FAULT RIDE THROUGH (FRT) / ACTIVE POWER RECOVERY (APR) STUDY ASSESSMENT GUIDE FOR DEMAND FACILITIES

March 2026

EirGrid

The Oval, 160 Shelbourne Road, Ballsbridge, Dublin D04 FW28
Telephone: +353 1 677 1700 | www.eirgrid.ie

Contents

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

Disclaimer

EirGrid, the Transmission System Operator (TSO) for Ireland, makes no warranties or representations of any kind with respect of this document, including, without limitation, its quality, accuracy and completeness. The TSO does not accept liability for any loss or damage arising from the use of this document or any reliance on the information it contains. Use of this document and the information it contains is at the user's sole risk. In addition, the TSO strongly recommends that any party wishing to decide based on the content of this document should consult the TSO in advance.

Acronyms

FRT	Fault Ride through
APR	Active Power Recovery
CP	Connection Point
CRU	Commission for Regulation of Utilities
EMT	Electromagnetic Transient
HV	High Voltage
LV	Low Voltage
MIC	Maximum Import Capacity
MEC	Maximum Export Capacity
MSS	Minimum System Strength
pu	per unit
SLD	Single-Line Diagram
TSO	Transmission System Operator
UPS	Uninterruptible Power Supply

1 Introduction

Fault Ride-Through (FRT) is defined as the ability of a grid user to stay connected to the electrical grid during and following a fault disturbance. Demand Facilities should remain connected to the transmission system during a disturbance and should return to pre-fault demand levels to help maintain overall grid stability.

This document is intended to provide a template and guidance for the content and scope of the technical studies required to demonstrate compliance with the FRT/APR requirements defined in [1] for Demand Facilities.

The numerical values and technical data given within this document (except explicitly stated to be used in the studies) are for illustration purposes only.

Note that the FRT/APR assessment should be done based on the up-to-date site-specific controller settings of the facility. If any controller parameter is modified during the preparation of the FRT/APR report, then the FRT/APR assessment and the simulation models should be updated accordingly. If any controller parameter is modified after the FRT/APR report submission, then the Demand Facility owner should contact EirGrid with the updated parameters and discuss if there was a material change in the settings that would significantly alter the FRT performance. Based on the impacts of the changes, the FRT study may need to be updated for Demand Facilities as compliance checks are made at CP. If facility has more than one CP, then customers are expected to submit more than one FRT study depending on the number of CPs.

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 FRT/APR study submissions.

The sections are briefly described below:

- In the **second section**, the timeline and the submission requirements for the FRT/APR study are given. Also, the expected introduction section in the customer FRT/APR report is described.
- In the **third section**, the relevant Grid Code (modification) clauses are listed to be used as a reference during FRT/APR studies.
- In the **fourth section**, the FRT analysis procedure and the simulation parameters are defined. The list of fault types for transmission connected – Demand Facilities are presented. The corresponding fault parameters and test case scenarios are given.
- In the **fifth section**, the requirements for the simulation outputs are shared. The parameters and plots needed for submission are described.
- In the **conclusions section**, a summary table is given to be used in the customer reports. In case of **non-compliances**, potential mitigation methods and proposals should be discussed in this section.
- In the appendices, sample Minimum System Strength (MSS) data at the CP for the modelling of external grid is shared. Also, a checklist for the submission of the FRT study is introduced.

2 FRT / APR Study Requirements

2.1 Overview

All TSO connected Demand Facilities are required to submit an FRT/APR study to EirGrid.

Table 1 - Customers Required to Submit an FRT/APR Study

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

The FRT/APR assessments must be based on the Minimum System Strength (MSS) data issued to the customers for the purpose of modelling the transmission in the simulation studies. The timeline for the FRT/APR related submissions is given in the Table 2 below:

Table 2 - Timeline for FRT/APR Study Submissions

Item	Timelines*	Responsible	Submit to
Minimum System Strength Data	MSS data will be issued to the customer upon request from the customer.	EirGrid	Customers
FRT/APR 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 2-3 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 FRT/APR 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.

