SONI and NIE Networks' proposal for the general application of technical requirements in accordance with Articles 13 – 28 of the Commission Regulation (EU) 2016/631 establishing a network code on requirements for grid connection of generators

20th December 2017

Updated with clarifications 17th January 2018

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1. Introduction

On the 17th May 2016 the Commission Regulation (EU) 2016/631 establishing a network code on requirements for grid connection of generators[1] (hereafter referred to as 'RfG') entered into force.

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The requirements of the RfG apply from three years after publication as per Article 72. The requirements of RfG do not apply to existing power generating modules (PGMs). A PGM is defined in Article 4 as existing if:

(a) It is already connected to either the transmission or distribution network in Northern Ireland by two years after entry into force of the RfG (17th May 2018); or

(b) The power-generating facility owner has concluded a final and binding contract for the purchase of the main generating plant by two years after entry into force of the RfG (17th May 2018).

It should be noted that whilst the RfG does not apply to existing PGMs as per the above, should a PGM owner substantially modify their generation plant then certain requirements of the RfG will apply to that generation plant.

The requirements in RfG apply to generators with a Maximum Capacity[2] of 800 W or greater connecting to either the transmission or distribution networks in Northern Ireland. These requirements cover different technical criteria and apply to generators based on their RfG Classification Type[3] (i.e. A, B, C and D).

This public consultation document is produced jointly by SONI Ltd in its role as the Transmission System Operator in Northern Ireland (hereafter referred to as the TSO) and Northern Ireland Electricity Networks in their role as the Distribution System Operator in Northern Ireland (hereafter referred to as the DSO). References in this document to the Relevant System Operator (RSO) mean the operator of the system to which the generator is connected i.e. either the TSO or DSO.

Under Article 7 (4) the RSO or TSO is required to submit a proposal for requirements of general application for approval by the Utility Regulator (UREGNI) within two years of entry into force of this Regulation i.e. 17th May 2018. It is not a requirement of RfG to consult upon the proposal for requirements of general application prior to submission to the CRU. The TSO and DSO are issuing this consultation document in the interest of transparency and to ensure that the TSO and DSO have the best information available to them to submit an appropriate set of recommendations to the CRU for the proposal of requirements of general application.

The TSO and DSO are consulting on the non-mandatory requirements and non-exhaustive[4] parameters in accordance with the requirements set out in Title II, Articles 13-28 of the RfG. This consultation document seeks readers' views on new or changed technical requirements that may or will apply to generators.

[1] https://publications.europa.eu/en/publication-detail/-/publication/1267e3d1-0c3f-11e6-ba9a-01aa75ed71a1/language-en

Field Code Changed

[2] Refer to section 3.4 for more information on the definition of Maximum Capacity.
[3] Refer to section 3.2 for more information on the different types and bands within RfG
[4] Refer to section 3.1 for more information on non-exhaustive parameters and non-mandatory requirements.

An equivalent consultation is being run concurrently by EirGrid plc in its role as the Transmission System Operator in Ireland and by ESB Networks in its role as the Distribution System Operator in Ireland.

1.1. Associated documents

The TSO and DSO strongly recommend that all readers review the RfG Network Code, The RfG Consultation on Banding Thresholds in Northern Ireland[5] and the RfG Banding Threshold Consultation Minded to Position in Northern Ireland[6].

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All references to Articles in this document refer to Articles set out in the RfG unless otherwise specified.

1.2. Definitions and Interpretations

For the purposes of this consultation document, terms used in this document shall have the meaning of the definitions included in Article 2 of RfG

In this consultation document, unless the context requires otherwise:

a) the singular indicates the plural and vice versa;
b) the table of contents and headings are inserted for convenience only and do not affect the interpretation of this consultation; and
c) any reference to legislation, regulations, directive, order, instrument, code or any other enactment shall include any modification, extension or re-enactment of it then in force.

1.3. Structure of this document

Sections 2 & 3 ‘Background’ and ‘Scope’ provide important information that guide the reader through the RfG concepts and the principles underpinning this consultation document.

Section 4 sets out the proposals that are being discussed in this consultation document. It details the proposal, justification and applicability of parameter or requirement as applicable.

In this document we have grouped parameters by technical theme, with a number of sub-themes discussed under each theme. Within each theme we go into detail on which parameter or requirement applies to each generator type. The themes are:

1. Frequency
2. Voltage & Fault Ride Through
3. System Restoration
4. Protection & Instrumentation

[5] http://www.soni.ltd.uk/media/documents/Consultations/RfG%20Banding%20Thresholds%20Consultation%20Northern%20Ireland.pdf

[6] http://www.soni.ltd.uk/InformationCentre/Publications/

2. Scope

The scope of this consultation is to seek your views on the TSO and DSO proposals for:

- making non-mandatory requirements mandatory; and
- parameter selection for the non-exhaustive parameters.

Note this consultation does not seek your views on the mandatory requirements or exhaustive parameters. These have been set by the Commission and cannot be changed. Further information on some of the background to these decisions is available in the ENTSO-E FAQ document[7].

In some cases exhaustive requirements are described in this document to provide context for relevant discussion point and this will be clearly indicated.

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7 http://www.acer.europa.eu/Media/News/Documents/120626%20-%20NC%20RfG%20-%20Frequently%20Asked%20Questions%20(2).pdf

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3. Background

The RfG applies to only new generators. The RfG defines when a generator is deemed to be an 'existing' or a 'new' generator in the following articles:

The RfG applies across the European Union. The RfG recognises that the requirements of power systems in different synchronous areas can be different due to the differing sizes. For this reason, the RfG provides that some of the requirements for general application are to be specified at National level, i.e.by the TSO, DSO or RSO of the member state, rather than at EU level.

To give effect to this concept the RfG contains requirements that are commonly described as either mandatory or non-mandatory and also requirements that are commonly described as exhaustive or non-exhaustive:

- A mandatory requirement must be applied by the RSO
- A non-mandatory requirement is one which the RSO may choose to apply
- An exhaustive parameter has a specified value or range in the RfG which the RSO must apply
- A non-exhaustive parameter is one for which either:
    - the RfG provides a range from which the RSO must select the applicable value for their region.
    - Or the RfG does not specify a value and the RSO must select the applicable value for their region

As mandatory and exhaustive parameters are not at the discretion of the RSO to modify they do not form part of this consultation.

3.1. Principles underpinning the Proposals

Many of the requirements for general application exist in Northern Ireland today in the Grid and/or Distribution Codes. Furthermore, many parameters and requirements in the Grid and Distribution Codes have been updated in recent years as a result of the work carried out under the DS3 Programme[8]. It is not intended to revisit this work.

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Non-Mandatory Requirement Selection

In the majority of cases the following assumptions are made:

- where the requirement provided in the RfG is an existing requirement in Ireland, the requirement is made mandatory nationally under the RfG.
- where the requirement provided in the RfG is not an existing requirement in Ireland, the requirement is not made mandatory nationally under the RfG.

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http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

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Non-Exhaustive Parameter Selection

There are two examples of non-exhaustive parameter selection under RfG;

1. RfG requests that the RSO selects the value from within a range or
2. RfG does not specify a range and requests that the RSO specify a value.

In the majority of cases the following assumptions are made:

- where the range for a non-exhaustive parameter provided in the RfG includes the existing value applied in Northern Ireland, the existing value is proposed.
- where the range for a non-exhaustive parameter provided in the RfG does not include the existing value applied in Northern Ireland then the value proposed represents the minimum amount of change possible.
- where the RfG does not provide a value for a non-exhaustive parameter but requests that the RSO defines the value and it is an existing parameter in Northern Ireland, the existing value is proposed.
- where the RfG does not provide a value for a non-exhaustive parameter but requests that the RSO defines the value and it is not an existing parameter in Northern Ireland, a justification is given

3.2. Overview of Generator Types

Requirements for general application become increasing extensive as the size of the generator increases. RfG classifies all generators into one of four types A, B, C and D. Generator Types are primarily based on maximum capacity size. SONI's Minded to Position on Banding Threshold proposes the following:

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- Type A units range from 800 W up to 0.09˙ MW
- Type B units range from 0.1MW up to 4.9˙ MW
- Type C units range from 5 MW to 9.9˙MW
- Type D units are great then 10MW

Note all generation connected at 110 kV or higher is automatically considered as Type D.

It is important to note the definition of Maximum Capacity in the RfG:

> *'maximum capacity' or 'Pmax' means the maximum continuous active power which a power-generating module can produce, less any demand associated solely with facilitating the operation of that power-generating module and not fed into the network as specified in the connection agreement or as agreed between the relevant system operator and the power-generating facility owner;*

Current Grid Code requirements are applied based on Maximum Export Capacity (MEC) or Registered Capacity.

All generation subject to the RfG will be considered based on the actual installed capacity less house load. **This represents a fundamental change to how requirements are applied to generators and should be fully understood by users.**

The majority of the RfG, Articles 13-16, covers the requirements for power generating modules or PGMs.

There are additional articles detailing specific additional requirements for PGMs of different types. The three additional types are:

- Synchronous PGMs (SPGMs)
- Power Park Modules (PPMs)
- Offshore PPMs

Articles 17 – 19 cover additional requirements for synchronous PGMS or SPGMs.

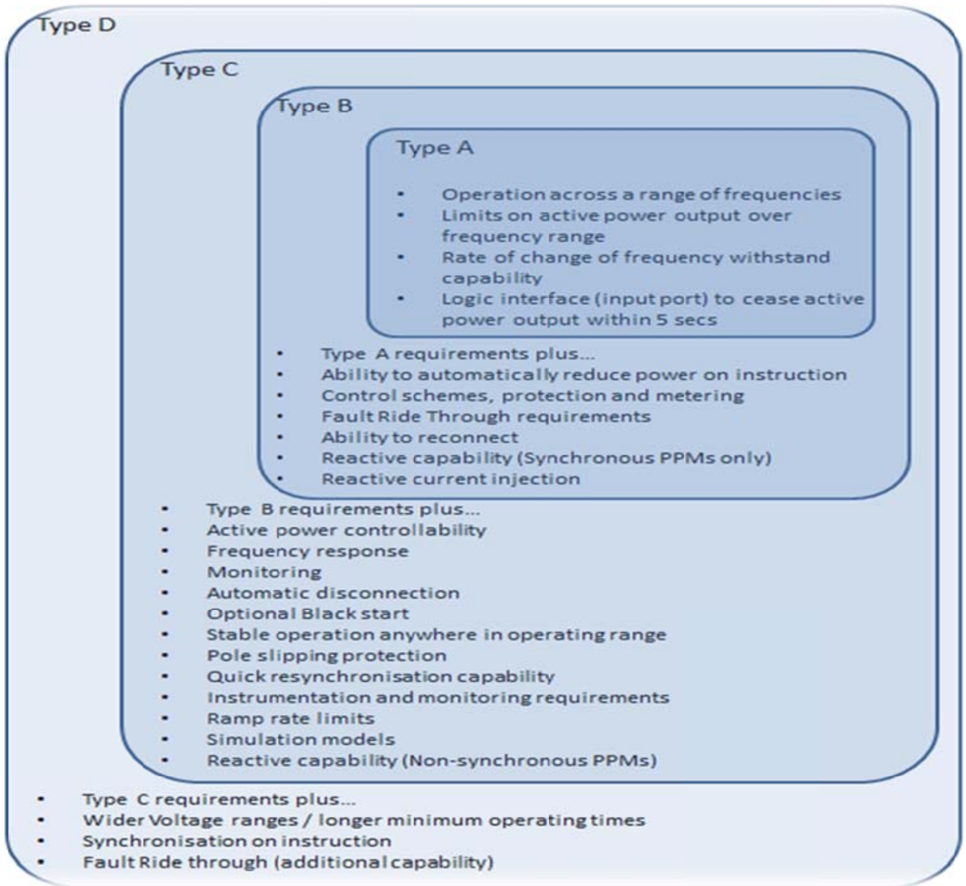
Articles 20 – 22 cover additional requirements for PPMs

Articles 23 – 28 cover additional requirements for Offshore PPMs

It should be noted that under the RfG the requirements for Offshore Power Park Modules depend on the location of the connection point.

- A PPM that is located offshore but has a **connection point onshore** shall be deemed to be an **onshore PPM**. Thus the requirements applicable to PPMs also apply to these units.
- A PPM that is located offshore and has a **connection point offshore** shall be deemed to be an **offshore PPM**. Thus the requirements applicable to offshore PPMs apply to these units.

An outline of the requirements of the RfG as applied to generators of each Type is shown below.



4. Proposals

This section covers the consultation proposals for the non-exhaustive parameter selection and non-mandatory requirement selection.

The document is laid out by theme, and in some cases further broken down into subtheme for clarity. The four main themes are:

4.1 Frequency

4.2 Voltage including Fault Ride Through

4.3 System Restoration

4.4 Protection and Instrumentation

Each section includes the article number and the topic being discussed. A brief description of the requirement is provided alongside a table of the items being consulted on. The tables contain:

- A description of the parameter or requirement;
- The RfG allowable range or an indication that a parameter needs to be specified by the RSO;
- The consultation proposal for the parameter or requirement;
- The RfG Article reference;
- a list of the generator types that this applies to and
- a justification code.

