

ROCOF Test Report

[Insert Generator Name]

Insert Unit (XX1)

Version 1

# Document Version History

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| **Document Version History** |
| **Version** | **Date** | **Comment** |
| 0.1 | dd/mm/yyyy | First submission for review/approval |
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# Executive Summary

**Summary of Testing**

Testing was completed on DATE. Comment on compliance with the pass criteria highlighting any issues encountered in performing the test or in the analysis or test results.

**Summary of Compliance:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case | The governor reacts in a correct manner to a simulated ROCOF event. | The governor decrement rate is correctly implemented | The governor is continuously acting and responds with the required droop characteristic. | The generator is able to withstand large frequency disturbances, and high rates of change of frequency, without tripping. |
| 8.1.1 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
| 8.1.2 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
| 8.1.3 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
| 8.1.4 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
| 8.1.5 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
| 8.1.6 | Pass/Fail | Pass/Fail | Pass/Fail | Pass/Fail |
|  |  |  |  |  |

# Abbreviations

CHCC Castlereagh House Control Centre

NCC National Control Centre

Mvar Mega Volt Ampere – reactive

MW Mega Watt

TSO Transmission System Operator

MEC Maximum Export Capacity

RPM Revolutions Per Minute

kV kilovolt

EDIL Electronic Dispatch Instruction Logger

POR Primary Operating Reserve

SOR Secondary Operating Reserve

TOR Tertiary Operating Reserve

ROCOF Rate of Change of Frequency

# Unit DATA

|  |  |
| --- | --- |
| Unit Test Coordinator | Unit to Specify Name, Company and contact details. |
| Unit name | Unit to Specify |
| Unit connection point | Unit to Specify |
| Unit connection voltage | Unit to Specify |
| Unit Fuel Type  | Primary Fuel / Secondary Fuel, Gas / Distillate. |
| Registered Capacity | Unit to Specify |
| Contracted MEC | Unit to Specify |
| Installed Plant | Unit to Specify |
| House Load  | Unit to Specify |
| Governor Droop Setting  | Unit to Specify |

|  |  |
| --- | --- |
| % of Registered Capacity | MW |
| 25% | Unit to specify |

# Eirgrid Grid Code references

|  |  |
| --- | --- |
| Grid Code Version:  | Unit to specify |

## 5.1 Rate of change of Frequency (existing Grid Code)

CC.7.3.1 The conditions specified in this section of the code apply to all **Generation Units** connected to or connecting to the **Transmission System**. Unless explicitly stated all conditions specified apply over the full operating capabilities of the **Generation Unit** at the **Connection Point**.

 (d) remain synchronised to the **Transmission System** during rate of change of **Transmission System Frequency** of values up to and including 0.5 Hz per second;

CC.7.3.7 Each **Generation Unit** must be fitted with a fast acting proportional turbine speed governor and unit load controller or equivalent control device to provide **Frequency** response under normal operating conditions in accordance with OC4. The governor must be designed and operated to the appropriate

(a) European Standards; or

(b) In the absence of a relevant European Standards, such other standard which is in common use within the European Union

as at the time when the installation of which it forms a part was designed. Normal governor regulation shall be between 3% and 5%.

## 5.2 CER Decision Paper (14081) [[1]](#footnote-1)

*Section 3.3*

*5. New units: new units will be required to declare compliance (*with the 1 Hz per second ROCOF measured over 500 ms) *during the commissioning process.*

## 5.3 Governor

CC.7.3.7

Each **Generation Unit** must be fitted with a fast acting proportional turbine speed governor and unit load controller or equivalent control device to provide **Frequency** response under normal operating conditions in accordance with OC4. The governor must be designed and operated to the appropriate

(a) European Standards; or

(b) In the absence of a relevant European Standards, such other standard which is in common use within the European Union

as at the time when the installation of which it forms a part was designed. Normal governor regulation shall be between 3% and 5%.

## 5.4 Grid Code Definitions

**Governor Droop**

The percentage drop in the **Frequency** that would cause the **Generation Unit** under free governor action to change its output from zero to its full **Capacity**. In the case of a **Controllable WFPS**, it is the percentage drop in the **Frequency** that would cause the **Controllable WFPS** to increase its output from zero to its full **Registered Capacity**

**Registered Capacity**

The maximum **Capacity**, expressed in whole MW, that a **Generation Unit** can deliver on a sustained basis, without accelerated loss of equipment life, at the **Connection Point** which is under the dispatch (or control of a **Controllable WFPS**) of the **TSO**. This shall be the value at 10°C, 70 % relative humidity and 1013 hPa. The values of an **Interconnector’s Operating Characteristics** for operation of the **Interconnector** pursuant to the **Grid Code** registered under the **Connection Conditions**.

