LIST OF STUDIES/TESTS TO BE CONDUCTED BY RE GENERATORS/PARKS IN PROCESS OF SUBMISSION OF FINAL TECHNICAL CONNECTION DATA FOR DEMONSTRATING COMPLIANCE WITH CEA TECHNICAL STANDARDS FOR CONNECTIVITY TO THE GRID

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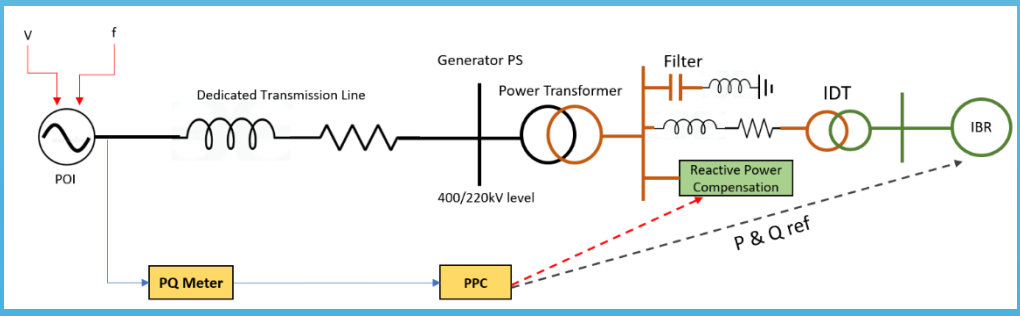

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List of Abbreviations

CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
DC	Direct Current
DMAT	Dynamic Model Acceptance Test
EMT	Electromagnetic Transients
HVRT	High Voltage Ride Through
IBR	Inverter Based Resource
LL	Line to Line
LVRT	Low Voltage Ride Through
OEM	Original Equipment Manufacturer
PCC	Point of Common Connection/Coupling
POI	Point of Interconnection
PPC	Power Plant Controller
PSCAD	Power Systems Computer Aided Design
PSS/E	Power System Simulation for Engineering
pf	Power Factor
pu	Per Unit
RE	Renewable Energy
RMS	Root Mean Square
SCR	Short Circuit Ratio
SMIB	Single Machine Infinite Bus
TSCG	Technical Standards for Connectivity to Grid
WTG	Wind Turbine Generator

A. Introduction

1. This document provides a list of tests to be carried out by RE Generators/Parks in EMT and RMS platform for demonstrating compliances w.r.t CEA Technical Standards for Connectivity to grid, 2007 (incl. amendments thereof). RE Generators/parks are required to submit tests and study reports in process of submission of final Technical Connection Data to CTU for issuance of Technical Connection Details and subsequent signing of Connectivity Agreement (CAT-II) as per CERC GNA Regulations, 2022.
2. The document shall be updated based on experiential learning and knowledge base gathered in future course and stakeholders shall consider updates and revision(s) in this context as may be published from by CTUL from time to time.
3. Dynamic Model Acceptance Test (DMAT) of the facility(ies) shall be done on Single Machine Infinite bus (SMIB), the details of which are given in this document.
4. The tests and technical details to be submitted by RE developers listed in this document are as per the CEA Technical Standards for Connectivity, GNA Regulations,2022 & the Detailed procedure thereunder and other relevant Regulations of CERC/CEA. No new requirements have been specified and hence the document shall not be construed as change in Law in any form.

B. General, Technical & Certification Details to be furnished by the entity:

1. General Details to be furnished by the entity:

Sr. No.	Relevant Regulation Clauses	Description	General Details (GD)
1.1	General Details	Name of Connectivity Grantee	GD
1.2		CTU Connectivity / GNA Application Number	GD
1.3		Connectivity Quantum (MW)	GD
1.4		Connection Details (CONN-TD 4) Quantum applied for (MW)	GD
1.5		CEA Registration Number	GD
1.6		Type of RE Plant (Solar/Wind/Hybrid/with or without BESS)	GD
1.7		Installed Capacity (in MW) with Breakup of different sources for Hybrid	GD
1.8		ISTS Station (POI bus)	GD
1.9		POI Bus Voltage	GD
1.10		Scheduled Date of First COD/Final COD	GD
1.11		Expected Date of First COD/Final COD	GD
1.12		Inverter/WTG Make(s)	GD
1.13		Inverter/WTG Model Name(s)	GD
1.14		Inverter/WTG Rating - Nameplate rating (MW and MVA both)	GD

Sr. No.	Relevant Regulation Clauses	Description	General Details (GD)
1.15		Inverter/WTG Rating at the site assessed extreme temperature (MW and MVA both)	GD
1.16		Number of Inverters/WTGs	GD
1.17	CEA TSCG - Part-I.1(3)	**Site temperature considered for plant compliance as per CEA Procedure for assessment of the Design Temperature for RE Plants**	GD

