responses against time for different frequency deviations

This is indicated graphically for an injection of a +2.0Hz step (as a 1 second ramp) in figures 1 & 2 and for an injection of a +0.6Hz ramp in figures 3 & 4. On the graphs the blue line indicates the injected frequency with the green line

showing the calculated minimum steady state response position in relation to the frequency deviation. The boundary of acceptable minimum response against time calculated in line with the methodology set out above is shown by the red dashed line. The difference between the orange and red lines indicates the permitted two second delay in for the initial measureable response but it is important to note that at the end of the time period (ie at 10 seconds) both the red and orange lines converge to the same point. For the avoidance of doubt any response which is on or below the red line is acceptable.

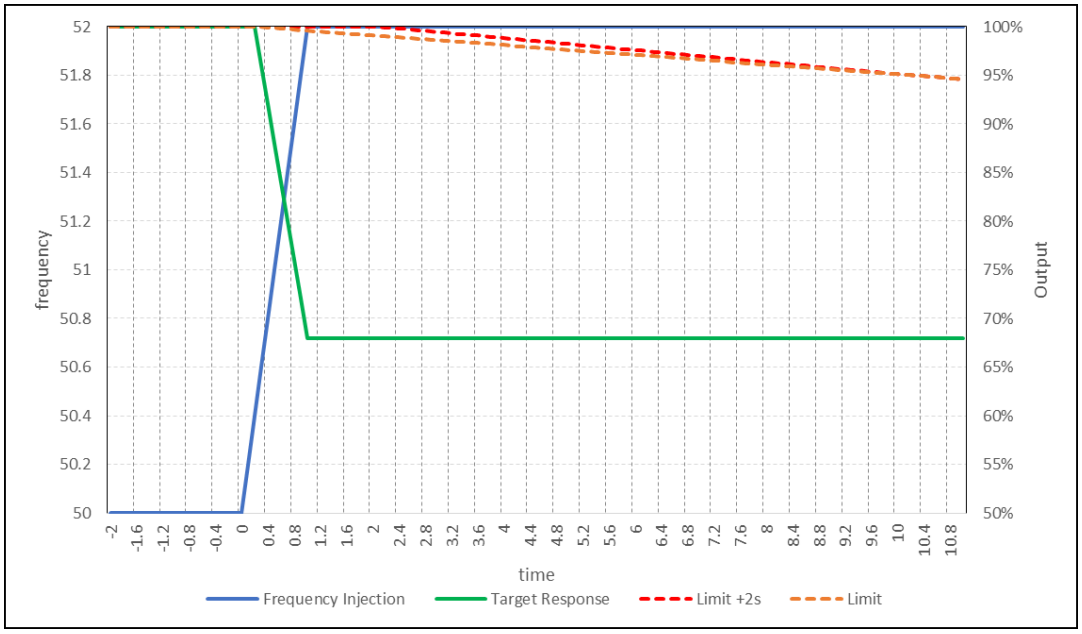

Figure 1 - +2.0Hz injection with 10% droop setting (initial response)

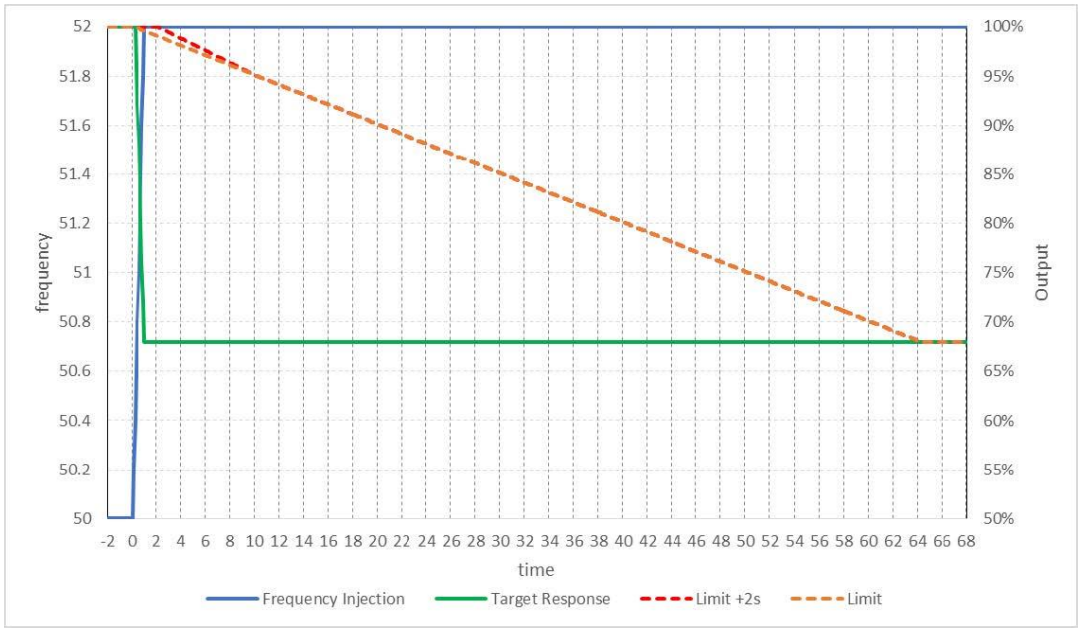

Figure 2 - +2.0Hz injection with 10% droop setting (whole response)

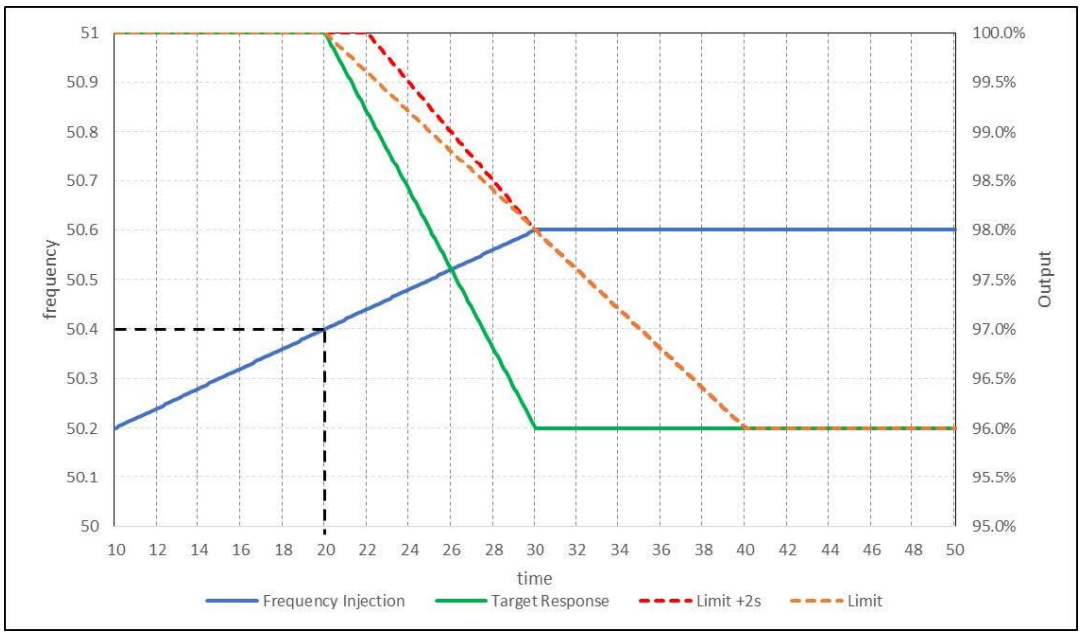

Figure 3 - +0.6Hz injection with 10% droop setting (initial response)

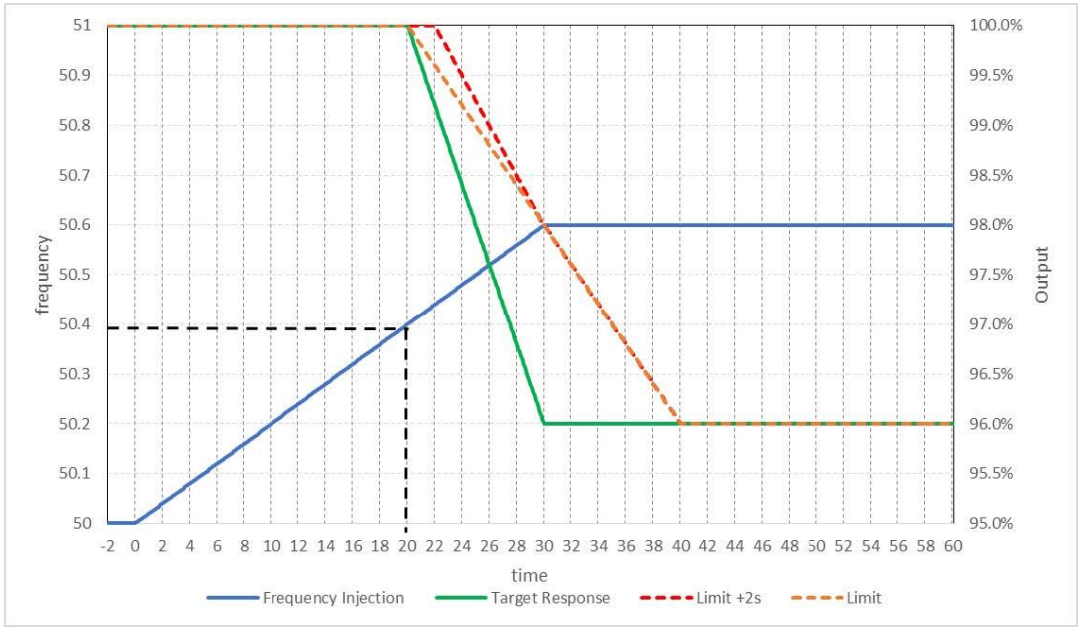

Figure 4 - +0.6Hz injection with 10% droop setting (whole response)

The requirements for Types A & B generators (as specified in ECC 6.3.7.1, in EREC G99 A.7.1.3, A7.2.4, B.5.6, B.6.6) have been updated as per the above principles and are detailed in Annex 2, with Annex 3 giving the G99 changes.

Final legal text for ECC 6.3.7.1 and G99 is included with this Workgroup Report.

5 Workgroup discussions and vote

The Workgroup met on 6 June 2018. Following discussion, the Workgroup supported the legal text (with one amendment), and agreed that the Workgroup Report should be submitted to the Grid Code Panel without a Workgroup Consultation to be approved and issued to Code Administrator Consultation.

Within the Work group it was queried wither the system frequency had ever risen above the LFSM-O trigger frequency of 50.4 Hz in GB other than in local islands

and it is not believed this has occurred within the last 20 years with the maximum frequency being 50.397Hz. Hence to date LFSM-O has never been required to deliver response in GB

The Work group also discussed wither the permitted 2 second delay in starting to respond to a frequency change should be allowed to apply after the 10 second activation period and hence change the red lines in figures 1,2,3 and 4 to be parallel to the orange line and not coincide after 10 second. After discussion it was agreed the current interpretation with the lines coinciding after 20 seconds as per the proposal is acceptable.

A discussion also took place as to whether this current proposal which is only limited to type A and B PGMs should be applied to all PGMs (i.e. type A, B, C and D). It was felt as type C and D response capabilities are already tested more vigorously with the FSM requirements they should easily meet the LRSM-O requirements and there was no benefit in adding this requirement to them. However, a Workgroup member noted that some of the obligations in Article 13 of RfG, for Type A PGMs, do flow through to Type B, C and D PGMs.

It was agreed to modify the legal text of ECC 6.3.7.2(iii) to make it clear that if a generating module needed to make use of the provision in Article 13.2(e) whereby the initial response could be delayed by more than 2 second, then it would be for the generator also to justify what the overall response would be and how much would be delivered in 10 second, as opposed to having to ensure that the overall response was not unduly arduous in meeting the 10 second requirement in 6.3.7.2(v). This modification to 6.3.7.2(iii) is included in Annex 2.

It was also noted that there risks to overall harmonization if the drafting of the Grid Code and G99 are not word-for-word identical. Whilst accepting this point and the theoretical risk the majority of the Workgroup were content that ensuring the requirements were identical, irrespective of the exact wording used, was the key objective and that the proposed drafting was adequate in this respect.

The Workgroup reviewed the efforts taken by the Code Administrators to ensure that affected parties were aware of the proposed revisions. The Code Administrators explained that apart from the normal circulation lists in use, the modification had also been brought to the attention of the VSM expert group currently meeting. The G99 consultation and workshops held between October and February had also extended the Distribution Code Administrator's circulation list, picking up a number of manufacturers of smaller generation equipment who had not previously been registered on the D Code mailing list. A small number of these who make inverters for Type A and B modules had been contacted directly to appraise them of the GC0110 work. The Workgroup did not identify any obvious additional publication of GC0110 that should be undertaken outside of the normal consultation process.

The Workgroup also discussed the materiality of the changes. It had been demonstrated to the Workgroup by National Grid that existing larger synchronous machines, and a variety of inverter connected generation would have no trouble meeting the newly defined LFSM-O timings (largely because they also have to meet the more onerous FSM requirements too). Representatives of

manufacturers of smaller synchronous generation in the Workgroup confirmed that they thought the proposed interpretation would have no effect on their current designs, i.e. there is no material effect on costs etc.

No potential alternatives were proposed as part of the Workgroup phase.

A presentation was also given by National Grid at the initial Workgroup meeting along with a paper that was circulated, these can be found in Annex 5 and add context to the discussions held.

Workgroup Vote

The Workgroup convened on the 18 June 2018 to carry out the Workgroup Vote. The details of this can be found below:

Vote 1 – *does the original or WACM facilitate the objectives better than the Baseline?*

Vote recording guidelines:
"Y" = Yes
"N" = No
"-" = Neutral

Workgroup Member	Better facilitates GCO (i)	Better facilitates GCO (ii)?	Better facilitates GCO (iii)?	Better facilitates GCO (iv)?	Better facilitates GCO (v)?	Overall (Y/N)
Chris Marsland						
Original	Y	Y	Y	Y	-	Y
Voting Statement: This modification better facilitates smaller A/B generators and their manufacturers to meet the requirements of LFSM-O and ensures a level playing field for all manufacturers.						
Simon Sheridan						
Original	Y	Y	Y	-	-	Y
Voting Statement: The mod proposal facilitates smaller type A/B generators and associated manufacturers of equipment to meet the requirements for LFSM-O and does not affect larger type C/D generators and what is already expected of them.						
Garth Graham						
Original	-	Y	-	Y	-	Y
Voting Statement: This modification makes LFSM-O requirements clearer to type A & B generators.						
Gregory Middleton						
Original	Y	Y	Y	-	-	Y
Voting Statement: This mod clears up ambiguities in the current wording ensuring a level playing field for equipment manufacturers.						
Alastair Frew						
Original	-	Y	-	Y	-	Y
Voting Statement: This modification makes LFSM-O requirements clearer to type A & B generators.						

David Saez/Sigrid Bolik						
Original	Y	-	Y	Y	-	Y
Voting Statement: Increasing the clarity of the requirement should allow generators to develop appropriate compliant functionality.						
Mike Kay						
Original	Y	Y	Y	Y	-	Y
Voting Statement: The modification is needed to ensure manufacturers can produce modules that are clearly demonstrably compliant with the LFSM-O requirements.						

<u>Vote 2</u> – *Which option is the best? (please enter either Baseline (Grid Code today) or Original solution)*

Workgroup Member	BEST Option?
Chris Marsland	**Original solution**
Simon Sheridan	**Original solution**
Garth Graham	**Original solution**
Gregory Middleton	**Original solution**
Alastair Frew	**Original solution**
David Saez/Sigrid Bolik	**Original solution**
Mike Kay	**Original solution**

The Workgroup concluded that GC0110 better facilitated the Grid Code Objectives and should be implemented. They also agreed that they had met their Terms of Reference and that the Workgroup Report should be issued to the Grid Code Review Panel for their approval to proceed to Code Administrator Consultation.

6 Impacts and Other Considerations

The key documents affected by this modification proposal are the Grid Code and EREC G99. There are no other effects on other industry documents.

Does this modification impact a Significant Code Review (SCR) or other significant industry change projects, if so, how?

No

Consumer Impacts

There are no consumer impacts.

7 Relevant Objectives – Proposers assessment

Impact of the modification on the Relevant Objectives:	
Grid Code Relevant Objectives	**Identified impact**

To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity	**Positive**
To facilitate competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity)	**Positive**
Subject to sub-paragraphs (i) and (ii), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national electricity transmission system operator area taken as a whole	**Neutral**
To efficiently discharge the obligations imposed upon the licensee by this license and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency; and	**Positive**
to promote efficiency in the implementation and administration of the Grid Code arrangement mote efficiency in the implementation and administration of the Grid Code arrangements	**Neutral**
Distribution Code Relevant Objectives	
Permit the development, maintenance, and operation of an efficient, coordinated and economical System for the distribution of electricity.	**Neutral**
Facilitate competition in the generation and supply of electricity.	**Neutral**
Efficiently discharge the obligations imposed upon DNOs by the Distribution Licence and comply with the Regulation (where Regulation has the meaning defined in the Distribution Licence) and any relevant legally binding decision of the European Commission and/or Agency for the Co-operation of Energy Regulators.	**Positive**
Promote efficiency in the implementation and administration of the Distribution Code	**Neutral**

Proposers view:

This change will dispel any confusion over what compliance with limited frequency sensitive mode- over-frequency means for Type A and B power generating modules and how it is to be demonstrated. This will help GB stakeholders comply efficiently with the RfG requirements.

8 Implementation

Original Proposal:

This modification needs to be progress without delay so that manufacturers gearing up for producing compliant equipment by the May 2019 deadline, have sufficient time to design and implement solutions. The date of implementation is proposed as ten Working Days after the end of the Self-Governance Appeal Window period.

Following Workgroup discussions:

This Workgroup Report will be issued to the Grid Code Panel for their approval to be issued to Code Administrator Consultation, following this the Grid Code Self-Governance Vote will take place and the modification will be implemented on the 21 September 2018 subject to any appeals being received following the Panel vote.

Annex 1: Terms of Reference

nationalgrid

Workgroup Terms of Reference and Membership

TERMS OF REFERENCE FOR GC0110 WORKGROUP

To update the Grid Code and G99 with revised text for *limited frequency sensitive mode- over frequency* compliance so that manufacturers have clear pass/fail criteria for limited frequency sensitive mode- over frequency compliance.

Responsibilities

1. The Workgroup is responsible for assisting the Grid Code Review Panel in the evaluation of Grid Code Modification Proposal **GC0110 LFSM-O compliance requirements for Type B PGMs** proposed by Chris Marsland of Centrica PB Limited in April 2018 and presented to the Grid Code Review Panel on 26 April 2018.

2. The proposal must be evaluated to consider whether it better facilitates achievement of the Grid Code Objectives. These can be summarised as follows:

   (i) To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity;

   (ii) To facilitate competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity);

   (iii) Subject to sub-paragraphs (i) and (ii), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national; and

   (iv) To efficiently discharge the obligations imposed upon the licensee by this license and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency. In conducting its business, the Workgroup will at all times endeavour to operate in a manner that is consistent with the Code Administration Code of Practice principles.

   (v) To promote efficiency in the implementation and administration of the Grid Code arrangements.

Scope

3. The Workgroup must consider the issues raised by the Modification Proposal and consider if the proposal identified better facilitates achievement of the Grid Code Objectives.

4. In addition to the overriding requirement of point 3 above, the Workgroup shall consider and report on the following specific issues:

   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 materiality of change*
e) *Workgroup consultation and whether required*

5. As per Grid Code GR20.8 (a) and (b) the Workgroup should seek clarification and guidance from the Grid Code Review Panel when appropriate and required.

6. The Workgroup is responsible for the formulation and evaluation of any Workgroup Alternative Grid Code Modifications arising from Group discussions which would, as compared with the Modification Proposal or the current version of the Grid Code, better facilitate achieving the Grid Code Objectives in relation to the issue or defect identified.

7. The Workgroup should become conversant with the definition of Workgroup Alternative Grid Code Modification which appears in the Governance Rules of the Grid Code. The definition entitles the Group and/or an individual member of the Workgroup to put forward a Workgroup Alternative Code Modification proposal if the member(s) genuinely believes the alternative proposal compared with the Modification Proposal or the current version of the Grid Code better facilitates the Grid Code objectives The extent of the support for the Modification Proposal or any Workgroup Alternative Modification (WACM) proposal WACM arising from the Workgroup's discussions should be clearly described in the final Workgroup Report to the Grid Code Review Panel.

8. Workgroup members should be mindful of efficiency and propose the fewest number of WACM proposals as possible. All new alternative proposals need to be proposed using the Alternative request Proposal form ensuring a reliable source of information for the Workgroup, Panel, Industry participants and the Authority.

9. All WACM proposals should include the Proposer(s)'s details within the final Workgroup report, for the avoidance of doubt this includes WACM proposals which are proposed by the entire Workgroup or subset of members.