All the following reports, documents and data should be submitted by the customers to EirGrid following the timeline given above in relation to the FRT/APR assessment studies:

Table 3 - FRT/APR Study Submission Requirements

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

2.2 Customer Self – Assessment FRT / APR Report

For an effective compliance review process, use this template heading structure for the preparation of the customer self-assessment FRT/APR report. Use the tables given in this template to share all required information in the corresponding sections. Refer to the provided figures for illustration needs.

2.3 Single-Line Diagram

Provide a legible detailed SLD in a separate file presenting at least the following information for Demand Facility where appropriate.

- On site generators (Steam or Natural Gas Turbine, Diesel Engine Generator etc)
- UPS batteries
- Motor Drives
- Static Load (Site Support)
- Internal distribution system (i.e. LV & MV cables and transformers)
- Grid connected transformers and HV reactive compensation devices (e.g. switched shunts, harmonic filters, etc)
- Busbars: Voltage level
- Protection Relays

2.4 FRT / APR - Simulation Studies

Customers must simulate how the demand facility respond for the balanced and unbalanced faults in the system. FRT/APR studies must be carried out in any dynamic time-domain software package (except PSS/E power system simulation tool).

2.5 Customer Report Introduction

In the introduction section of FRT/APR assessment, provide the information for the facility as shown in the following Tables [4,5,6].

Table 4 - Facility Data

Name of the Facility	Facility name
Connection Type	Demand Facility
Customer Type	TSO customer
Location	Address of the facility under study
Owner of the Facility	Company name

Table 5 - FRT Study Data

FRT Study Prepared by	Consultant company name
Grid Code	Version number, date
Software Used	Software name and version

Table 6 - Facility Technical Data

Connecting Station	Station name
CP Voltage	Voltage [kV]
MIC	MIC [MVA]
Demand Facility	All component (on site generators, UPS, Motor drives for cooling, Static load for site support, IT equipment etc)
Grid Connected Transformer	HV/MV [kV], size [MVA]
Internal distribution system	LV & MV cables and transformers
Other Devices (if any)	Reactive compensation devices (e.g. switched shunts, harmonic filters, etc)

Also include a simplified single-line diagram (SLD) for the Demand Facility being studied in the simulation study analysis with the data given in the Figure 1 below showing the facility as represented in the modelling.

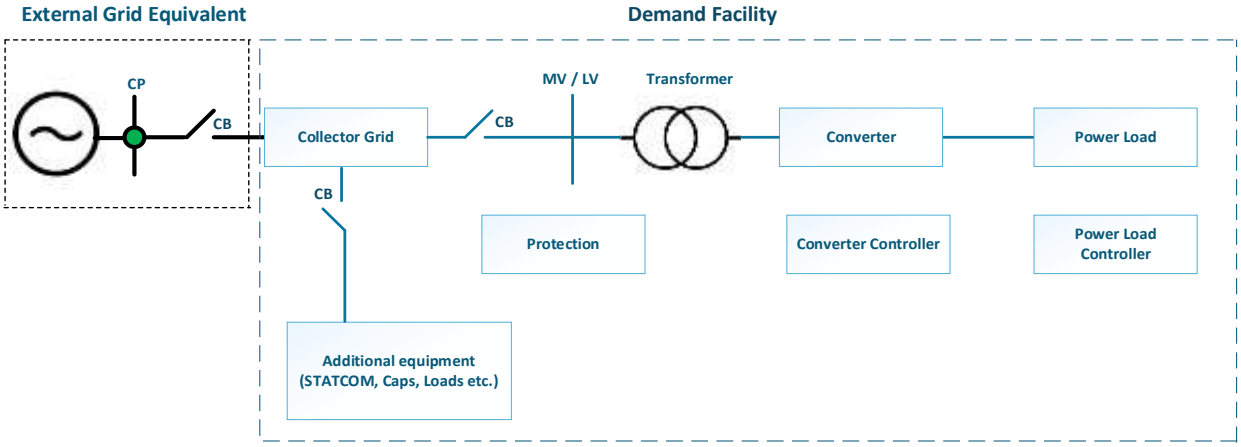


Figure 1 Simplified Representation of Demand Facility

3 Grid Code (Modification) Requirements

For completeness of the study, quote FRT-related clauses from the applicable Grid Code for Demand Facility units under study. The FRT/APR requirements for Demand Facility units are referred in [1] 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 clauses in [1] s at the time of preparation of this document are shown in the Table 7 below.

