“Welcome“ "स्वागतम“

1st Stakeholders consultation workshop for OPERATING PROCEDURE (as per IEGC Regulation 28(3))

Procedure/formats for periodic testing of power system elements

Clause 40 of IEGC 2023:

- **(1)** There shall be periodic testings carried out on power system elements
  - For ascertaining the correctness of mathematical models used for simulation studies
  - Ensuring desired performance during an event in the system
- (2) General provisions
  - Responsibility - Owner of the power system element shall be responsible for carrying out tests and submit reports NLDC/RLDC/SLDCs, CTU/STU and CEA
  - Testing plan - to be submitted to RPC by 31st Oct for next financial year, changes needs to be communicated in advance.
  - Periodicity - The tests shall be performed once every five (5) years or whenever major retrofitting is done.
  - If any adverse performance is observed during any grid event, SLDC/RLDC/NLDC/RPC may advise to carry out testing even earlier.

Clause 40 of IEGC 2023:

- **(3) Testing requirements**

Power System Elements	Tests	Applicability
Synchronous Generator	(1) Real and Reactive Power Capability assessment. (2) Assessment of Reactive Power Control Capability as per CEA Technical Standards for Connectivity (3) Model Validation and verification test for the complete Generator and Excitation System model including PSS. (4) Model Validation and verification of Turbine/Governor and Load Control or Active Power/ Frequency Control Functions (5) Testing of Governor performance and Automatic Generation Control.	Individual Unit of rating 100MW and above for Coal/lignite, 50MW and above gas turbine and 25 MW and above for Hydro.

Clause 40 of IEGC 2023:

- **(3) Testing requirements**

Power System Elements	Tests	Applicability
Non synchronous Generator (Solar/Wind)	(1) Real and Reactive Power Capability for Generator (2) Power Plant Controller Function Test (3) Frequency Response Test (4) Active Power Set Point change test. (5) Reactive Power (Voltage / Power Factor / Q) Set Point change test	Applicable as per CEA Technical Standards for Connectivity.

Clause 40 of IEGC 2023:

- **(3) Testing requirements**

Power System Elements	Tests	Applicability
HVDC/FACTS Devices	(1) Reactive Power Controller (RPC) Capability for HVDC/FACTS (2) Filter bank adequacy assessment based on present grid condition, in consultation with NLDC. (3) Validation of response by FACTS devices as per settings.	To all ISTS HVDC as well as Intra-State HVDC/FACTS, as applicable

Objectives

- As per Clause 40(2)(a), *The owner of the power system element shall be responsible for carrying out tests as specified in these regulations and for submitting reports to NLDC, RLDCs, CEA and CTU for all elements and to STUs and SLDCs for intra-State elements*
- All equipment owners shall submit a testing plan for the next year to the concerned RPC by 31st October
- Tests are to be carried out by owners as per test plan
- The intention of this procedure is to establish the outcomes desired from these tests:
  - Submission of the test results in required formats
  - Submission of validated mathematical models of power system elements

Real Power Assessment of Synchronous generators

Data to be Provided by Generator:

1	Generating station and Unit	Name and Number	
2	Installed Capacity	MW	
3	Maximum Continuous rating (MCR)	MW	
4	Over load capability as % of MCR	As % of MCR & in MW	
5	Minimum turndown level (Technical minimum)	As % of MCR & in MW	
6	Ramp up capability	(% of MCR/ Minute)	
7	Ramp down capability	(% of MCR/ Minute)	
8*	Full reservoir level (FRL)	Metre	
9*	Design Head	Metre	
10*	Minimum draw down level (MDDL)	Metre	
11*	Water released at Design Head	M^3 / MW	
12*	Unit-wise forbidden zones	MW	

Ramp Up:

1. Operation at a load of fifty five (55) percent or minimum turn down level declared by plant of MCR as per the CEA Technical Standards for Construction for a sustained period of four (4) hours.