10. There is an option for the Workgroup to undertake a period of Consultation in accordance with Grid Code GR. 20.11, if defined within the timetable agreed by the Grid Code Panel. Should the Workgroup determine that they see the benefit in a Workgroup Consultation being issued they can recommend this to the Grid Code Review Panel to consider.

11. Following the Consultation period the Workgroup is required to consider all responses including any Workgroup Consultation Alternative Requests. In undertaking an assessment of any Workgroup Consultation Alternative Request, the Workgroup should consider whether it better facilitates the Grid Code Objectives than the current version of the Grid Code.

12. As appropriate, the Workgroup will be required to undertake any further analysis and update the appropriate sections of the original Modification Proposal and/or WACM proposals (Workgroup members cannot amend the original text submitted by the Proposer of the modification) All responses including any Workgroup Consultation Alternative Requests shall be included within the final report including a summary of the Workgroup's deliberations and conclusions. The report should make it clear where and why the Workgroup chairman has exercised their right under the Grid Code to progress a Workgroup Consultation Alternative Request or a WACM proposal against the majority views of Workgroup members. It should also be explicitly stated where, under these circumstances, the Workgroup chairman is employed by the same organisation who submitted the Workgroup Consultation Alternative Request.

13. The Workgroup is to submit its final report to the Modifications Panel Secretary on 19 September 2018 for circulation to Panel Members. The final report conclusions will be presented to the Grid Code Review Panel meeting on 27 September 2018

Membership

It is recommended that the Workgroup has the following members:

Role	Name	Representing (User nominated)
Chair & Technical Secretary	Chrissie Brown	Code Administrator
National Grid Representative*	Simon Sheridan	National Grid Electricity Transmission
Workgroup Member*	Gregory Middleton	Deep Sea Electronics plc
Workgroup Member*	Garth Graham	SSE
Workgroup Member*	Rui Rui	Scottish Power Renewables
Workgroup Member*	Sigrid Bolik	Senvion
Workgroup Member*	Alastair Frew	Scottish Power Generation
Workgroup Member*	Mike Kay	Electricity North West
Authority Representative	None provided to date	
Observer	Ian Wassman	Industrial Power Units Ltd

14. A (*) Workgroup must comprise at least 5 members (who may be Panel Members). The roles identified with an asterisk (*) in the table above contribute toward the required quorum, determined in accordance with paragraph 15 below.

15. The Grid Code Review Panel must agree a number that will be quorum for each Workgroup meeting. The agreed figure for GC0110 is that at least 5 Workgroup members must participate in a meeting for quorum to be met.

16. A vote is to take place by all eligible Workgroup members on the Modification Proposal and each WACM proposal and Workgroup Consultation Alternative Request based on their assessment of the Proposal(s) against the Grid Code objectives when compared against the current Grid Code baseline.

    - Do you support the Original or any of the alternative Proposals?
    - Which of the Proposals best facilitates the Grid Code Objectives?

    The Workgroup chairman shall not have a vote, casting or otherwise.

    The results from the vote and the reasons for such voting shall be recorded in the Workgroup report in as much detail as practicable.

17. It is expected that Workgroup members would only abstain from voting under limited circumstances, for example where a member feels that a proposal has been insufficiently developed. Where a member has such concerns, they should raise these with the Workgroup chairman at the earliest possible opportunity and certainly before the Workgroup vote takes place. Where abstention occurs, the reason should be recorded in the Workgroup report.

18. Workgroup members or their appointed alternate are required to attend a minimum of 50% of the Workgroup meetings to be eligible to participate in the Workgroup vote.

19. The Technical Secretary shall keep an Attendance Record for the Workgroup meetings and circulate the Attendance Record with the Action Notes after each meeting. This will be attached to the final Workgroup report.

20. The Workgroup membership can be amended from time to time by the Grid Code Review Panel and the Chairman of the Workgroup.

Annex 2: Grid Code Legal Text

ECC.6.3.7 FREQUENCY RESPONSE

ECC.6.3.7.1 Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)

ECC.6.3.7.1.1 Each **Power Generating Module** (including **DC Connected Power Park Modules**) and **HVDC Systems** shall be capable of reducing **Active Power** output in response to **Frequency** on the **Total System** when this rises above 50.4Hz. For the avoidance of doubt, the provision of this reduction in **Active Power** output is not an **Ancillary Service**. Such provision is known as **Limited High Frequency Response**. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** shall be capable of operating stably during **LFSM-O** operation. However for a **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** operating in **Frequency Sensitive Mode** the requirements of LFSM-O shall apply when the frequency exceeds 50.5Hz.

ECC.6.3.7.1.2 (i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of **System Frequency** above 50.4Hz (ie a **Droop** of 10%) as shown in Figure ECC.6.3.7.1 below. This would not preclude a **EU Generator** or **HVDC System Owner** from designing their **Power Generating Module** with a **Droop** of less than 10% but in all cases the **Droop** should be 2% or greater~~.~~.

(ii) The reduction in **Active Power** output must be continuously and linearly proportional, as far as is practicable, to the excess of **Frequency** above 50.4 Hz and must be provided increasingly with time over the period specified in (iii) below.

(iii) As much as possible of the proportional reduction in **Active Power** output must result from the frequency control device (or speed governor) action and must be achieved within 10 seconds of the time of the **Frequency** increase above 50.4 Hz. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** shall be capable of initiating a power **Frequency** response with an initial delay that is as short as possible. If the delay exceeds 2 seconds the **EU Generator** or **HVDC System Owner** shall justify the ~~delay~~variation, providing technical evidence to **NGET**.

(iv) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC System** output control devices other than the frequency control devices (or speed governors) must be achieved within 3 minutes for the time of the **Frequency** increase above 50.4Hz.

(v) For the avoidance of doubt, the **LFSM-O** response must be reduced when the **Frequency** falls again and, when to a value less than 50.4Hz, as much as possible of the increase in **Active Power** must be achieved within 10 seconds.

~~(iv)~~(vi) For Ty**pe A** and **Type B Power Generating Modules** which are not required to have **Frequency Sensitive Mode** (**FSM**) as described in ECC.6.3.7.3 for deviations in **Frequency** up to 50.9Hz at least half of the proportional reduction in **Active Power** output must be achieved in 10 seconds of the time of the **Frequency** increase above 50.4 Hz. For deviations in **Frequency** beyond

50.9Hz the measured rate of change of **Active Power** reduction must exceed 0.5%/sec of the initial output. The **LFSM-O** response must be reduced when the **Frequency** subsequently falls again and, when to a value less than 50.4Hz, at least half the increase in **Active Power** must be achieved in 10 seconds. For a **Frequency** excursion returning from beyond 50.9Hz the measured rate of change of **Active Power** increase must exceed 0.5%/second.

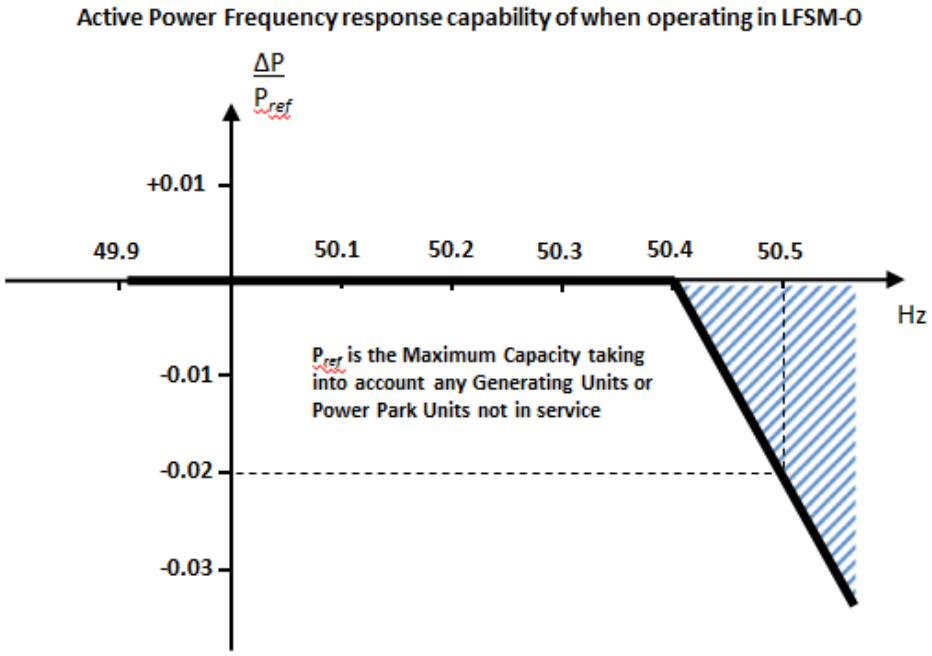

Figure ECC.6.3.7.1 – P_{ref} is the reference **Active Power** to which ΔP is related and ΔP is the change in **Active Power** output from the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC System**. The **Power Generating Module** (including **DC Connected Power Park Modules** or **HVDC Systems)** has to provide a negative **Active Power** output change with a droop of 10% or less based on Pref.

ECC.6.3.7.1.3 Each **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** which is providing **Limited High Frequency Response (LFSM-O)** must continue to provide it until the **Frequency** has returned to or below 50.4Hz or until otherwise instructed by **NGET**. **EU Generators** in respect of **Gensets** and **HVDC Converter Station Owners** in respect of an **HVDC System** should also be aware of the requirements in BC.3.7.2.2.

ECC.6.3.7.1.4 Steady state operation below the **Minimum Stable Operating Level** in the case of **Power Generating Modules** including **DC Connected Power Park Modules** or **Minimum Active Power Transmission Capacity** in the case of **HVDC Systems** is not expected but if **System** operating conditions cause operation below the **Minimum Stable Operating Level** or **Minimum Active Power Transmission Capacity** which could give rise to operational difficulties for the **Power Generating Module** including a **DC Connected Power Park Module** or **HVDC Systems** then the **EU Generator** or HV**DC System Owner** shall be able to return the output of the **Power Generating Module** including a **DC Connected Power Park Module** to an output of not less than the

Minimum Stable Operating Level or **HVDC System** to an output of not less than the **Minimum Active Power Transmission Capacity**.

ECC.6.3.7.1.5 All reasonable efforts should in the event be made by the **EU Generator** or **HVDC System Owner** to avoid such tripping provided that the **System Frequency** is below 52Hz in accordance with the requirements of ECC.6.1.2. If the **System Frequency** is at or above 52Hz, the requirement to make all reasonable efforts to avoid tripping does not apply and the **EU Generator** or **HVDC System Owner** is required to take action to protect its **Power Generating Modules** including **DC Connected Power Park Modules** or **HVDC Converter Stations**.

ECC.6.3.7.2 Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)

ECC.6.3.7.2.1 Each **Type C Power Generating Module** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** operating in **Limited Frequency Sensitive Mode** shall be capable of increasing **Active Power** output in response to **System Frequency** when this falls below 49.5Hz. For the avoidance of doubt, the provision of this increase in **Active Power** output is not a mandatory **Ancillary Service** and it is not anticipated **Power Generating Modules** (including **DC Connected Power Park Modules**) or **HVDC Systems** are operated in an inefficient mode to facilitate delivery of **LFSM-U** response, but any inherent capability (where available) should be made without undue delay. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** shall be capable of stable operation during **LFSM-U Mode**. For example, a **EU Generator** which is operating with no headroom (eg it is operating at maximum output or is de-loading as part of a run down sequence and has no headroom) would not be required to provide **LFSM-U**.

ECC.6.3.7.2.2 (i) The rate of change of **Active Power** output must be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of **System Frequency** below 49.5Hz (ie a **Droop** of 10%) as shown in Figure ECC.6.3.7.2.2 below. This requirement only applies if the **Power Generating Module** has headroom and the ability to increase **Active Power** output. In the case of a **Power Park Module** or **DC Connected Power Park Module** the requirements of Figure ECC.6.3.7.2.2 shall be reduced pro-rata to the amount of **Power Park Units** in service and available to generate. For the avoidance of doubt, this would not preclude an **EU Generator** or **HVDC System Owner** from designing their **Power Generating Module** with a lower **Droop** setting, for example between 3 – 5%.

(ii) As much as possible of the proportional increase in **Active Power** output must result from the **Frequency** control device (or speed governor) action and must be achieved for **Frequencies** below 49.5 Hz. The **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** shall be capable of initiating a power **Frequency** response with minimal delay. If the delay exceeds 2 seconds the **EU Generator** or HV**DC System Owner** shall justify the delay, providing technical evidence to **NGET***).*

(iii) The actual delivery of **Active Power Frequency Response** in **LFSM-U** mode shall take into account

The ambient conditions when the response is to be triggered

The operating conditions of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** in particular limitations on operation near **Maximum Capacity** or **Maximum HVDC Active Power Transmission Capacity** at low frequencies and the respective impact of ambient conditions as detailed in ECC.6.3.3.

The availability of primary energy sources.

(iv) In **LFSM_U Mode**, the **Power Generating Module** (including **DC Connected Power Park Modules**) and **HVDC Systems**, shall be capable of providing a power increase up to its **Maximum Capacity** or **Maximum HVDC Active Power Transmission Capacity** (as applicable).

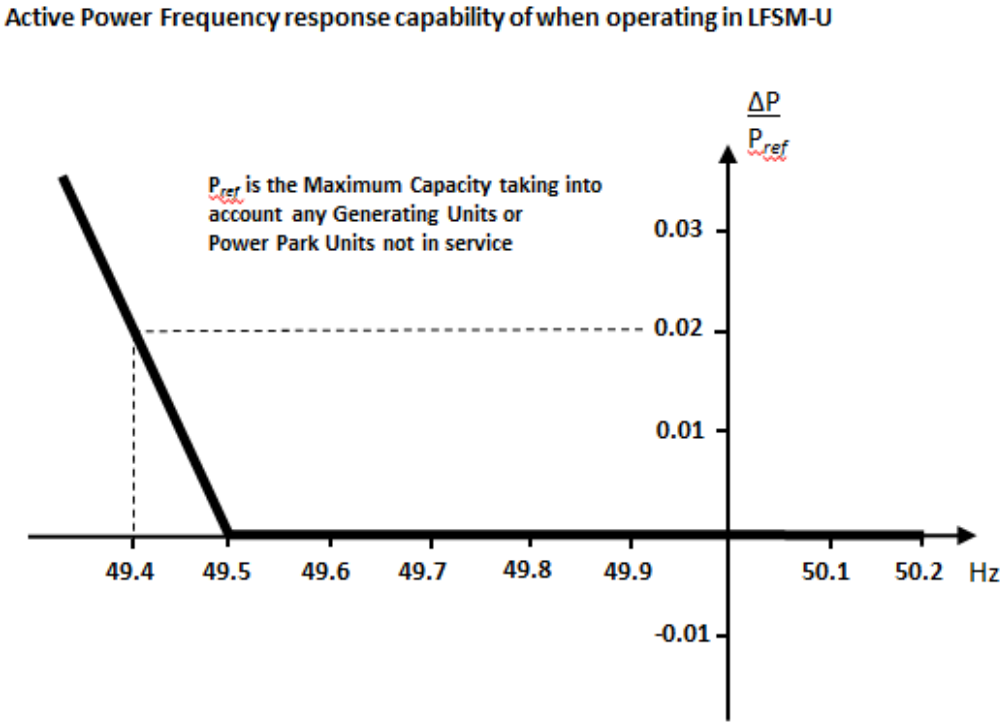

Figure ECC.6.3.7.2.2 – P_{ref} is the reference **Active Power** to which ΔP is related and ΔP is the change in **Active Power** output from the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC System**. The **Power Generating Module** (including **DC Connected Power Park Modules** or **HVDC Systems)** has to provide a positive **Active Power** output change with a droop of 10% or less based on Pref.

ECC.6.3.7.3 Frequency Sensitive Mode – (FSM)

ECC.6.3.7.3.1 In addition to the requirements of ECC.6.3.7.1 and ECC.6.3.7.2 each **Type C Power Generating Module** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems** must be fitted with a fast acting proportional **Frequency** control device (or turbine speed governor) and unit load controller or equivalent control device to provide **Frequency** response under normal operational conditions in accordance with **Balancing Code 3** (**BC3**). In the case of a **Power Park Module** including a **DC Connected Power Park Module**, the **Frequency** or speed control device(s) may be on the **Power Park Module** (including a **DC Connected Power Park Module**) or on each individual **Power Park Unit** (including a **Power Park Unit** within a **DC Connected Power Park Module**) or be a combination of both. The **Frequency** control device(s) (or speed governor(s)) must be designed and operated to the appropriate:

(i) **European Specification**: or

(ii) in the absence of a relevant **European Specification**, such other standard which is in common use within the European Community (which may include a manufacturer specification);

as at the time when the installation of which it forms part was designed or (in the case of modification or alteration to the **Frequency** control device (or turbine speed governor)) when the modification or alteration was designed.

The **European Specification** or other standard utilised in accordance with sub paragraph ECC.6.3.7.3.1 (a) (ii) will be notified to **NGET** by the **EU Generator** or **HVDC System Owner**:

(i) as part of the application for a **Bilateral Agreement**; or

(ii) as part of the application for a varied **Bilateral Agreement**; or

(iii) in the case of an Embedded Development, within 28 days of entry into the Embedded Development Agreement (or such later time as agreed with **NGET**) or

(iv) as soon as possible prior to any modification or alteration to the **Frequency** control device (or governor); and

ECC.6.3.7.3.2 The **Frequency** control device (or speed governor) in co-ordination with other control devices must control each **Type C Power Generating Module** and **Type D Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems Active Power Output** or **Active Power** transfer capability with stability over the entire operating range of the **Power Generating Module** (including **DC Connected Power Park Modules**) or **HVDC Systems**; and

ECC.6.3.7.3.3 **Type C** and **Type D Power Generating Modules** and **DC Connected Power Park Modules** shall also meet the following minimum requirements:

(i) capable of providing **Active Power Frequency** response in accordance with the performance characteristic shown in Figure 6.3.7.3.3(a) and parameters in Table 6.3.7.3.3(a)

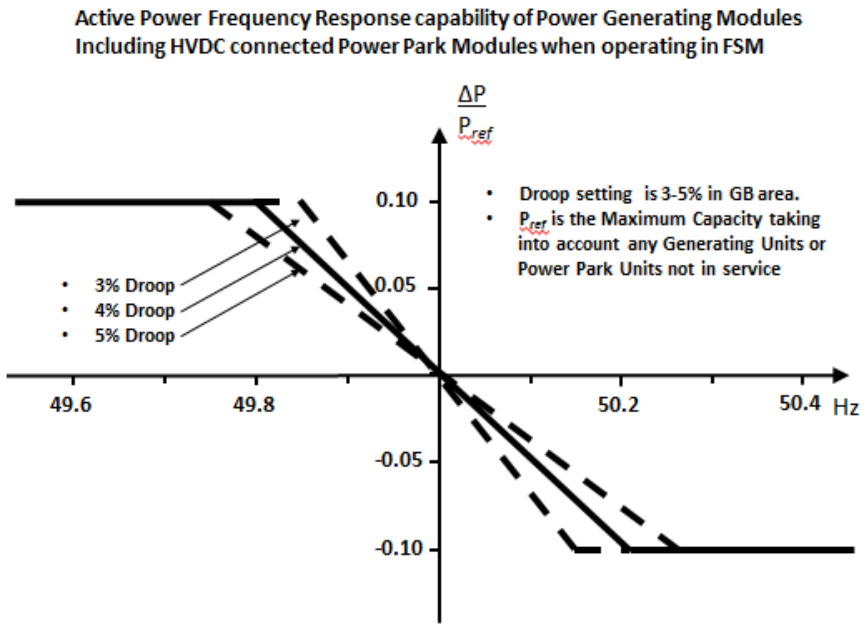

Figure 6.3.7.3.3(a) – **Frequency Sensitive Mode** capability of **Power Generating Modules** and **DC Connected Power Park Modules**

Parameter	Setting
Nominal **System Frequency**	50Hz
Active Power as a percentage of **Maximum Capacity** ($\frac{\lvert\Delta P_1\rvert}{P_{max}}$)	10%
Frequency Response Insensitivity in mHz ($\lvert\Delta f_i\rvert$)	±15mHz
Frequency Response Insensitivity as a percentage of nominal frequency ($\frac{\lvert\Delta f_i\rvert}{f_n}$)	±0.03%
Frequency Response Deadband in mHz	0 (mHz)
Droop (%)	3 – 5%

Table 6.3.7.3.3(a) – Parameters for **Active Power Frequency** response in **Frequency Sensitve Mode** including the mathematical expressions in Figure 6.3.7.3.3(a).

(ii) In satisfying the performance requirements specified in ECC.6.3.7.3(i) **EU Generators** in respect of each **Type C** and **Type D Power Generating Modules and DC Connected Power Park Module** should be aware:-

in the case of overfrequency, the **Active Power Frequency** response is limited by the **Minimum Regulating Level**,

in the case of underfrequency, the **Active Power Frequency** response is limited by the **Maximum Capacity,**

the actual delivery of **Active Power** frequency response depends on the operating and ambient conditions of the **Power Generating Module** (including **DC Connected Power Park Modules**) when this response is triggered, in particular limitations on operation near **Maximum Capacity** at low **Frequencies** as specified in ECC.6.3.3 and available primary energy sources.

