Rate Of Change Of Frequency (RoCoF) Study Assessment Guide For Demand Facilities

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EirGrid

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Contents

Revision History				
Revision	**Date**	**Description**	**Originator**	**Reviewer / Approver**

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Acronyms

CP	Connection Point
LV	Low Voltage
MIC	Maximum Import Capacity
MSS	Minimum System Strength
pu	per unit
RoCoF	Rate of Change of frequency
TSO	Transmission System Operator

1 Introduction

As a Transmission System Operator (TSO) of Ireland, EirGrid proposed the grid code modification for Rate of Change of Frequency (RoCoF), outlines that any demand facility connected to the grid, should be remain connected to the Transmission System during rate of change of Transmission System Frequency of values up to and including 1Hz per second as measured over a rolling 500 milliseconds period. To assess the performance of demand facilities in response to such an event, this document describes a set of electrical dynamic simulations to be carried out by the customer, which will then be reviewed by EirGrid to ascertain grid code compliance of the facility.

1.1 Description of the Sections

In each section, technical requirements are defined while providing a background or discussion on the specific subjects. It is suggested to follow the approach presented in this document including heading structure, table formats and plots for an effective review of the RoCoF study submissions.

The sections are briefly described below:

- In the **second section**, the timeline and the submission requirements for the RoCoF study are given. Also, the expected introduction section in the customer RoCoF report is described.
- In the **third section**, the relevant Grid Code (modification) clauses are listed to be used as a reference for RoCoF studies.
- In the **fourth section**, the RoCoF study methodology is defined which include the list of frequency traces are presented and corresponding test case scenarios.
- In the **fifth section**, the requirements for the simulation outputs are shared. The parameters and plots needed for submission are described.
- In the appendices, sample frequency traces and Minimum System Strength (MSS) data at the CP for modelling of external grid is shared.

2 RoCoF Study Requirements

2.1 Overview

All TSO connected demand facilities are required to submit RoCoF study to EirGrid.

Table 1: Customers Required to Submit an RoCoF Study

Customer Type	Demand Facility
Transmission Connected - Demand Facility	No limit, all Customers

The RoCoF assessments must be based on the Minimum System Strength (MSS) data issued to the customers for the purpose of modelling the external grid in the simulation studies. Table 2 outlines the timeline for the RoCoF related submissions.

Table 2: Timeline for RoCoF Study Submissions

Item	Timelines*	Responsible	Submit to
Minimum System Strength Data	MSS data will be issued to the customer upon request from the customer following the customer's notice of intention to show compliance	EirGrid	Customers
RoCoF Study Submission	For existing connected Demand Facilities within the timelines specified in CRU's approved MPID345 Compliance and Derogation Framework. For new Demand Facilities, please refer to "Getting Connected".	Customers	EirGrid
Review of Customer Submissions	Within 3 weeks after customer submission; comment log will be issued to customer.	EirGrid	Customers
Response to EirGrid Comments	Within 2 weeks after receiving comments.	Customers	EirGrid
Decision on RoCoF study	The outcome will be notified to customer after detailed review & engagement process.	EirGrid	Customers

* should timelines not be met by customers, this may impact compliance process.

In relation to the RoCoF assessment studies, while adhering to the timeline in Table 2, the customer should submit all the relevant reports, documents and data as per Table 3 to EirGrid.

Table 3: RoCoF Study Submission Requirements

#	Report / Document / Data
1	Customer self-assessment RoCoF Report
2	Single-line diagram of the facility
3	Simulation and modelling files
4	Documents used as reference in the RoCoF study
5	Other supporting documents, if needed

2.2 RoCoF – Simulation Studies

Customers must simulate how the demand facility would behave during the frequency events are listed in Table 5 and demonstrate whether the facilities remain connected for allowed RoCoF threshold values. RoCoF simulation studies must be carried out in any dynamic time-domain software package.

3 Grid Code (Modification) Requirements

For completeness of the study, RoCoF-related clauses should be quoted from the applicable Grid Code for Demand Facility units under study. The grid code requirements for Demand Facility units are referred in "MPID 345 Fault Ride Through, RoCoF and Post Fault Active Power Recovery for Demand Facilities" at the time of drafting this document.

As defined in the EirGrid Grid Code, a Demand Facility is "a facility which consumes electrical energy and is connected at one or more Connection Points to the Transmission System. The Distribution System and/or auxiliary supplies of a Generation Unit do not constitute a Demand Facility."

The relevant grid code clauses for RoCoF study from the proposed grid code modification is shown below in Table 4.