Table 7 - Relevant Grid Code Clause

Connection Type	Grid Code (Modification) Clause
Demand Facility Units	CC.7.4.3.2

CC.7.4.3.2 Demand Facilities shall remain connected to the Transmission System during and following any Fault Disturbance on the Power System which results in a Voltage deviation which remains on or above the voltage-against-time profile specified in Figure CC.7.4.3.2 at the Connection Point. Following clearance of the Fault Disturbance, the Demand Facility should return to at least 90% of its prefault Active Power Demand within 500 ms of the Transmission System Voltage recovering to 90% of the nominal Voltage. The post Fault Disturbance ramp up rate for the Demand Facility, shall be coordinated and agreed between the TSO and the Demand Facility owner. The voltage-against-time profile specifies the required minimum capability as a function of voltage and Fault Ride-Through Time at the Connection Point before, during and after the Fault Disturbance.

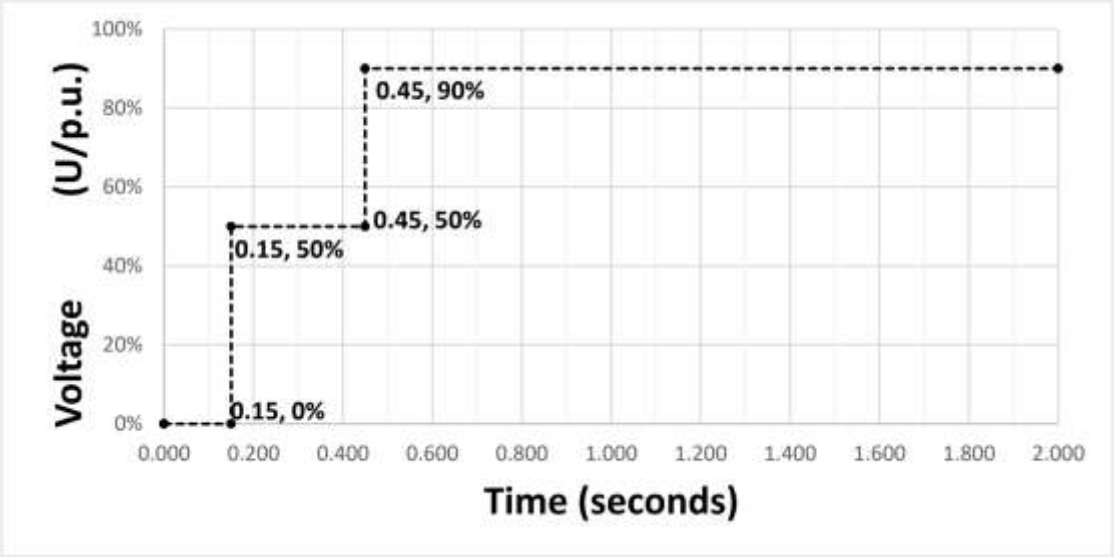


Figure 2 Voltage-against-time profile at the connection point for fault condition

3.1 Clarification on Grid Code (Modification) Requirements

This section summarises the **EirGrid position in relation to simulation analysis and compliance** of the demand facility and how certain FRT/APR clauses within the Grid Code should be interpreted.

The FRT/APR clauses for demand facility connections set out the following requirements:

- The Demand Facility under consideration should remain connected during and following voltage dips at the CP.
- Following the fault clearance, the Demand Facility should return to its pre-fault conditions subject to.
    - at least 90% of its prefault Active Power Demand within 500 ms of the Transmission System Voltage recovering to 90% of the nominal Voltage (0.9 pu – 1.118 pu).

4 Simulation Study Methodology

Simulation studies must be carried out to demonstrate that the facility is designed to comply with the FRT/APR requirements defined in [1].

The external power system must be represented as an infinite bus behind the Equivalent Thevenin Impedances (i.e. Minimum System Strength data) provided by EirGrid. An example report is shown in Appendix A: Sample MSS Data Report.

The models must include two external grids with a changeover between the pre-disturbance and post-disturbance characteristics. The switchover scheme is presented in Figure 3.