The frequency control device (or speed governor) must also be capable of being set so that it operates with an overall speed **Droop** of between 3 – 5%. The **Frequency Response Deadband** and **Droop** must be able to be reselected repeatedly. For the avoidance of doubt, in the case of a **Power Park Module** (including **DC Connected Power Park Modules**) the speed **Droop** should be equivalent of a fixed setting between 3% and 5% applied to each **Power Park Unit** in service.

(iii) In the event of a **Frequency** step change, each **Type C** and **Type D Power Generating Module** and **DC Connected Power Park Module** shall be capable of activating full and stable **Active Power Frequency** response (without undue power oscillations), in accordance with the performance characteristic shown in Figure 6.3.7.3.3(b) and parameters in Table 6.3.7.3.3(b).

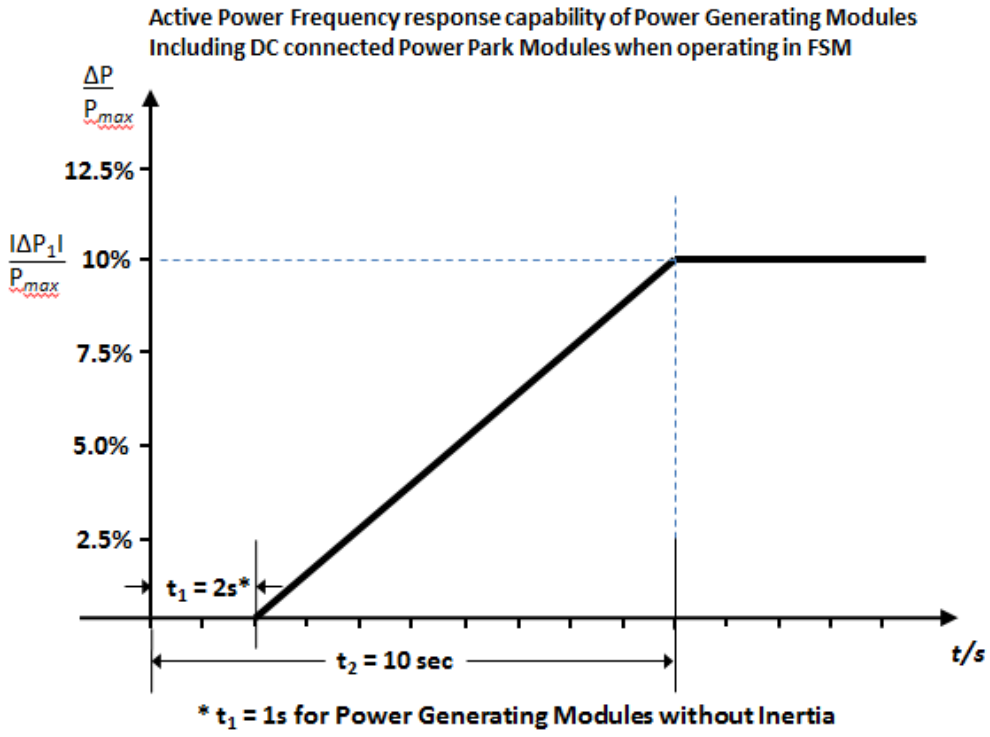

Figure 6.3.7.3.3(b) **Active Power Frequency Response** capability.

Parameter	Setting

Active Power as a percentage of **Maximum Capacity (frequency response range)** ($\frac{\lvert\Delta P_1\rvert}{P_{max}}$)	10%
Maximum admissible initial delay t_1 for **Power Generating Modules** (including **DC Connected Power Park Modules**) with inertia unless justified as specified in ECC.6.3.7.3.3 (iv)	2 seconds
Maximum admissible initial delay t_1 for **Power Generating Modules** (including **DC Connected Power Park Modules**) which do not contribute to **System** inertia unless justified as specified in ECC.6.3.7.3.3 (iv)	1 second
Activation time t_2	10 seconds

Table 6.3.7.3.3(b) – Parameters for full activation of **Active Power Frequency** response resulting from a **Frequency** step change. Table 6.3.7.3.3(b) also includes the mathematical expressions used in Figure 6.3.7.3.3(b).

(iv) The initial activation of **Active Power Primary Frequency** response shall not be unduly delayed. For **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) with inertia the delay in initial **Active Power Frequency** response shall not be greater than 2 seconds. For **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) without inertia, the delay in initial **Active Power Frequency** response shall not be greater than 1 second. If the **Generator** cannot meet this requirement they shall provide technical evidence to **NGET** demonstrating why a longer time is needed for the initial activation of **Active Power Frequency** response.

(v) in the case of **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) other than the **Steam Unit** within a **CCGT Module** the combined effect of the **Frequency Response Insensitivity** and **Frequency Response Deadband** of the **Frequency** control device (or speed governor) should be no greater than 0.03Hz (for the avoidance of doubt, ±0.015Hz). In the case of the **Steam Unit** within a **CCGT Module**, the **Frequency Response Deadband** should be set to an appropriate value consistent with the requirements of ECC.6.3.7.3.5(ii) and the requirements of BC3.7.2.2 for the provision of **LFSM-O** taking account of any **Frequency Response Insensitivity** of the Frequency control device (or speed governor);

ECC.6.3.7.3.4 **HVDC Systems** shall also meet the following minimum requirements:

(i) **HVDC Systems** shall be capable of responding to **Frequency** deviations in each connected AC **System** by adjusting their **Active Power** import or export as shown in Figure 6.3.7.3.4(a) with the corresponding parameters in Table 6.3.7.3.4(a).

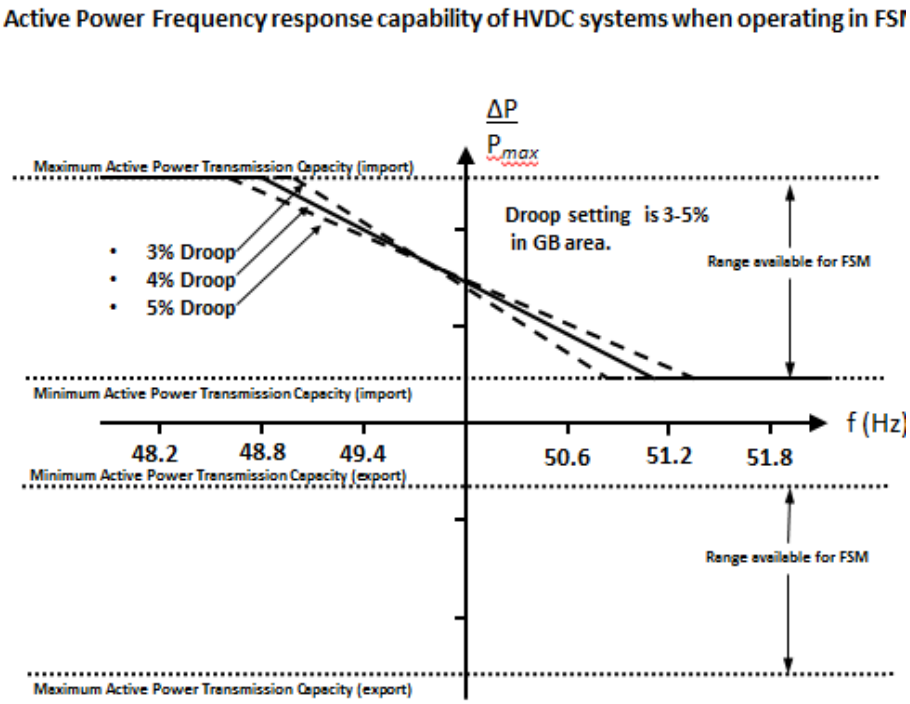

Figure 6.3.7.3.4(a) – **Active Power** frequency response capability of a **HVDC System** operating in **Frequency Sensitive Mode** (FSM). ΔP is the change in active power output from the **HVDC System**..

Parameter	Setting
Frequency Response Deadband	0
Droop S1 and S2 (upward and downward regulation) where S1=S2.	3 – 5%
Frequency Response Insensitivity	±15mHz

Table 6.3.7.3.4(a) – Parameters for **Active Power Frequency** response in **FSM** including the mathematical expressions in Figure 6.3.7.3.4.

(ii) Each **HVDC System** shall be capable of adjusting the **Droop** for both upward and downward regulation and the **Active Power** range over which **Frequency Sensitive Mode** of operation is available as defined in ECC.6.3.7.3.4.

(iii) In addition to the requirements in ECC.6.3.7.4(i) and ECC.6.3.7.4(ii) each **HVDC System** shall be capable of:-

delivering the response as soon as technically feasible

delivering the response on or above the solid line in Figure 6.3.7.3.4(b) in accordance with the parameters shown in Table 6.3.7.3.4(b)

initiating the delivery of **Primary Response** in no less than 0.5 seconds unless otherwise agreed with **NGET**. Where the initial delay time (t_1 – as shown in Figure 6.3.7.3.4(b)) is longer than 0.5 seconds the **HVDC Converter Station Owner** shall reasonably justify it to **NGET**.

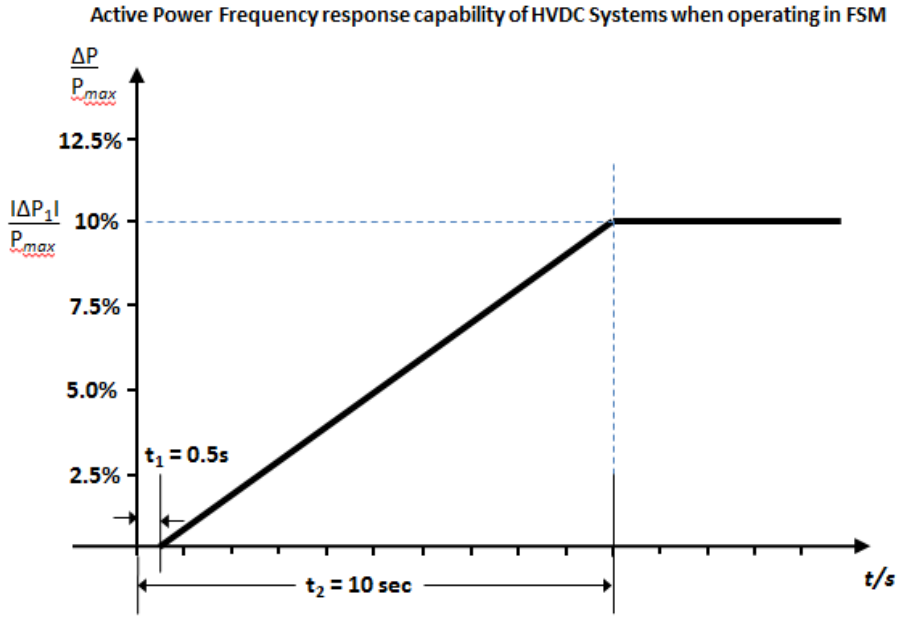

Figure 6.3.7.3.4(b) **Active Power Frequency Response** capability of a **HVDC System**. ΔP is the change in **Active Power** triggered by the step change in frequency

Parameter	Setting
Active Power as a percentage of **Maximum Capacity (frequency response range)** ($\frac{\lvert\Delta P_1\rvert}{P_{max}}$)	10%
Maximum admissible delay t_1	0.5 seconds
Maximum admissible time for full activation t_2, unless longer activation times are agreed with **NGET**	10 seconds

Table 6.3.7.3.4(b) – Parameters for full activation of **Active Power Frequency** response resulting from a **Frequency** step change.

(iv) For **HVDC Systems** connecting various **Synchronous Areas**, each **HVDC System** shall be capable of adjusting the full **Active Power Frequency Response** when operating in **Frequency Sensitive Mode** at any time and for a continuous time period. In addition, the **Active Power** controller of each **HVDC System** shall not have any adverse impact on the delivery of frequency response.

ECC.6.3.7.3.5 For **HVDC Systems** and **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**), other than the **Steam Unit** within a **CCGT Module** the combined effect of the **Frequency Response Insensitivity** and **Frequency Response Deadband** of the **Frequency** control device (or speed governor) should be no greater than 0.03Hz (for the avoidance of doubt, ±0.015Hz). In the case of the **Steam Unit** within a **CCGT Module**, the **Frequency Response Deadband** should be set to an appropriate value consistent with the requirements of ECC.6.3.7.3.5(ii) and the requirements of BC3.7.2.2 for the provision of **LFSM-O** taking account of any **Frequency Response Insensitivity** of the **Frequency** control device (or speed governor);

(i) With regard to disconnection due to underfrequency, **EU Generators** responsible for **Type C** and **Type D Power Generating Modules** (including **DC Connected Power Park Modules**) capable of acting as a load, including but not limited to **Pumped Storage** and tidal **Power Generating Modules**, **HVDC Systems** and **Remote End HVDC Converter Stations**, shall be capable of disconnecting their load in case of underfrequency which will be agreed with **NGET**. For the avoidance of doubt this requirement does not apply to station auxiliary supplies; **EU Generators** in respect of **Type C** and **Type D Pumped Storage Power Generating Modules** should also be aware of the requirements in OC.6.6.6.

(ii) Where a **Type C** or **Type D Power Generating Module**, **DC Connected Power Park Module** or **HVDC System** becomes isolated from the rest of the **Total System** but is still supplying **Customers**, the **Frequency** control device (or speed governor) must also be able to control **System Frequency** below 52Hz unless this causes the **Type C** or **Type D Power Generating Module** or **DC Connected Power Park Module** to operate below its **Minimum Regulating Level** or **Minimum Active Power Transmission Capacity** when it is possible that it may, as detailed in BC 3.7.3, trip after a time. For the avoidance of doubt **Power Generating Modules** (including **DC Connected Power Park Modules**) and **HVDC Systems** are only required to operate within the **System Frequency** range 47 - 52 Hz as defined in ECC.6.1.2 and for converter based technologies, the remaining island contains sufficient fault level for effective commutation;

(iii) Each **Type C** and **Type D Power Generating Module** and **HVDC Systems** shall have the facility to modify the **Target Frequency** setting either continuously or in a maximum of 0.05Hz steps over at least the range 50 ±0.1Hz should be provided in the unit load controller or equivalent device.

ECC.6.3.7.3.6 In addition to the requirements of ECC.6.3.7.3 each **Type C** and **Type D Power Generating Module** and **HVDC System** shall be capable of meeting the minimum **Frequency** response requirement profile subject to and in accordance with the provisions of Appendix A3.

ECC.6.3.7.3.7 For the avoidance of doubt, the requirements of Appendix A3 do not apply to **Type A** and **Type B Power Generating Modules**.

Annex 3: Distribution Code Legal Text

Figure 11.1 Change in Active Power with falling frequency

11.2.3.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.

11.2.4 **Limited Frequency Sensitive Mode – Over frequency**

11.2.4.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module** has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when frequency exceeds 50.5 Hz.

(a) The rate of change of **Active Power** output must be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a **Droop** of 10%) as shown in Figure 11.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a **Droop** of less than 10%, but in all cases the **Droop** should be 2% or greater.

(b) The **Power Generating Module** shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.

(c) For deviations in frequency up to 50.9 Hz at least half of the proportional reduction in **Active Power** output ~~As much as possible of the proportional reduction in **Active Power** output must result from the frequency control device (or speed governor) action and must be achieved~~ within 10 s of the time of the frequency increase above 50.4 Hz.

(d) For deviations in frequency beyond 50.9 Hz the measured rate of change of **Active Power** reduction must exceed 0.5%/s of the initial output.

~~(b)~~(e) The **LFSM-O** response must be reduced when the frequency subsequently falls again and, when to a value less than 50.4 Hz, at least half the increase in **Active Power** must be achieved in 10 seconds. For a frequency excursion returning from beyond 50.9 Hz the measured rate of change of **Active Power** increase must exceed 0.5%/s.

~~(c)~~(f) If the reduction in **Active Power** is such that the **Power Generation Module** reaches its **Minimum Generation**, it must continue to operate stably at this level.

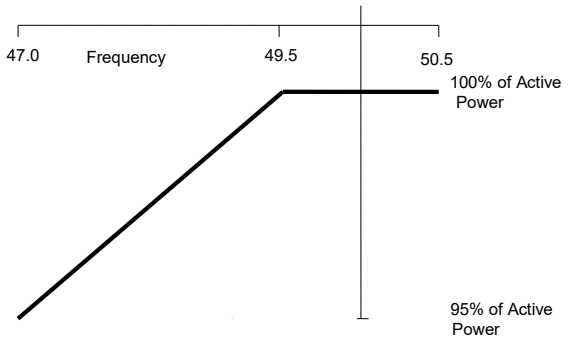

Figure 12.1 Change in Active Power with falling frequency

12.2.3.2 For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.

12.2.4 **Limited Frequency Sensitive Mode – Over frequency**

12.2.4.1 Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module**, has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when frequency exceeds 50.5 Hz.

(a) The rate of change of **Active Power** output must be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a **Droop** of 10%) as shown in Figure 12.2. For the avoidance of doubt, this would not preclude a **Generator** from designing their **Power Generating Module** with a **Droop** of less than 10%, but in all cases the **Droop** should be 2% or greater.

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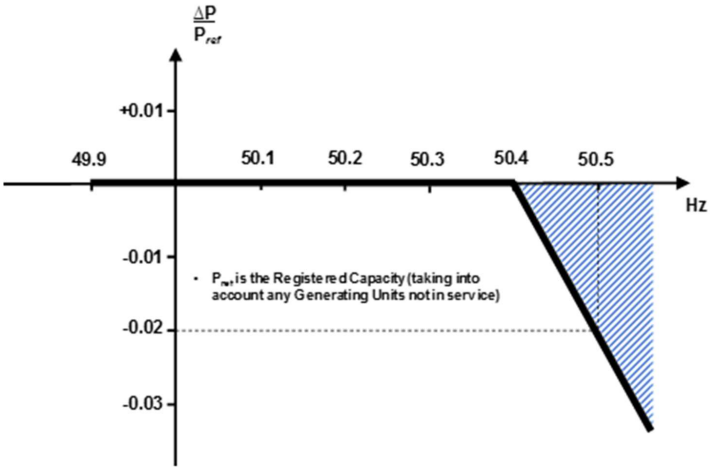
~~(a)~~(b) The **Power Generating Module** shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.

~~(b)~~(c) For deviations in frequency up to 50.9 Hz at least half of the proportional reduction in **Active Power** output ~~As much as possible of the proportional reduction in **Active Power** output must result from the frequency control device (or speed governor) action and~~ must be achieved within 10 s of the time of the frequency increase above 50.4 Hz. ~~The **Power Generating Module** shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **NETSO**.~~

(d) For deviations in frequency beyond 50.9 Hz the measured rate of change of **Active Power** reduction must exceed 0.5%/s of the initial output.

(e) The **LFSM-O** response must be reduced when the frequency subsequently falls again and, when to a value less than 50.4 Hz, at least half the increase in **Active Power** must be achieved in 10 seconds. For a frequency excursion returning from beyond 50.9 Hz the measured rate of change of **Active Power** increase must exceed 0.5%/s of the **Active Power.**

~~(c)~~(f) If the reduction in **Active Power** is such that the **Power Generation Module** reaches its **Minimum Generation**, it must continue to operate stably at this level.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 12.2 Active Power Frequency Response capability when operating in LFSM-O

12.2.4.2 When the **Power Generating Module** is providing **Limited Frequency Sensitive Mode Over frequency (LFSM-O)** response it must continue to provide the frequency response until the frequency has returned to or is below 50.4 Hz.

12.2.4.3 Steady state operation below **Minimum Generation** is not expected but if system operating conditions cause operation below **Minimum Generation** which give rise to operational difficulties then the **Generator** shall be able to return the output of the **Power Generating Module** to an output of not less than the **Minimum Generation.**

12.3 Fault Ride Through and Phase Voltage Unbalance

12.3.1 Paragraphs 12.3.1.1 to 12.3.1.7 inclusive set out the fault ride through, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules**, subject to disturbances from faults on the **Network** up to 140 ms in duration.

12.3.1.1 Each **Synchronous Power Generating Module** and **Power Park Module** is required to remain connected and stable for any balanced and unbalanced fault

not trip during this test.

The results shall be recorded on the test sheet of Annex A.2-1.

A.7.2.3 Power Output with Falling Frequency

The **Generator** will propose and agree a test procedure with the **DNO**, which will demonstrate how the **Synchronous Power Generating Module Active Power** output responds to changes in system frequency.

The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A8.6. In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered Capacity**.

The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.

The frequency should then be set to 49.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 99% of **Registered Capacity**.

The frequency should then be set to 48.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 97% of **Registered Capacity**.

The frequency should then be set to 47.6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output must not be below 96.2% of **Registered Capacity**.

The frequency should then be set to 47.1 Hz and held at this frequency for 20 s. The **Active Power** output must not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** must not trip in less than the 20s of the test.

The **Generator** shall inform the **DNO** if any load limiter control is additionally employed.

A.7.2.4 Limited Frequency Sensitive Mode – Over (LFSM-O)

Note that this test is also an alternative to the test in A.7.1.3.