<u>Justification Codes</u>

The justification codes identify which of three categories the proposed parameters falls into. For category 1 further rationale is only provided where it is felt it is required to aid understanding. If a proposal falls into category 2 or 3 an explanation is provided.

1. “In line with existing”
   The proposed parameter is in line with the existing grid or Distribution Code requirements.

2. “As close as possible to the existing”
   The existing grid or Distribution Code requirements do not fit within the allowable RfG range. In this case the proposed parameter is as close to the existing grid or Distribution Code requirements as is allowable under RfG

3. “New of Different”
   The requirement either does not exist in our grid and Distribution Code s today and a rationale for the selection is provided. In some cases we have the requirement today but we are proposing a different value and a rationale is provided for this choice

4. “N/A”
   Please note that in some tables we have also shown mandatory and/or exhaustive parameters to provide context to the non-exhaustive or non-mandatory parameter. These items are in greyed out cells and are not subject to consultation, as we do not have the right to change them.

4.1 Frequency Theme

The non-exhaustive and non-mandatory frequency parameters in RfG cover a number of different requirements. The following sub-themes are discussed in the following sections:

- Frequency ranges
- Rate of Change of Frequency (RoCoF) withstand capability
- Automatic connection to the network
- Active Power Control
    - Admissible Active Power reduction from maximum output with falling frequency
    - Remote operation of facility to cease active power
    - Achieving Active Power Set-points
- Frequency Modes
    - Limited Frequency Sensitive Mode: Over-frequency (LFSM)-O
    - Limited Frequency Sensitive Mode: Under-frequency (LFSM)-U
    - Frequency Sensitive Mode (FSM)

4.1.1 Frequency ranges

4.1.1.1 Article 13.1 (a) (i): Frequency Ranges

Non-Exhaustive Parameter Selection

Applies to Type A, B, C, D PGMs and Offshore PPMs

Requirement

A power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in the table below. Please note that only the item in bold is a non-exhaustive parameter and therefore subject to consultation. The other parameters are provided for context.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency Ranges	*47,5 Hz-48,5 Hz for 90 minutes*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*
Frequency Ranges	48,5 Hz-49,0 Hz for a time to be specified by each TSO, but not less than 90 minutes	90 Minutes	13.1.a.(i)	*A, B, C, D PGMs and Offshore PPMs*	2
Frequency Ranges	*49,0 Hz-51,0 Hz for an unlimited time*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*
Frequency Ranges	*51,0 Hz-51,5 Hz for 90 minutes*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*

Table 1 Frequency Withstand Time Periods

Justification

The RfG states that the operation time in the frequency range of 48.5 – 49.0 Hz shall be specified by the TSO but not less than 90 minutes. The current Grid Code requirement in this frequency range is 60 minutes. The proposed parameter of 90 minutes is the closest allowable to the current Grid Code Requirement. Please note the Grid Code in Northern Ireland also requires power-generating modules to remain connected to the network as follows

- between 47-47.5 Hz for 20 seconds
- and between 51.5 -52 Hz for 60 minutes

These requirements will remain in the Grid Code in addition to the RfG requirements in the table above.

4.1.2 Rate of Change of Frequency

4.1.2.1 Article 13.1 (b): RoCoF

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

With regard to the rate of change of frequency withstand capability, a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection.

Proposal: RoCoF Withstand Capability

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
The maximum RoCoF for which the Power Generating Module (PGM) shall stay connected	Not Specified	1 Hz/s over 500ms window	13.1.b	A, B, C and D PGMs and Offshore PPMs	1
The proposal for loss of mains protection	Not Specified	1 Hz/Sec with a 500ms delay.	13.1.b	A, B, C and D and Offshore PPMs	1

Table 2 Rate-of-change-of-frequency-type loss of mains protection & withstand capability

Justification

The proposal is to maintain the ‘agreed in principle’ Grid Code standard for RoCoF (df/dt) of 1 Hz/ sec over a 500 ms rolling window. It is proposed to review the RoCoF requirement of 1 Hz/ sec as part of the 3 year review in 2021.

4.1.3 Active Power Control

4.1.3.1 Article 13.4.a: Admissible reduction from maximum output with falling frequency

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

The relevant TSO shall specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 1 below.

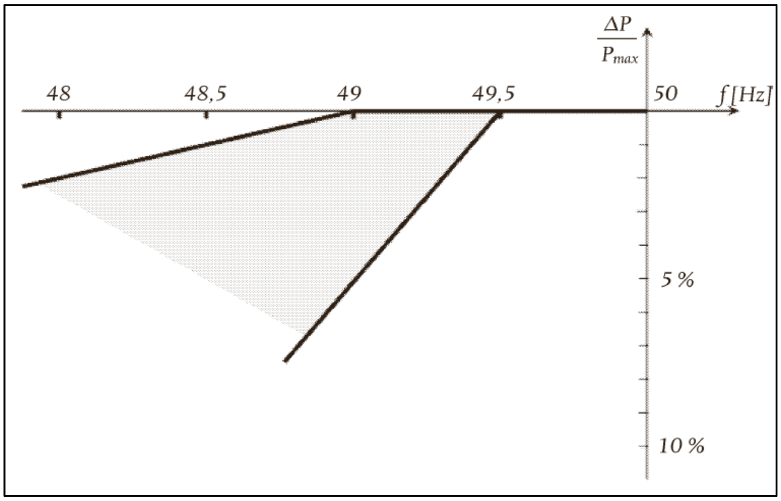


Figure 1 Maximum Power Capability Reduction with Falling Frequency

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Applicable Types	Justification Code
Admissible active power reduction from maximum output with falling frequency	below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50 Hz per 1 Hz frequency drop **<u>or</u>** Below 49.5 Hz falling by a reduction rate of 10% of the maximum capacity at 50 Hz per 1 Hz frequency drop.	below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50 Hz per 1 Hz frequency drop	13.4 (a)	A, B, C and D PGMs and Offshore PPMs	3

Table 3 Admissible active power reduction from maximum output with falling frequency

Justification

As the system frequency decreases, it is essential that any reduction in generation output is minimised, in order to prevent the frequency from falling any further.

In the current Grid Code CC.S1.1.3.4, CC.S1.2.3.1, CC.S2.1.3.4 and CC.S2.2.3.1 requires “any decrease in output whilst frequency is falling to a level below registered capacity occurring in the frequency range 49.5Hz to 47Hz must not be more than pro rata with any decrease below nominal frequency”

The proposal is to allow a maximum decrease in generation output of 2% when the frequency is falling below 49Hz, were as the current Grid Code permits a proportional reduction in generation output from 49.5Hz.

It is acknowledged that this proposal does not align with the current Grid Code requirements and is an increased requirement on PGMs. However by increasing the requirement here, we are able to lessen any further reduction in the system frequency by minimising the reduction in the generation MW output. This allows time for frequency response measures to be activated and ultimately the system frequency to stabilise.

4.1.3.2 Article 13.5: Admissible reduction from maximum output with falling frequency taking Account of Technical Capabilities of PGMs

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs

Requirement

The admissible active power reduction from maximum output shall: (a) clearly specify the ambient conditions applicable; (b) take account of the technical capabilities of power-generating modules.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Ambient Conditions	Not Specified	10°C, 70% relative humidity and 1013 hPa for gas fired turbine generators	13.5	~~Gas-fired~~Gas Turbine Generator SPGMs (A, B, C and D).	3

Table 4 Admissible active power reduction from maximum output

Justification

The RfG allows the TSO to specify the applicable ambient conditions. ~~applicable.~~ It is proposed to use~~The current version of the Grid Code states, under the definition of registered capacity, that the standard ambient conditions for the measurement of registered capacity will be~~ 10°C, 70 % relative humidity and 1013 hPa. ~~As the RfG allows the TSO to specify the applicable ambient conditions, it is proposed to continue to use these ambient conditions requirements.~~ The ENTSO-E guidance document for national implementation for network codes on grid connection (Implementation Guidelines Documents) highlights that the need for this requirement and is driven by the characteristics of gas turbine generators~~gas fired generation units~~. Other generation units should not require a reduction with falling frequency. For this reason it is proposed to limit the application of this clause to gas turbine generator~~gas fired generation~~ units.

4.1.3.3 Article 13.6: Remote operation of facility to cease active power output

Non-Mandatory Requirement being made Mandatory

Applies to Type A ~~and B~~ PGMs

Requirement

The power-generating module shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. The relevant system operator shall have the right to specify requirements for equipment to make this facility operable remotely.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Specify requirements for equipment to make this facility operable remotely for Type A	A right to specify	Maintain the right to specify for Type A only in due time for plant design (c/f Art 14 (2) (b) for Type B	13.6	A PGMs	3

Table 5 Specify requirements for equipment to make this facility operable remotely for Type A

Justification

The RFG allows the RSO to specify requirements for equipment to enable the generator to cease active power output within 5 seconds and to operate remotely.

The TSO and DSO reserve the right to make this requirement mandatory for Type A PGMs. As the generation portfolio on the Power System changes it may be necessary for these units to cease active power output in order to maintain system security or safety.

The proposal is to maintain the right to specify the requirement for remote control equipment but to advise on a case by case basis, as necessary, taking into consideration that the specific requirements will be dependent on the plant design and compatibility requirements. The intention of the phrase, 'in due time for plant design' is intended to mean during the connection offer phase.

4.1.3.4 Article 13.7: Automatic connection to the network

Non-Exhaustive Parameter Selection

Applies to Type A, B and C PGMs

Requirement

The relevant TSO shall specify the conditions under which a power-generating module is capable of connecting automatically to the network. Those conditions shall include:

(a) frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and

(b) maximum admissible gradient of increase in active power output.

Automatic connection is allowed unless specified otherwise by the relevant system operator in coordination with the relevant TSO.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
(i) Frequency Ranges and Time Delay	Non-specific	47 Hz to 50.2 Hz with a three minute delay	13.7	A, B, and C PGMs	3 1
(ii) Maximum admissible gradient of increase in power	Non-specific	10% of Pmax per minute	13.7	A, B and C PGMs	1
(iii) Allowing automatic connection	A right to not allow	Allow automatic connection for Type A & B Do not allow automatic connection for Type C	13.7	A, B and C PGMs	1

Table 6 Conditions under which a PGMs is capable of connecting automatically to the network

Justification

The frequency ranges differ from the existing settings today and are highlighted with a ‘3’ above to indicate this. The time delay is an existing requirement and is highlighted with a ‘1’ above to indicate this.

The RFG allows the relevant system operator to specify the conditions under which a power-generating module is capable of connecting automatically to the network. SONI currently does not use automatic connection and would specify that it is not allowed in Northern Ireland for Type C PGMs. However Engineering Recommendations G59 & G83 settings allow PGMs of sizes Type A and Type B to automatically connect once the frequency is within normal operating ranges. This right will be retained under the RfG.

The TSO would not wish to compromise system frequency stability by permitting Types A and B generator to connect automatically when the system frequency is above 50.2Hz since this action could cause high frequency instability. However, we would permit generation to automatically connect within the range 47 – 50.2Hz. This is why the proposal differs from the current settings today.

4.1.3.5 Article 14.2.b: Remote operation of power output

Non-Mandatory Requirement being made Mandatory

Applies to Type B PGMs

Requirement

Type B PGMs shall fulfil the following requirements in relation to frequency stability:

> *(a) to control active power output, the power-generating module shall be equipped with an interface (input port) in order to be able to reduce active power output following an instruction at the input port; and*
>
> *(b) the relevant system operator shall have the right to specify the requirements for further equipment to allow active power output to be remotely operated*.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Right to specify the requirements for further equipment to allow active power output to be remotely operated	To specify or not to specify	RSO to specify for Type B generators; in due time for plant design.	14.2 (b)	B PGMs	3

Table 7 Remote operation of Power Output

Justification

Due to the current levels of connected generation capacity, the TSO & DSO will require controllability of all Type B PGMs. This RfG proposal is in line with that proposal and ensures the DSO can specify equipment to allow active power output to be remotely operated.

4.1.3.6 Article 15.2.a: Achieving Active Power Set points

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs

Requirements

… power-generating modules shall fulfil the following requirements relating to frequency stability:

(a) with regard to active power controllability and control range, the power-generating module control system shall be capable of adjusting an active power set point in line with instructions given to the power-generating facility owner by the relevant system operator or the relevant TSO.