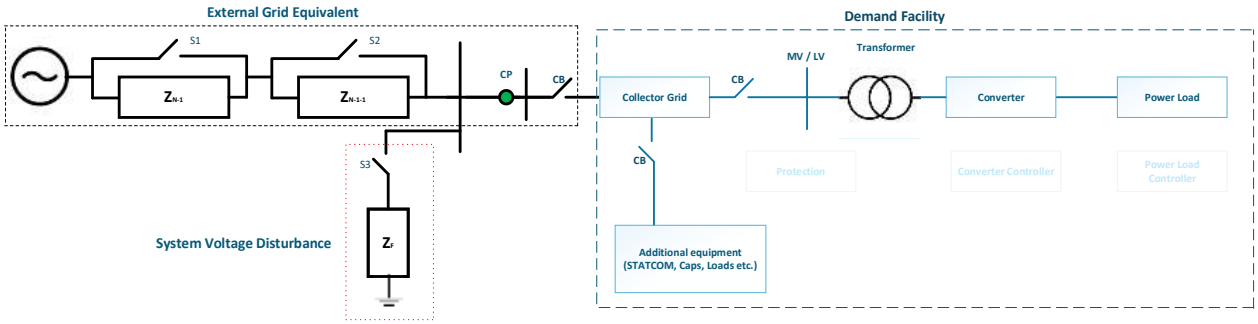


Figure 3 Representation of External Grid & Demand Facility

The switching scheme is described below in the Table 8.

Table 8 - Switching Scheme of External Grid equivalents

Period	S_1	S_2	S_3	Comment
Pre-disturbance T < T1	Open	Closed	Open	Steady state under Z_{N-1}.
Disturbance T1 ≤ T < T2	Open	Closed	Closed	Apply voltage disturbance under Z_{N-1}.
Post-disturbance T2 ≤ T	Closed	Open	Open	Remove disturbance, Change external grid impedance to Z_{N-1-1}.

Indicate the external grid impedance values assumed in the study as provided by EirGrid with the Minimum System Strength (MSS) data applicable at the CP [3].

4.1 Simulation Procedure

The simulation procedure consists of three main intervals: *Pre-disturbance*, *Disturbance* and *Post-disturbance periods*.

- *The pre-disturbance period*:
  - The pre-disturbance voltage magnitude at the CP must be set to
    - Pre-fault voltage at 0.9 pu (minimum)
    - Pre-fault voltage at 1.118 pu (maximum).
  - Facilities consuming at the CP shall be equal to 100% load. The external grid must be modelled using the impedance under N-1 condition issued by EirGrid in the Minimum System Strength (MSS) data report.
  - Set the control mode of the facility under normal operating conditions.

- *The disturbance period*:
    - Apply fault at the CP with suitable fault impedance (ZF) as long as the defined duration to depress the voltage at the CP to the retained voltage level.
- *The post-disturbance period*:
    - Remove voltage disturbance at the CP.
    - Change external grid model with the impedance under N-1-1 condition issued by EirGrid in MSS data report.
    - Revert to pre-fault control mode and setpoint.
    - The simulations must be run until a new steady state is reached at the CP.

4.2 Faults to Apply

The compliance studies must simulate faults at the CP with suitable fault impedance (Z_F) to depress the voltage at the CP to the levels described in Table 9. For the FRT/APR assessment of demand facilities, the following fault types will be simulated at the CP:

Table 9 - Faults to Apply at CP

#	Fault Type	Z_{Fault}
1	3 Phase	Z_F
2	2 Phase to Ground	$Z_{F\ (phase\ to\ phase)}$ $Z_{F\ (phase\ to\ ground)}$
3	1 Phase to Ground	$Z_{F\ (phase\ to\ ground)}$
4	Phase to Phase	$Z_{F\ (phase\ to\ phase)}$

The fault resistance and reactance values (R_F and X_F) must be calculated for each simulation test case to achieve retained voltages specified at the CP. The retained voltage levels at the CP and fault parameters for each facility type are given in the following sections. Indicate fault impedances applied for each case study as shown in the following Table 10.

Table 10 - Faults Impedance Applied at CP

Case #	Fault Type	R_F [Ohm]	X_F [Ohm]	X/R*
Case 1	3 Phase	X.YZ	X.YZ	X
Case 2	3 Phase	X.YZ	X.YZ	X
…		…	…	…
Case N	Line to line	X.YZ	X.YZ	X
	Line to ground	X.YZ	X.YZ	X

In unbalanced fault cases, the fault impedance should be adjusted considering the **target retained voltage** level of the faulted phase.