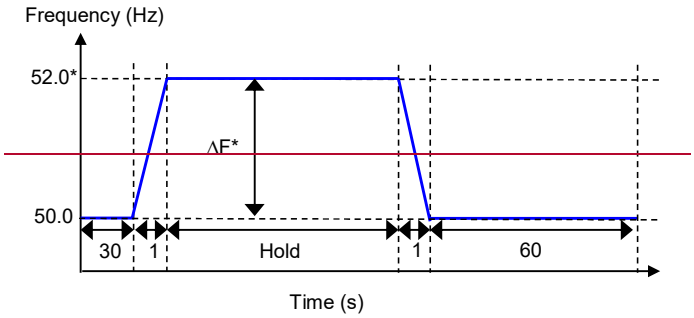
The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a frequency injection as shown by Figures A.7.8 and Figures A.7.9 are to be conducted at **Registered Capacity**.

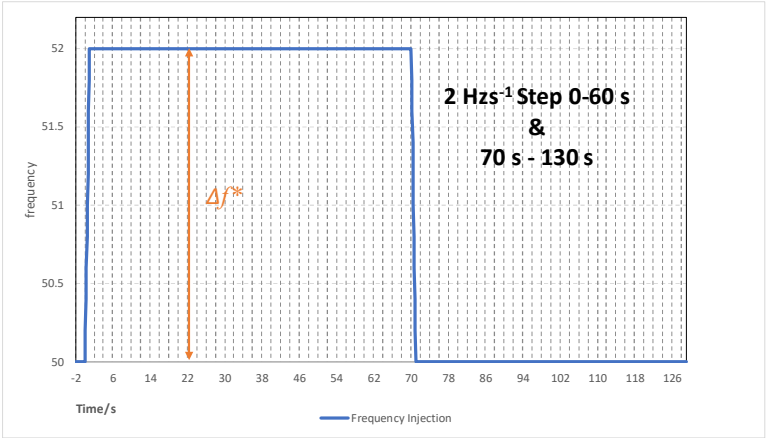
There should be sufficient time allowed between tests for control systems to reach steady state. ~~Where the diagram states 'HOLD' t~~The injection signal should be maintained until the **Active Power** (MW) output of the **Power Generating Module** has stabilised. The **DNO** may require repeat tests should the tests give unexpected results.

The frequency input and t~~T~~he expected **Active Power** response ~~which is~~ are illustrated for different periods from 0 s to 130 s in Figures A.7.~~9~~8 for a step change in frequency and in Figures A.7.~~10~~9 for a ramp change in frequency. This should be in accordance with Section 11.2.4 (a threshold frequency of 50.4 Hz and a **Droop** of 10%) and undamped oscillations should not occur after the step or ramp

frequency change. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilised after the first step or ramp.

The response should commence within 2 s and the response must be to the left of the red line (ie between the green line and the red line), and be as close to the green line as possible, when following the frequency step or ramp. Note that the red line represents the 0.5%/s specified in 11.2.4.1.~~The response should commence within 2 s (or such time as the **DNO** might agree with the **Generator**); ie the response should normally be contained within the blue lines, and as close to the left as possible, when following the frequency ramp. The response should be complete in a reasonable time and the **DNO** can agree with the **Generator** a longer completion time than suggested by the blue lines taking into account the technical capabilities of the **Power Generating Module** and its prime mover.~~





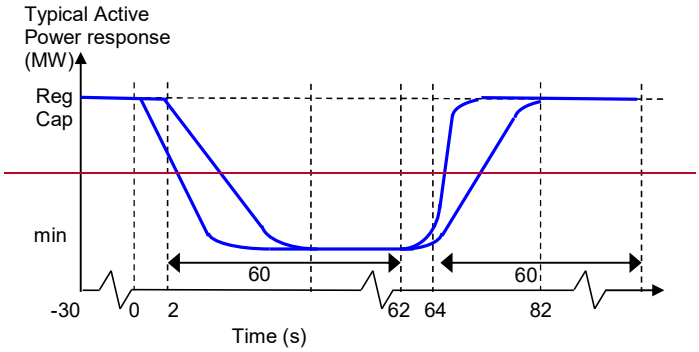


Figure A.7.8(i): LFSM-O step response test – frequency injection

Figure A.7.8(ii): LFSM-O step response test – target response and limits

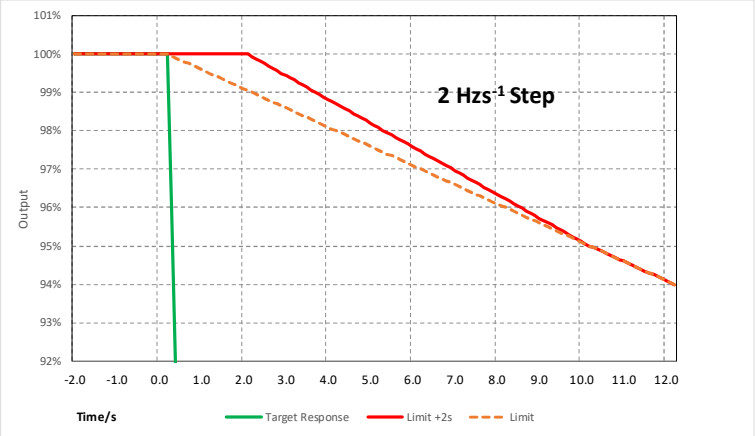


Figure A.7.8(iii): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency increase)

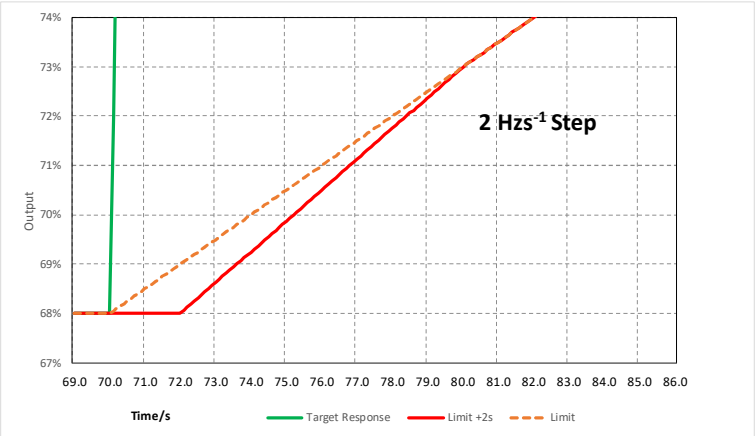


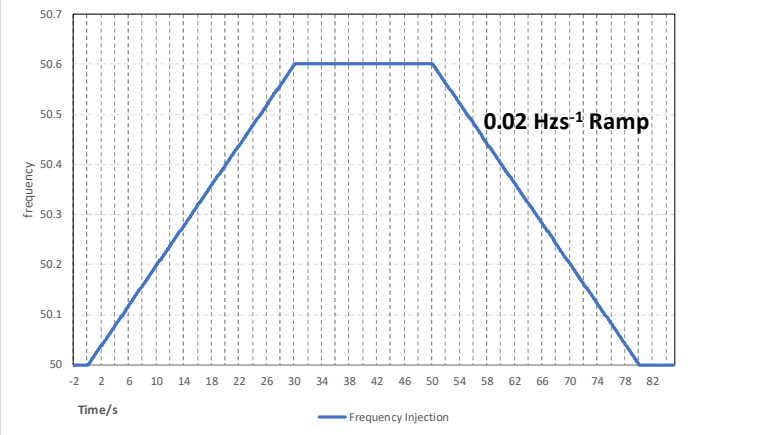
Figure A.7.8(iv): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency decrease)

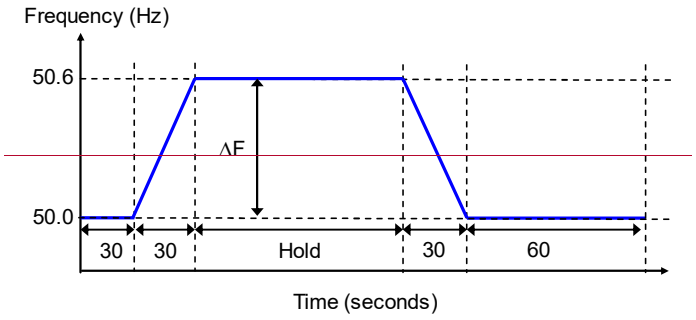
** This frequency step Δf will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Generation** in which case an appropriate injection should be calculated in accordance with the following:

For example 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

Initial output	100%

Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz





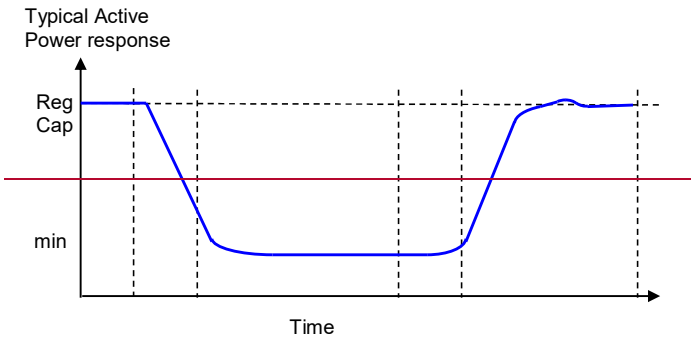


Figure A.7.9(i): LFSM-O ramp response test – frequency injection

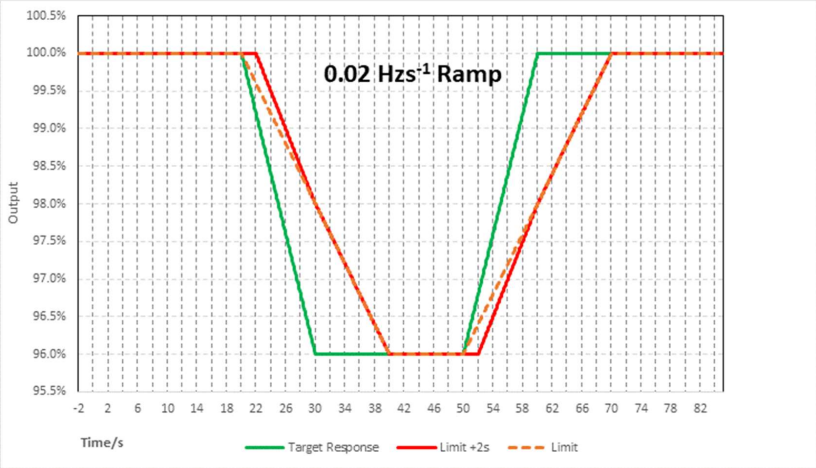


Figure A.7.9(ii): LFSM-O ramp response test – target response and limits

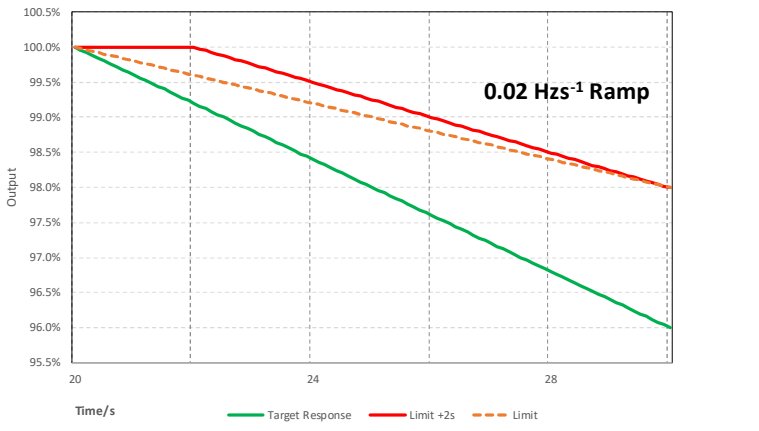


Figure A.7.9(iii): LFSM-O ramp response test – expansion (frequency increase)

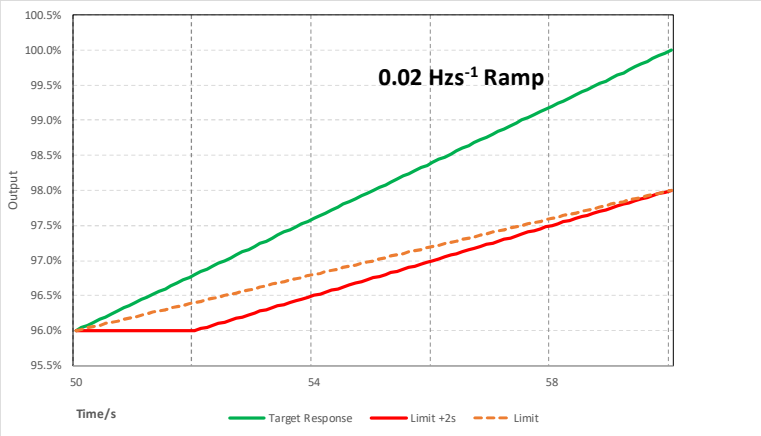


Figure A.7.9(iv): LFSM-O ramp response test – expansion (frequency decrease)

~~Figure A.7.9: LFSM-O ramp response test~~

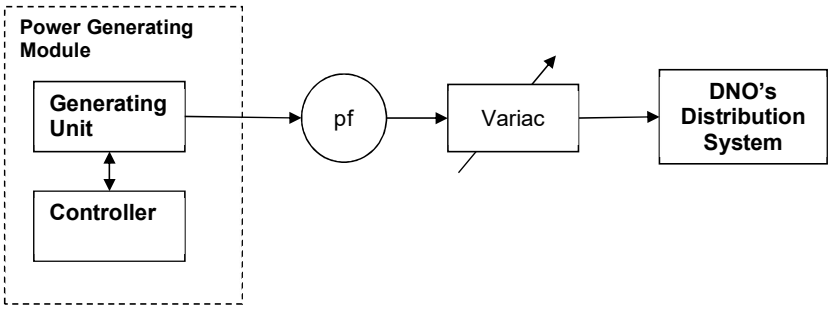
A.7.2.5 Power Quality

A.7.2.5.1 Harmonics

The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of maximum export capacity.

A.7.2.5.2 Power Factor

The test set up shall be such that the **Power Generating Module** supplies full load to the **DNO's Distribution Network** via the **Power Factor** (pf) meter and the variac as shown below in Figure A.7.10. The **Power Generating Module** pf should be within the limits given in paragraph 11.1.5, for three test voltages 230 V –6%, 230 V and 230 V +10%.



NOTE 1. For reasons of clarity the points of isolation are not shown

	Generating Unit running at **Registered Capacity** and maximum lagging **Reactive Power**.	
	Over-excitation Limit temporarily set close to this operating point.	
1	• Inject positive voltage step into **AVR** Voltage setpoint and hold • Wait till **Over-excitation Limiter** operates after sufficient time delay to bring back the excitation back to the limit. • Remove step returning **AVR** Voltage setpoint to nominal.	
	Over-excitation Limit restored to its normal operating value.	

B.5.5 Reactive Capability

B.5.5.1 The **Reactive Power** capability on each **Synchronous Power Generating Module** will normally be demonstrated by:

(a) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and **Registered Capacity** for 1 hour.

(b) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and **Registered Capacity** for 1 hour.

(c) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and **Minimum Generation** for 1 hour.

(d) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and **Minimum Generation** for 1 hour.

(e) operation of the **Synchronous Power Generating Module** at maximum lagging **Reactive Power** and a power output between **Registered Capacity** and **Minimum Generation**.

(f) operation of the **Synchronous Power Generating Module** at maximum leading **Reactive Power** and a power output between **Registered Capacity** and **Minimum Generation**.

B.5.5.2 Where **Distribution Network** considerations restrict the **Synchronous Power Generating Module Reactive Power** output then the maximum leading and lagging capability will be demonstrated without breaching the **DNO** limits.

B.5.5.3 The test procedure, time and date will be agreed with the **DNO** and will be to the instruction of the **DNO** control centre and shall be monitored and recorded at both the **DNO** control centre and by the **Generator**.

B.5.5.4 Where the **Generator** is recording the voltage, **Active Power** and **Reactive Power** at the **Connection Point** the voltage, **Active Power** and **Reactive Power** at the **Synchronous Power Generating Module** terminals may also be included. The results shall be supplied in an electronic spreadsheet format. Where applicable the **Synchronous Power Generating Module** transformer tap changer position should be noted throughout the test period.

B.5.6 Governor and Load Controller Response Performance

B.5.6.1 The governor and load controller response performance will be tested by injecting

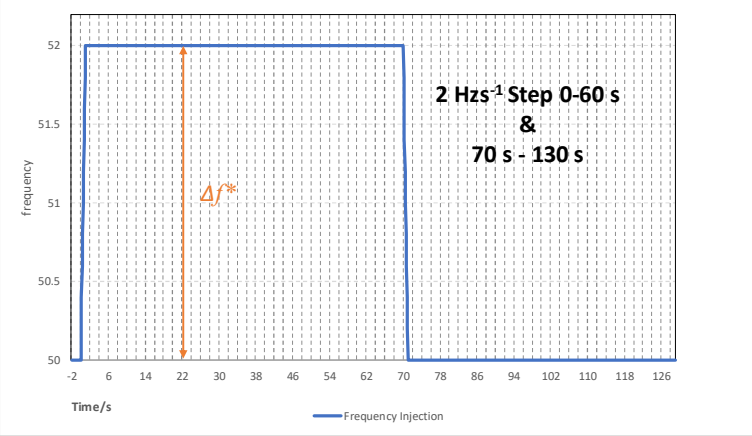
simulated frequency deviations into the governor and load controller systems.

B.5.6.2 The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a frequency injection as shown by Figures B.5.1 and Figures B.5.2 are to be conducted at **Registered Capacity**.

B.5.6.3 There should be sufficient time allowed between tests for control systems to reach steady state. ~~Where the diagram states 'HOLD' t~~The injection signal should be maintained until the **Active Power** (MW) output of the **Synchronous Power Generating Module** or **CCGT Module** has stabilised. The **DNO** may require repeat tests should the tests give unexpected results.

B.5.6.4 The frequency input and the expected **Active Power** response which ~~is~~ are illustrated for different time periods from 0 to 130 s in Figures B.5.1 for a step change in frequency ~~and~~ and B.5.2 for a ramp change in frequency. These should be in accordance with Section 12.2.4 and undamped oscillations should not occur after the step or ramp frequency change. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilised after the first step or ramp.

B.5.6.5 The response should commence within 2 s ~~(or such time as the **DNO** might agree with the **Generator**); ie~~and the response ~~should normally~~must be to the left of the red line (ie between the green and red line), and as close to the green line as possible, when following the frequency step or ramp~~contained within the blue lines, and as close to the left as possible, when following the frequency ramp. The response should be complete in a reasonable time and the **DNO** can agree with the **Generator** a longer completion time than suggested by the blue lines taking into account the technical capabilities of the **Power Generating Module** and its prime mover~~. Note that the red line represents the 0.5%/s specified in 12.2.4.