The relevant system operator or the relevant TSO shall establish the period within which the adjusted active power set point must be reached. The relevant TSO shall specify a tolerance (subject to the availability of the prime mover resource) applying to the new set point and the time within which it must be reached;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
The period within which the adjusted active power setpoint must be reached	No range provided	*PPM controllable generation* The Active power set point and the time to achieve this is determined by the TSO , however following shut down a PPM must commence active power export within 90secs WFPS setting schedule 6.11 (WFPS section 6.1, Wind following ramp rate 5MW per minute) *SPGM dispatchable generation* Active power set point and time to achieve the set point is given via TSO dispatch instructions in accordance with SDC2. Minimum ramp rates and start-up times specified in CC.S1.3.7 & CC.S1.2.3.4. (Grid code CC.S1.1.3.7 (b) & (c) ramping up and de-loading at rate of at least 3% of MCR).	15.2 (a)	C and D PGMs	1

Tolerance (subject to the availability of the prime mover resource) applying to the new setpoint and the time within which it must be reached	No Range Provided	*PPM controllable generation* Active power output to be within 3% of set point (based on RC) Time to achieve set point within ±10 seconds of target time. (See WFPS Setting Schedule 6.1) *SPGM dispatchable generation* Tolerance bands for dispatch instructions is specified in OC11 Part B	15.2 (a)	C and D PGMs	3

Table 8: Achieving Active Power Set-points

Justification

Tolerance limits for dispatchable generation specifically SPGM's are as per the current operational and market monitoring tolerances. By aligning the tolerances for RFG with the current practices, it will ensure the monitoring and assessment of active power set point is consistent for dispatchable generation. For PPM controllable generation the chosen parameters for tolerances are in alignment with the current Grid Code requirements.

Notes: In the context of paragraph (b) we interpret this section to apply to remotely controlled generation units where the set point is issued directly to the control system (controllable PPM generation) and does not apply to generation units where a dispatch instruction is issued via EDIL from the TSO to an operator to implement.

4.1.4 Frequency Modes

4.1.4.1 Frequency Modes Explanation

This section explains the difference between frequency sensitive mode and limited frequency sensitive modes prior to defining the parameters.

Frequency Sensitive Mode:

The vast majority of synchronous generation units, which are currently in operation on the Transmission System today, operate in what is known in the RfG as Frequency Sensitive Mode (FSM). That is, the generation units continuously respond to changes in the system frequency, in accordance with their governor droop characteristics for both increases and decreases in system frequency. This helps maintain the system frequency within the normal operating range.

In RfG parameters relating to the capability of units to operate in FSM must be specified by the TSO and are broken down into two types of parameters – responses required in normal operation and responses required following a step change in frequency.

- In normal operation the parameters to be specified are the % droop and any associated frequency dead bands. There is no parameter relating to the time allowed to achieve the required response. These parameters are consistent with today's Grid Code requirements for free governor regulation.
- The parameters to be specified to assist with recovering the system frequency following a sudden imbalance and associated frequency step change are a specified % increase in active power relative to the maximum generation of the unit (or available active power for PPMs) within a specified time period (usually seconds). This is similar to today's Grid Code requirements for units to provide operating reserves.

These parameters also apply to PPMs. Under the existing Grid Code PPMs are required to operate in FSM when in '% curtailed' mode. PPMs are not actually acting under the control of a traditional governor. Instead they are moving to MW set points which are calculated in the control system based on measured changes in system frequency. The calculation of the set points is based on a droop characteristics and time for delivery as specified in these FSM parameter settings.

Limited Frequency Sensitive Mode:

When a PGM is operating in Limited Frequency Sensitive Mode (LFSM), the generation unit does not provide any frequency response when the system frequency is within a specified dead band around the nominal frequency. The dead band for LFSM mode is much wider than that specified for FSM mode. FSM dead bands are very small and generally specified to reflect the technical inability of some units to respond to very small changes in frequency and / or to avoid generator hunting.

RfG provides for different LFSM capabilities to be required for over and under frequency events. It should be noted that currently only a very small number of generation units operate in LFSM today. The only generators which act in LFSM mode today are PPMs when in 'emergency action' mode.

At the moment, it is planned to continue to operate the majority of existing and future PGMs in FSM. However, as the transmission system evolves and new technology connects, the use of both FSM and LFSM will be assessed on a regular basis.

Summary

For clarity the following table highlights the links between our current frequency control modes and the RfG frequency control modes

RfG Frequency Control Mode	Equivalent Grid Code Frequency Control Mode for PPMs	Equivalent Grid Code Frequency Control Mode for SPGM
LFSM-O	Emergency Action Mode	Not applicable in Northern Ireland today
LFSM-U	Not applicable in Northern Ireland today	Not applicable in Northern Ireland today
FSM Normal	% Curtailed Mode	Free Governor Action
FSM Frequency Step Change	Same as above	Operating Reserves

For the avoidance of doubt, relay activated response such as over and under frequency tripping of units or high frequency runback schemes are not covered by this RfG section as they are not related the inherent capability of the unit.

4.1.4.2 Article 13.2.a: LFSM-O Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

With regard to the limited frequency sensitive mode — over frequency (LFSM-O), the following shall apply, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas:

(a) *the power-generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and droop settings specified by the relevant TSO*;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency threshold	Between 50.2-50.5 Hz	50.2 Hz	13.2(a)	A, B, C and D PGMs & offshore PPMs	2
Droop settings	Between 2-12 %	Machines should be capable of operating in the range 2-12%. The default setting is 4%	13.2(a)	A, B, C and D PGMs & offshore PPMs	2

Table 9: LFSM-O Parameter Selection

Justification:

<u>Frequency Threshold</u>

In SONI SPGM's do not operate in LFSM-O for the provision of FCR; these generators operate in FSM mode. LFSM-O is exclusively used in NI by PPM's operating in emergency action mode and resource following mode. The current threshold specified in the WFPS setting schedule is 50.15Hz, the proposal is to adopt the minimum permissible threshold value in RFG of 50.2Hz.

<u>Droop Settings</u>

The SONI Grid Code requires a droop setting for PPM's of between 2 - 20% (CC.S2.1.5.2 & CC.S2.2.5.2) and gas turbines are required to operate on a 4% droop (CC.S1.1.5.2 & CC.S1.2.4.2).The proposal is to adopt the RFG frequency droop range of between 2 - 12%. The existing Grid Code requirement for Gas turbines lies within this range and aligns with the default droop setting used across the island of Ireland which is 4%.

4.1.4.3 Article 13.2.b: LFSM-O: Automatic disconnection and reconnection

Non-Mandatory Requirement being made Mandatory

Applies to Type A PGM

Requirement

(b) *instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power-generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the cooperation of power-generating facility owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;*

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Applicable Type	Justification Code
Automatic disconnection and reconnection of PGMs	Allow or do not allow	Do not allow	13.2 (b)	A PGMs	3

Table 10: LFSM-O Automatic Disconnection & Reconnection

Justification

It is not currently planned to invoke this non-mandatory proposal for Type A generators. Which replaces LFSM-O with automatic disconnection of generation at frequencies above the frequency threshold.

Currently in addition to LFSM-O the RSO in coordination with the TSO can apply such settings to ensure the maintenance of frequency stability through disconnection of Type A PGMs. This will be agreed on a case by case basis as per current practice. The G59 & G83 engineering recommendations settings allow PGMs of size A to automatically connect once the frequency is within normal operating ranges. This right will be retained under the RfG The reconnection of these units can occur when the frequencies have recovered.

4.1.4.4 Article 13.2.f: LFSM-O: Actions at minimum regulating level

Non-Mandatory Requirement being made Mandatory

Applies to Type A, B, C and D PGMs and offshore PPMs

Requirement

The relevant TSO may require that upon reaching minimum regulating level, the power-generating module be capable of either:

(i) continuing operation at this level; or

(ii) further decreasing active power output;

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Actions in LFSM-O upon reaching minimum regulating level,	Choose between (i) continuing operation at this level; or (ii) further decreasing active power output	(i) continuing operation at this level;	13.2 (f)	A, B, C and D PGMs & offshore PPMs	1

Table 11: LFSM-O Actions at Minimum Regulating Level

Justification

The TSO's current practice is that when generators are scheduled and dispatched to operate at minimum generation level, there is no requirement for generators to provide negative regulation.

Therefore we propose that when generators reach their minimum regulation level that they continue operation at this level and don't further decrease active power output.

4.1.4.5 Article 15.2.c: LFSM-U Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs and offshore PPMs

Requirement

(i) the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified by the relevant TSO in coordination with the TSOs of the same synchronous area as follows:

– the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive;

– the droop settings specified by the TSO shall be in the range 2 – 12%.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency threshold	between 49.8 Hz and 49.5 Hz inclusive	49.5 Hz	15.2 (c)	C and D PGMs & offshore PPMs	3
Droop settings	2-12%	Default is 4% unless otherwise specified by the TSO on a site specific basis	15.2 (c)	C and D PGMs & offshore PPMs	3

Table 12 LFSM-U Frequency Threshold & Droop Settings

Justification

LFSM-U is not currently used as a mode of frequency response in Northern Ireland. However looking to the future the introduction of new market conditions or system services may require LFSM_U for the provision of frequency restoration reserve (FRR), it is for this reason the above parameters for LFSM-U are specified

In Article 15 (c) (ii) it deals with the delivery of active power response in LFSM-U mode taking into account of ambient conditions. These ambient conditions are as described paragraphs 4 and 5 of Article 13.

4.1.4.6 Article 15.2.d.(i) and (ii): FSM Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and Offshore PPMs

Requirement

(i) *The power-generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4* (as given in the RfG)*. In specifying those parameters, the relevant TSO shall take account of the following facts:*

- *In case of over frequency, the active power frequency response is limited by the minimum regulating level,*
- *In case of under frequency, the active power frequency response is limited by maximum capacity,*
- *The actual delivery of active power frequency response depends on the operating and ambient conditions of the power-generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources;*

(ii) *The frequency response dead band of frequency deviation and droop must be able to be reselected repeatedly;*

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Active Power Range (ΔP/Pmax)	1.5-10%	Not proposing a value at this time See note below	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	1
Frequency Response Insensitivity (Δf)	10-30 mHz	15mHz*	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	3
Frequency Response Insensitivity (Δf/f)	0.02-0.06%	0.03%	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	3
Frequency Response Deadband	0-500mHz	+/-15mHz*	15.2 (d) (i) and (ii)	C and D PGMs& offshore PPMs	3
Droop	2-12%	Depends on gen type – default is 4%	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	1

Table 13 FSM Parameter Selection

Justification

Active Power Range

The TSO have consulted with the ENTSO-E Frequency Expert Group in relation to FSM. ENTSO-E have confirmed that this parameter was included in the above table as an error and as such will not be specified as part of this consultation.

For this reason we are not proposing a value for active power range in Table 13.

Frequency Response Insensitivity and Frequency Response Deadband

The current version of the Grid Code does not specify requirements for Frequency Response insensitivity. It only specifies the Frequency Response Deadband. It is proposed to retain the current Grid Code requirement of 15 mHz by setting a maximum absolute value of 15 mHz for both the Frequency Response Insensitivity and Frequency Response Deadband.

*In addition to the individual requirements for Frequency Response Insensitivity (ΔF) and Frequency Response Deadband and as per Annex V of the System Operating Guidelines (SOGL), the maximum combined effect of Frequency Response Insensitivity and Frequency Response Deadband cannot exceed a value of +/- 15 mHz.

4.1.4.7 Article 15.2.d.(iii): FSM: Step Change in Frequency

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs and Offshore PPMs

Requirement

In the event of a frequency step change, the power-generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 (as given in the RfG) *in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power-generating module) within the ranges given in Table 5* (as given in the RfG) *. The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account;*

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Active power range	1.5-10%	10%	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Admissible initial time delay for activation of active power frequency response for PGMs	*2s*	*2s*	*15.2 (d) (iii)*	*C and D PGMs & offshore PPMs*	*N/A*
Admissible initial time delay for activation of active power frequency response for PPMs	Less than 2 seconds	0s No time delays other than those inherent in the design of the frequency response system	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Maximum admissible choice of full activation time	30 seconds	5 seconds	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Capability relating to the duration of provision of full active power frequency response	15-30 minutes	20	15.2 (d) (v)	C and D PGMs & offshore PPMs	3

Table 14 Activating full active power frequency response

Justification

Active Power Range

SPGM

In SONI this is specified during the connection ~~offer~~ process. ~~in an MFS.~~ At a full activation time of 5 seconds this is comparable with the existing requirements specified to generation during the connection process. ~~of this MFS.~~

PPMs

The current requirements in the SONI WFPS Setting Schedule requires a minimum of 60% of expected MW Output change value based on droop characteristic within 5 seconds and 100% of expected MW Output change value based on droop characteristic within 15 seconds. This requirement is core to the achievement of a 40% RES-E target and the ability to operate the system at System Non Synchronous Penetration (SNSP) levels up to 75%. The RfG range in Table 14 only allows us specify a value for the change in power output relative to the Active Power output at the moment the frequency threshold was reached (or the maximum capacity as defined by the TSO) between 1.5-10% i.e. it does not allow us to specify the levels that currently exist in the Grid Code. However to lose the capability provided for in today's Grid Code would be very damaging to the success of the DS3 program and ultimately to the integration of high levels of renewable energy into the power system.

We do not believe that the regulations intentionally undermine this capability and therefore we are going to investigate options to retain todays Grid Code requirements for PPMs.

For the avoidance of doubt, in this consultation we have reflected the permissible ranges in the RfG but respondents should understand that it is our intention to retain the Grid Code requirements for PPMs, in addition to the RfG requirements.

Admissible initial time delay for activation of active power frequency response for PPMs

The current version of the SONI WFPS Setting Schedule stated in section 6.5:

The TSO deems Fast acting with regards to Frequency Control response as being:

No time delays, such as moving average frequency filters, other than those necessarily inherent in the design of the Controllable WFPS shall be introduced.