4.3 Fault Parameters

In this section, the fault parameters for TSO customers are presented. The voltage levels and disturbance durations for each simulation case in FRT/APR analysis for demand facilities are given. Note that the voltage disturbances are described in terms of retained voltage at the CP (i.e. the HV bushings of the grid transformer).

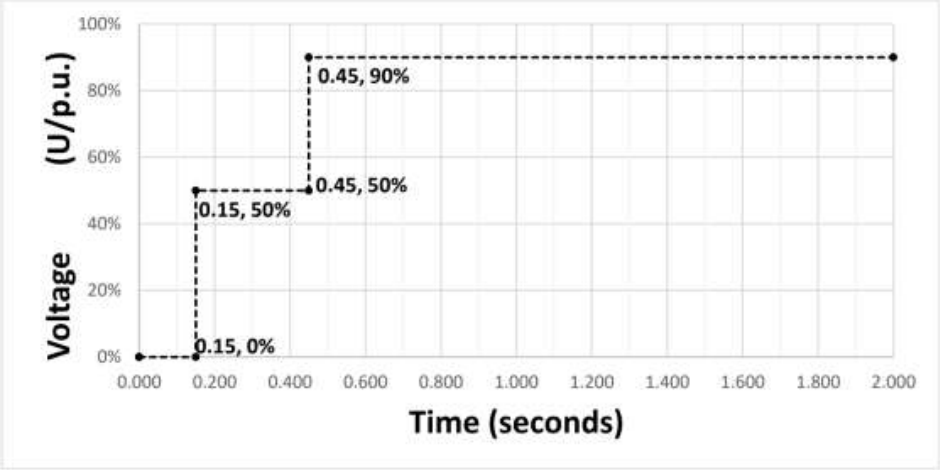
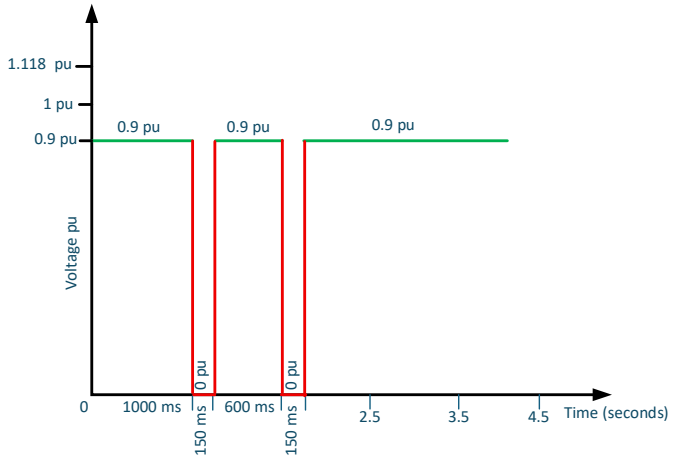


Figure 4 FRT Capability Curve for Demand Units (TSO Customer)

For each fault type, the retained voltage and fault duration based on the FRT capability curve (in Figure 4) are given in the Tables [11-12] below.

*Table 11 - FRT / APR Testing for Demand Facility at **Prefault Voltage 0.9 pu** (TSO Customer)*

Test ID	Fault Type	Retained Voltage in Faulted Phases (pu)	Duration (ms)	Test ID	Fault Type	Retained Voltage in Faulted Phases (pu)	Duration (ms)
A1	3Φ	0.00	150	A11	1Φ-G	0.00	150
A2	3Φ	0.50	150	A12	1Φ-G	0.50	150
A3	3Φ	0.50	450	A13	1Φ-G	0.50	450
A4	3Φ	0.85	450	A14	1Φ-G	0.85	450
A5	3Φ	0.89	2000	A15	1Φ-G	0.89	2000
A6	2Φ-G	0.00	150	A16	Φ-Φ	0.00	150
A7	2Φ-G	0.50	150	A17	Φ-Φ	0.50	150
A8	2Φ-G	0.50	450	A18	Φ-Φ	0.50	450
A9	2Φ-G	0.85	450	A19	Φ-Φ	0.85	450
A10	2Φ-G	0.89	2000	A20	Φ-Φ	0.89	2000
Note	**3Φ**: 3 Phase **2Φ-G**: 2 Phase to Ground **1Φ-G**: 1 Phase to ground **Φ-Φ**: Phase to Phase						