## 5.5 Calculation of MW response and Governor Droop

$$ΔMW=\frac{\left(Δf\right)\left(Registered Capacity\right)}{\left(f\_{n} \right)\left(droop\right)}$$

ΔMW=Expected MW

Δf = frequency change in Hz

Registered Capacity = XXX MW (expected value)

Fn = 50 Hz

Droop = 0.04 (expected value)

# SONI Grid Code References

6.1 Rate of Change of Frequency (existing Grid Code**)**

CC8.8.3 Variations in **System Frequency**

The **DNO** shall provide in the **Distribution Code** that, apart from those circumstances set out in CC8.8.4, all **Independent Generating Plant** connected to the **Distribution** **System** with an **Output** of 100 kW or more shall stay connected and operate:

(a) continuously where the **System Frequency** varies within the range 49.5 to 52.0 Hz;

(b) for a period of up to one hour where the **System Frequency** varies within the range 48.0 to 49.5 Hz; and

(c) for a period of up to 5 minutes where the **System Frequency** varies within the range 47.0 to 48.0 Hz.

The **DNO** shall notify the **TSO** if an **Independent Generating Plant** above 100KW does not operate within the parameters set out above and, if required by the **TSO,** shall use reasonable endeavours to enforce the **Distribution Code** obligations on the **Independent Generating Plant**.

CC8.8.4 The requirements of CC8.8.3 do not apply where:

(a) the islanding protection has operated correctly, consistent with the settings agreed with the **DNO**;

(b) the **System Frequency** has changed at a rate greater than 0.5HZ/s; or

(c) there is manual intervention by the **Generator**.

##  Proposed Modification (Regulatory approved with phased implementation)

CC5.3.2 In exceptional circumstances, **System Frequency** will rise to 52 Hz or fall to 47 Hz but sustained operation outside the range specified in the Electricity Supply Regulations (N.I.) 1991(as amended, updated or superseded) is not envisaged. **Users** should take these factors into account in the design of **Plant** and **Apparatus**.

CC5.3.3 In exceptional circumstances, **System Frequency** will vary causing a considerable **Rate of Change of Frequency**. Under such conditions, **Users** must ensure that their **Plant** and **Apparatus** remains **synchronised** to the **NI System** for a **Rate of Change** **of Frequency** up to and including 1 Hz per second as measured over a rolling 500 milliseconds period within the frequency range mentioned in CC5.3.2.

CC5.3.4 Notwithstanding CC5.3.3, until such time as a notification given by the **TSO** pursuant to this CC5.3.4 that there is additional system re-enforcement, **Users** must ensure that their **Plant** and **Apparatus** remains **synchronised** to the **NI System** for a **Rate of** **Change of Frequency** up to and including 2 Hz per second as measured over a rolling 500 milliseconds period within the frequency range mentioned in CC5.3.2. For the avoidance of doubt, this requirement relates to the capabilities of **Generating Units** only and does not impose the need for **Rate of Change of Frequency** protection nor does it impose a specific setting for anti-islanding protection relays.

# Pass Criteria

##  Ireland

The Unit must demonstrate for the following test cases that:

* The governor reacts in a correct manner to a simulated ROCOF event.
* The governor decrement rate is correctly implemented.
* The governor is continuously acting and responds with the required droop characteristic.
* The generator is able to withstand large frequency disturbances, and high rates of change of frequency, without tripping.

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Load Level** | **Frequency Injection****(for 22 min)** | **Estimated response with a 4 % droop** | **Hold Step for a minimum of** |
| 1 | Min load | -0.5Hz(ramp of 1Hz/sec) | +25% | 10 minutes |
| 2 | Min load | +0.5Hz(ramp of 1Hz/sec) | TBC | 10 minutes |
| 3 | 75% | -0.5Hz(ramp of 1Hz/sec) | +25% | 10 minutes |
| 4 | 75% | +0.5Hz(ramp of 1Hz/sec) | -25% | 10 minutes |
| 5 | 90% | -0.5Hz(ramp of 1Hz/sec) | +10% | 10 minutes |
| 6 | 100% | +0.5Hz(ramp of 1Hz/sec) | -25% |  10minutes |

## 7.2 Northern Ireland

**Criteria of Assessment:**

* The governor reacts in a correct manner to a simulated ROCOF event.
* The governor decrement rate is correctly implemented.
* The governor is continuously acting and responds with the required droop characteristic.
* The generator is able to withstand large frequency disturbances, and high rates of change of frequency, without tripping.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Load Level** | **Frequency Injection** | **Estimated response with a 4 % droop** | **Hold Step for a minimum of** |
| 1 | Min load | -0.5Hz(ramp of 2Hz/sec) | +25% | 10 minutes |
| 2 | Min load | +0.5Hz(ramp of 2Hz/sec) | 0% | 10 minutes |
| 3 | 75% | -0.5Hz(ramp of 1Hz/sec)Hold for 1sec+1Hz(ramp of 1Hz/sec) | +25%-25% | 10 minutes |
| 4 | 75% | -0.5Hz(ramp of 2Hz/sec) | +25% | 10 minutes |
| 5 | 75% | +0.5Hz(ramp of 1Hz/sec)Hold for 1sec-1Hz(ramp of 1Hz/sec) | -25%+25% | 10 minutes |
| 6 | 75% | +0.5Hz(ramp of 2Hz/sec) | -25% | 10 minutes |
| 7 | 100% | -0.5Hz(ramp of 2Hz/sec) | 0% | 10 minutes |
| 8 | 100% | +0.5Hz(ramp of 2Hz/sec) | -25% | 10 minutes |