2. Technical Details to be furnished by the entity:

Sr. No.	Relevant Regulation Clauses	Description	Technical Details (TD)
2.1	CEA TSCG: 6, CERC GNA Regulations: Clause-10.1	**Technical Details of IBR Unit**	
2.1.1		Technical Datasheet (including Wind speed Vs Power Curve or Irradiance Vs Power characteristics)	TD
2.1.2		Reactive Power Capability Curve (PQ, VQ curve)	TD
2.1.3		Temperature Derating PQ Curve	TD
2.1.4		Operator Manual of Inverter/WTG unit(s)	TD
2.1.5		Proposed Protection Settings of Inverter/WTG unit (in accordance with Grid-India's FTE&I procedure)	TD
2.1.6		Actual Protection Settings of Inverter/WTG unit (in accordance with Grid-India's FTE&I procedure)	Required during FTE stage only
2.2	CEA TSCG: Part-I.8	**Single Line Diagram**	
2.2.1		RE Pooling Station Switchyard (should include 220 kV, 33kV, IBR level SLD)	TD
2.2.2		Proposed Geographical SLD (shall comprise lengths, location of IBRs, conductor type, rating)	TD
2.3	CEA TSCG: Part-I.8	**Equipment details**	
2.3.1		Technical Datasheet of IBR unit transformer	TD
2.3.2		Nameplate of the IBR unit transformer	TD
2.3.3		Technical Datasheet of Power transformer	TD
2.3.4		Nameplate of the Power transformer	TD
2.3.5		Technical Datasheet of cables	TD

Sr. No.	Relevant Regulation Clauses	Description	Technical Details (TD)
2.3.6		Technical Datasheet of overhead conductors	TD
2.4	CEA TSCG: Part-II.B2(4)	**PPC_MASTER**	
2.4.1		PPC Model & Make	TD
2.4.2		Technical Datasheet of PPC	
2.4.3		Functional description of the PPC and technical functionality document	
2.4.4		Operator manual of PPC	
2.4.5		Control settings of PPC	
2.5	CEA TSCG: Part-II.B2(4)	**PPC_SLAVE (if applicable - details to be filled for all the slave PPCs in the plant)**	
2.5.1		PPC Model & Make	TD
2.5.2		Technical Datasheet of PPC	
2.5.3		Functional description of the PPC and technical functionality document	
2.5.4		Operator manual of PPC	
2.5.5		Control settings of PPC	
2.6		**Technical Details of SVG**	
2.6.1		Technical Datasheet of SVG	
2.6.2		Control Philosophy document of SVG	
2.6.3		Protection settings of SVG	
2.6.4		Operator Manual of the SVG	
2.6.5		Nameplate rating of SVG	
2.6.6		SVG rating (both capacitive and inductive) at site assessed extreme temperature	

C. Certification & Unit level testing to be furnished by the entity:

Sr. No.	Relevant Regulation Clauses	Description	Reports (R)
3.1	CEA TSCG: Part-I.1(2), IEGC 2023: 24	**Type Certification**	
3.1.1		Type Certificate of single WTG Unit(s)	R
3.2	CEA TSCG: Part-II(B), IEGC 2023: 24	**Type Test Report for Inverter / WTG** (Tests to be covered as per CEA Connectivity Standards)	
3.2.1	CEA TSCG: Part-II.B1(1)	Harmonics	Single report containing all the test results.
3.2.2	CEA TSCG: Part-II.B1(2)	DC Current Injection	
3.2.3	CEA TSCG: Part-II.B1(3)	Flicker	

Sr. No.	Relevant Regulation Clauses	Description	Reports (R)
3.2.4	CEA TSCG: Part-II.B2(1)	PQ Capability Test	Tests to be conducted as per the details provided in respective benchmarking section
3.2.5	CEA TSCG: Part-II.B2(2)	Capable to operate in frequency range: 47.5 Hz to 52 Hz with +/-5% voltage variation	
3.2.6		Capable to provide rated output in frequency range of 49.5 Hz to 50.5 Hz with +/-5% voltage variation	
3.2.7	CEA TSCG: Part-II.B2(3)	LVRT (Shall include details of Id & Iq calculation principles for LVRT & HVRT)	
3.2.8	CEA TSCG: Part-II.B2(4)(i)	Active power control feature and Rate of change of active power	
3.2.9	CEA TSCG: Part-II.B2(4)(ii,iii) IEGC: 30(10)	Primary Frequency Response (PFR)	
3.2.10	CEA TSCG: Part-II.B2(4)(ii, iii)	Immediate (within 1 second) real power primary frequency response of at least 10% of the maximum Alternating Current active power capacity for frequency deviation in excess of 0.3 Hz	
3.2.11	CEA TSCG: Part-II.B2(7)	HVRT	
3.3	CEA TSCG: Part-II.B1/B2, IEGC 2023: 24	**Evaluation Report on Test Reports of IBR Units**	R
3.4		**Statement of Compliance of IBR Unit**	
3.5		**Test Reports for SVG/STATCOM Unit(s) - If installed**	
3.5.1	CEA TSCG: Part-II.B1(1)	Harmonics	Single report containing all the test results
3.5.2	CEA TSCG: Part-II.B1(2)	DC Current Injection	
3.5.3	CEA TSCG: Part-II.B1(3)	Flicker	
3.5.4	CEA TSCG: Part-II.B2(1)	PQ Capability Test	
3.5.5	CEA TSCG: Part-II.B2(2)	Capable to operate in frequency range: 47.5 Hz to 52 Hz with +/-5% voltage variation	
3.5.6	CEA TSCG: Part-II.B2(2)	Capable to provide rated output in frequency range of 49.5Hz to 50.5Hz with +/-5% voltage variation	
3.5.7	CEA TSCG: Part-II.B2(3)	LVRT (Shall include details of Id & Iq calculation principles for LVRT & HVRT)	