Maximum admissible choice of full activation time

The choice of full activation time is 5 seconds in line with the existing MFS.

Capability relating to duration of provision of full active power frequency response

The Frequency Containment Reserves must remain in place until such time that the Frequency replacement reserves are available. In the case of Ireland, the FCR equates to the POR, SOR, TOR1 and TOR2 under the Grid Code. The existing Grid Code Replacement Reserves must be made available from 20 minutes to four hours after the event.

4.1.5 Additional Non-Mandatory Frequency Requirements

There are a number of additional areas with non-mandatory requirements detailed in the RfG. Table 15 identifies the areas. In all cases, we do not intend to invoke these non-mandatory requirements at this time.

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability
Shorter initial FSM response delay for PGMs without inertia	Not specified	Not Mandatory – can be agreed on a case by case basis with System Services Contracts	15.2.d(iv)	Type A, B, C and D PGMs and offshore PPMs
Synthetic inertia capability for PPM	Not Specified	Not Mandatory – can be agreed on a case by case basis with System Services Contracts	21(2)	C and D PPMs

Table 15 - Areas with non-mandatory requirements detailed in the RfG

4.2 Voltage Theme

The non-exhaustive and non-mandatory voltage / fault ride through parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Automatic disconnection
- Reactive Power capability
    - Supplementary requirements
    - At maximum capacity
    - Below maximum capacity
    - Reactive power control modes
- Voltage Control System for Synchronous PGMs
- Fault Ride Through (FRT)
    - FRT capability for PGMs connected at voltages less than 110 kV
    - FRT capability for PGMS connected at voltages of 110 kV or more
    - Fast fault current injection for PPMs
    - Post fault active power recovery for PPMs
    - Priority to active or reactive current

4.2.1 Automatic Disconnection Due to Voltage Level

4.2.1.1 Article 15.3: Type C Automatic Disconnection Due to Voltage Level

Non-Exhaustive Parameter Selection

Applies to Type C PGMs

Requirement

With regard to voltage stability, type C power-generating modules shall be capable of automatic disconnection when voltage at the connection point reaches a minimum/maximum voltage level for a certain period of time. Table 16 specifies the voltage and duration settings.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Minimum Voltage below which Module will automatic disconnect	Not specified	Specified at plant design stage	15.3	C PGMs	1
Maximum Voltage above which Module will automatic disconnect	Not specified	Specified at plant design stage	15.3	C PGMs	1

Table 16: Parameters for Automatic Disconnection

Justification

Currently automatic disconnection for minimum and maximum voltage is required to establish anti-islanding protection as specified as part of Engineering Recommendations G59 and G83. The function within the generator would need to coordinate with these standards and is therefore to be specified at plant design stage.

4.2.1.2 Article 16.2.c: Type D Automatic Disconnection Due to Voltage Level

Non-Exhaustive Parameter Selection

Applies to Type D PGMs

Requirement

With regard to voltage stability, *the relevant system operator in coordination with the relevant TSO shall have the right to specify voltages at the connection point at which a power-generating module is capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator and the power-generating facility owner*

Proposal: Automatic Disconnection Due to Voltage Level

Table 17 specifies the voltage and duration settings.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Minimum Voltage below which Module will automatic disconnect	Not specified	Not Allowed	16.2.c	D PGMs	3
Maximum Voltage above which Module will automatic disconnect	Not specified	Not Allowed	16.2.c	D PGMs	3

Table 17: Type D Parameters for Automatic Disconnection

Justification: Automatic Disconnection Due to Voltage Level [Transmission Connected]

The current Grid Code does not stipulate voltage threshold which allows for automatic disconnection. The TSO and DNO invoke the right to prohibit the automatic disconnection from the transmission and distribution systems.

4.2.2 Reactive Power Capability

The following sections discuss the reactive power capability requirements under RfG. Section 4.2.2.1 discusses the requirements at maximum capacity whilst section 4.2.2.3 discusses the requirements below maximum capacity. The requirements for synchronous power generating modules (SPGM) and Power Park Modules (PPMs) are discussed separately under each of these two sections.

It should be noted that the capabilities are different for different connections. The requirements are split out in the following sections to indicate this. The relevant elements of a connection for this discussion are:

1. Connection at 110 kV or more
2. Connection at less than 110 kV

4.2.2.1 Reactive Power Capability for Type B PGMs

4.2.2.1.1 Article 17.2.a: Reactive Power capability for Type B SPGMs

Non-Mandatory Requirement being made Mandatory

Applies to Type B PGMs

Requirement

(a) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a synchronous power generating module to provide reactive power;

Proposal

Parameter	Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Low Voltage	u_{min}	0.875 p.u.	0.94 p.u.	17.2 (a) & 20.2 (a)	B	1
	u_{max}	1.1 p.u.	1.1 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.203 p.u.	17.2 (a) & 20.2 (a)	B	1
Below 110kV	u_{min}	0.875 p.u.	0.94 p.u.	17.2 (a) & 20.2 (a)	B	1
	u_{max}	1.1 p.u.	1.06 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.203 p.u.	17.2 (a) & 20.2 (a)	B	1

Table 18: Right to specify reactive power capability for SPGMs

Justification

The NIEN Distribution Code ~~-~~specifies a range for power stations of 0.95pf leading to 0.98pf lagging. This is equivalent to a range of -0.33 Qmin/Pmax (lead) to 0.203 Qmin/Pmax (lag).

4.2.2.1.2 Article 20.2.a: Reactive Power capability for Type B PPMs

Non-Mandatory Requirement being made Mandatory

Applies to Type B PPMs

Requirement

(b) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a power park modules to provide reactive power;

Proposal

Parameter	Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Low Voltage	u_{min}	0.875 p.u.	0.94 p.u.	17.2 (a) & 20.2 (a)	B	1
	u_{max}	1.1 p.u.	1.1 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.203 p.u.	17.2 (a) & 20.2 (a)	B	1
Below 110kV	u_{min}	0.875 p.u.	0.94 p.u.	17.2 (a) & 20.2 (a)	B	1
	u_{max}	1.1 p.u.	1.06 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	17.2 (a) & 20.2 (a)	B	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.203 p.u.	17.2 (a) & 20.2 (a)	B	1

Table 19: Right to specify reactive power capability for PPMs

Justification

The NIEN Distribution Code specifies a range for power stations of 0.95pf leading to 0.98pf lagging. This is equivalent to a range of -0.33 Qmin/Pmax (lead) to 0.203 Qmin/Pmax (lag).

4.2.2.2 Reactive Power Capability at Maximum Capacity: U-Q/Pmax Profiles

4.2.2.2.1 Article 18.2.b.(i): SPGM: Parameters required for U-Q/Pmax Profiles

Non-Exhaustive Parameter Selection

Applies to Type C and D SPGMs

Requirement

In relation to voltage stability, synchronous power-generating modules shall fulfil the requirements with regard to reactive power capability at maximum capacity. For that purpose a U-Q/P_{max}-profile is specified (inner envelope) within the boundaries of the fixed outer envelope of which the synchronous power-generating module shall be capable of providing reactive power at its maximum capacity (P_{max}).

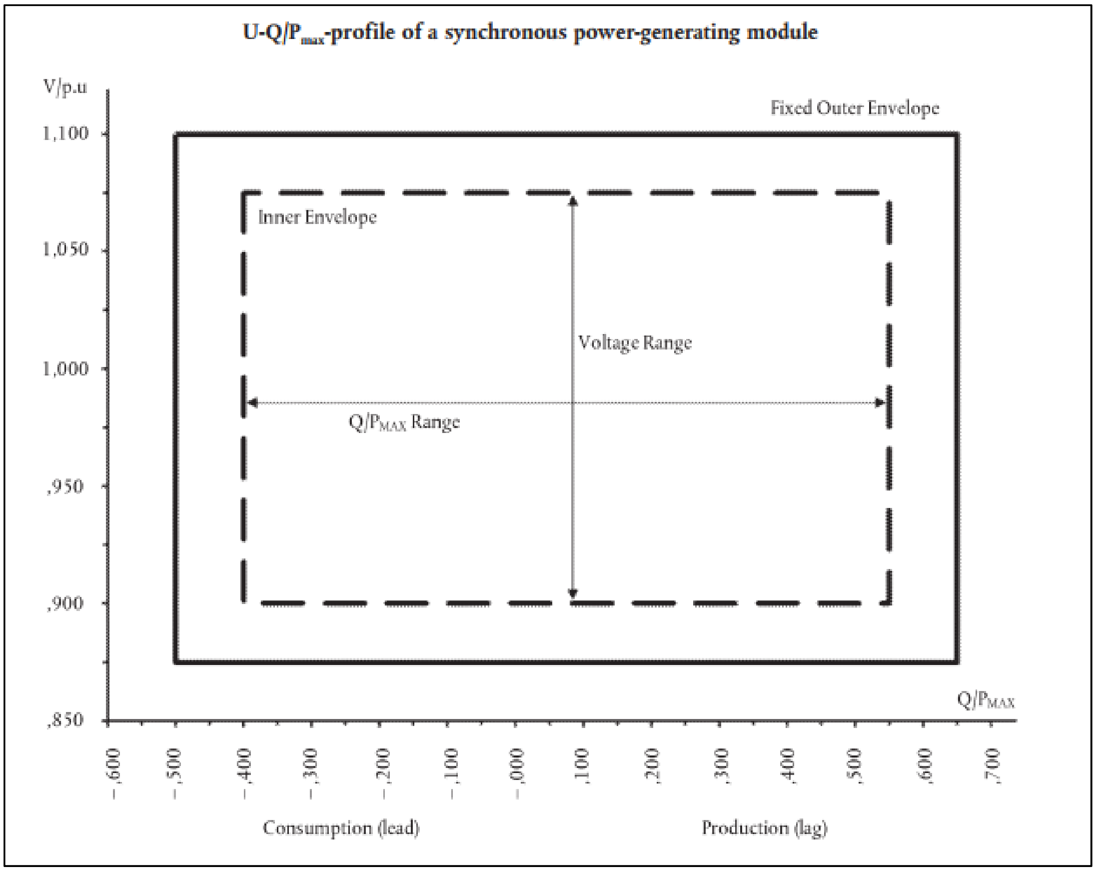


Figure 2: U-Q/P_{max}-profile for synchronous Power-Generating Modules

Figure 2 represents boundaries of a U-Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1 p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the envelope are indicative. The dimensions of the inner envelope are limited by a maximum range of Q/P_{max} of 1.08 and maximum range of steady state voltage level of 0.218 p.u.

Proposal for SPGMs connected at a voltage level ≥ 110 kV

Table 20 lists the parameters which describe the U-Q/P_{max}-profile for SPGMs connected at a voltage level ≥ 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV	u_{min}	0.875 p.u.	0.9 p.u.	18.2.b (ii)	D SPGMs	1
	u_{max}	1.1 p.u.	1.1 p.u.			1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.48 p.u.			3
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.6 p.u.			3
275 kV	u_{min}	0.875 p.u.	0.9 p.u.			1
	u_{max}	1.1 p.u.	1.1 p.u.			1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.48 p.u.			3
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.6 p.u.			3
400 kV	u_{min}	0.875 p.u.	0.875 p.u.			3
	u_{max}	1.1 p.u.	1.05 p.u.			3
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.48pu			3
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.6 p.u.			3

Table 20: Definition of U-Q/Pmax-profile at Maximum Capacity for SPGMs: connection @ ≥110 kV

Justification: SPGMs connected at a voltage level ≥ 110 kV

The existing reactive power range in the SONI Grid Code is specified as 0.95pf leading to 0.8pf lagging, measured at the generator terminals (see CC.S1.3.2). This has been approximated to the connection point as range -0.48 p.u. Qmin/Pmax (lead) to 0.6 p.u. Qmax/Pmax (lag). These are within the range required by the RfG. The SONI Grid Code requirements may need to be changed to specify the requirements at the connection point rather than at the generator terminals.

There is current no 400 kV operating voltage in Northern Ireland. As and when the proposed Turleenan – Woodland 400kV circuit is constructed this will introduce a 400 kV node into the Northern Ireland transmission system. The voltage range chosen for the 400 kV voltages are aligned with the Ireland Grid Code.

Proposal for SPGMs connected at a voltage level < 110 kV

Table 21 below lists the parameters which describe the U-Q/P_{max}-profile for SPGMs connection at a voltage level < 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
Below 110kV	u_{min}	0.875 p.u.	0.94 p.u.	18.2.b (ii)	C and D SPGMs	1
	u_{max}	1.1 p.u.	1.06 p.u.	18.2.b (ii)	C and D SPGMs	1
	Q_{min}/P_{max} (import)	-0.5 p.u.	-0.33 p.u.	18.2.b (ii)	C and D SPGMs	1
	Q_{max}/P_{max} (Export)	0.65 p.u.	0.33 p.u.	18.2.b (ii)	C and D SPGMs	1

Table 21: Definition of U-Q/Pmax-profile at Maximum Capacity for SPGMs: connection @ <110 kV

Justification: SPGMs connected at a voltage level <110 kV

The NIEN Distribution Code specifies a range for power stations of 0.95pf leading to 0.95pf lagging. This is equivalent to a range of -0.33 Qmin/Pmax (lead) to 0.33 Qmin/Pmax (lag).