Table 4: Grid Code Clause – for RoCoF study

Connection Type	Grid Code (Modification) Clause
Demand Facility	**CC.7.4.3.1** Demand Facilities shall remain connected to the Transmission System during rate of change of Transmission System Frequency of values up to and including 1Hz per second as measured over a rolling 500 milliseconds period. (Voltage dips may cause localised RoCoF values in excess of 1 Hz per second for short periods, and in these cases, the Fault-Ride Through clause CC.7.4.3.2 supersedes this clause (CC.7.4.3.1).

4 Simulation Study Methodology

Simulation studies must be carried out to demonstrate that the facility is designed to comply with the RoCoF requirements are defined in the grid code modification.

4.1 Frequency Traces

The RoCoF assessment demonstrates the ability of the demand facility to remain connected and operate stably during network events that cause RoCoF. EirGrid requires considering the four 1 Hz per second **frequency events occurring at Connection Point** (see Table 5). The corresponding sample frequency traces are included in Appendix 2.

Table 5: List of frequency events

Frequency Trace	Frequency Trace Characteristics
1	Frequency rise
2	Frequency rise with subsequent fast drop resulting in under-frequency
3	Frequency drop
4	Frequency drop with subsequent fast recovery resulting in over-frequency

The frequency events in Table 5 should be examined for each of the following scenarios:

1. Demand facility at their load 50%, 70%, 100% of Maximum Import capacity (MIC)
2. N-1 short-circuit levels as provided in EirGrid's Minimum System Strength (MSS) data

4.2 Simulation Test Scenarios

RoCoF simulation studies evaluate how quickly system frequency changes after a disturbance in a system. Since system voltage influences inertia, fault levels, protection sensitivity, and dynamic response, therefore, users must study RoCoF under different operating voltages—including low-voltage (0.9 pu) and high-voltage (1.118 pu) conditions.

The **four frequency** traces are to be studied for each of the scenarios resulting from different combinations of load and short circuit level. The core scenarios at voltage 0.9 pu and 1.118 pu per frequency trace are listed in Table 6 and Table 7 respectively.

*Table 6: Core Scenarios at **Voltage 0.9 pu***

Scenarios	Load	Short Circuit Level
Scenario 1	50% of MIC	N-1
Scenario 2	70% of MIC	N-1
Scenario 3	100% of MIC	N-1

*Table 7: Core Scenarios at **Voltage 1.118 pu***

Scenarios	Load	Short Circuit Level
Scenario 1	50% of MIC	N-1
Scenario 2	70% of MIC	N-1
Scenario 3	100% of MIC	N-1

If any of the core scenarios for any of the frequency traces exhibit non-compliance, further scenarios from the combination of different system conditions should be studied. This approach is shown graphically in Figure 1.

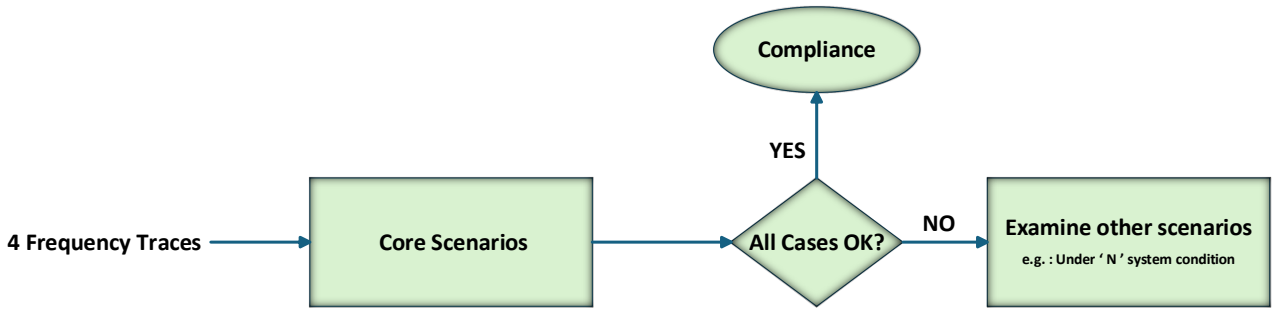

Figure 1: RoCoF - dynamic simulations

As highlighted in Figure 1, there are **24** (**4** frequency traces x **6** core scenarios) number of cases for demand facility to be studied initially. However, if non-compliance is identified in one or more of core cases, then further cases must be examined.

5 Simulation Results

A summary table should be provided for all the compliant and non-compliant scenarios for all the four frequency events. Tables [8-9] represents a sample summary table for one of the frequency traces i.e. "Frequency rise" event. Similarly, a summary table should be presented in the RoCoF report for other frequency traces as well.