Sr. No.	Relevant Regulation Clauses	Description	Reports (R)
3.5.8	CEA TSCG: Part-II.B2(7)	HVRT	
3.6	CEA TSCG: Part-II.B1/B2	**Evaluation Report on Test Reports of SVG/STATCOM Unit(s)**	R
3.7		**Statement of Compliance of SVG/STATCOM Unit(s)**	

D. IBR/WTG Single Unit - Benchmarked Simulation Model and Report Submission:

The objective of Unit IBR benchmarking in RMS domain is to demonstrate that the IBR performance as given in the type test report is matching with model performance to the extent possible in RMS platform.

a) List of Benchmarking report & Unit IBR Models to be submitted:

Sr. no.	Relevant Regulation Clause	Details of unit models & benchmarking report of SVG/STATCOM	Simulation Models (SM)/Reports (R)
1	CEA TSCG: 6(6)	Benchmarked Generic RMS (**PSS/E**) model of IBR unit(s) alongwith test setup and user model guide	SM
2		.sav files, .dyr files, .sld files, .plb files, .py files	
3		Benchmarking Report of RMS (**PSS/E**) IBR unit(s) model (Tests to be conducted as per CEA Connectivity Standards are provided below)	R
4		Whether SCR and X/R ratio considered in the simulation study (**PSS/E**) is same as the one considered in the test results?	[Y/N]
5		Benchmarked EMT(**PSCAD**) model of IBR unit(s) along with user model guide & other supporting files	SM
6		.pscx, .pswx, .dll files along with test setup & test cases	
7		Benchmarking Report of EMT (**PSCAD**) model of IBR unit(s)	R
8		Report on comparison of RMS & EMT equivalent model response under steady state & dynamic condition	
9		Whether SCR and X/R ratio considered in the simulation study (**PSCAD**) is same as the one considered in the test results?	[Y/N]

b) List of tests to be incorporated in RMS Benchmarking report

1. PQ Capability Curve of IBR / WTG		
Test No.	Relevant Regulation Clause	**POI / PCC Voltage (pu)**
1	CEA TSCG: Part-II.B2(1)	1.0
2		0.95
3		1.05

2. Capability to operate in frequency range: 47.5Hz to 52Hz with +/-5% voltage variation				
Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI Voltage (pu)	Power factor
4	CEA TSCG: Part-II.B2(2)	50 to 47.5	1.0	Any
5		50 to 52		

3. Capability to provide rated output in frequency range of 49.5Hz to 50.5Hz with +/-5% voltage variation					
Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI Voltage (pu)	Power factor (pf)	Active Power dispatch (pu)
6	CEA TSCG: Part-II.B2(2)	50 to 49.5	0.95	Lagging (0.95)	1.0
7			1.05	Leading (0.95)	
8		50 to 50.5	0.95	Lagging (0.95)	
9			1.05	Leading (0.95)	

4. Low voltage ride through [Other partial active power levels in place of 25% and 50% may also be considered] [For WTGs, full load test may be conducted at any power level between 90-100%] [Test for voltage dip up to 0.5 p.u. may be conducted for any other voltage dip also between 0.15 p.u. to 0.85 p.u. The time duration shall be considered as per the LVRT curve in CEA TSCG]					
Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre-fault Active Power dispatch (pu)	Nature of voltage dip
10	CEA TSCG: Part-II.B2(3)	0.85	3.0	1.0	Balanced Three-Phase
11		0.5	1.65		
12		0.15	0.3		
13		0.85	3.0	0.5	
14		0.5	1.65		
15		0.15	0.3		
16		0.85	3.0	0.25	
17		0.5	1.65		
18		0.15	0.3		

5. Active power set-point and Rate of change of active power				
Test No.	Relevant Regulation Clause	**Change in active power dispatch**	POI Voltage (pu)	Power factor (pf)
19	CEA TSCG: Part-II.B2(4)(i)	Active power set-point and Ramp up test (ramp rate < 10% per minute)	1.0	Unity
20		Active power set-point and Ramp down test (ramp rate < 10% per minute)		