4.2.2.2.2 Article 18.2.b. (iv): SPGM: Time to Achieve Target Value within U-Q/Pmax Profile

Non-Exhaustive Parameter Selection

Applies to Type C and D SPGMs

Requirement

(iv) *the synchronous power-generating module shall be capable of moving to any operating point within its U-Q/Pmax profile in appropriate timescales to target values requested by the relevant system operator*;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time to achieve target value	Not specified	Without undue delay but at least within 120 seconds	18.2.b (iv)	C and D SPGMs	3

Table 22: Timescales to Achieve Target Values at Maximum Capacity

Justification

The time to achieve the target value is a new parameter in the SONI Grid Code and the NIEN Distribution Code~~-~~. The time to achieve the target value is aligned with the current requirement set out in the Ireland Grid Code in the Scheduling and Dispatch Code Appendix B (SDC2.B.8) for centrally dispatched generating units. These units are being dispatched via the TSO electronic interface program (EDIL); however the same time period will apply for units being dispatched via set point control.

4.2.2.2.3 Article 21.3.b (i) and (ii) & Article 25.5: PPM: Parameters required for U-Q/Pmax Profiles

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs and Offshore PPMs

Requirement

Power Park modules shall fulfil requirements in relation to voltage stability with regard to reactive power capability at maximum capacity. For that purpose a U-Q/P_{max}-profile (inner envelope) is specified within the boundaries of the fixed outer envelope of which the Power Park Module shall be capable of providing reactive power at its maximum capacity (P_{max}).

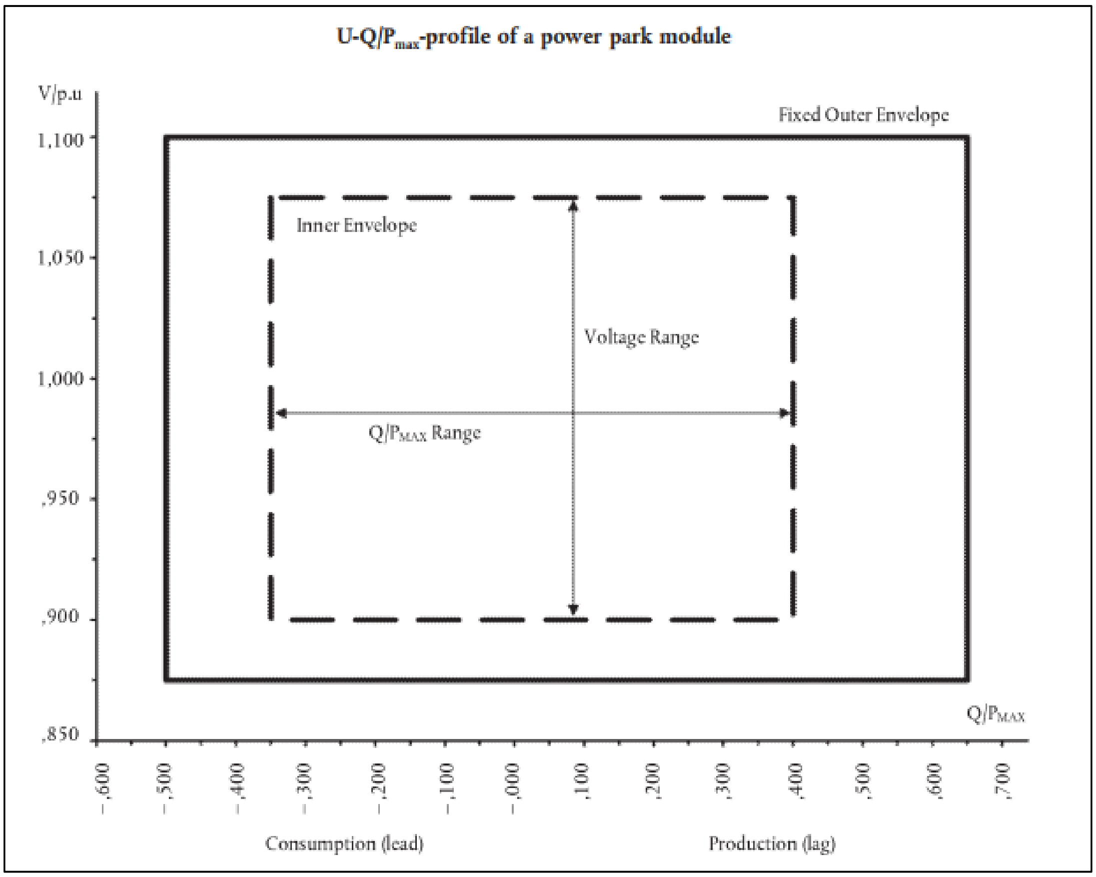


Figure 3: U-Q/P_{max}-profile for Power Park Modules

Figure 3 represents boundaries of a U-Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1 p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.

The dimensions of the inner envelope are limited by a maximum range of Q/P_{max} of 0.66 and maximum range of steady state voltage level of 0.218 p.u.

Proposal for PPMs connection at a voltage level ≥ 110 kV

Table 23 lists the parameters which describe the U-Q/P_{max}-profile for PPMs connected at a voltage level ≥ 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV	u_{min}	0.875 p.u.	0.9 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
275 kV	u_{min}	0.875 p.u.	0.9 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	Q_{max}/P_{max} (lead)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
400 kV	u_{min}	0.875 p.u.	0.875 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	3
	u_{max}	1.1 p.u.	1.05 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	3
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs & offshore PPMs	1

Table 23: Definition of a U-Q/Pmax-profile at Maximum Capacity PPMs: connected @ ≥ 110 kV

Justification: PPMs connected at a voltage level ≥110 kV:

The SONI Grid Code specifies a range for wind farm power stations of 0.95pf leading to 0.95pf lagging. This is equivalent to a range of -0.33 Qmin/Pmax (lead) to 0.33 Qmin/Pmax (lag).

There is currently no 400kV system in Northern Ireland. The values chosen above are aligned with the Ireland Grid Code.

Proposal for PPMs connected at a voltage level < 110 kV

Table 24 lists the parameters which describe the U-Q/Pmax-profile lists the parameters which describe the revised U-Q/P_{max}-profile for PPMs connected a voltage level < 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
Below 110kV	u_{min}	0.875 p.u.	0.94 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	u_{max}	1.1 p.u.	1.06 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1

Table 24: Definition of a U-Q/Pmax-profile at Maximum Capacity PPMs connected @ <110 kV

Justification: PPMs connected at a voltage level <110 kV

The NIEN Distribution Code specifies a range for power stations of 0.95pf leading to 0.95pf lagging. This is equivalent to a range of -0.33 Qmin/Pmax (lead) to 0.33 Qmin/Pmax (lag).

4.2.2.3 Reactive Power Capability below Maximum Capacity: P-Q/Pmax Profiles

4.2.2.3.1 Article 21.3.c.(i), (ii) and (iv): PPM: Parameters required for P-Q/Pmax Profiles

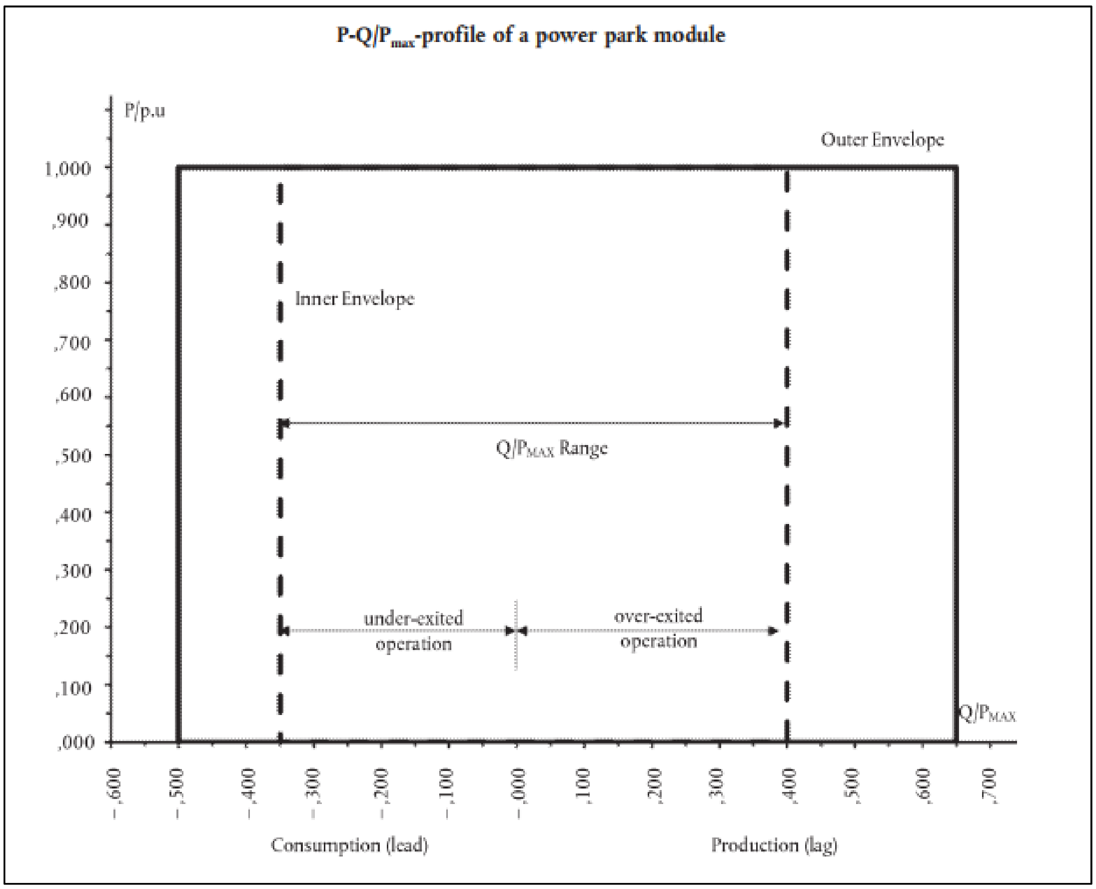
Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

Power park modules shall fulfil the following additional requirements in relation to voltage stability with regard to reactive power capability below maximum capacity. For that purpose a P- Q/P_{max}-profile is specified within the boundaries of which the power park module shall be capable of providing reactive power below maximum capacity ($P < P_{max}$).

The figure below represents boundaries of a P- Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1 p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.



The diagram represents boundaries of a $P\text{-}Q/P_{max}$-profile at the connection point by the fixed outer envelope.

Proposal PPMs connected at a voltage level ≥ 110 kV

Table 25~~Table 25~~ lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level ≥110 kV.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
110 to 400 kV	p_{min}	0.0 p.u.	0.12 p.u.	21.3.c (ii)	D PPMs	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	D PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.c (ii)	D PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.c (ii)	D PPMs	1

Table 25: Definition of a U-Q/Pmax-profile at Maximum Capacity PPMs connected @ ≥110 kV

Justification: PPMs connected at a voltage level ≥ 110 kV

The proposals above are consistent with the existing SONI Grid Code for Wind Farm Power Stations.

Proposal PPMs connected at a voltage level < 110 kV

Table 26 lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level <110 kV and in Topology 2.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Below 110kV	p_{min}	0.0 p.u.	0.15 p.u.	21.3.c (ii)	C and D PPM	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	C and D PPM	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.c (ii)	C and D PPM	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.c (ii)	C and D PPM	1

Table 26: P-Q/Pmax-profile below Maximum Capacity PPMs: connection @ <110 kV & in Topology 2

Justification: PPMs connected at a voltage level <110 kV

The NIEN Distribution Code specifies that power stations should be able to operate over a range of reactive power of -0.33 Qmin/Pmax (lead) to 0.33 Qmin/Pmax (lag) at all active power outputs from P_{max} to a P_{min} value of 0.15p.u.

4.2.2.3.2 Article 21.3.c.(iv): PPM: Time to Achieve Target Value within P-Q/Pmax Profile

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

(v) the PPM shall be capable of moving to any operating point within its P-Q/P_{max}-profile in appropriate timescales to target values requested by the relevant system operator.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time to achieve target value [transmission connected]	Not specified	Without delay but within 20 seconds	21.3.c.(iv)	C and D PPM	3
Time to achieve target value [distribution connected]	Not specified	Without delay but within 20 seconds	21.3.c.(iv)	C and D PPM	3

Table 27: Timescales to Achieve Target Values at Maximum Capacity

Justification

This aligns with the current SONI WFPS Setting Schedule which stipulates that a change in set-point shall be implemented within 20 seconds of receipt of the appreciate signal from the TSO.

4.2.2.4 Supplementary Reactive Power Requirements

4.2.2.4.1 Article 18.2.a: SPGM: Supplementary reactive power requirements

Non-Mandatory Requirement being made Mandatory

Applies to Type C and D SPGMs

Requirement

The *relevant system operator may specify supplementary reactive power to be provided if the connection point of a synchronous power-generating module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power-generating module or its alternator terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable*.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Right to specify supplementary reactive power requirements when the connection point is remote	To specify or not to specify	RSOs reserve the right to specify	18.2.a	Type C and D SPGMs	1

Table 28: Right to Specify Supplementary Reactive Power Requirements for SPGMs

Justification

The TSO and DSO invoke the right to specify supplementary reactive power requirements for remote connection points in order to align with the supplementary reactive power requirements. This is not a new requirement. Currently the TSO and DSO have the right to specify supplementary reactive power requirements during the connection offer process.