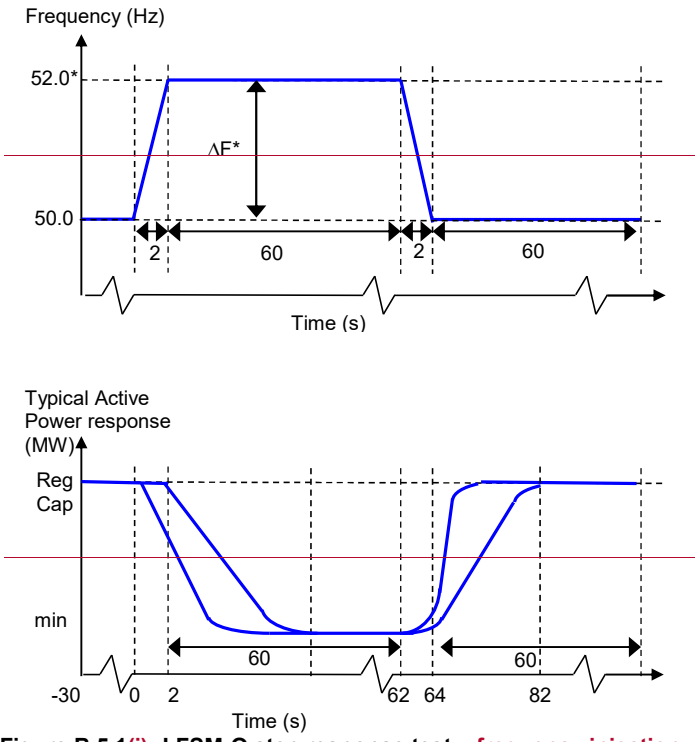


Figure B.5.1(i): LFSM-O step response test – frequency injection

Figure B.5.1(i): LFSM-O step response test – frequency injection

Figure B.5.1(ii): LFSM-O step response test – target response and limits

Figure B.5.1(ii): LFSM-O step response test – target response and limits

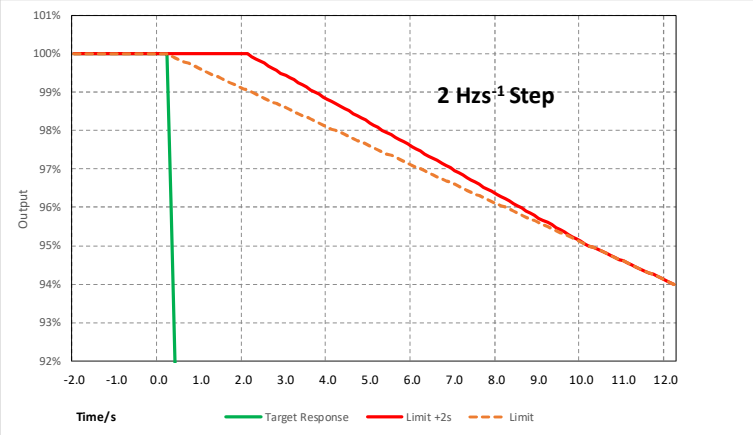


Figure B.5.1(iii): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency increase)

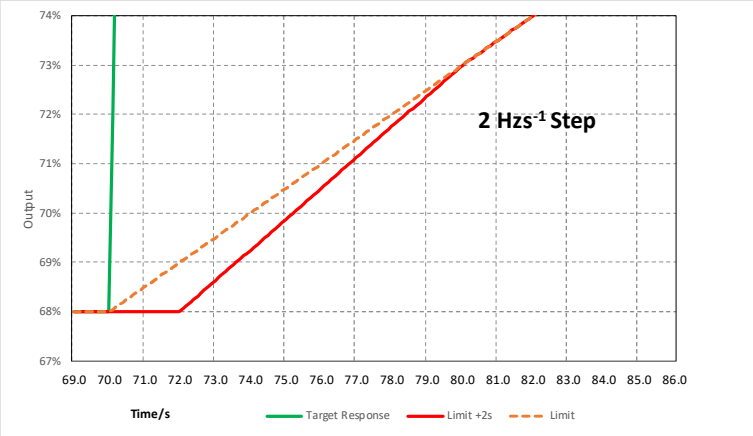


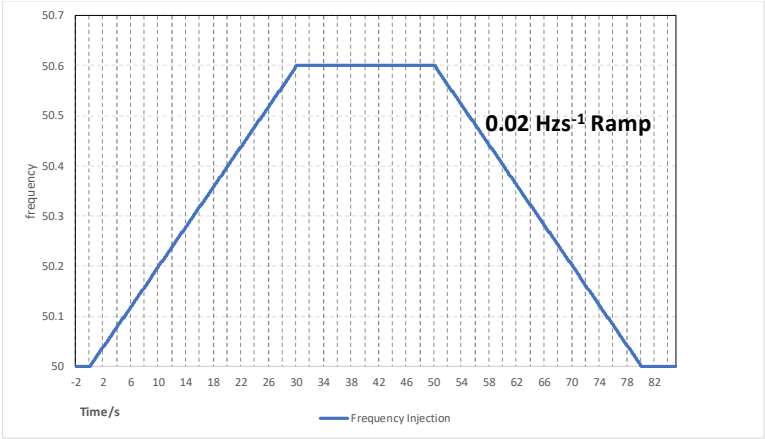
Figure B.5.1(iv): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency decrease)

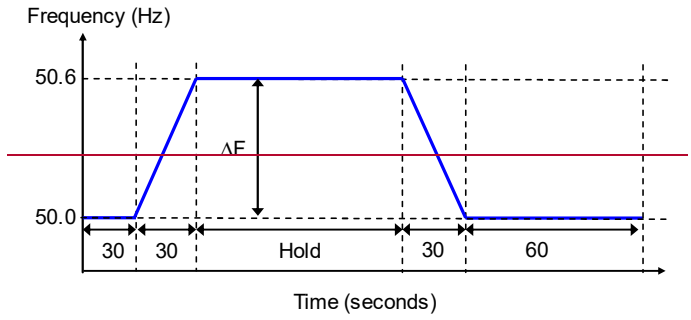
*The frequency step *Δf** ~~This~~ will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Generation** in which case an appropriate injection should be calculated in accordance with the following:

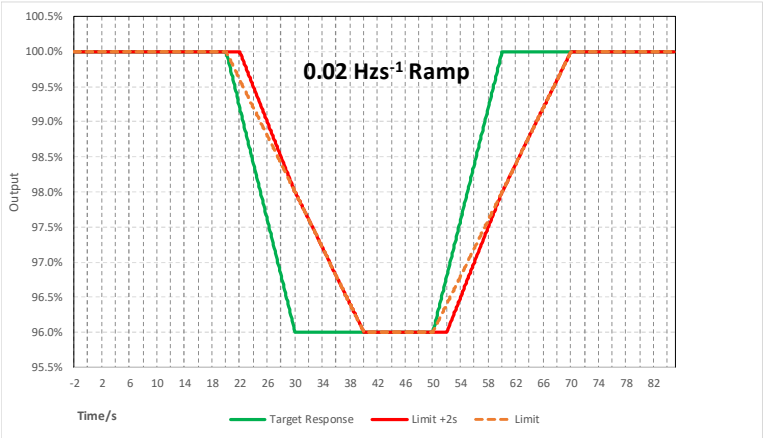
For example 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

Initial output	100%

Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz







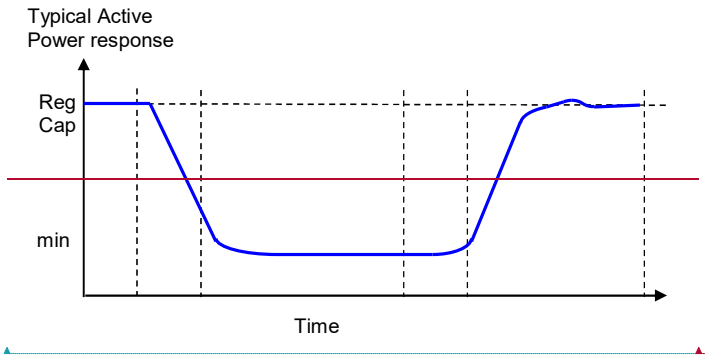


Figure B.5.2(i): LFSM-O ramp response test – frequency injection

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Figure B.5.2(ii): LFSM-O ramp response test – target response and limits

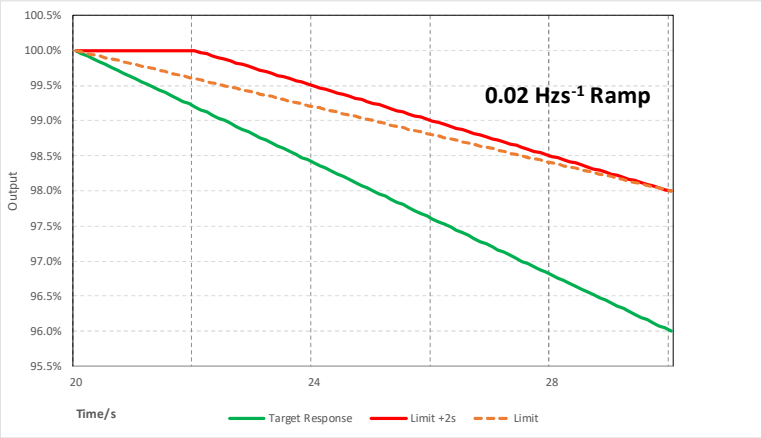

Figure B.5.2(iii): LFSM-O ramp response test – expansion (frequency increase)

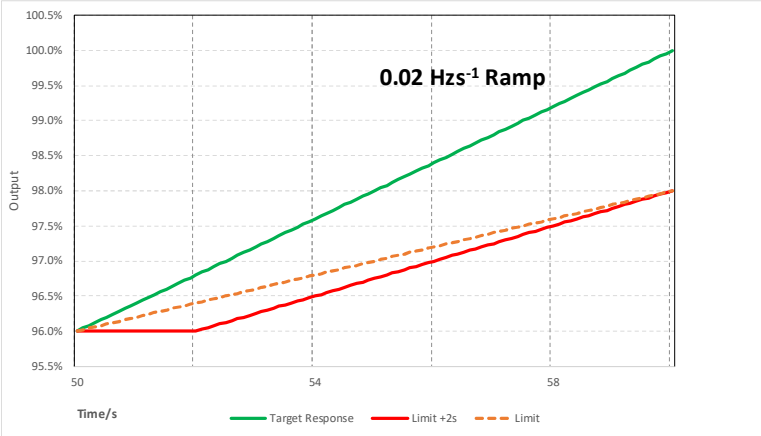

Figure B.5.2(iv): LFSM-O ramp response test – expansion (frequency decrease)

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B.5.7 Compliance with Output Power with falling frequency Functionality Test

B.5.7.1 The **Generator** will propose and agree a test procedure with the **DNO**, which will demonstrate how the **Synchronous Power Generating Module Active Power** output responds to changes in system frequency.

B.5.7.2 The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A8.6. In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered**

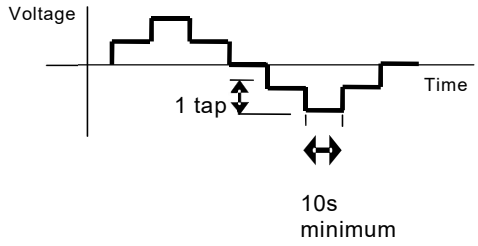


Figure B.6.1 – Transformer tap sequence for voltage control tests

(ii)

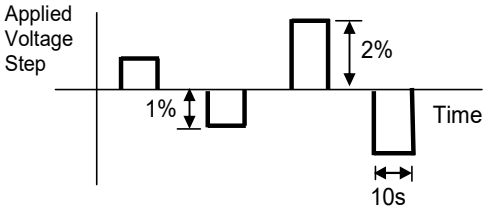


Figure B.6.2 – Step injection sequence for voltage control tests

B.6.5 Frequency Response Tests

B.6.5.1 This section describes the procedure for performing frequency response testing on a **Power Park Module**. These tests should be scheduled at a time where there are at least 95% of the **Generating Units** within the **Power Park Module** in service. There should be sufficient MW resource forecasted in order to generate at least 65% of **Registered Capacity** of the **Power Park Module**.

B.6.5.2 The frequency controller shall be in **Limited Frequency Sensitive Mode** for each test. Simulated frequency deviation signals shall be injected into the frequency controller setpoint/feedback summing junction.

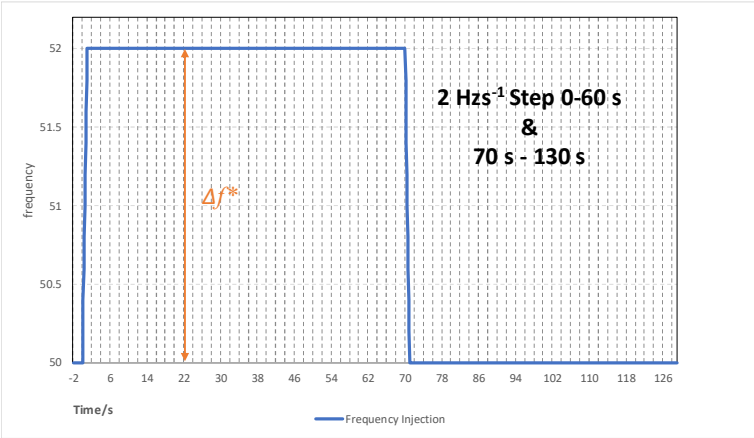
B.6.5.3 The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a change in frequency as shown by Figure B.6.3 and B.6.4 are to be conducted at **Registered Capacity**.

B.6.5.4 There should be sufficient time allowed between tests for control systems to reach steady state (depending on available power resource). ~~Where the diagram states 'HOLD' t~~ The injection signal should be maintained until the **Active Power** (MW) output of the **Power Park Module** has stabilised. the **DNO** may require repeat tests should the response volume be affected by the available power, or if tests give unexpected results.

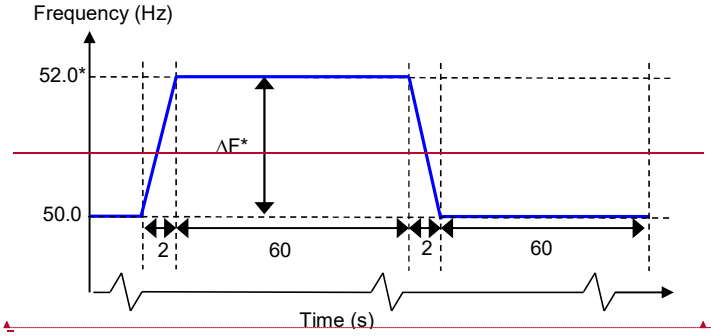
B.6.5.5 The frequency input and the expected **Active Power** response which are illustrated for different time periods from 0 to 130 s in Figures B.6.3 for a step change in frequency and Figures B.6.4 for a ramp change in frequency. This should be in accordance with Section 12.2.4 and undamped oscillations should not occur after

the step or ramp frequency change. Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilised after the first step or ramp.~~The expected **Active Power** response which is illustrated in Figure B.6.1 and B.6.2 should be in accordance with Section 12.2.4 and undamped oscillations should not occur after the step or ramp frequency change.~~

B.6.6.5 The response should commence within 2 s and the response must be to the left of the red line (ie between the green and red line), and as close to the green line as possible, when following the frequency step or ramp. Note that the red line



represents the 0.5%/s specified in 12.2.4.~~The response should commence within 2 s (or such time as the **DNO** might agree with the **Generator**) and complete in a reasonable time (typically no longer than 30 s); ie the response should be contained within the blue lines, and as close to the left as possible, when following the frequency ramp.~~



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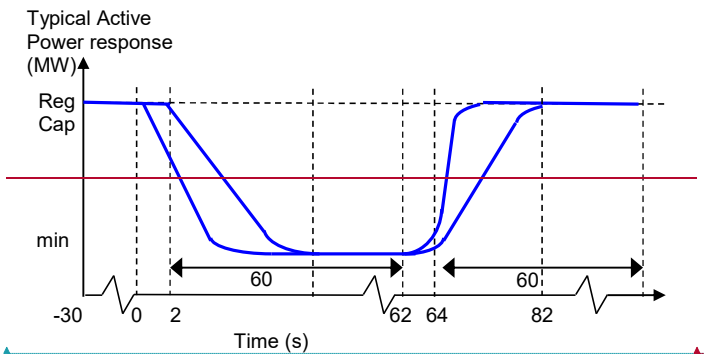

Figure B.6.3(i): LFSM-O step response test – frequency injection

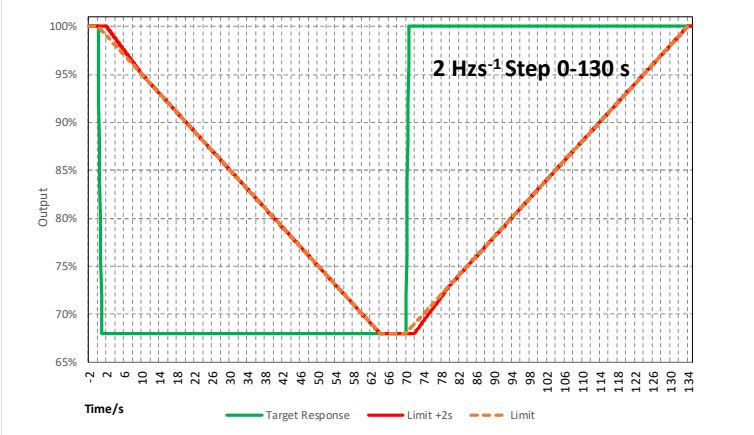

Figure B.6.3(ii): LFSM-O step response test – target response and limits

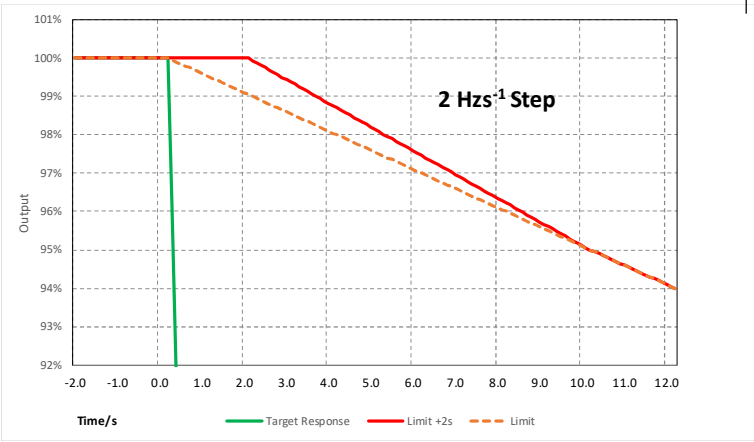

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Figure B.6.3(iii): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency increase)

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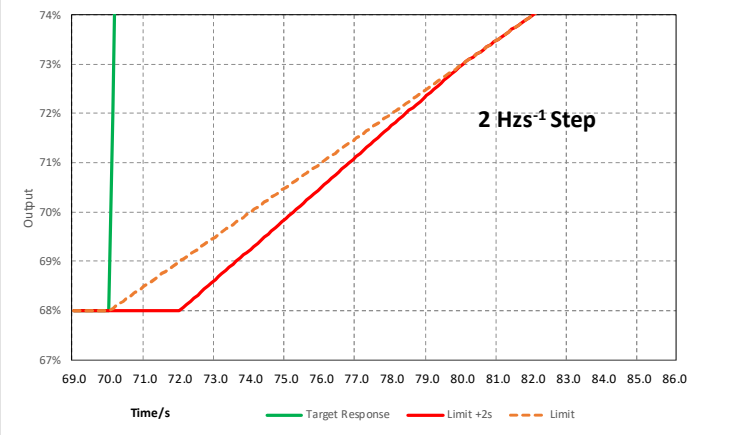


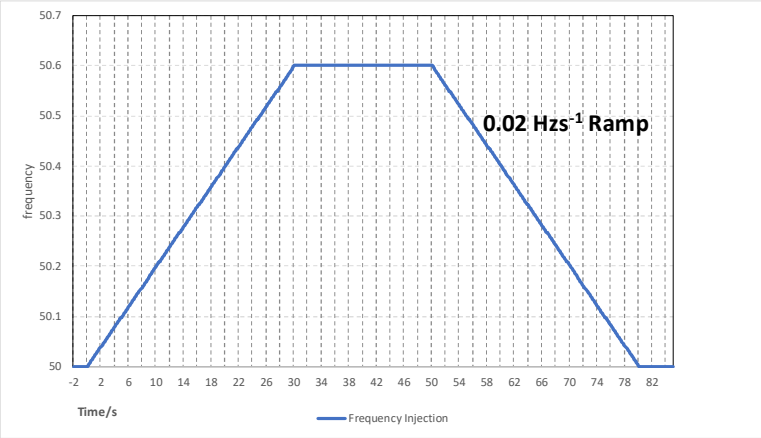
Figure B.6.3(iv): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency decrease)

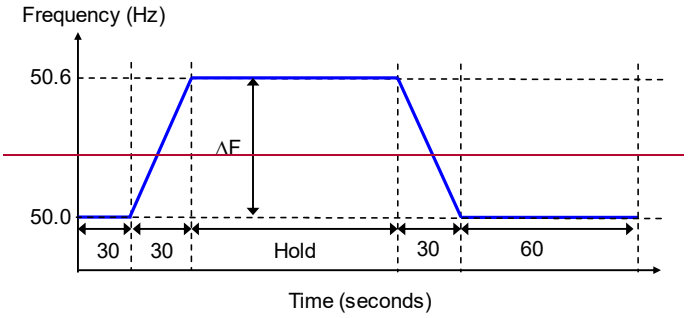
The frequency step Δf ~~This~~ will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Generation** in which case an appropriate injection should

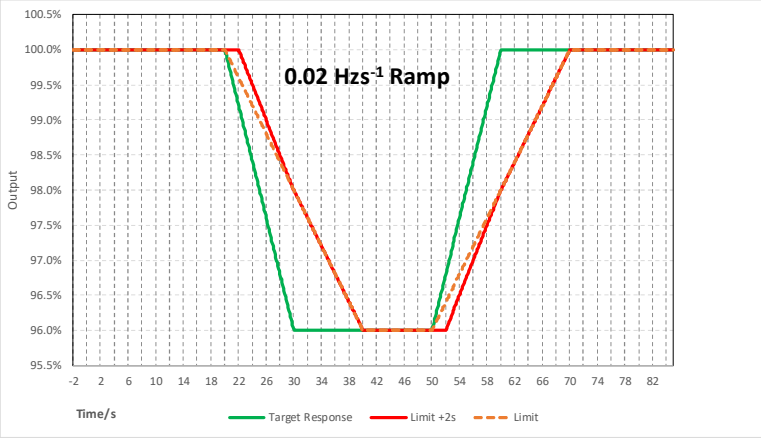
For example, 1.5 Hz is needed to take an initial output 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Generation** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:

Initial output	100%
Minimum Generation	70%
Frequency controller **Droop**	10%
Frequency to be injected	= (1.00 – 0.70) x 0.1 x 50 = 1.5Hz

Figure B.6.4: LFSM-O BC2 ramp response test


50.7
50.6
50.5
50.4
50.3
50.2
50.1
50
frequency
-2 2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82
Time/s
0.02 Hzs-1 Ramp
Frequency Injection