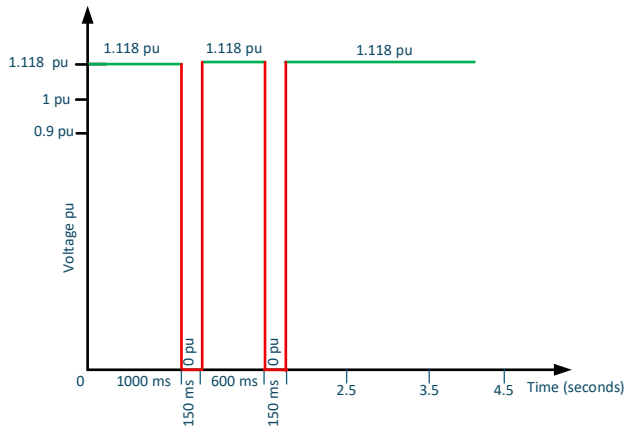
Additional Case: Automated Re-closing	 Users are requested to demonstrate the additional case (Fault type: **1ΦG**) reflecting the impact of transmission system auto-reclosing in the single time series graph, as an example shown here.

The above faults are required to simulate **balanced and unbalanced** cases at the CP for FRT/APR assessment of the demand facility.

*Table 12 - FRT / APR Testing for Demand Facility at **Prefault Voltage 1.118 pu** (TSO Customer)*

Test ID	Fault Type	Retained Voltage in Faulted Phases (pu)	Duration (ms)	Test ID	Fault Type	Retained Voltage in Faulted Phases (pu)	Duration (ms)
B1	3Φ	0.00	150	B11	1Φ-G	0.00	150
B2	3Φ	0.50	150	B12	1Φ-G	0.50	150
B3	3Φ	0.50	450	B13	1Φ-G	0.50	450
B4	3Φ	0.85	450	B14	1Φ-G	0.85	450
B5	3Φ	0.89	2000	B15	1Φ-G	0.89	2000
B6	2Φ-G	0.00	150	B16	Φ-Φ	0.00	150
B7	2Φ-G	0.50	150	B17	Φ-Φ	0.50	150
B8	2Φ-G	0.50	450	B18	Φ-Φ	0.50	450
B9	2Φ-G	0.85	450	B19	Φ-Φ	0.85	450
B10	2Φ-G	0.89	2000	B20	Φ-Φ	0.89	2000

Note	**3Φ**: 3 Phase **2Φ-G**: 2 Phase to Ground **1Φ-G**: 1 Phase to ground **Φ-Φ**: Phase to Phase

Additional Case: Automated Re-closing	 Users are requested to demonstrate the additional case (Fault type: **1ΦG**) reflecting the impact of transmission system auto-reclosing in the single time series graph, as an example shown here.

The above faults are required to simulate **balanced and unbalanced** cases at the CP for FRT/APR assessment of the demand facility.

5 Simulation Results

Provide numerical results of Voltage, Frequency, active power demand at the CP for each simulated test ID scenario as shown in the following Tables [13-14]. Indicate non-compliances in red colour.

The numerical values and non-compliances in red shown in the Tables [13-14] below are for demonstration purposes only without referral to any particular simulation case. The corresponding Grid Code clauses for demand facility are given in the Tables [13-14].

*Table 13 - Simulation Results at CP for **Prefault Voltage as 0.9 pu***

Test ID #	Simulation Results	
	Remain Connected to the Transmission System during and following any disturbance (Yes)	**Recovery time: 90% of its prefault Active Power Demand within 500 ms of the Transmission System Voltage recovering to 90% of the nominal Voltage**
	CC.7.4.3.2	**CC.7.4.3.2**
A1	Yes	340 ms
A2	Yes	700 ms
…	…	…
A20	…	…

*Table 14 - Simulation Results at CP for **Prefault Voltage as 1.118 pu***

Test ID #	Simulation Results	
	Remain Connected to the Transmission System during and following any disturbance (Yes)	Recovery time: 90% of its prefault Active Power Demand within 500 ms of the Transmission System Voltage recovering to 90% of the nominal Voltage
	CC.7.4.3.2	CC.7.4.3.2
B1	Yes	340 ms
B2	Yes	700 ms
…	…	…
B20	…	…

5.1 Plotting Requirements

Provide plots of the dynamic response of the facility, as seen at the CP and at the Demand Unit LV Terminal.