4.2.2.4.2 Article 21.3.a: PPM: Supplementary reactive power requirements

Non-Mandatory Requirement being made Mandatory

Applies to Type C and D PPMs

Requirement

The relevant system operator may specify supplementary reactive power to be provided if the connection point of a power park module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the convertor terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high- voltage line or cable between the high-voltage terminals of the step-up transformer of the power park module or its convertor terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Right to specify supplementary reactive power requirements when the connection point is remote	To specify or not to specify	RSOs reserve the right to specify	21.3.a	Type C and D PPMs	1

Table 29: Right to Specify Supplementary Reactive Power Requirements for PPMs

Justification

The TSO and DSO invoke the right to specify supplementary reactive power requirements for remote connection points in order to align with the supplementary reactive power requirements. This is not a new requirement. Currently the TSO and DSO have the right to specify supplementary reactive power requirements during the connection offer process (Shallow Connection Design).

4.2.2.5 Reactive Power Control Modes for PPMs

4.2.2.5.1 Article 21.3.d.(iv)- Voltage Control Mode

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs

Requirement

Following a step change in voltage, the power park module shall be capable of achieving 90% of the change in reactive power output within a time t_1 and must settle at the value specified by the slope within a time t_2 with a steady-state reactive tolerance no greater than 5% of the maximum reactive power.

Proposal

The proposed times are listed in Table 30.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
t_1 = time within which 90% of the change in reactive power is reached	1 – 5 sec	1	21.3.d.(iv)	C and D PGMs	1
t_2 = time within which 100% of the change in reactive power is reached	5 – 60 sec	5	21.3.d.(iv)	C and D PGMs	1

Table 30: Parameters of the Voltage Control Mode

Justification

These requirements are currently detailed in the WFPS Settings Schedule.

PPMs shall be able to perform Direct Voltage Control With Slope:

Whilst the PPM is operating in this Voltage Control mode, it is required to respond as follows:

Voltage Control of PPM in response to a Voltage set point received: The Generator will ensure the PPM is capable of performing Closed-loop Voltage Control (without a slope) with proportional-integral action with responses in a stable manner. i.e. if a Voltage set point instruction is received by the PPM via SCADA, the PPM will achieve the set point if it has the reactive capability to do so.

Voltage Control of PPM in response to a System Voltage perturbation after a Voltage set point received via SCADA has been achieved: When the required voltage set point has been achieved (if the reactive capability of the PPM is there to do so) the PPM will operate on a reactive slope characteristic to System Voltage perturbations.

The Voltage Control System of the PPM should have a reactive slope characteristic which must be adjustable over a range of between 2 - 7% with a resolution of 0.5%. The

PPM must demonstrate the ability to operate on a 3% reactive slope characteristic. Therefore if the System voltage drops by 3% below the voltage set point received via SCADA, the PPM will go to its maximum lagging Reactive Power capability and export the maximum Reactive Power of the PPM on to the System. Conversely, if the System voltage increases by 3% above the voltage set point received via SCADA, the PPM will go to its maximum leading Power Factor and absorb the maximum amount of Reactive Power possible from the System. The magnitude of the Reactive Power output response shall vary linearly in proportion to the magnitude of the step change in voltage.

<u>Performance Criteria Required:</u>

The speed of response of the voltage regulation System, following a step change in voltage at the Connection Point, shall be such that the change in reactive power commences within 0.2 seconds of the application of the step injection

The PPM shall achieve 90% of its steady-state Reactive Power response within 1 second(t1).

Any oscillations settle to within 5% of the change in steady state Reactive Power within 2 seconds of the application of the step injection.

The final steady state reactive value is achieved within 5 seconds (t2) of the step application.

4.2.2.6 Article 21.3.d (vi) - Power Factor Control Mode

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs

Requirement

For the purpose of power factor control mode, the power park module shall be capable of controlling the power factor at the connection point within the required reactive power range with a target power factor in steps no greater than 0,01.

Proposal

The target power factor value, its tolerance and the period of time to achieve the target power factor following a sudden change of active power output are specified in Table 31.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Target power factor	Not specified	site-specific	21.3.d.(vi)	C and D PGMs	3
Time period to reach the set point	Not specified	5 seconds	21.3.d.(vi)	C and D PGMs	3
Tolerance	Not specified	5%	21.3.d.(vi)	C and D PGMs	3

Table 31: Parameters of the Power Factor Control Mode

Justification

These requirements are currently detailed in the WFPS Settings Schedule (Version). The reactive power requirements are determined by local factors and depend highly on the subset of generators and loads connected to local transmission/distribution system and the supplementary reactive power consumption of overhead lines and cables. To meet the local needs in terms of reactive power requirement in power factor control mode the parameters are proposed to be site-specific.

<u>PPMs shall be able to perform Power Factor Control</u>:

Whilst the PPM is operating in this Power Factor Control mode, it is required to respond as follows:

- The speed of response of the power factor control system, following a change in the power factor set point at the Connection Point, shall be such that the change in reactive power commences within 0.2 seconds of the application of the step injection.
- The PPM shall achieve 90% of its steady-state reactive power response within 1 second.
- Any oscillations settle to within 5% of the change in steady state Reactive Power within 2 seconds of the application of the step injection.
- The final steady state reactive value according to the slope characteristic is achieved within 5 seconds of the step application.

4.2.3 Voltage Control System for SPGM

4.2.3.1 Article 19.2.a and 19.2.b.(v)

Non-Exhaustive Parameter Selection

Applies to Type D SPGMs

Requirement

In relation to voltage stability, power-generating facility owner and the relevant system operator, in coordination with the relevant TSO, shall agree on the parameters and settings of the components of the voltage control system. The agreement shall cover the specifications and performance of an automatic voltage regulator ('AVR') with regard to steady-state voltage and transient voltage control (site-specific non-exhaustive Parameter). Further the specifications and performance of the excitation control system of an automatic voltage regulator shall include a Power System Stabilizer (PSS) function to attenuate power oscillations, among other, if the synchronous power-generating modules size is above the value proposed in Table 32.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Power Threshold	Not specified	All Type D SPGMs	19.2.b.(v)	D SPGMs	2

Table 32: Power Threshold above which PSS Function is required

Justification

Due to the increasing complexity of the transmission system, along with the increasing levels of non-synchronous generation, it is likely the frequency and levels of oscillations will increase. In order manage this going forward and to maintain the security and safety of the transmission system, PSSs will be required on all type D PGMs.

4.2.4 Fault Ride Through Capability

The following sections discuss the fault ride through (FRT) capability requirements under RfG. The requirements for SPGM and PPMs are discussed separately under each of these two sections.

It should be noted that the capabilities are different for different connection types. The requirements are split out in the following sections to indicate this. The relevant elements of a connection for this discussion are:

1. Connection at 110 kV or more
2. Connection at less than 110 kV

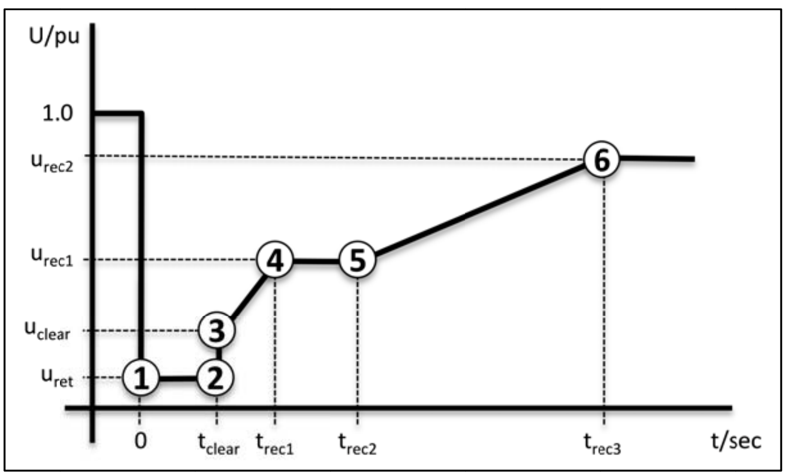
4.2.4.1 Article 14.3.a & 16.3.a: FRT Capability for PGMs connected at voltage level <110 kV

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PGMs and offshore PPMs

Requirement

Power-generating modules shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. That capability shall be in accordance with a voltage-against-time profile at the connection point for fault conditions in line with the figure below:



Fault Ride Through Profile of a Power-Generating Module

The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault.

That lower limit is specified for synchronous power-generating modules and power park modules connected below the 110 kV level in the following subsections.

Proposal: SPGMs connected at a voltage level < 110 kV

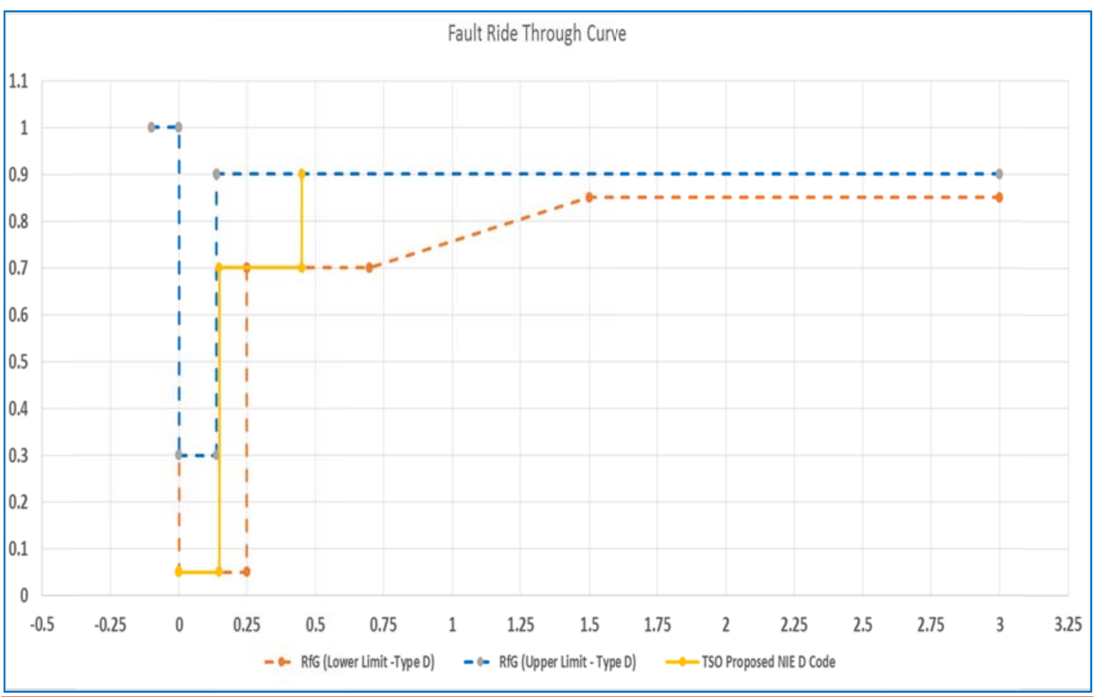
Table 33 lists the parameters which describe the FRT capability parameters for SPGMs connection at a voltage level < 110 kV.

Voltage parameters (pu)			Time parameters (s)			Justification Code
Parameter	RfG Range	Proposal	Term	RfG Range	Proposal	
U_{ret}	0.05-0.3	0.05	t_{clear}	0.14-0.25	0.15	3
U_{clear}	0.7-0.9	0.7	t_{rec1}	t_{clear}	t_{clear}	3
U_{rec1}	U_{clear}	U_{clear}	t_{rec2}	t_{rec1}-0.7	0.45	3
U_{rec2}	0.85-0.9 & >=U_{clear}	0.9	t_{rec3}	t_{rec2}-1.5	t_{rec2}	3

Table 33: Definition of FRT parameters for SPGMS connected @ <110 kV

Justification: SPGMs connected at a voltage level <110 kV

The Distribution Code does not provide fault ride through requirement for synchronous generators that are compliant with the above. The most onerous retained voltage is chosen to reflect the radial nature of the Northern Ireland distribution system. The fault clearance time is also chosen as the most onerous to reflect the type of protection schemes used on the distribution system.