Frequency (Hz)
50.6
50.0
ΔF
30
30
Hold
30
60
Time (seconds)



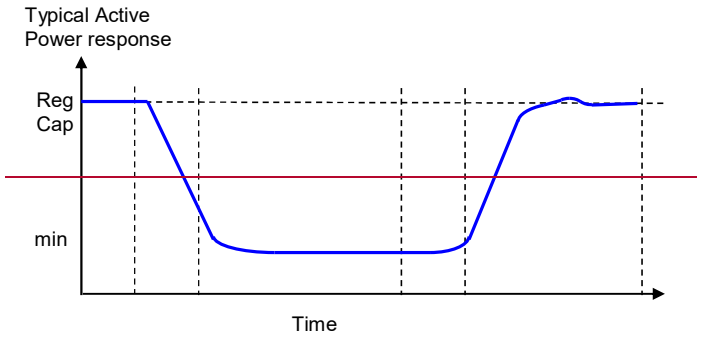
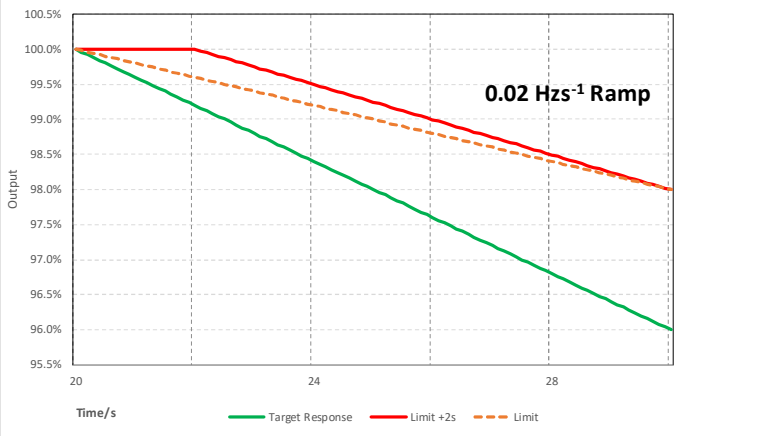


Figure B.6.4(ii): LFSM-O ramp response test – target response and limits



~~**Figure B.6.4: LFSM-O BC2 ramp response test**~~

Figure B.6.4(iii): LFSM-O ramp response test – expansion (frequency increase)

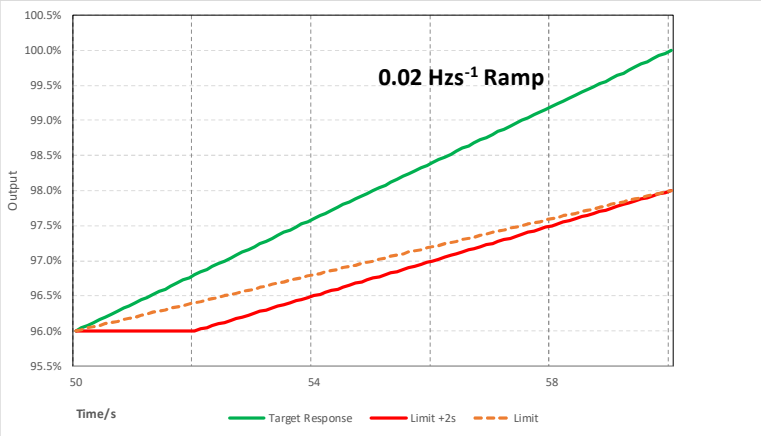


Figure B.6.4(iv): LFSM-O ramp response test – expansion (frequency decrease)

Annex 4: Grid Code Self-Governance Statement

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Chrissie Brown
Grid Code Modifications Panel
Secretary
Christine.brown1@nationalgrid.com
Direct tel+44 (0)1926 653328

17 June 2018

www.nationalgrid.com

Reference: GC0110 Self-Governance Statement

Dear Gurpal

This is the Grid Code Review Panel's Self-governance Statement to the Authority for Grid Code Modification Proposal ***GC0110 - LFSM-O compliance requirements for Type As and B PGMs***. National Grid Code Administrator has prepared this Self-Governance Statement on behalf of the Grid Code Review Panel and submits it to you in accordance with the Grid Code.

On 26 April 2018 the Grid Code Review Panel considered GC0110 and confirmed unanimously that it meets the Self-Governance Criteria.

As such, GC0110 is unlikely to discriminate between different classes of Grid Code Parties and is unlikely to have a material effect on:

i) Existing or future electricity customers;
ii) Competition in the generation, distribution, or supply of electricity or any commercial activities connected with the generation, distribution or supply of electricity,
iii) The operation of the National Electricity Transmission System
iv) Matters relating to sustainable development, safety or security of supply, or the management of market or network emergencies
v) The Grid Code's governance procedures or the Grid Code's modification procedures

The proposed timetable for the progression of GC0110 is as follows:

18 April 2018	Grid Code Modification Proposal submitted
26 April 2018	Proposal presented to Grid Code Review Panel
06 July 2018	Code Administrator Consultation issued
29 July 2018	Code Administrator Consultation closes
07 August 2018	Draft Modification Self-Governance Report issued to Panel
15 August 2018	Draft Modification Self-Governance Report presented to Panel
15 August 2018	Panel Determination vote
16 August 2018	Final Modification Self-Governance Report published
16 August 2018	Appeal window opens

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07 September 2018	Appeals window closes
21 September 2018	Implementation (10 Working days after appeal window closes)

The GC0110 form is available at;

https://www.nationalgrid.com/uk/electricity/codes/grid-code/modifications/gc0110-lfsm-o-compliance-requirements-type-and-b-pgms

If you require any further information please do not hesitate to contact me.

Yours Sincerely,

Chrissie Brown
Grid Code Review Panel Secretary

Annex 5: LFSM-O National Grid paper & presentation

LFSM- O Interpretation ECC.6.3.7.1 & G99

A Note by Ian Nuttall 2 February 2018.

In GB Article 13.2 of the Requirements for Generators sets out the requirement for Limited Frequency Sensitive Mode – Over (LFSM-O) and in GB the trigger frequency has been proposed at 50.4Hz by National Grid across the GB synchronous area. The requirement applies to all Type A-D Power Generating Modules regardless of their connection point and so applies equally to transmission and distribution connected plant. Within GB the maximum permissible frequency ahead of independent action is 52Hz.

This gives maximum frequency deviation of 52.0 – 50.4 = 1.6Hz

ECC.6.3.7.1.2(i) Minimum steady state response accepted is 2% / 0.1Hz (ie 10% droop).

Frequency (Hz)	Frequency Deviation above 50.4Hz	Minimum acceptable steady state response	50% of steady state response in 10s capped at 5%
50.4	0	0%	0
50.5	0.1	2%	1%
50.6	0.2	4%	2%
50.7	0.3	6%	3%
50.8	0.4	8%	4%
50.9	0.5	10%	5%
51.0	0.6	12%	5%
51.1	0.7	14%	5%
51.2	0.8	16%	5%
51.3	0.9	18%	5%
51.4	1.0	20%	5%
51.5	1.1	22%	5%
51.6	1.2	24%	5%
51.7	1.3	26%	5%
51.8	1.4	28%	5%
51.9	1.5	30%	5%
52.0	1.6	32%	5%

For a 1.6Hz deviation, a 10% droop would represent a 32% steady state output reduction. Any controlled response in excess of the 32% minimum reduction is acceptable.

ECC6.3.7.1.2(ii) - Continuous and Linear

Output reduction once commenced should continue without stalling and the response should be a least linear in relation to the rise in frequency. The as far as practicable this permits possible exclusion where it can be reasonably demonstrated to not be technically possible.

ECC.6.3.7.1.2.(iii) - As much as possible of the reduction in 10 seconds.

The current GB Grid Code requires as much as possible of the steady state deviation to be achieved in 10 seconds but offers no further guidance on what represents an acceptable level for this. In addition, there is no indication of an acceptable delivery time for the full droop response. In lay terms, "as much as possible", could sensibly be interpreted as a delivery at least in excess of 50% of the total.

Automatic frequency control is managed by the operation of a governor or frequency control device. In GB, FSM plant is required to achieve a minimum response standard of 10% of its maximum output capability delivered in 10 seconds in response to falling or rising frequency of +/-0.5Hz.

The LFSM-O requirement also seeks automatic action in response to high frequency in excess of 50.4Hz. In managing a high frequency event, it therefore makes sense that in this mode, a similar response capability should be sought as a measure of as much as possible for the largest deviations in frequency. However as the minimum acceptable droop is 10% and therefore the steady state response expectation is half that of FSM mode (frequency response droop is between 3-5%) it makes some sense to seek a minimum standard of 5% response in 10 seconds for the LFSM plant.

Therefore interpreting "as much as possible" of the change in 10s NG, suggests a value of 50% of the steady state change is achieved in 10 seconds but noting that the requirement continues for larger frequency this should be capped at a maximum of 5% of maximum output as an acceptable level of a fast acting contribution.

Applying this plus the linear and proportional principle to the 0.2Hz, 0.5Hz & 1.6Hz active deviations for LFSM-O gives a view of minimum acceptable responses as follows:

	ΔF = 0.2Hz (50.6Hz)	ΔF = 0.5Hz (50.9Hz)	ΔF = 1.6Hz (52Hz) .
10s	2% of maximum output	5% of maximum output	5% of maximum output
20s	4% of maximum output	10% of maximum output	10% of maximum output
30s	4% of maximum output	10% of maximum output	15% of maximum output
40s	4% of maximum output	10% of maximum output	20% of maximum output
50s	4% of maximum output	10% of maximum output	25% of maximum output
60s	4% of maximum output	10% of maximum output	30% of maximum output
64s	4% of maximum output	10% of maximum output	32% of maximum output

This is indicated graphically for the +2.0Hz step and +0.6Hz ramp injections in the following figures with the green lines indicating the calculated response position in relation to the frequency deviation The red dashed line indicates the boundary of acceptable response in line with the interpretation set out above. The difference between the orange and red lines indicates the permitted two second delay in for the initial measureable response but it is important to note that at the end of the tine period (ie at 10secconds) both the red and brown lines converge to the same point..

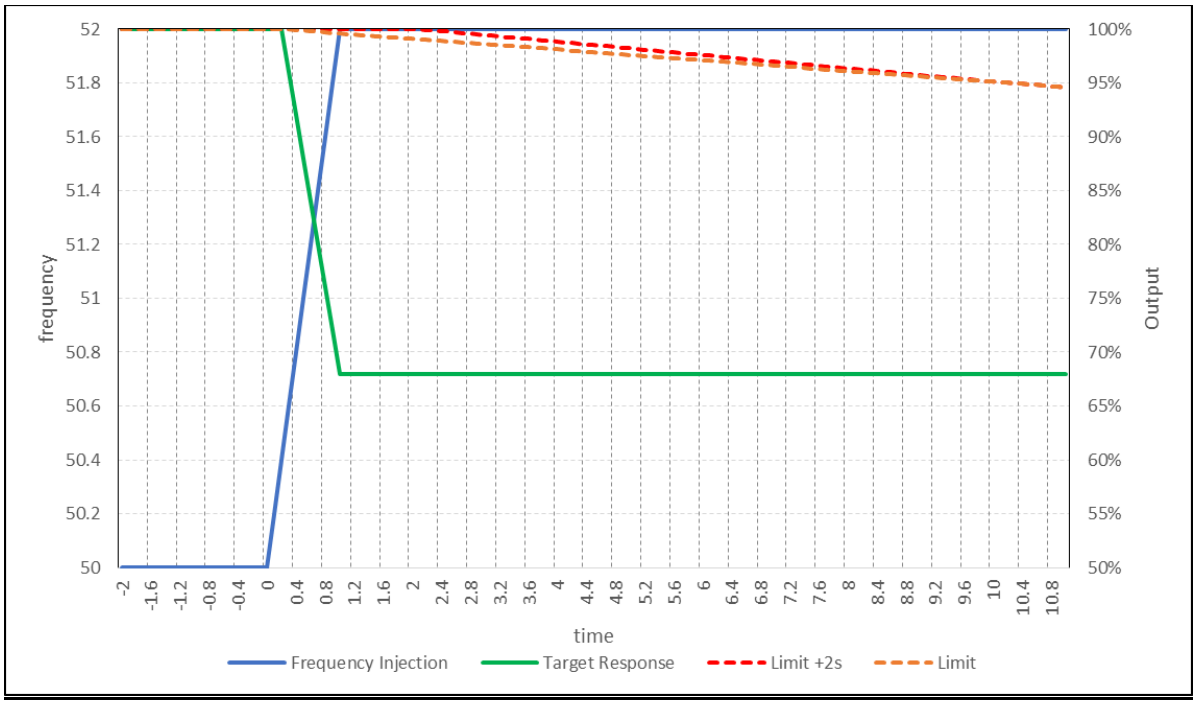

Figure 1 - +2.0Hz injection with 10% droop setting (initial response)

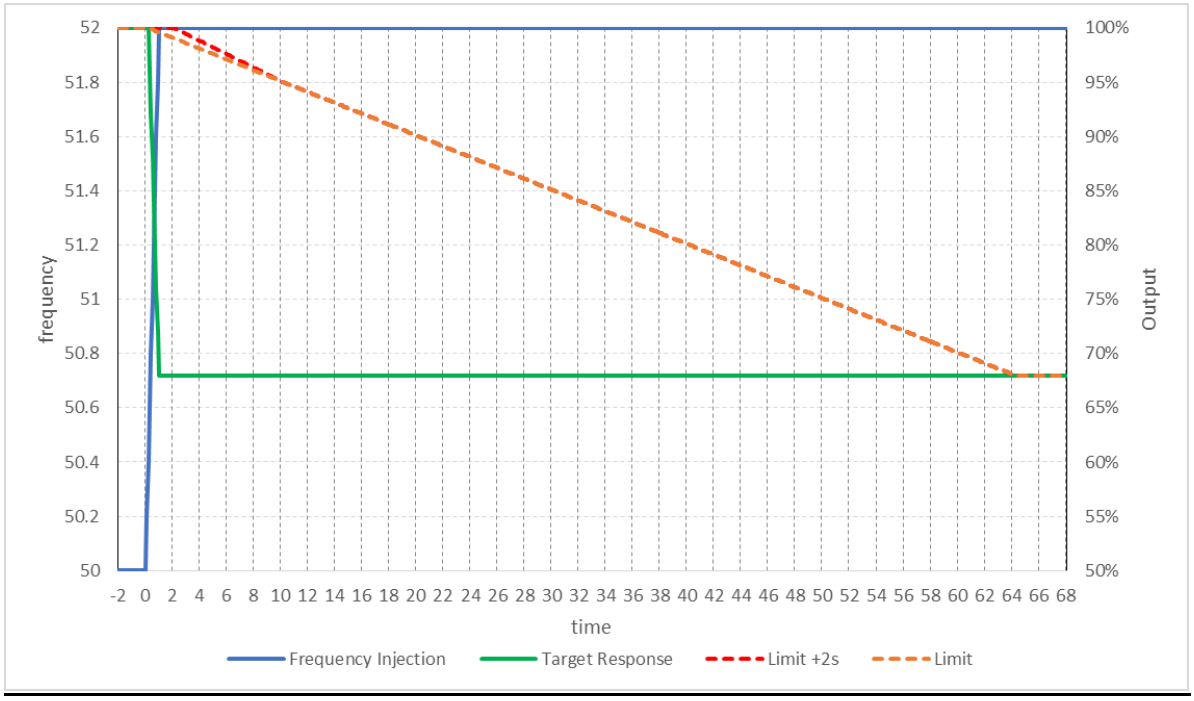

Figure 2 - +2.0Hz injection with 10% droop setting (whole response)

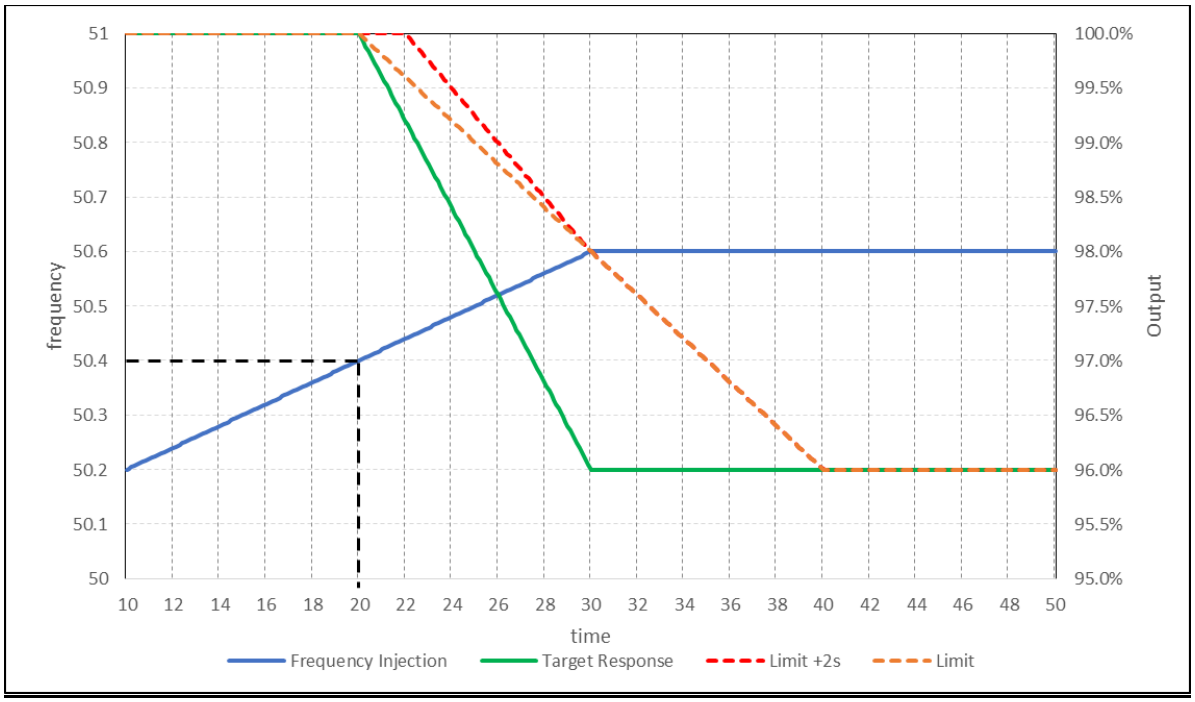

Figure 3 - +0.6Hz injection with 10% droop setting (initial response)

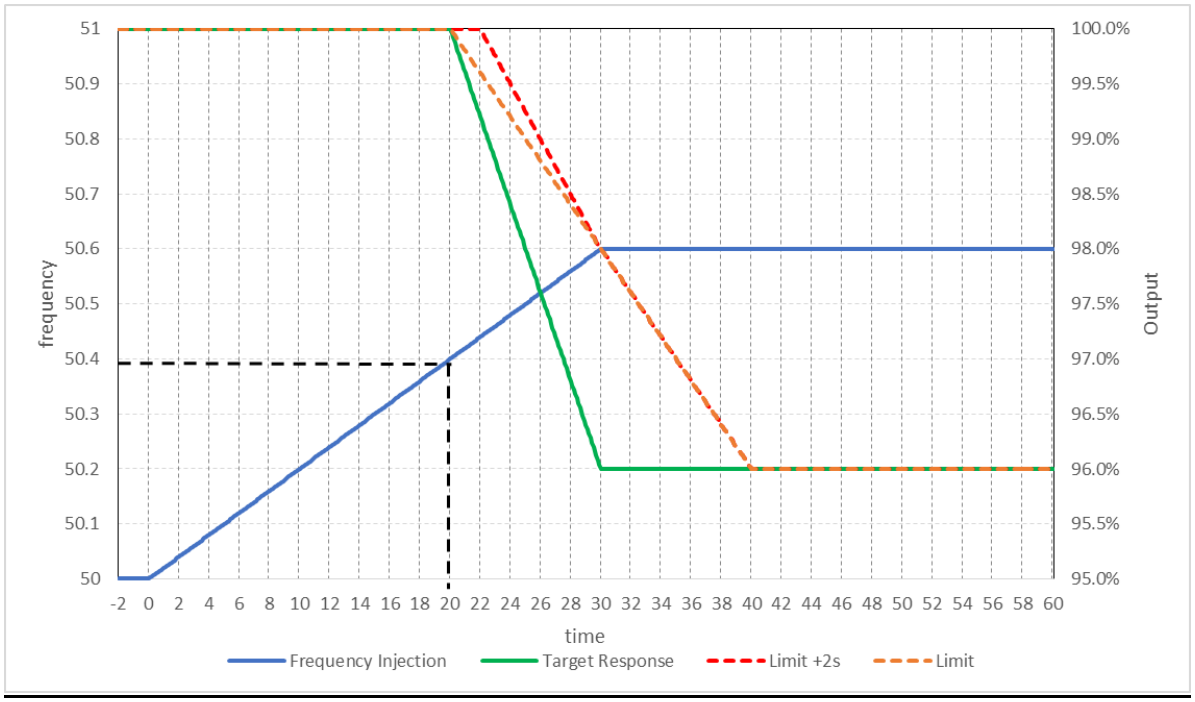

Figure 4 - +0.6Hz injection with 10% droop setting (whole response)

ECC.6.3.7.1.2.(iii) - Initial delay as short as possible and delays > 2 seconds justified.