6. Frequency response test (any droop in range of 3 - 6%) [In place of step change of 0.15 Hz, any other step change for tests may also be considered] [Other partial active power levels in place of 10% and 50% may also be considered]					
Test No.	Relevant Regulation Clauses	**Frequency change (Hz)**	Active Power dispatch (pu)	POI/PCC Voltage (pu)	Power factor (pf)
21	CEA TSCG: Part-II.B2(4)(ii,iii) IEGC: 30(10)	50 to 50.15	0.9-1.0	1.0	Unity
22			0.5		
23			0.1		
24		50 to 49.85	0.5		
25			0.1		
Note: During the above test, frequency shall be first changed upto dead band limit to show its insensitivity to active power change					

7. Demonstration of immediate (within 1 second) real power primary frequency response of at least 10% of maximum Alternating Current active power capacity for frequency deviation in excess of 0.3 Hz					
Test No.	Relevant Regulation Clause	**Change in frequency (Hz)**	Active Power dispatch (pu)	POI/PCC Voltage (pu)	Power factor (pf)
26	CEA TSCG: Part-II.B2(4) (ii, iii)	Greater than 0.3Hz (upwards)	0.9-1.0	1.0	Unity
27		Greater than 0.3Hz (downwards)			

8. High voltage ride through [For WTGs, full load test may be conducted at any power level between 90-100%] [Other partial active power levels in place of 25% and 50% may also be considered]					
Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
28	CEA TSCG: Part-II.B2(7)	1.3	0.2	1.0	Balanced Three phase
29		1.2	2		
30		1.3	0.2	0.5	
31		1.2	2		
32		1.3	0.2	0.25	
33		1.2	2		

c) List of tests to be incorporated in Unit IBR EMT Benchmarking report

The objective of Unit IBR benchmarking in EMT domain is to demonstrate that the IBR performance as given in the type test report is matching with model performance to the extent possible in EMT platform.

Entity shall submit the unit benchmarking report containing following tests:

1. PQ Capability Curve of IBR / WTG		
Test No.	Relevant Regulation Clause	**POI /PCC Voltage (pu)**
1	CEA TSCG: Part-II.B2(1)	1.0
2		0.95
3		1.05

2. Capability to operate in frequency range: 47.5Hz to 52Hz with +/-5% voltage variation				
Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI Voltage (pu)	Power factor
4	CEA TSCG: Part-II.B2(2)	50 to 47.5	1.0	Any
5		50 to 52		

3. Capability to provide rated output in frequency range of 49.5Hz to 50.5Hz with +/-5% voltage variation					
Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI /PCC Voltage (pu)	Power factor (pf)	Active Power dispatch (pu)
6	CEA TSCG: Part-II.B2(2)	50 to 49.5	0.95	Lagging (0.95)	1.0
7			1.05	Leading (0.95)	
8		50 to 50.5	0.95	Lagging (0.95)	
9			1.05	Leading (0.95)	

4. Low Voltage Ride Through (LVRT) [Other partial active power levels in place of 25% and 50% may also be considered] [For WTGs, full load test may be conducted at any power level between 90-100%] [Test for voltage dip up to 0.5 p.u. may be conducted for any other voltage dip also between 0.15 p.u. to 0.85 p.u. The time duration shall be considered as per the LVRT curve in CEA TSCG]					
Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Active Power dispatch (pu)	Nature of voltage dip
10		0.85	3.0	1.0	Balanced Three phase
11		0.5	1.65		
12		0.15	0.3		
13		0.85	3.0		Unbalanced (LL)
14		0.5	1.65		
15		0.15	0.3		
16		0.85	3.0		Unbalanced (L)
17		0.5	1.65		
18		0.15	0.3		

4. Low Voltage Ride Through (LVRT)

[Other partial active power levels in place of 25% and 50% may also be considered]
[For WTGs, full load test may be conducted at any power level between 90-100%]
[Test for voltage dip up to 0.5 p.u. may be conducted for any other voltage dip also between 0.15 p.u. to 0.85 p.u. The time duration shall be considered as per the LVRT curve in CEA TSCG]

Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Active Power dispatch (pu)	Nature of voltage dip
19	CEA TSCG: Part-II.B2(3)	0.85	3.0	0.5	Balanced Three phase
20		0.5	1.65		
21		0.15	0.3		
22		0.85	3.0		Unbalanced (LL)
23		0.5	1.65		
24		0.15	0.3		
25		0.85	3.0		Unbalanced (L)
26		0.5	1.65		
27		0.15	0.3		
28		0.85	3.0	0.25	Balanced Three phase
29		0.5	1.65		
30		0.15	0.3		
31		0.85	3.0		Unbalanced (LL)
32		0.5	1.65		
33		0.15	0.3		
34		0.85	3.0		Unbalanced (L)
35		0.5	1.65		
36		0.15	0.3		

5. Active power set-point and Rate of change of active power

Test No.	Relevant Regulation Clause	**Change in active power dispatch**	POI/PCC Voltage (pu)	Power factor (pf)
37	CEA TSCG: Part-II.B2(4)(i)	Active power set-point and Ramp up test (ramp rate < 10% per minute)	1.0	Unity
38		Active power set-point and Ramp down test (ramp rate < 10% per minute)		