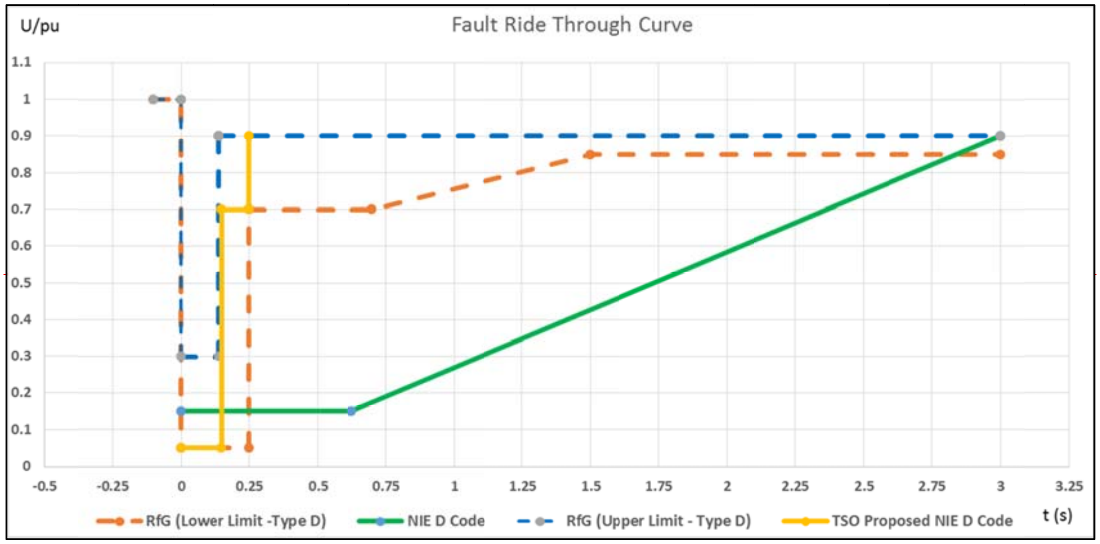


Figure 4: FRT capability synchronous PGM connected at voltage less than 110 kV

Proposal: PPMs connected at a voltage level < 110 kV

Table 34 lists the parameters which describe the FRT capability parameters for SPGMs connection at a voltage level < 110 kV.

Voltage parameters (pu)			Time parameters (s)			Justification Code
Parameter	RfG Range	Proposal	Parameter	RfG Range	Proposal	
U_{ret}	0.05-0.15	0.15	t_{clear}	0.14-0.25	0.25	3
U_{clear}	U_{ret} -0.15	0.15	t_{rec1}	t_{clear}	t_{clear}	3
U_{rec1}	U_{clear}	U_{clear}	t_{rec2}	t_{rec1}	t_{clear}	3
U_{rec2}	0.85	0.85	t_{rec3}	1.5-3.0	2.9	3

Table 34: Definition of FRT parameters for PPMs connected @ <110 kV

Justification: PPMs connected at a voltage level <110 kV

The fault ride through requirements in the existing Distribution Code –are indicated in Figure 8 below. The modifications made are considered to be the minimum required to comply with the RfG.

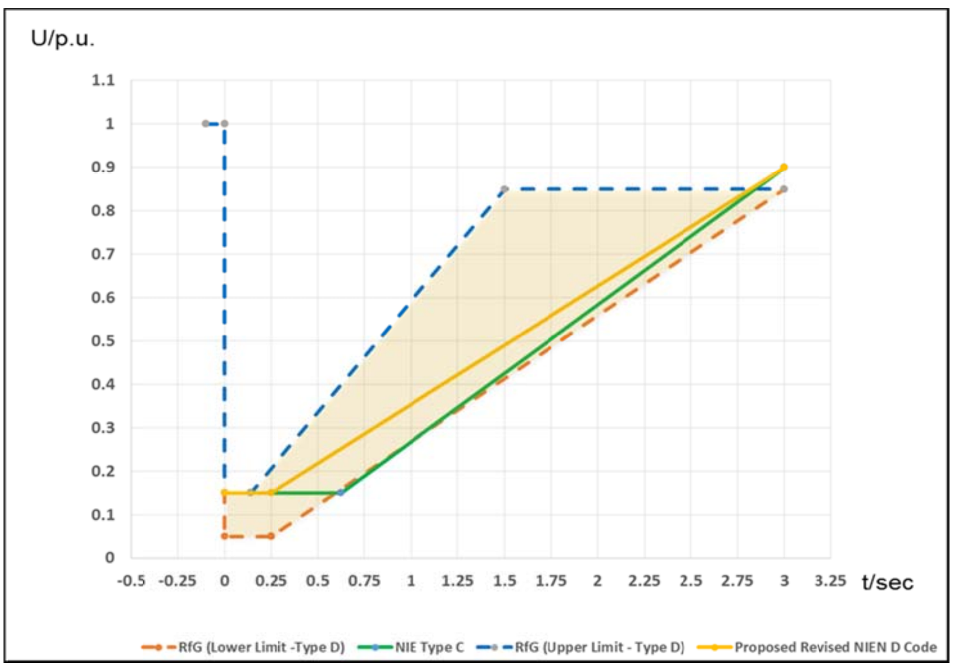


Figure 5: FRT capability PPM connected at voltage less than 110 kV

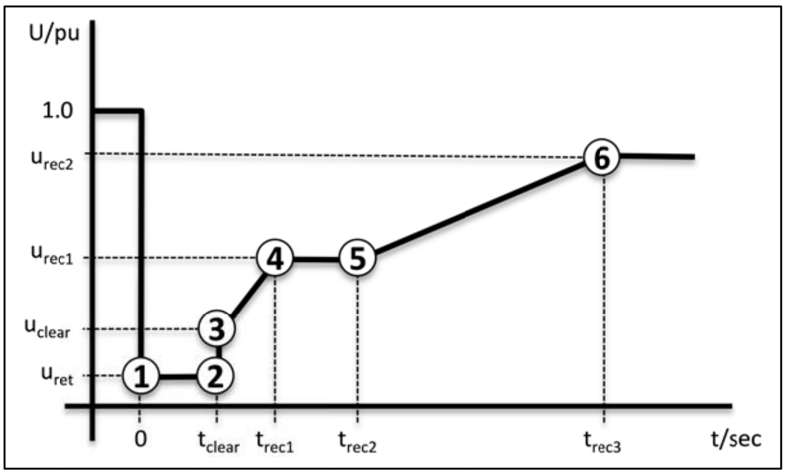
4.2.4.2 Article 16.3.a FRT Capability for PGMs connected at voltage level ≥110 kV

Non-Exhaustive Parameter Selection

Applies to Type D PGMs and offshore PPMs

Requirement

Power-generating modules shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. That capability shall be in accordance with a voltage-against-time profile at the connection point for fault conditions in line the figure below.



Fault Ride Through Profile of a Power-Generating Module

The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault.

That lower limit is specified for synchronous power-generating modules and power park modules connected at or above the 110 kV level in the following subsections.

Proposal: SPGMs connected at a voltage level ≥ 110 kV

Table 35 lists the parameters which describe the FRT capability parameters for SPGMs connection at a voltage level ≥ 110 kV.

Voltage parameters (pu)			Time parameters (s)			Justification Code
Parameter	**RfG Range**	**Proposal**	**Term**	**RfG Range**	**Proposal**	
U_{ret}	0	0	t_{clear}	0.14-0.25	0.15	3
U_{clear}	0.25	0.25	t_{rec1}	t_{clear} -0.45	t_{clear}	3
U_{rec1}	0.5-0.7	0.5	t_{rec2}	t_{rec1}-0.7	0.45	3
U_{rec2}	0.85-0.9	0.9	t_{rec3}	t_{rec2}-1.5	t_{rec2}	3

Table 35: Definition of FRT parameters for SPGMs connected @ □110 kV

Justification: SPGMs connected at a voltage level ≥110 kV

The Grid Code does not provide fault ride through requirement for synchronous generators that are compliant with the above. The proposal is based on the proposed modifications to the Ireland Grid Code and Distribution Code –for the equivalent module.

Figure 6 shows the fault ride through capabilities including for completeness, the RfG boundaries.

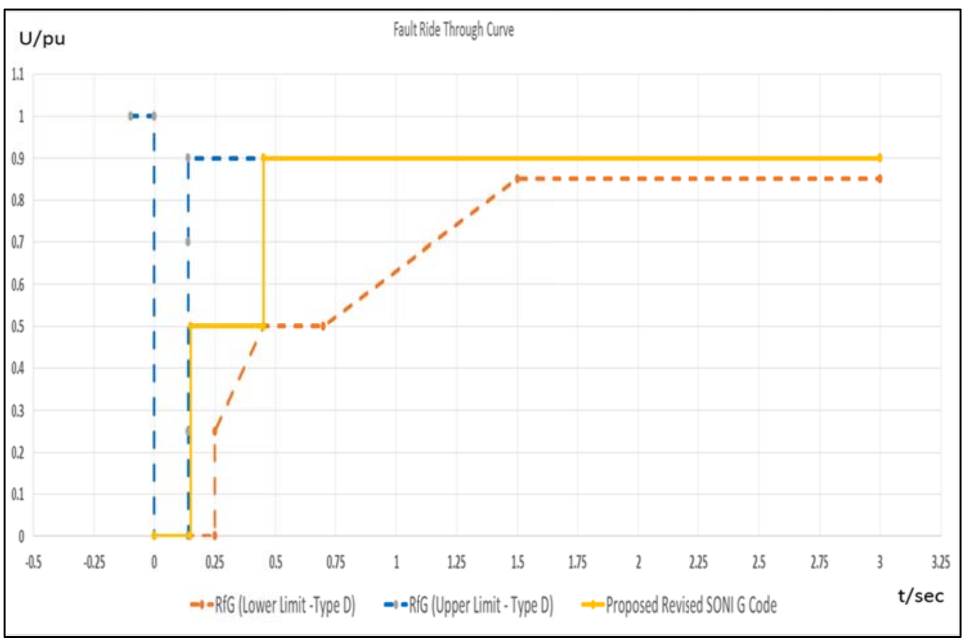


Figure 6: FRT capability of SPGMs connected at ≤ 110 kV

Proposal: PPMs connected at a voltage level ≥ 110 kV

Table 36 lists the parameters which describe the FRT capability parameters for PPMs connection at a voltage level ≥ 110 kV.

Voltage parameters (pu)			Time parameters (s)			Justification Code
Parameter	RfG Range	Proposal	Term	RfG Range	Proposal	
U_{ret}	0	0	t_{clear}	0.14-0.25	0.15	3~~1~~
U_{clear}	U_{ret}	U_{ret}	t_{rec1}	t_{clear}	t_{clear}	
U_{rec1}	U_{clear}	U_{clear}	t_{rec2}	t_{rec1}	t_{clear}	
U_{rec2}	0.85	0.85	t_{rec3}	1.5-3.0	2.9	3~~1~~

Table 36: Definition of FRT parameters for PPMs connected @ ≥ 110 kV

Justification: PPMs connected at a voltage level ≥110 kV

The proposal above is based on the fault ride through contained within the Grid Code for Wind Farm Power Stations (WFPS). The retained voltage is required to be reduced to zero the fault clearance time reduced to 0.15 seconds. The term WFPS will be amended to use the same terminology as the RfG. Figure 7 shows the fault ride through capabilities including the RfG boundaries.

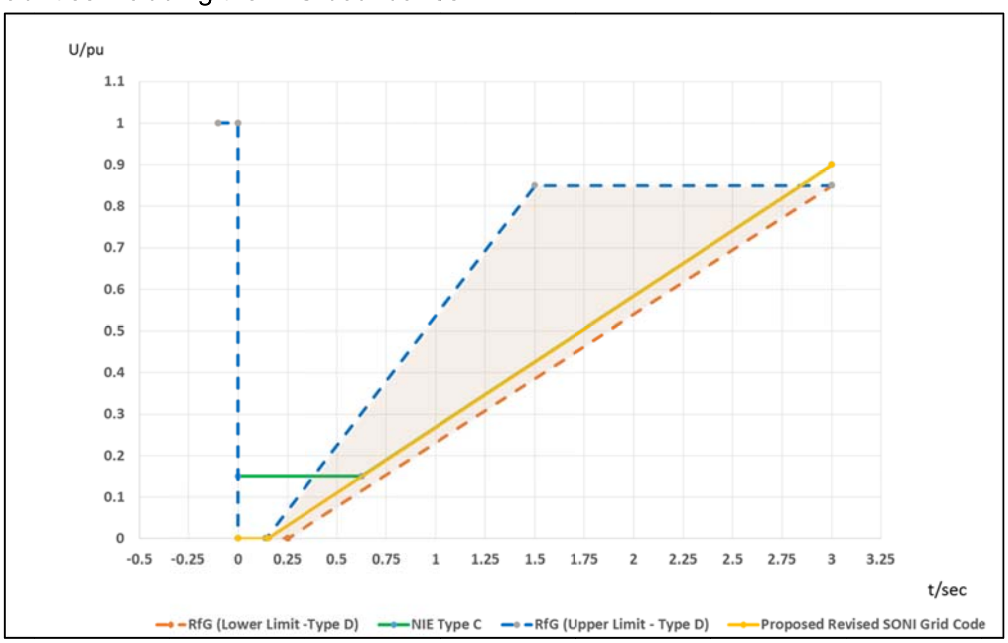


Figure 7: FRT capability of PPMs connected at ≤ 110 kV

4.2.4.3 Fast Fault Current Injection

4.2.4.3.1 Article 20.2.b Fast Fault Current Injection for Symmetrical Faults

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

The relevant system operator in coordination with the relevant TSO shall have the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults, under the following conditions

(i) the power park module shall be capable of activating the supply of fast fault current either by:
   a. ensuring the supply of the fast fault current at the connection point, or
   b. measuring voltage deviations at the terminals of the individual units of the PPM and providing a fast fault current at the terminals of these units;

(ii) the relevant system operator in coordination with the relevant TSO shall specify:
   a. how and when a voltage deviation is to be determined as well as the end of the voltage deviation,
   b. the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current, for which current and voltage may be measured differently from the method specified in Article 2,
   c. the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Voltage threshold for fast fault current injection	Not specified	During voltage dips i.e. when the voltage is below 0.9 p.u.	20.2.b	B, C and D PPMs	3
End of the voltage deviation	Not specified	Once the voltage has recovered to within normal operating voltage range	20.2.b	B, C and D PPMs	3
the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current	Not specified	Reactive current should be provided for the duration of the voltage deviation within the rating of the PPM	20.2.b	B, C and D PPMs	3
the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance	Not specified	Rise Time no greater than 100ms and a Settling Time no greater than 300ms.	20.2.b	B, C and D PPMs	3

Table 37: Fast Fault Current Injection - Symmetrical Faults

Justification:

The existing Distribution Code and Grid Code are silent on the provision of fast fault current. The DNO and TSO invoke the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults under the conditions given.