In responding to a frequency >50.4Hz NG expects to see a measureable reduction in active power within as short a time as possible of the frequency exceeding the threshold. Where measured delays are less than 2 seconds, they will not result in challenge but any delay longer than 2 seconds will need to be accompanied with evidence as to why the delay cannot practically be reduced to 2 seconds. For the avoidance of doubt, economic arguments are unlikely to be accepted to justify delays longer than 2 seconds. This is covered in RfG Art 13.2(e).

GC110 Workgroup
Limited Frequency Sensitive Mode - Over



6th June 2018

Ian Nuttall

Connection Compliance Team

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National Grid Frequency Control Responsibility

- NG Licence Obligation
  - Generation & Demand need to matched minute by minute / second by second
  - National Grid Control GB system frequency at 50Hz +/-1%.
  - Generation and demand held in readiness to manage all credible circumstances that might result in frequency variations.
  - Breaches outside these limits are reportable to Ofgem.
- Dynamic Response
  - Continuously provided service used to manage the normal second by second changes on the system.
- Non-dynamic or Static Response
  - Usually a discrete service triggered at a defined frequency deviation.
  - Reset once frequency recovers.

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National Grid Frequency Control Approach

- Mandatory Frequency Response (MFR)
  - Automatic active power output change in response to system frequency deviation.
  - Applies to all Large and Medium Power Stations with Synchronous Plant and all Power Park Modules of 50MW or greater.
- Firm Frequency Response (FFR)
  - Commercial service for the firm provision of dynamic or non-dynamic response to changes in frequency.
- Enhanced Frequency Response (EFR)
  - EFR is a commercial service, …… to provide frequency response in one second or less.
- Automatic defense action outside normal operating range
  - Demand reduction for low frequency below 48.8Hz
  - Generation reduction for high frequency above 50.4Hz

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The Winds of Change

- Decentralised Generation
  - Large transmission connected generators are closing or running much less often.
  - Energy is being generated locally at distribution level.
  - Traditional services and protective actions from large generators can no longer be relied upon to secure the system.
- RfG places obligations on smaller units
  - Frequency Range, RoCoF withstand and output power with falling frequency.
  - Fault Ride Through.
  - Limited Frequency Sensitive Mode (LFSM-O).
- All plant (irrespective of size) needs to contribute to System frequency control and containment.

RfG Implementation

- RfG applies LFSM-O for Type A upwards
  - Type A - System Operator option as droop response or optional auto disconnection with a frequency trigger.
  - NGET selected droop control option for Type A in GB which was supported through the GC0101 consultation
  - Type B, C & D - Droop response only

RfG Type	GB thresholds – approved	Connection Voltage
A	800W – 1MW	<110kV
B	1 – 10MW	<110kV
C	10 – 50MW	<110kV
D	>50MW	>110kV

- In implementing RfG LFSM-O, clear links to existing Grid Code requirement BC.3.7.2
  - Wording from BC.3.7.2 retained and then carried forward into Grid Code ECC and G99.
  - Testing methodology also transferred into ECP section.
  - Indicated response in G99 is typical response as it always has been in the Grid Code.

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Grid Code – BC3 requirement

- BC3.7.2 is a very similar requirement to LFSM-O
  - Included in Grid Code since 1990.
  - Specifies trigger level as 50.4Hz.
  - Specifies 2%/0.1Hz as a minimum response level. (10% droop).
  - Continuously and linearly proportional, as far as practical.
  - As much as possible of reduction in 10 seconds.
- Testing from late 1990s
  - +0.6Hz ramp over 30s, hold till stable then reverse injection at same rate of change. (test BC4).
  - Larger step change introduced following concern over poor part-load rejection. (test BC3).
  - Both test descriptions entered Grid Code OC5 in August 2012 following Compliance Process consultation.

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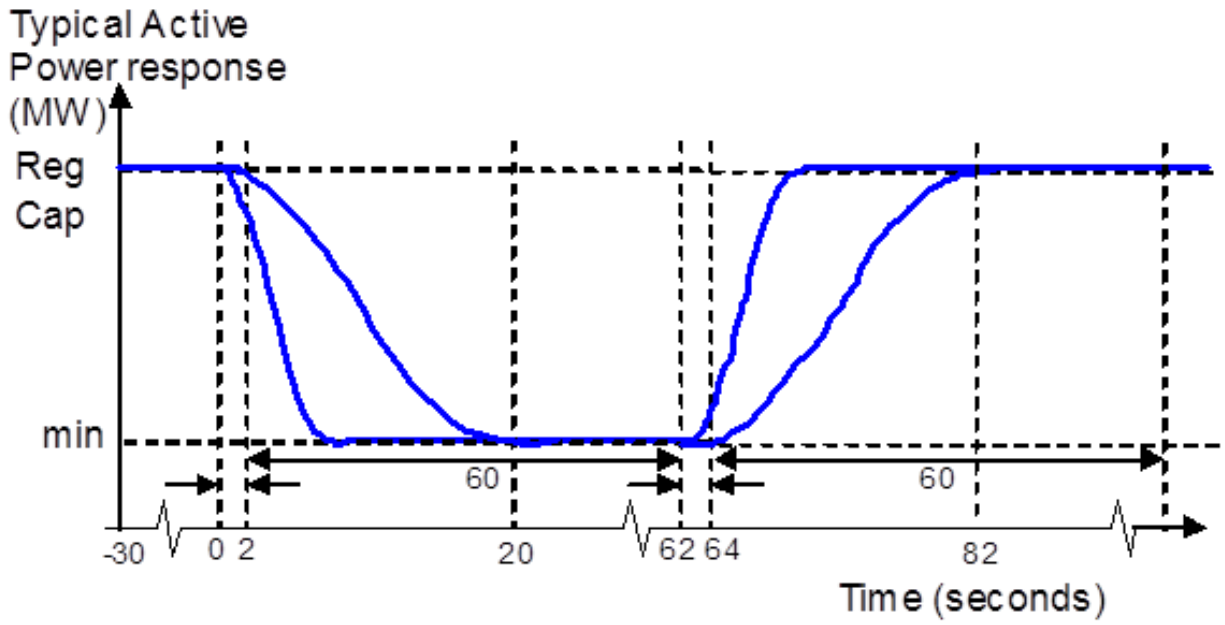
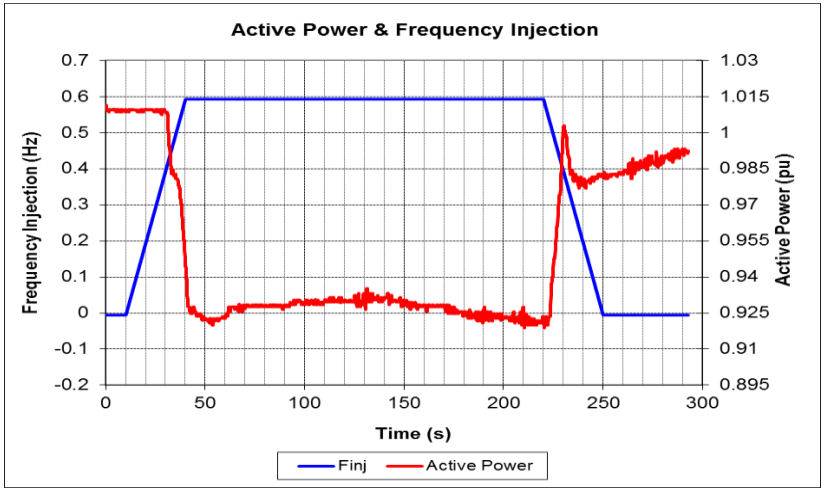
Examples of Responses to BC3 / BC4 test

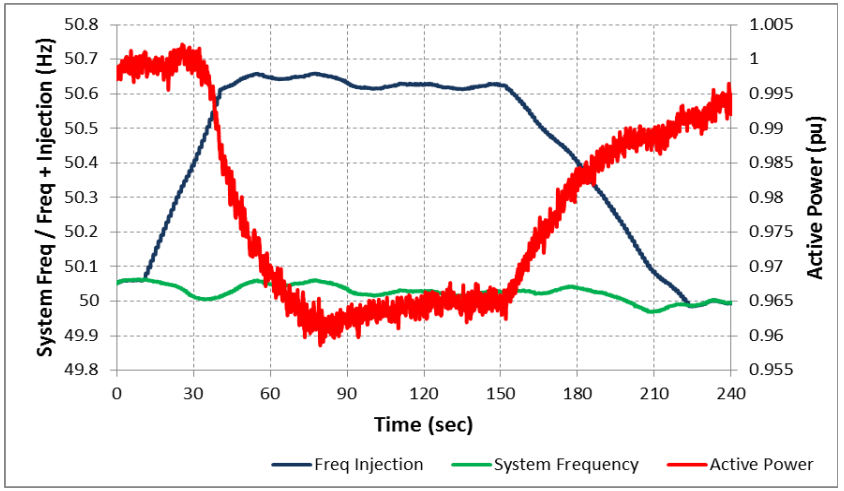
- Typical Response indicated in Grid Code and G99.

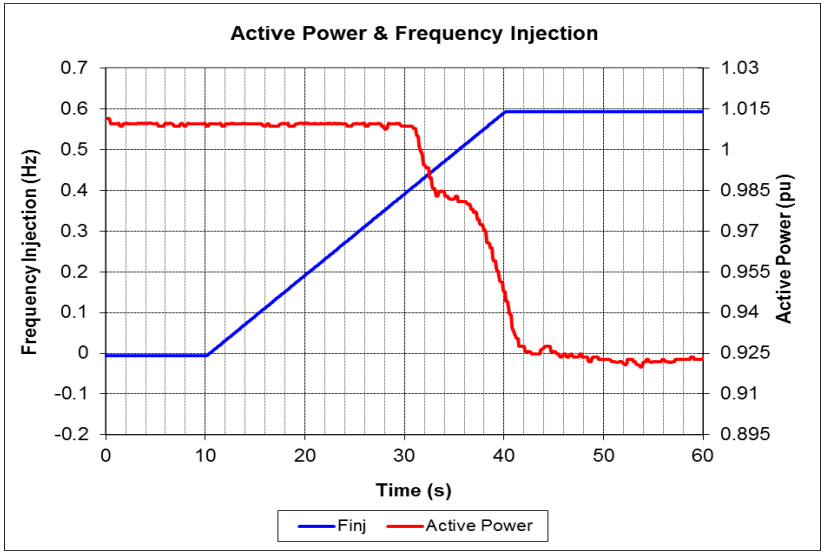


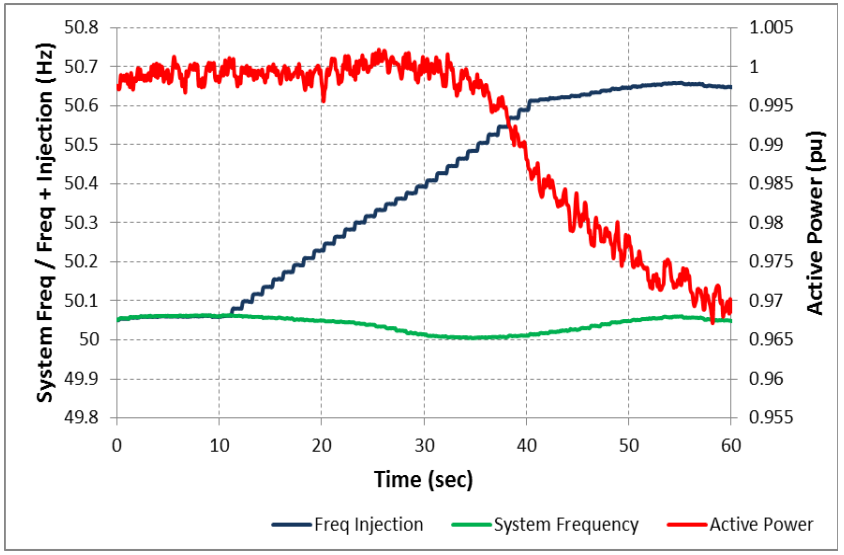
- Following examples taken from CCGT, Wind & Coal.