6. Frequency response test (any droop in range of 3 - 6%)

[In place of step change of 0.15 Hz, any other step change for tests may also be considered]
[Other partial active power levels in place of 10% and 50% may also be considered]

Test No.	Relevant Regulation Clauses	**Frequency change (Hz)**	Active Power dispatch (pu)	POI/PCC Voltage (pu)	Power factor (pf)
39	CEA TSCG: Part-II.B2(4)(ii,iii)	50 to 50.15	0.9-1.0	1.0	Unity
40			0.5		
41			0.1		

42	IEGC: 30(10)	50 to 49.85	0.5		
43			0.1		
Note: During the above test, frequency shall be first changed upto dead band limit to show its insensitivity to active power change					

7. Demonstration of immediate (within 1 second) real power primary frequency response of at least 10% of maximum Alternating Current active power capacity for frequency deviation in excess of 0.3 Hz:

Test No.	Relevant Regulation Clause	**Change in frequency (Hz)**	Active Power dispatch (pu)	POI/PCC Voltage (pu)	Power factor (pf)
44	CEA TSCG: Part-II.B2(4)(ii, iii)	Greater than 0.3Hz (upwards)	1.0	1.0	Unity
45		Greater than 0.3Hz (downwards)			

8. High Voltage Ride Through (HVRT)

[For WTGs, full load test may be conducted at any power level between 90-100%]
[Other partial active power levels in place of 25% and 50% may also be considered]

Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
46	CEA TSCG: Part-II.B2(7)	1.3	0.2	1.0	Balanced Three phase
47		1.2	2		
48		1.3	0.2		Single phase
49		1.2	2		
50		1.3	0.2	0.5	Balanced Three phase
51		1.2	2		
52		1.3	0.2		Single phase
53		1.2	2		
54		1.3	0.2	0.25	Balanced Three phase
55		1.2	2		
56		1.3	0.2		Single phase
57		1.2	2		

Total number of tests to be performed at Unit IBR level (RMS+EMT) = 33 + 57 = 90nos.

E. SVG/STATCOM Single Unit - Benchmarked Simulation Model and Report

a) List of Benchmarking report & Unit SVG/STATCOM Models to be submitted

The objective of Unit IBR benchmarking in EMT domain is to demonstrate that the SVG/STATCOM performance as given in the type test report is matching with model (simulation) performance to the extent possible.

Sr. No.	Relevant Regulation Clause	Details of unit models & benchmarking report of SVG/STATCOM	Simulation Models (SM)/Reports (R)
1	CEA TSCG: 6(6)	Benchmarked RMS (**PSS/E**) model of SVG/STATCOM with supporting files like .sav, .dyr, .sld along with test setup	SM
2		Benchmarked EMT (**PSCAD**) model of SVG/STATCOM with supporting files like .dll, .pswx, .pscx along with test setup	
3		Benchmarking Report of RMS (**PSS/E**) model of SVG/STATCOM	R
4		Benchmarking Report of EMT (**PSCAD**) model of SVG/STATCOM	
5		Report on comparison of RMS & EMT equivalent model response under steady state & dynamic condition	

b) List of tests to be incorporated in RMS Benchmarking report

1. Low voltage ride through				
Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre-fault Reactive Power dispatch
1	CEA TSCG: Part-II.B2(3)	0.85	3.0	Max. absorption
2		0.5	1.65	
3		0.15	0.3	

2. High voltage ride through				
Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Initial Reactive Power dispatch
4	CEA TSCG: Part-II.B2(7)	1.3	0.2	Max. injection
5		1.2	2	

3. Demonstration of ± Q capability		
Test No.	Relevant Regulation Clause	**Range**
6	CEA TSCG: Part-II.B2(1)	Upto full capacitive range
7		Upto full inductive range

c) List of tests to be done on EMT Benchmarking report

The objective of Unit IBR benchmarking in EMT domain is to demonstrate that the SVG/STATCOM performance as given in the type test report is matching with model performance to the extent possible in EMT platform.

1. Low voltage ride through					
Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre-fault Reactive Power dispatch (pu)	Nature of voltage dip
1	CEA TSCG: Part-II.B2(3)	0.85	3.0	Max. absorption mode	Balanced Three phase
2		0.5	1.65		
3		0.15	0.3		
4		0.85	3.0		Unbalanced (LL)
5		0.5	1.65		
6		0.15	0.3		

2. High voltage ride through					
Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Initial Reactive Power dispatch (pu)	Nature of voltage dip
7	CEA TSCG: Part-II.B2(7)	1.3	0.2	Max. injection mode	Balanced Three phase
8		1.2	2		
9		1.3	0.2		Single phase
10		1.2	2		

3. Demonstration of ± Q capability		
Test No.	Relevant Regulation Clauses	**Range**
11	CEA TSCG: Part-II.B2(1)	Upto full capacitive range
12		Upto full inductive range