*Table 8: Summary - RoCoF Study at **Voltage 0.9 pu***

Frequency Trace 1	Scenarios	System Conditions at Voltage 0.9 pu		Compliant? (Yes/No)	Reason for Non-compliance
		Load	Short Circuit Level		
Frequency rise	Scenario 1	50% of MIC	N-1		
	Scenario 2	70% of MIC	N-1		
	Scenario 3	100% of MIC	N-1		

*Table 9: Summary - RoCoF Study at **Voltage 1.118 pu***

Frequency Trace 1	Scenarios	System Conditions at Voltage 1.118 pu		Compliant? (Yes/No)	Reason for Non-compliance
		Load	Short Circuit Level		
Frequency rise	Scenario 1	50% of MIC	N-1		
	Scenario 2	70% of MIC	N-1		
	Scenario 3	100% of MIC	N-1		

5.1 Plotting Requirements

Provide plots of the dynamic response of the demand facility for each frequency trace with all scenarios, as seen at the Connection Point and LV Terminal.

Table 10: Required Plots

Plot #1	Signals/Parameters	Node	Unit
Plot 1	Three phase Voltage (Phase 1, Phase 2, Phase 3)	CP	Per Unit
Plot 2	Frequency	CP & LV terminal	Actual Values
Plot 3	Rate of Change of Frequency	CP & LV terminal	Actual Values
Plot 4	Power Component	CP	Actual Values
Plot 5	Three phase Voltage (Phase 1, Phase 2, Phase 3) and Power Component	LV terminal	Actual Values

6 Conclusions

Include a high-level description of the outcome and findings for the RoCoF study. Also, discuss the mitigations option for non-compliance are identified.