# Analysis

## Ireland

Results table:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Step** | **Frequency deviation in Hz** | **Initial MW** | **Final MW** | **MW change** | **Expected MW** | **Delta MW** | **Calculated Droop in %** | **Expected droop in %** | **Delta Droop** | **Comment** |
| Min load -0.5 Hz Ramp at 1 Hz/Second | -0.5 |  |  | 0 | **25** | **-25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |
| Min load +0.5 Hz Ramp at 1 Hz/Second | 0.5 |   |   | 0 | **-25** | **25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |
| 75% -0.5 Hz Ramp at 1 Hz/Second | -0.5 |   |   | 0 | **25** | **-25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |
| 75% +0.5 Hz Ramp at 1 Hz/Second | 0.5 |   |   | 0 | **-25** | **25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |
| 90% -0.5 Hz Ramp at 1 Hz/Second | -0.5 |   |   | 0 | **25** | **-25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |
|  100% +0.5 Hz Ramp at 1 Hz/Second | 0.5 |   |   | 0 | **-25** | **25** | #DIV/0! | **4.00%** | **#DIV/0!** |   |

For each of the cases below

* Insert graph of simulated frequency injection and exported active power output covering 0 to 15 seconds and 0 to 10 minutes
* Insert graph of simulated frequency injection and generated reactive power covering 0 to 15 seconds and 0 to 10 minutes
* Insert any other graphs required in analysis
* Calculate the exported MW change and droop based on pre-injection MW and post step settled MW
* Provide analysis of actual response vs expected response and any observed oscillation in active or reactive power

### Min load -0.5 Hz Ramp at 1 Hz/Second

### Min load +0.5 Hz Ramp at 1 Hz/Second

### 75% -0.5 Hz Ramp at 1 Hz/Second

### 75% +0.5 Hz Ramp at 1 Hz/Second

### 90% -0.5 Hz Ramp at 1 Hz/Second

### 100% +0.5 Hz Ramp at 1 Hz/Second

##  Northern Ireland

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Step** | **Freq deviation in Hz** | **Initial MW** | **Final MW** | **MW change** | **Expected MW** | **Delta MW** | **Calculated Droop in %** | **Expected droop in %** | **Delta Droop** | **Comment** |
| 100%-0.5 HzRamp at 2 Hz/s | -0.5 |  |  |  |  |  |  |  |  |  |
| 100%+0.5 HzRamp at 2 Hz/s | +0.5 |  |  |  |  |  |  |  |  |  |
| 75%-0.5 HzRamp at 1 Hz/s, Hold for 1s,+1 HzRamp at 1 Hz/s | -0.5, +1.0 |  |  |  |  |  |  |  |  |  |
| 75%-0.5 Hz Ramp at 2 Hz/s | -0.5 |  |  |  |  |  |  |  |  |  |
| 75%+0.5 HzRamp at 1 Hz/s, Hold for 1s,-1 HzRamp at 1 Hz/s | +0.5, -1.0 |  |  |  |  |  |  |  |  |  |
| 75%+0.5 Hz Ramp at 2 Hz/s | +0.5 |  |  |  |  |  |  |  |  |  |
| Min load-0.5 Hz Ramp at 2 Hz/s | -0.5 |  |  |  |  |  |  |  |  |  |
| Min load+0.5 Hz Ramp at 2 Hz/s | +0.5 |  |  |  |  |  |  |  |  |  |

For each of the cases below

* Insert graph of simulated frequency injection and exported active power output covering 0 to 15 seconds and 0 to 10 minutes
* Insert graph of simulated frequency injection and generated reactive power covering 0 to 15 seconds and 0 to 10 minutes
* Insert any other graphs required in analysis
* Calculate the exported MW change and droop based on pre-injection MW and post step settled MW
* Provide analysis of actual response vs expected response and any observed oscillation in active or reactive power

### Verification of Base Load

### 100% -0.5 Hz Ramp at 2 Hz/Second

### 100% +0.5 Hz Ramp at 2 Hz/Second

### 75% -0.5 Hz Ramp at 1 Hz/Second, Hold for 1 Second, +1 Hz Ramp at 1 Hz/Second

### 75% -0.5 Hz Ramp at 2 Hz/Second

### 75% +0.5 Hz Ramp at 1 Hz/Second, Hold for 1 Second, -1 Hz Ramp at 1 Hz/Second

### 75% +0.5 Hz Ramp at 2 Hz/Second

### Min Load -0.5 Hz Ramp at 2 Hz/Second

### Min Load +0.5 Hz Ramp at 2 Hz/Second

#  Appendices

As required e.g. include ROCOF study graphs for

Min loading, full leading, low short circuit level 1 Hz/s frequency drop

Max loading, full leading, low short circuit level 1 Hz/s frequency rise

1. <http://www.cer.ie/docs/000260/CER14081%20ROCOF%20Decision%20Paper%20-%20FINAL%20FOR%20PUBLICATION.pdf> [↑](#footnote-ref-1)