Total number of tests to be performed at SVG/STATCOM (RMS+EMT) = 7+12 = 19

F. List of tests to be conducted at plant level in EMT platform

1. Power Quality tests:

a) Evaluation of current harmonics at POI (Harmonic Load Flow model)

Test No.	Relevant Regulation Clause	Default Active Power (pu)
1	CEA TSCG: Part-II.B1(2)	P=1.0
2		P=0.9
3		P=0.8
4		P=0.7
5		P=0.6
6		P=0.5
7		P=0.4
8		P=0.3
9		P=0.2
10		P=0.1

b) DC Current injection at POI

Test No.	Relevant Regulation Clause	Default Active and Reactive power dispatch (pu)
11	CEA TSCG: Part-II.B1(2)	P=1.0; Q=0

c) Flicker study at POI (Pst & Plt)

Test No.	Relevant Regulation Clause	Default Active and Reactive power dispatch (pu)
12	CEA TSCG: Part-II.B1(2)	P=1.0; Q=0

2. Reactive power capability test

Test No.	Relevant Regulation Clause	**POI Voltage (pu)**	Supplemental device (if any) (In service/out of service)
13	CEA TSCG: Part-II.B2(1)	0.95	In service
14		1.05	
15		0.95	Out of service
16		1.05	

3. Capability to operate in frequency range: 47.5Hz to 52Hz with +/-5% voltage variation

Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	Active Power dispatch (pu)	POI Voltage (pu)	Power factor (pf)	PPC Frequency Flag
17	CEA TSCG: Part-II.B2(2)	50 to 47.5	P=1.0	1.0	Any	Off
18		50 to 52				

4. Capability to provide rated output in frequency range of 49.5Hz to 50.5Hz with +/-5% voltage variation

Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI Voltage (pu)	Power factor (pf)	Active Power dispatch (pu)	PPC Frequency Flag
19	CEA TSCG: Part-II.B2(2)	50 to 49.50	0.95	0.95 lagging	1.0	Off
20			1.05	0.95 leading		
21		50 to 50.50	0.95	0.95 lagging		
22			1.05	0.95 leading		

5. Low voltage ride through

Test No.	Relevant Regulation Clauses	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre-fault Active Power dispatch (pu)	Nature of voltage dip
23	CEA TSCG: Part-II.B2(3)	0.85	3.0	1.0	Balanced Three phase
24		0.5	1.65		
25		0.15	0.3		
26		0.85	3.0		Unbalanced (LL)
27		0.5	1.65		
28		0.15	0.3		
29		0.85	3.0		Unbalanced (LG)
30		0.5	1.65		
31		0.15	0.3		
32		0.85	3.0	0.5	Balanced Three phase
33		0.5	1.65		
34		0.15	0.3		
35		0.85	3.0		Unbalanced (LL)
36		0.5	1.65		
37		0.15	0.3		
38		0.85	3.0		Unbalanced (LG)
39		0.5	1.65		
40		0.15	0.3		
41		0.85	3.0	0.25	Balanced Three phase
42		0.5	1.65		
43		0.15	0.3		
44		0.85	3.0		Unbalanced (LL)
45		0.5	1.65		
46		0.15	0.3		
47		0.85	3.0		Unbalanced (LG)
48		0.5	1.65		
49		0.15	0.3		

6. Rate of change of active power:

Test No.	Relevant Regulation Clause	**Change in active power dispatch**	POI Voltage (pu)	Power factor (pf)
50	CEA TSCG: Part-II.B2(4)(i)	Active power set-point and Ramp up test (ramp rate < 10% per minute)	1.0	Unity
51		Active power set-point and Ramp down test (ramp rate < 10% per minute)		

7. Frequency response test (any droop in range of 3 - 6%):

Test No.	Relevant Regulation Clauses	**Frequency change (Hz)**	Active Power dispatch (pu)	POI Voltage (pu)	Power factor (pf)	PPC Frequency Flag
52	CEA TSCG: Part-II.B2(4)(ii,iii) IEGC: 30(10)	50 to 50.15	1.0	1.0	Unity	On
53			0.5			
54			0.1			
55		50 to 49.85	1.0			
56			0.5			
57			0.1			
Note: During the above test, frequency shall be first changed upto dead band limit to show its insensitivity to active power change						

8. Demonstration of immediate (within 1 second) real power primary frequency response of at least 10% of maximum Alternating Current active power capacity for frequency deviation in excess of 0.3 Hz:

Test No.	Relevant Regulation Clause	**Change in frequency (Hz)**	Active Power dispatch (pu)	POI Voltage (pu)	Power factor (pf)
58	CEA TSCG: Part-II.B2(4)(ii, iii)	Greater than 0.3Hz (upwards)	0.9	1.0	Unity
59		Greater than 0.3Hz (downwards)			

9. High voltage ride through:

Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
60		1.3	0.2	1.0	Balanced Three phase
61		1.2	2		
62		1.1	Continuous		
63		1.3	0.2		Single phase
64		1.2	2		
65		1.1	Continuous		

Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
66	CEA TSCG: Part-II.B2(7)	1.3	0.2	0.5	Balanced Three phase
67		1.2	2		
68		1.1	Continuous		
69		1.3	0.2		Single phase
70		1.2	2		
71		1.1	Continuous		
72		1.3	0.2	0.25	Balanced Three phase
73		1.2	2		
74		1.1	Continuous		
75		1.3	0.2		Single phase
76		1.2	2		
77		1.1	Continuous		

G. List of tests to be conducted at plant level in RMS platform:

1. Reactive power capability test:

Test No.	Relevant Regulation Clause	**POI Voltage (pu)**	Supplemental devices (SVC/STATCOM) (if any) (In service/out of service)
1	CEA TSCG: Part-II.B2(1)	1.0	In-service (If installed)
2		0.95	
3		1.05	
4		1.0	Out of service
5		0.95	
6		1.05	

2. Capability to operate in frequency range: 47.5Hz to 52Hz with +/-5% voltage variation

Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	Default Active Power dispatch (pu)	POI Voltage (pu)	PPC Frequency Flag
7	CEA TSCG: Part-II.B2(2)	50 to 47.5	1.0	1.0	Off
8		50 to 52			

3. Capability to provide rated output in frequency range of 49.5Hz to 50.5Hz with +/-5% voltage variation

Test No.	Relevant Regulation Clause	**Frequency change (Hz)**	POI Voltage (pu)	Power factor (pf)	Active Power dispatch (pu)	PPC Frequency Flag
9	CEA TSCG: Part-II.B2(2)	50 to 49.5	0.95	Lagging (0.95)	1.0	Off
10			1.05pu	Leading (0.95)		
11		50 to 50.5	0.95pu	Lagging (0.95)		
12			1.05pu	Leading (0.95)		

4. Low voltage ride through

Test No.	Relevant Regulation Clause	**LVRT Target Voltage (pu)**	Duration of voltage dip (sec)	Pre-fault Active Power dispatch (pu)	Nature of voltage dip
13	CEA TSCG: Part-II.B2(3)	0.85	3.0	1.0	Balanced Three-Phase
14		0.50	1.65		
15		0.15	0.3		
16		0.85	3.0	0.5	
17		0.50	1.65		
18		0.15	0.3		
19		0.85	3.0	0.25	
20		0.5	1.65		
21		0.15	0.3		

5. Active power set-point and Rate of change of active power

Test No.	Relevant Regulation Clauses	**Change in active power dispatch**	POI Voltage (pu)	Power factor (pf)
22	CEA TSCG: Part-II.B2(4)(i)	Active power set-point and Ramp up test (rate < 10% per minute)	1.0	Unity
23		Active power set-point and Ramp down test (ramp rate < 10% per minute)		

6. Frequency response test (any droop in range of 3 - 6%)

Test No.	Relevant Regulation Clauses	**Frequency change (Hz)**	Active Power dispatch (pu)	POI Voltage (pu)	Power factor (pf)	PPC Frequency Flag
24	CEA TSCG: Part-II.B2(4)(ii,iii) IEGC: 30(10)	50 to 50.15	1.0	1.0	Unity	On
25			0.5			
26			0.1			
27		50 to 49.85	1.0			
28			0.5			
29			0.1			
Note: During the above test, frequency shall be first changed upto dead band limit to show its insensitivity to active power change						

7. Demonstration of immediate (within 1 second) real power primary frequency response of at least 10% of maximum Alternating Current active power capacity for frequency deviation in excess of 0.3 Hz:

Test No.	Relevant Regulation Clauses	**Change in frequency (Hz)**	Default Active Power dispatch (pu)	POI Voltage (pu)	Power factor (pf)
30	CEA TSCG: Part-II.B2(4)(ii, iii)	Greater than 0.3Hz (upwards)	0.9	1.0	Unity
31		Greater than 0.3Hz (downwards)			

8. High voltage ride through:

Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
32	CEA TSCG: Part-II.B2(7)	1.3	0.2	1.0	Balanced Three-Phase
33		1.2	2		
34		1.1	Continuous		
35		1.3	0.2	0.5	
36		1.2	2		
37		1.1	Continuous		

Test No.	Relevant Regulation Clause	**HVRT Target Voltage (pu)**	Duration of voltage rise (sec)	Initial Active Power dispatch (pu)	Nature of voltage rise
38		1.3	0.2	0.2	
39		1.2	2		
40		1.1	Continuous		