Appendix A

Frequency traces

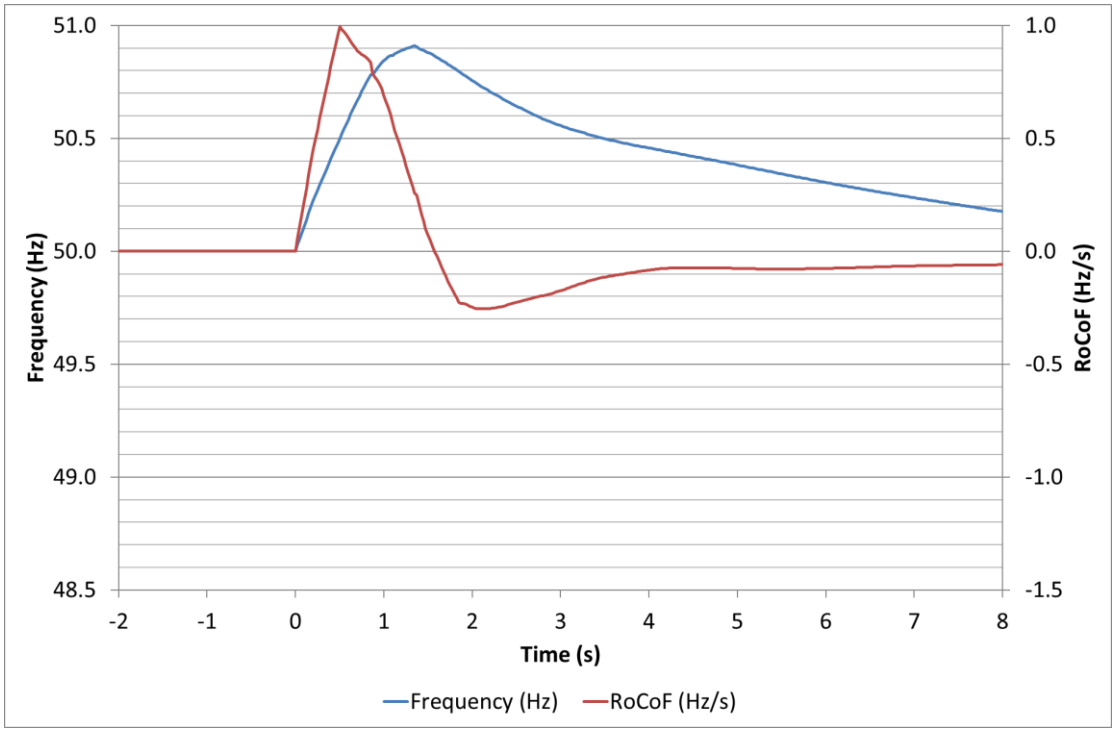

Figure 2: 1 Hz/s frequency rise representative trace

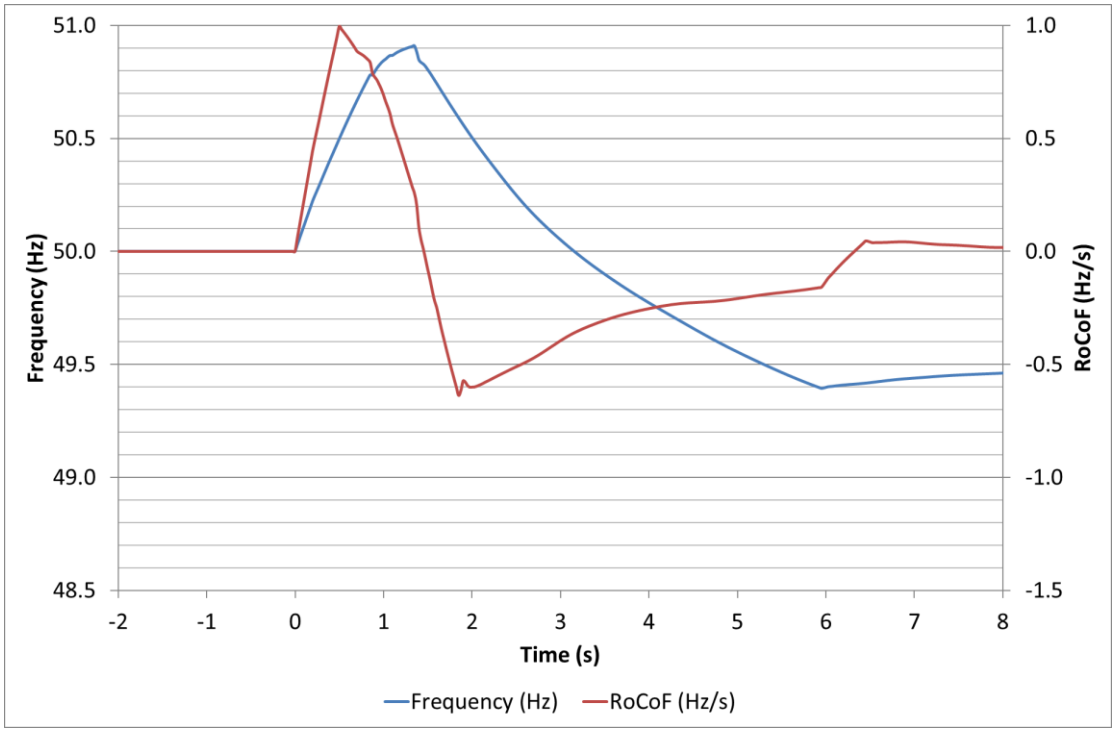

Figure 3: 1 Hz/s frequency rise with subsequent fast drop resulting in under-frequency representative trace