Table 15 - Required Plots/signals

Plot #1	Signals/Parameters	Node	Unit
Plot 1	Three phase Voltage (Phase 1, Phase 2, Phase 3)	CP	Per Unit
Plot 2	Frequency	CP	Actual Values
Plot 3	Active Power Demand, Reactive Power	CP	Actual Values
Plot 4	Three phase Voltage (Phase 1, Phase 2, Phase 3), Active Power Demand	CP	Actual Values
Plot 5	Voltage, Active Power Demand	LV terminal	Actual Values

For each simulation test case, clear plots showing the following parameters must be provided as a minimum. Additional plots can be included to illustrate specific behaviour of individual demand units, if necessary (for example, to illustrate the trip of a group of units and the retained voltage at their terminals).

Important notes for the plots:

- Use the image file formats of ".emf (enhanced metafile)" or ".wmf (windows metafile)" providing vector graphics of the plots with a good resolution and small file size in kilobyte. Avoid using raster graphics file formats such as ".jpeg", ".png" or ".gif".
- All outputs signals should be plotted in the requested demand units aligned in the same horizontal axis (i.e. same intervals with same scales). This feature is important for an effective review in the outputs.
- Cursors in the plots showing results values at relevant times would be appreciated.

- Ensure all information (time marks, obtained outputs) in the plots corresponds to summary results table.
- The scale and resolution of the plots must be sufficient to clearly identify the FRT/APR-response during and after the voltage disturbance and to allow easy comparison against the responses specified in the Grid Code, which must be captured in the graphs as well.
- The scale may need to be re-adjusted for the different disturbances to clearly show compliance with the required timescales. In some cases, it may be necessary to provide a second plot with a zoomed-in area. The relevant outputs and response times must be clearly highlighted in the plots.

6 Conclusions

Include a high-level description of the outcome and findings from the simulation analysis of FRT/APR study. Include a summary Table 16 as given below for demand facilities flagging all non-compliances.

Fill in the table stating compliance and non-compliance with the relevant clause for each case study. Indicate the numerical values describing the maximum performance that achieved during simulation studies. The clauses below apply to the Grid Code modification [1] only.

Note that the numerical values given in the table below are for demonstration purposes only without referral to any particular simulation case for demand connections.

Table 16 - Summary of FRT/APR Compliance Assessment at CP

Clause	Requirement	Obtained Results	Notes
	Remain Connected to the Transmission System during and following any disturbance	Test ID - A1: Yes Test ID – B20: No Other Test IDs are compliant.	- Non-compliance is due to XY condition.
CC.7.4.3.2	Recovery time: 90% of its prefault Active Power Demand within 500 ms of the Transmission System Voltage recovering to 90% of the nominal Voltage	Test ID - A1: 400 ms Test ID – B20: 700 ms Other Test IDs are compliant.	- Non-compliance is due to XY condition.

7 References

[1] MPID 345 Fault Ride Through, RoCoF and Post Fault Active Power Recovery for Demand Facilities.

[2] The Grid Code | EirGrid

[3] Information on the MSS data report provided by EirGrid (Sample MSS Data report in appendix A1).

Appendix A

A1: 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		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										

A2: Checklist

For an effective review process, items (2-5) below are requested to be submitted as separate files/documents, i.e. not in the FRT/APR self-assessment report appendices.

Table 17 - Checklist for FRT/APR Study Submission

#	Item	Note
1	Customer Self-Assessment FRT/APR Report	Use this template heading structure for an effective review.
2	Detailed SLD of the Facility	Must be legible.
3	Simulation and Modelling Files	Provide all modelling files together including libraries during the FRT report submission.
4	Documents Used as Reference	For EirGrid's records.
5	Other Supporting Documents	If needed.