Total number of tests to be performed at Plant level (EMT+RMS) = 77+40 = 117

H. List of models & reports to be submitted at plant level:

Sr. No.	Relevant Regulation Clauses	Description	Reports (R) / Simulation Models (SM)
1	CEA TSCG: 6(6)	Compliance Report in RMS (**PSS/E**)- Reactive power Analysis	R
2		Compliance Report in RMS (**PSS/E**)- Dynamic Studies	
3		Compliance Report in EMT (**PSCAD**)- Dynamic & other applicable tests	
4		Compliance Report in EMT (**PSCAD**) for Power Quality Assessment	
5		Report on **comparison of RMS & EMT** equivalent model response under steady state & dynamic conditions	
6		Generic RMS (**PSS/E**) model of RE plant (**detailed**) along with all supporting files (.dyr, .sav, .raw, .sld, .py, model user guide etc.)	SM
7		Generic RMS (**PSS/E**) model of RE plant (**equivalent**) along with all supporting files (.dyr, .sav, .raw, .sld, .py, model user guide etc.)	
8		RE Plant EMT (**PSCAD**) model of RE plant (equivalent model) along with all supporting files including model user guide	
9		RE Plant EMT (**PSCAD**) Power Quality Assessment model along with all supporting files including model user guide	
10	CEA TSCG: Part-III.5	Short Circuit (Non-Conventional Source - Fault Contribution) Table & Model (.seq)	

I. Others Technical Requirements (Required at the time of FTE Only)

Sr. No.	Relevant Regulation Clauses	Description	Remarks
1	CEA Technical Standards for Construction of Electric Plants and Electric Lines: 48(6)	Installation of Phasor measurement units	**Required at the time of FTE only**

Sr. No.	Relevant Regulation Clauses	Description	Remarks
2	CEA TSCG: 6(4)	Installation of DR/EL	
3	CEA TSCG: Part-III.6	Power Supply to Sub-station Auxiliaries	
4	CEA Technical Standards for Construction of Electric Plants and Electric Lines: 48(3)	Whether auto reclose setting enabled in 220 kV line for single phase	
5	CEA Grid Standards 2010	Data reporting format (For analysis of LVRT and HVRT events, IBR level high resolution data is required. Sample data may be provided)	

J. Details of Models for carrying out different studies

Sr. No.	Simulation Test Description	Simulation to be carried out on
1	Reactive Power Capability	Detailed RMS and Equivalent EMT Model
2	Power Quality	Power Quality Assessment Model
3	Low Voltage Ride Through	Equivalent RMS and Equivalent EMT Model
4	High Voltage Ride Through	
5	Operating Frequency Range	
6	Frequency Response	
7	Dynamic Reactive Power Support	
8	Ramping Capability	

K. Points to be considered while submission:

1. The above list shall be considered for a RE plant involving one type of IBR. In case of hybrid, the above DMAT shall be carried out for following scenarios:
   a) With both **Solar and Wind capacity taken into account** subject to condition that active power observed at POI is not exceeding the connectivity quantum as per CTU grant (as per the proportionality of the sources).
   b) With consideration of **only solar component**.
   c) With consideration of **only wind component**.
2. Based on specific requirements, additional tests shall be carried out by the entity.
3. For all the tests except power quality assessment, if actual SCR at the POI is more than 5 then SCR of 5 needs to be considered in the plant level dynamic simulation studies. If actual SCR is less than 5, then actual SCR shall be considered in simulation studies. The power quality studies shall be carried out considering the **actual SCR**.
4. The entity shall ensure that SCR and X/R considered while Unit IBR type testing is same as in the single unit IBR /supplemental device model(s) also.

5. The X/R ratio of 10 shall be considering while **modelling the POI** in SMIB models unless specifically provided.
6. The X/R ratio of 10 shall be considering while conducting **Low Voltage Ride through Tests** if voltage dips are emulated through application of fault in plant level SMIB models unless specifically provided.
7. The dedicated transmission line(s) shall be modelled as frequency dependent model in the plant level EMT model.
8. The power transformer(s) at Generator Pooling Station shall be modelled explicitly and no aggregation shall be done at such level.
9. Communication delays, polling rates & IBR level protections shall be appropriately modelled in the plant level models.
10. Time series data indicated in Unit IBR/SVG test report shall be of appropriate resolution and scale. Entity may refer IEC 61400-21 for data reporting table and representation of electrical quantities.
11. Unit level IBR/Supplemental device model and Plant level PSS/E model shall be submitted in Version 36.0 and above. In PSCAD platform unit level and plant level models shall be submitted in Version 5.0 or above and 64-bit compiler alongwith IVF 2015 or above.
12. Entity shall conduct the benchmarking of equivalent model with detailed plant model (in PSS/E) to validate the steady state and dynamic performance (one LVRT & HVRT case).
13. The aggregation of IBRs shall be done only for IBR of same make (OEM) and model. Also, aggregation shall be done for the same nature of source (e.g. WTG to WTG).
14. Entity shall include the Rate-1,2,3 (as applicable) in all elements in the models.
15. Entity shall use element ID “S” for Solar and “W” for WTGs in the models.
16. In case of unbalances cases, entity shall also include Negative Sequence currents & Negative sequence Voltage of IBR (including supplemental devices) and POI.
17. Stakeholders may align their test sequences matching with plant level tests given in this document.
18. Other requirements as mentioned in the **Report of the working group & CONN TD-1** shall remain same.

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