4.2.4.3.2 Article 20.2.c Fast Fault Current Injection for Asymmetrical Faults

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

(iii) with regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the relevant system operator in coordination with the relevant TSO shall have the right to specify a requirement for asymmetrical current injection

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Voltage threshold for fast fault current injection	Not specified	During voltage dips i.e. when the voltage is below 0.9 p.u.	20.2.b	B, C and D PPMs	1
the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current	Not specified	Reactive current should be provided for the duration of the voltage deviation within the rating of the PPM	20.2.b	B, C and D PPMs	1
the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance	Not specified	Rise Time no greater than 100ms and a Settling Time no greater than 300ms.	20.2.b	B, C and D PPMs	2

Table 38: Fast Fault Current Injection - Asymmetrical Faults

Justification:

The DNO and TSO invoke the right to specify a requirement for asymmetrical current injection as above

4.2.4.4 Article 20.3.a Post-Fault Active Power Recovery for PPMs

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

(a) the relevant TSO shall specify the post-fault active power recovery that the power park module is capable of providing and shall specify certain parameters

Proposal

Table 39 details the specification of post fault active power recovery capability that power park module shall be capable of providing.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
when the post-fault active power recovery begins, based on a voltage criterion	Not specified	u_n< 0.9 p.u.	20.3.a	B, C and D PPMs	**1**
maximum allowed time for active power recovery	Not specified	500ms	20.3.a	B, C and D PPMs	**1**
magnitude and accuracy for active power recovery	Not specified	90%	20.3.a	B, C and D PPMs	**1**

Table 39: Post-Fault Active Power Recovery for PPMs

Justification

The proposal of parameters which specify the capability of post-fault active power recovery is in line with CC.S2.1.3.6 c) of the current SONI Grid Code and section 7.12.3.2. of the Distribution Code .

4.2.4.5 Article 21.3.e Priority Given to Active or Reactive Power Contribution for PPMs

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

With regard to prioritising active or reactive power contribution, the relevant TSO shall specify whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception.

Proposal

Table 40 specifies the priority to power contribution during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Prioritisation requirements during FRT	Active/Reactive	Active	21.3.e	C and D PPMs	3

Table 40: Priority given to Active or Reactive Power Contribution

Justification

The SONI Grid Code is silent on this requirement in respect of wind farm power stations. The choice of active considered a priority for the Northern Ireland transmission system and is consistent with EirGrid Grid Code.

4.2.5 Additional Non-Mandatory Voltage Requirements

There is one remaining non-mandatory requirements detailed in the RfG. Table 41 below identifies the area. We do not intend to invoke this non-mandatory requirement at this time.

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability
Simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency	Do we want to expertise the right to specify this non-mandatory RfG?	Not invoking at this time.	16(02)(a)(ii)	Type A, B, C and D PGMs

Table 41: List of Non-Mandatory and not invoked Requirements for Generators

4.3 System Restoration Theme

There is only one article in RfG with a non-exhaustive parameter under the system restoration theme. The sub theme is on:

- Operation of PGM following tripping to house load.

4.3.1 Article 15.5.c.(iii) Operation following tripping to house load

Non- Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

A power-generating module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the system operator's switchgear position signals. Power-generating modules shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Operation Following Tripping to House Load	Not Specified	4 hours	15.5.c.iii	C and D PGMs and offshore PPMs with a minimum re-synchronisation time greater than 15 minutes*	3

Table 42: Operation Following Tripping to House Load

Justification

Under the current version of the SONI Grid, there is no requirement for PGMs to be capable of tripping to houseload. Instead, under SONI Grid Code CC.S1.1.1.4, each CDGU or CCGT installation must be capable of restarting without a connection to an external power supply.

However, under the RfG, Type C and D PGMs, with synchronization times of 15 minutes or more, must be capable tripping to house load. For the purpose of this consultation the only item being consulted on is the operation time following tripping to house load. The TSO is proposing 4 hours which aligns with the expected time that it would take to resynchronise to the transmission system, under the SONI Power System Restoration Plan.

4.4 Protection and Instrumentation Theme

The non-exhaustive and non-mandatory protection and instrumentation parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Manual Local Measures where the automatic remote devices are out of service
- Instrumentation
- Dynamic system behaviour monitoring
- Simulations
- Neutral Earthing
- Synthetic Inertia

4.4.1 Article 15.2.b: Manual, local measures where the automatic remote devices are out of service

Non- Exhaustive Parameter Selection

Applies to Types B, C and D PGMs

Requirement

Manual local measures shall be allowed in cases where the automatic remote control devices are out of service.

The relevant system operator or the relevant TSO shall notify the regulatory authority of the time required to reach the set point together with the tolerance for the active power.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time required to achieve setpoint when automatic remote devices are unavailable	Not Specified	1 hour	15(2)(b)	B, C and D PGMs	3

Table 43: Time required to Achieve Set point when Automatic Remote Devices are Unavailable

Justification:

Under the current version of the SONI WFPS Settings Schedule (section 6.4), if the remote control of a WFPS is lost, the WFPS must remain its pre-fault set point for 10 minutes, before shutting down to 0 MW within 1 minute.

The proposal is that one hour after automatic remote control has been lost, manual intervention must be taken to return the PGMs to the required setpoint. The proposal of 1 hour is intended to allow the operator a reasonable time to attend the PGM site.

4.4.2 Article 15.6.b (i): Instrumentation: Quality of Supplies

Non-Mandatory Requirement being made Mandatory

Applies to Types C and D PGMs and offshore PPMs

Requirement

Power-generating facilities shall be equipped with a facility to provide fault recording and monitoring of dynamic system behaviour. This facility shall record the following parameters:

- Voltage,
- Active power,
- Reactive power, and
- Frequency

The relevant system operator shall have the right to specify quality of supply parameters to be complied with on condition that reasonable prior notice is given.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Quality of supplies parameters to be recorded.	Not Specified	Site Specific	15(6)(b)(i)	C and D PGMs and offshore PPMs	1

Table 44: Quality of Supplies Parameters to be Recorded

Justification:

Under SONI Grid Code OC11.5, the TSO has the right to carry out monitoring at any time and involves the analysis of the output of the generation unit.

However, as station and/or generation unit configuration can vary between sites, as well as possible compatibility issues with existing equipment, the exact requirement of the fault recording equipment will need to be specified on a site specific basis.

4.4.3 Article 15.6.b.(iii): Dynamic System Behaviour Monitoring

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

The dynamic system behaviour monitoring shall include an oscillation trigger specified by the relevant system operator in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Oscillation trigger detecting poorly damped power oscillations.	Not Specified	Site Specific	15(6)(b)(iii)	C and D PGMs and offshore PPMs	1

Table 45: Oscillation Trigger Detecting Poorly Damped Power Oscillations

Justification

Under the SONI Metering Code, the event recorders can be specified by the TSO. While the high level functional requirements of these recorders are detailed in the Code, the detailed implementation must be specified on a case by case due to:

- Variations in Generation/site configurations
  Compatibility with existing equipment

4.4.4 Article 15.6.c.(iii) Simulation Model Provision

Non-Mandatory Requirement being made Mandatory

Applies to Types C and D PGMs and offshore PPMs

Requirement

The request by the relevant system operator referred to in point (i) shall be coordinated with the relevant TSO. It shall include:

- The format in which models are provided,
- The provision of documentation on a model's structure and block diagrams,
- An estimate of the minimum and maximum short circuit capacity at the connection point, expressed in MVA, as an equivalent of the network.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Model Provision	Not Specified	Retain the existing model provision requirements with the inclusion of min and max short circuit levels	15(6)(c)(iii)	C and D PGMs and offshore PPMs	2

Table 46: Simulation Model Provision

Justification

PC6 the Planning Data Requirements from Users defines the format of the models to provided, along with details of the supporting documentation. Any information that is required to be provided to the customer will be provided through the current pre-energisation process. This will be provided to the user up to two years in advance of connection, along with the minimum short circuit level as a per unit value.

The proposal is to retain the existing requirements in PC6 but with the inclusion of additional fields for the provision of the min and max short circuit levels in MVA.

4.4.5 Article 15.6.f: Neutral-point at the network side of step transformers

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

Earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Earthing arrangement of the neutral-point	Not Specified	Site specific - Will be specified as a part of the connection agreement	15(6)(f)	C and D PGMs and offshore PPMs	1

Table 47: Neutral-point at the Network Side of Step Transformers

Justification:

The proposal is to retain the existing SONI Grid Code requirement as detailed in CC.6.8.1 which states that the specification of a User's Apparatus shall meet the voltages which will be imposed on the Apparatus as a result of the method of Earthing of the Transmission System, as specified in the relevant Connection Agreement.

4.2.6 Additional Non-Mandatory Protection & Instrumentation Requirements

There are a number of additional areas with non-exhaustive parameters detailed in the RfG. Table 48 below identifies the areas. In all cases these requirements will be highly dependent on the type of PGM, the location of the connection, etc. As such, these requirements must be dealt with on a case by case basis and do not form part of this consultation.

Parameter	Parameters in RfG	Article Number	Type Applicability
Control Scheme and Settings: Agreement and coordination between the TSO, the RSO (TSO and DSO) and the power generating facility owner (PGFO)	Control schemes and settings of the control devices	14.5.a	B,C and D PGMs and offshore PPMs
Electrical Protection Schemes and settings: Agreement and coordination between the RSO and the PGFO	Protection schemes and settings	14.5.b	B,C and D PGMs and offshore PPMs
Loss of angular stability or loss of control: Agreement between PGFO and the RSO (DSO or TSO), in coordination with the TSO	Criteria to detect loss of angular stability or loss of control	15.6.a	C and D PGMs and offshore PPMs
Instrumentation: Settings of the fault recording equipment, including triggering criteria and sampling rate **Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO.**	Settings of the fault recording equipment, including triggering criteria and sampling rate	15.6.b(ii)	C and D PGMs and offshore PPMs
Instrumentation: Protocols for recorded data **Agreement between PGFO, the RSO and the relevant TSO**	Protocols for recorded data	15.6.b(iv)	C and D PGMs and offshore PPMs
Installation of devices for system operations and system security: Agreement between RSO or TSO and PGFO	Definition of the devices needed for system operation and system security	15.6.d	C and D PGMs and offshore PPMs
Synchronisation: Agreement between the RSO and the PGFO	Settings of the synchronisation devices	16.4	D PGMs and offshore PPMs
Angular stability under fault conditions: Agreement between the TSO and PGFO	Agreement for technical capabilities of the power generating module to aid angular stability.	19.3	D SPGM

Table 48: Parameters to be agreed on a Case by Case basis

5. Consultation Process

5.1. Webinar

To facilitate public engagement on the proposed RfG parameters the TSO and the DSO will host an industry webinar during the consultation process. This webinar, scheduled for the 11th of January 2018, will provide an opportunity for discussion on the proposed RfG parameters as specified in this consultation document.

5.2. Consultation Responses

The TSO and DSO welcome feedback on the proposals set out in Section 4 of this paper. A template has been provided to facilitate this feedback.

Whilst we welcome any feedback on the proposals included in this document, in particular we would like your views on the following:

- Do you agree with the proposed values for each of the specific parameters as set out in this paper
- Do you think that other parameters should have been selected for any of the parameters?
- If yes, please explain what values you would have proposed for the specific parameters.
- If yes, please explain why you would have proposed the value including any costs/benefits/saving you believe will materialise from your proposal.
- Do you believe that any non-exhaustive parameters have been excluded from this document incorrectly
- If yes, please detail the RfG reference
- Do you please that any non-mandatory requirements have been excluded from this document incorrectly?
- If yes please detail the RfG reference

The consultation period ends on 9th February 2018.

Responses should be submitted to SONI at gridcode@soni.ltd.uk before 5pm on **9th February 2018**.

Field Code Changed

6. Next Steps

Following the closure of the consultation period the TSO and DSO shall consider any comments received and shall submit a proposal to the UREGNI.

After the UREGNI has approved the proposal the TSO and DSO shall implement the approved RfG parameters into the Northern Ireland Grid Code and Northern Ireland Distribution Code.

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