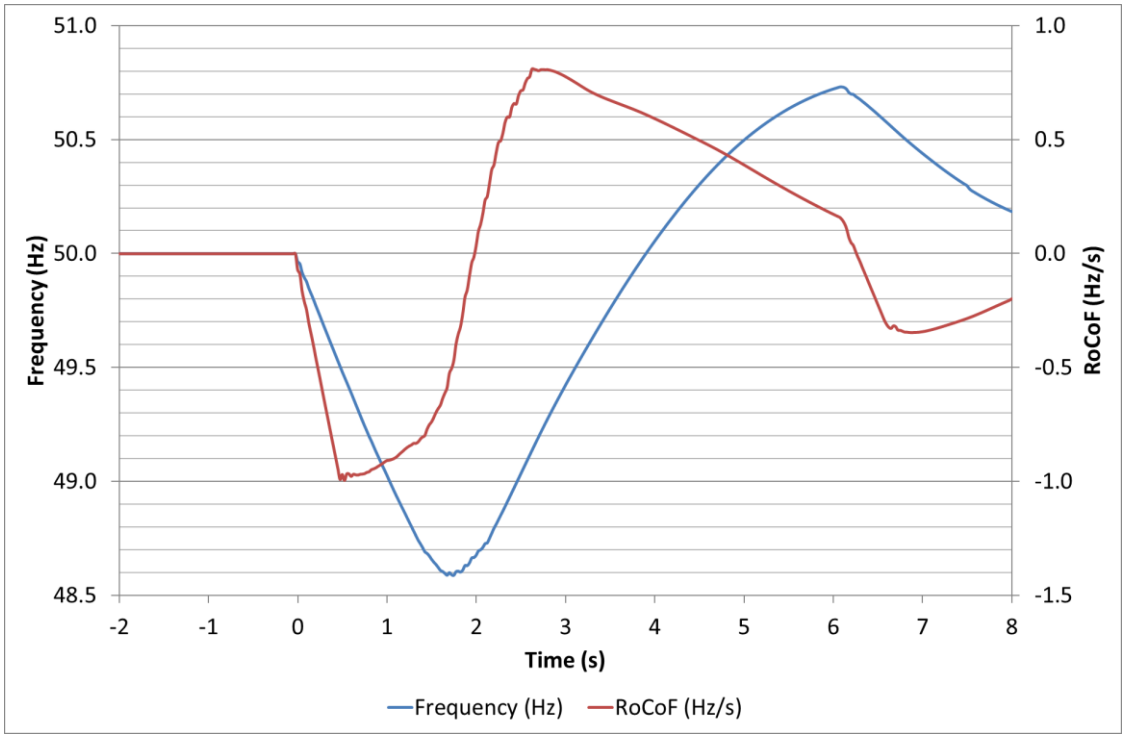

Figure 4: 1 Hz/s frequency drop with subsequent fast recovery resulting in over-frequency representative trace

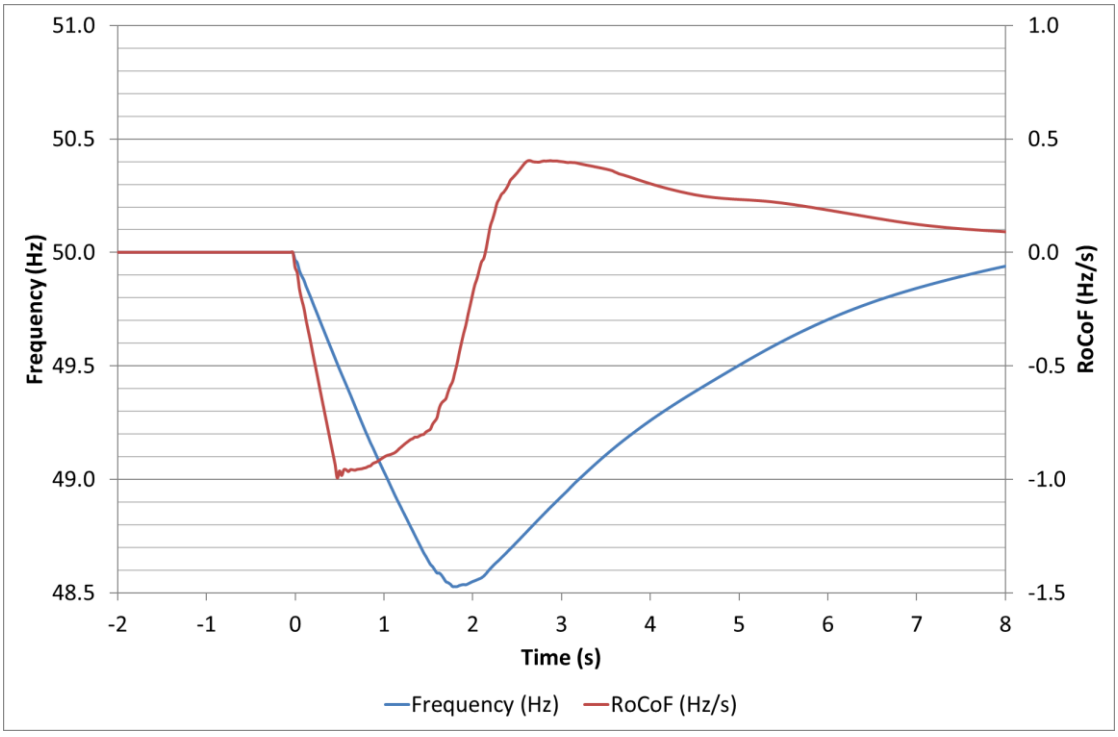

Figure 5: 1 Hz/s frequency drop representative trace

Appendix B

Sample MSS Data Report

Minimum System Strength (MSS) Data

EirGrid

Future Networks & Strategic Offshore Planning Design Authority - CTTOO

Facility Name		**TSO**	
Connection Type		**Node**	
Customer Type		**MEC & MIC**	
Energisation Date		**Gate**	
Connection Method			

Equivalent Thevenin System Impedance [pu]
at XXX kV Busbar

Customer's facility is not included. $S_{base} = 100\ MVA,\ V_{base} = Busbar\ Voltage\ [kV],\ Z_{base} = V^2/S$

	R_{pos} [pu]	X_{pos} [pu]	$(X/R)_{pos}$	R_{neg} [pu]	X_{neg} [pu]	$(X/R)_{neg}$	R_{zero} [pu]	X_{zero} [pu]	$(X/R)_{zero}$	3Ph Skss [MVA]
N										
N-1										
N-1-1										