BC4 Conventional unit results

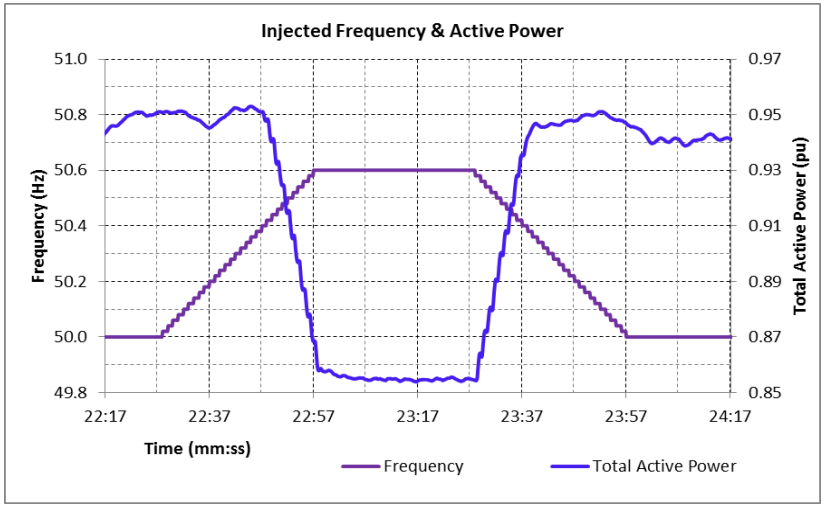


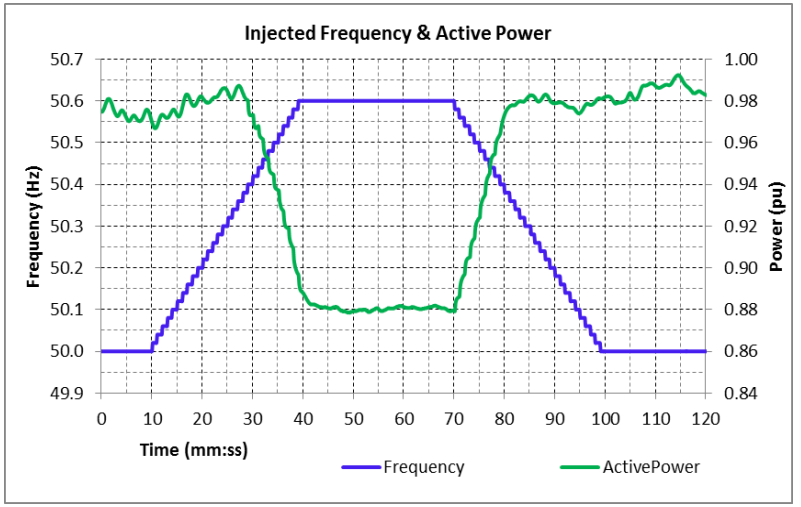


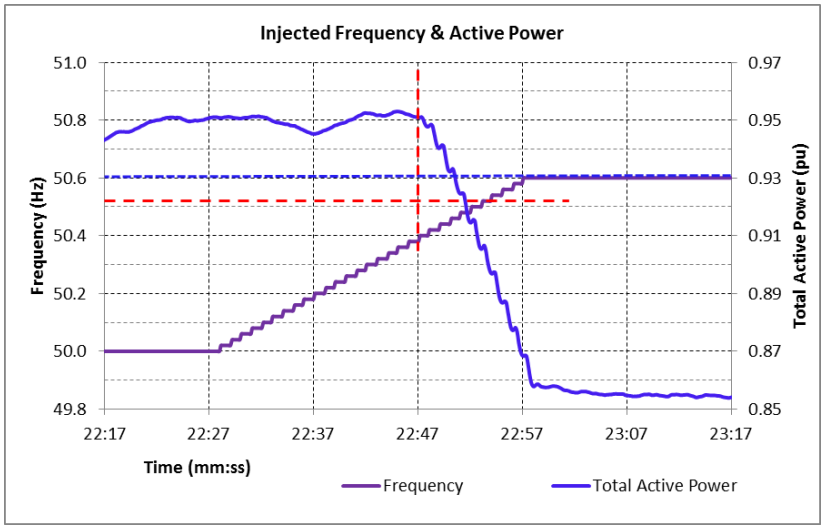


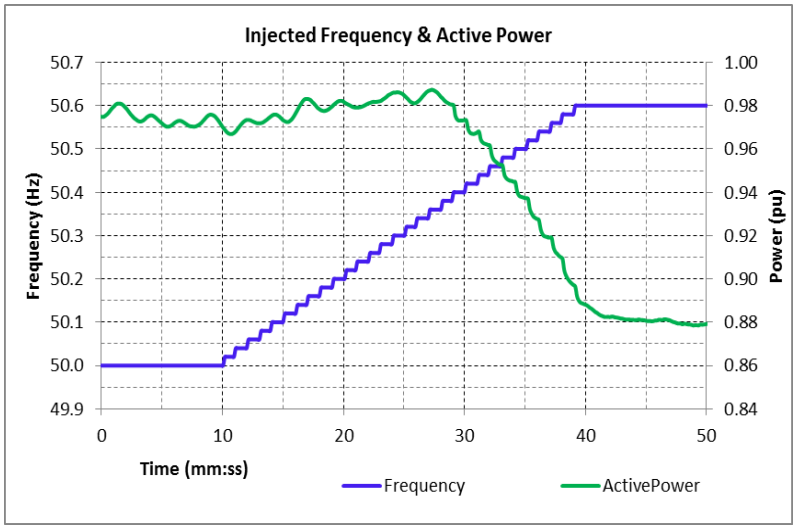


BC4 Windfarm results

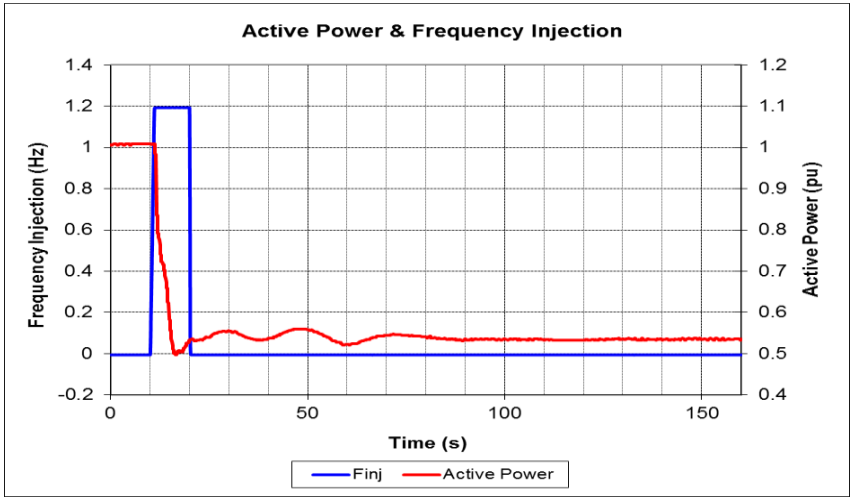


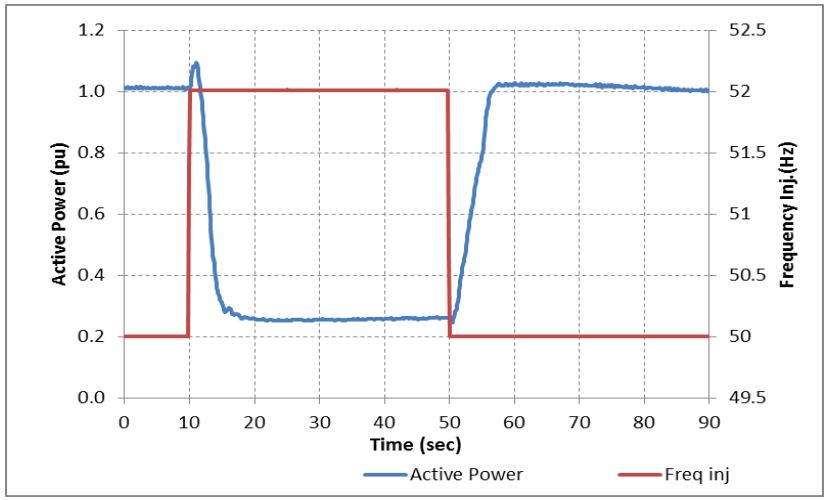


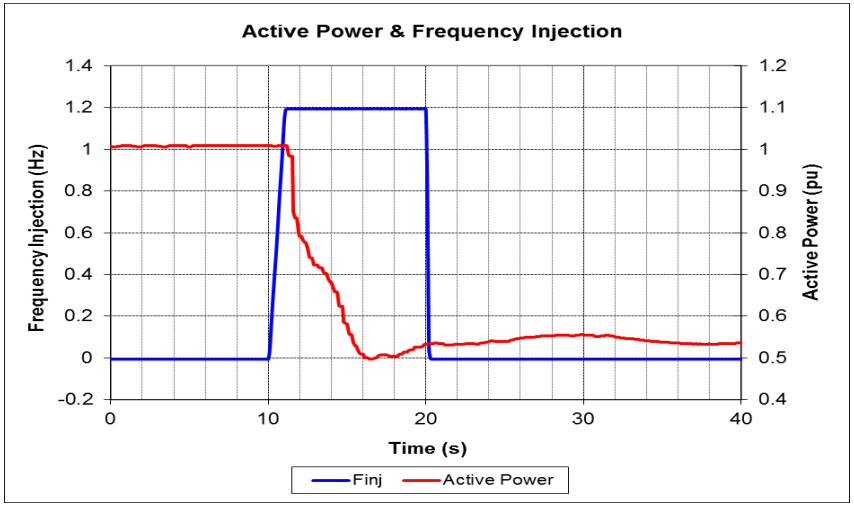


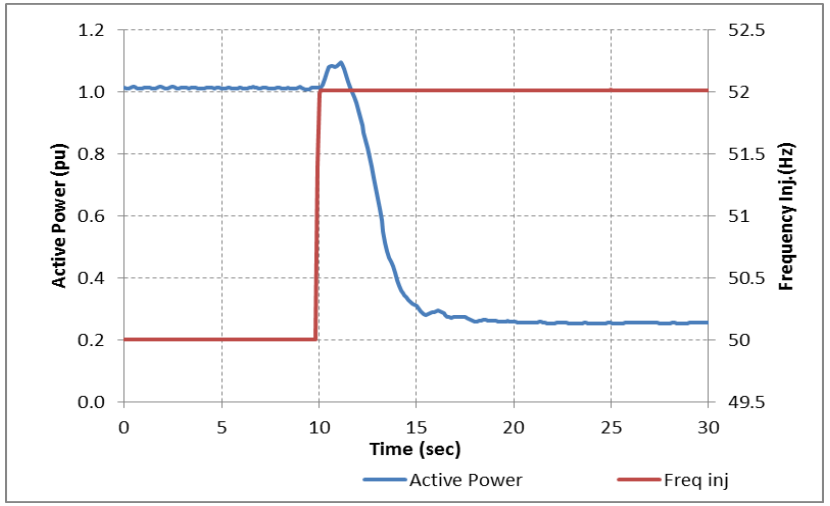


BC3 Conventional unit results

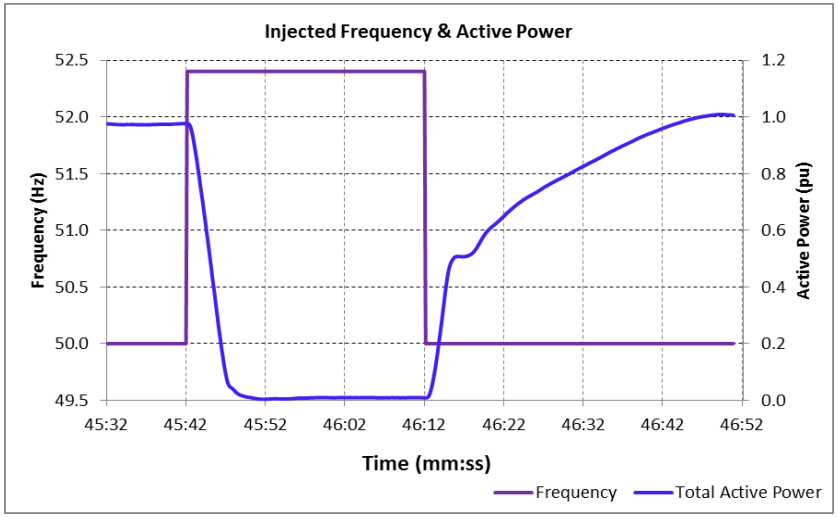


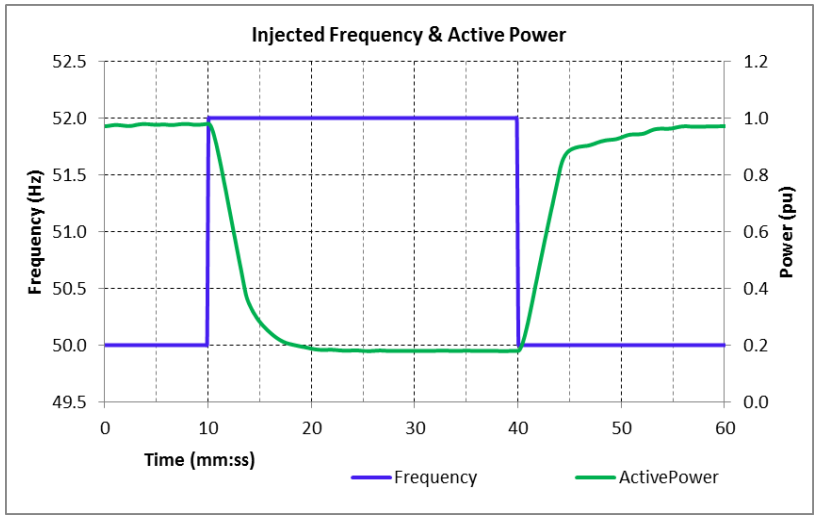


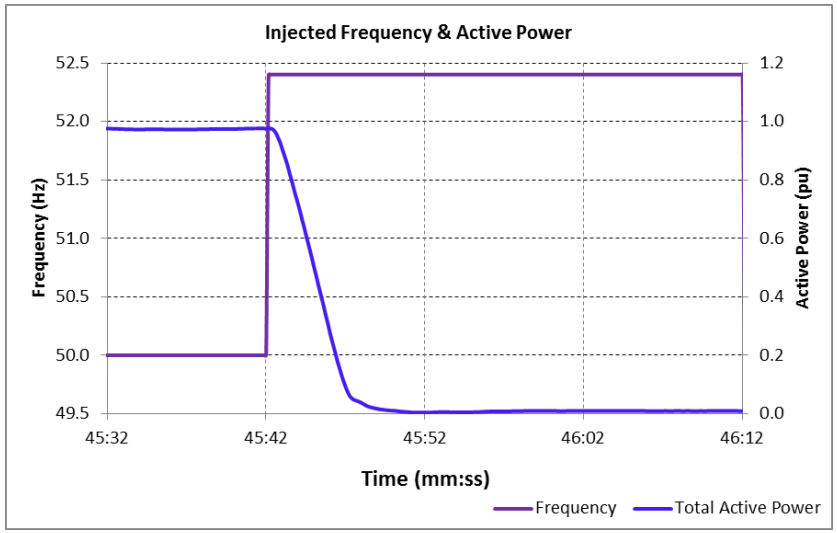


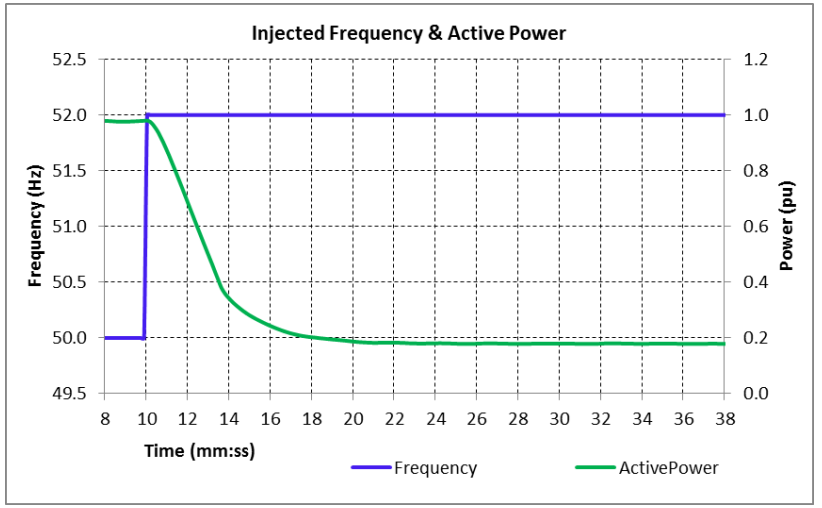


BC3 Windfarm results









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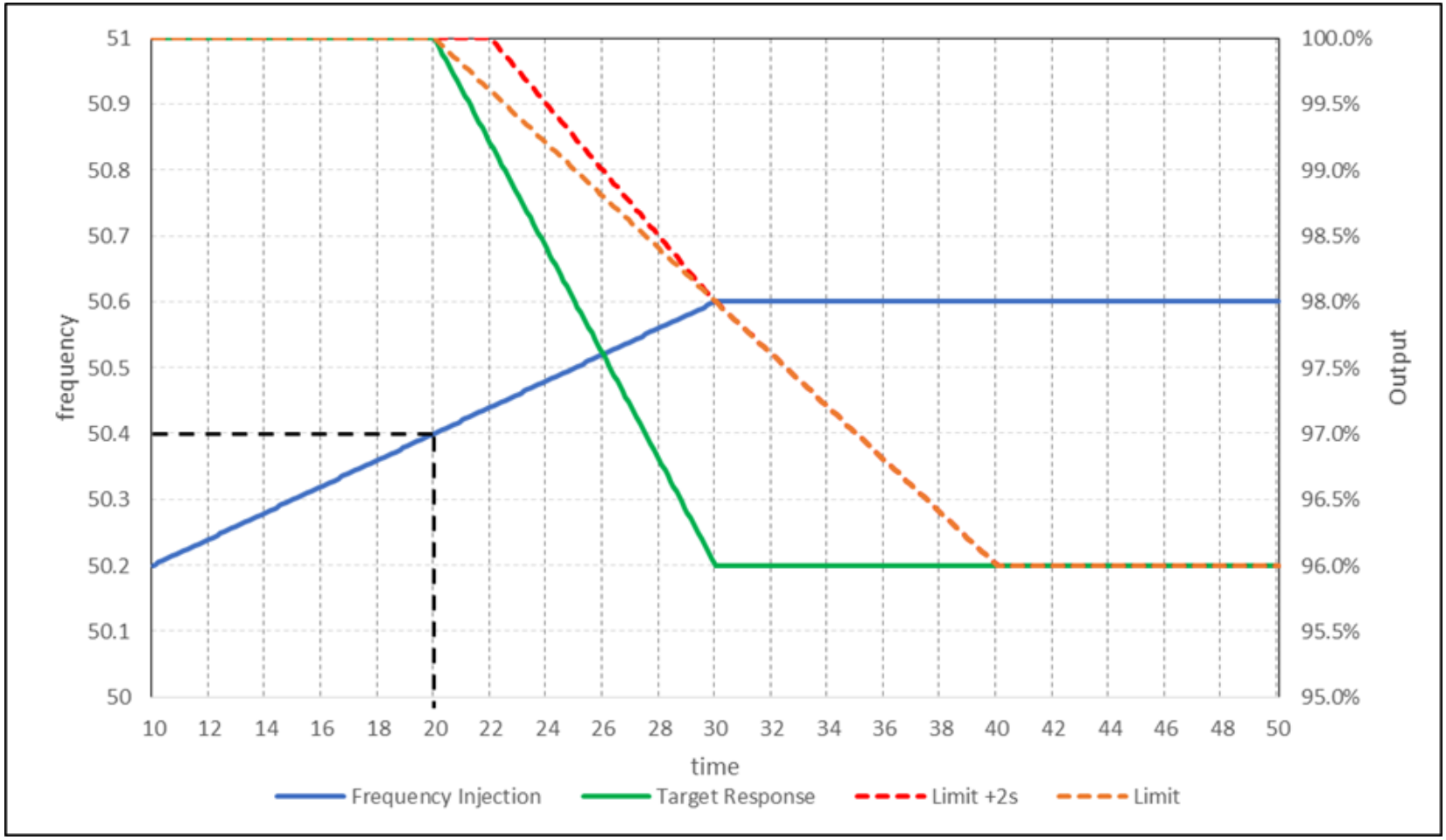
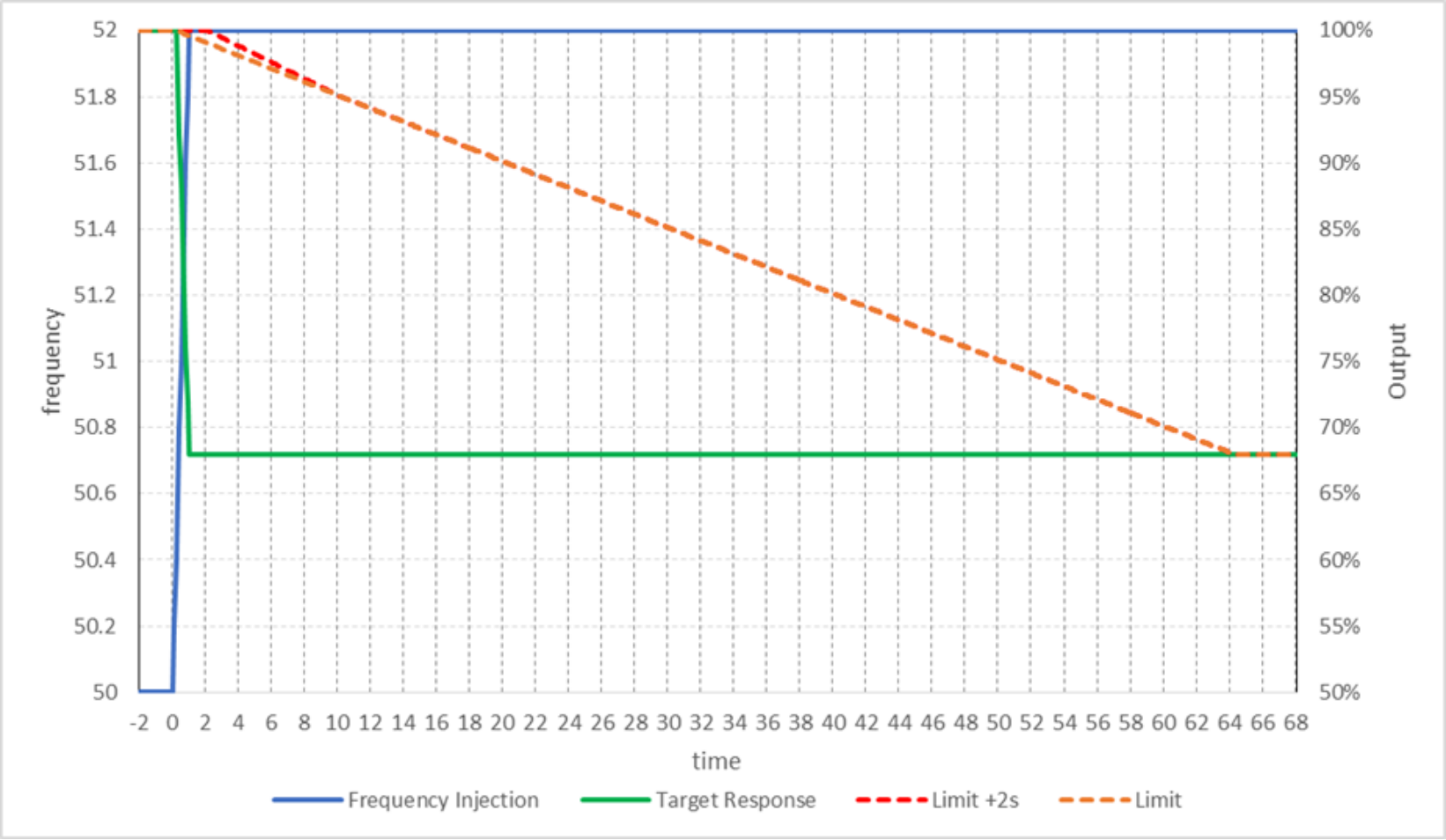
GC102 Responses & Comments

- What is the limit of compliance for LFSM-O?
- Recognised for Type B, a product spec is the best approach. This needs a clear position for compliance to test against.
- RfG offers no clue on acceptable timing for delivery of the droop response, but a dynamic requirement is necessary to satisfy the droop.
- Grid Code text still does not give a clear position for compliance. Generally not an issue for larger plant (Type C/D) with FSM capability.
- Discussion note developed with ENA which sets backstop position of 50% of response capped at 5% in 10 seconds.

LFSM-O BC4 test – Application of minimum response dynamic

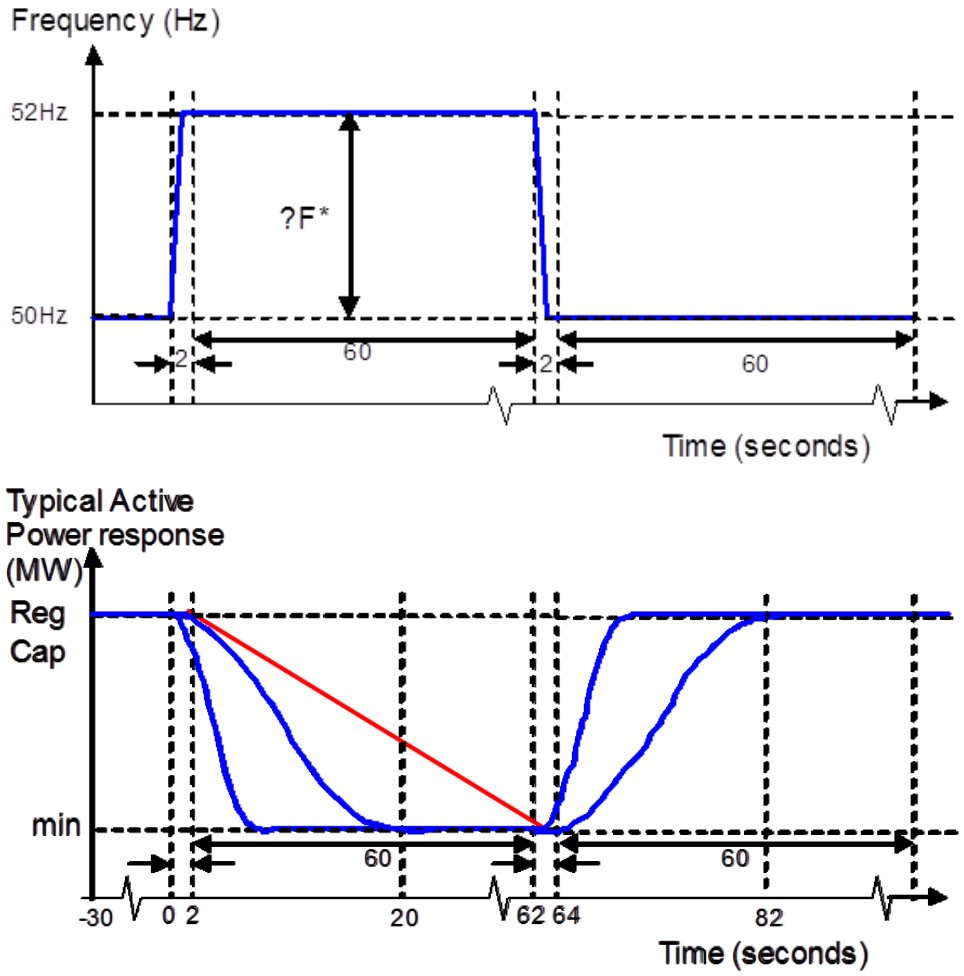


LFSM-O BC3 test – Application of minimum response dynamic



LFSM-O Backstop Compliance Position

- Limit of compliance for LFSM-O test BC3 compared to Typical



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LFSM-O Conclusion

- Clarification is appropriate hence GC110 WG initiated.
- For Type A and Type B which only have LFSM-O requirement an additional clarification is provided in ECC.6.3.7.1.2 (vi) with similar in for D Code in G98/G99.
- ECC.6.3.7.1.2 (v) is proposed which clarifies that LFSM-O response should be removed as the over-frequency reduces.

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LFSM-O Summary

- LFSM-O is a connection requirement aimed at preventing a run away High Frequency situation.
- Trigger level falls outside normal operating region for mandatory and commercial services and exceeding 50.4Hz is a rare event.
- 10% droop requirement requires a dynamic performance.
- Remaining connected and operational is equally important.
- BC3 and BC4 tests remain as in previous Grid Code.
- As much as possible remains with clarification of where the limit of compliant response is defined.
- Minimum requirement proposed of 50% of response delivery in 10 seconds, capped at 5%.

Annex 6: Attendance Register

A – Attended/Dialled in
X – Absent

Name	Organisation	Role	6/06/2018	18/06/2018
Chrissie Brown	Grid Code Code Administrator	Technical Secretary	A	A
Mike Kay	Distribution Code Code Administrator	Chair (Distribution Code)/Workgroup member	A	A
Chris Marsland	Centrica	Proposer and Workgroup member	A	A
Simon Sheridan	National Grid System Operator	Workgroup member	A	A
Garth Graham	SSE Generation	Workgroup member	A	A
Isaac Gutierrez/ Rui Rui	Scottish Power Renewables	Workgroup member	A	X
Gregory Middleton	Deep Sea Electronics Plc	Workgroup member	A	A
Alastair Frew	Scottish Power Generation	Workgroup member	A	X
David Saez/Sigrid Bolik	Senvion	Workgroup member	A	A
Ian Wassman	Industrial Power Units	Observer	A	X