- Result: Plot showing operation at 55% load for 4 hours

2.Ramp-up from fifty five (55) percent of MCR to seventy (70) percent of MCR at a ramp rate of at least one (1) percent of MCR per minute (with stabilization period of 30 minutes), then 70% to 100% of MCR.

Sl.No	Time	Active power generation in MW (A)	Active power as % of MCR (B)	Ramp per minute	Ramp rate (as % of MCR)
1.	00:01		55%	--	
2.	00:02			B_2-B_1	
3.	00:03			B_3-B_2	
..					
45.	00:15		70%	B_{15}-B_{14}	

Ramp Up:

3. Operation at a MCR as per the CEA Technical Standards for Construction for a sustained period of four (4) hours. Plot showing operation at 100% load for 4 hours to be shown.

Result: Plot showing operation at 100% load for 4 hours

4. Demonstrate overload capability with the valve wide open as per the CEA Technical Standards for Construction and sustained operation at that level for at least five (5) minutes.

Sl.No	Time	Active power generation in MW	Active power as % of MCR
Applicable over load capability: %			
1.	00:01 (Time where active power generation reached to 105%/110% of MCR as applicable)		
2.	00:02		
3.	00:03		
4.	00:04		
5.	00:05		

LV side data of Generator transformer will be used to check the compliance.

Ramp Down:

5.Ramp-down from MCR to seventy (70) percent of MCR at a ramp rate of at least one (1) percent of MCR per minute, (with stabilization period of 30 minutes). Then 70% to 55% of MCR.

Sl.No	Time	Active power generation in MW (A)	Active power as % of MCR (B)	Ramp per minute
1.	00:01		100%	--
2.	00:02			B_2-B_1
3.	00:03			B_3-B_2
..				
45.	00:29			B_{29}-B_{28}
46	00:30		70%	B_{30}-B_{29}

- **Active power and reactive power data at 1 sec or lowest available resolution to be shared in excel format and active power plots for each test showing compliance to relevant regulations shall be submitted.**
- **Detailed test report covering all the tests and relevant plots shall be submitted.**

Reactive Power Assessment of Synchronous generators

Features

- On site testing shall be carried out in the presence of OEM.
- Representatives from Beneficiary/RPC/RLDC/SLDC/NLDC may witness the test.
- Both MVAR injection (lagging pf) and absorption (leading pf) sides testing to be performed at full load and at a load just above technical minimum of the generating unit.
- Test timings for injection/absorption has to be finalized based on past voltage profile of connected substation.
- Bus/line reactors switching and MVAR capability of other units of the same generating station can be utilized to test MVAR capability as close as to the capability curve.

Lagging Reactive Capability :

7.a). Lagging Reactive Capability Test While operating in a steady state mode at near rated output, raise excitation in automatic voltage control mode until one of the following conditions occurs:

i) The 100% MVA rating of the machine is reached (reach capability curve).

ii) Rated field current or field voltage is reached.

iii) Terminal voltage limit is reached (105-110%, depending on unit).

iv) Generator temperature limits are reached (either stator winding or field winding).

v) The maximum/over excitation limiter is reached/alarms.

vi) Maximum auxiliary bus voltage is reached.

Hold unit at this level for a minimum of 15 minutes (30 minutes is a preferable duration) or till the temperature stabilizes then take the measurements as per format. Repeat the test at reduced loading (MW) level.

Leading Reactive Capability :

b). Leading Reactive Capability Test While operating in a steady state mode at almost rated load, lower excitation in automatic voltage control mode until one of the following conditions occurs:

i) Under excitation Limiter (UEL) is activated.

ii) 100% MVA rating is reached.

iii) Generator temperature limits are reached;(either stator or field).

iv) Minimum auxiliary bus voltage is reached.

v) Minimum terminal voltage is reached.

Recording sheet:

MVAR Capability Testing - Recording Sheet

MVAR testing at (Station): **Unit Number:**
Date:
GT Tap no and corresponding voltage:

S.No	Time (HH:MM)	Gross Generator Output		Generator Terminal		Field		Frequency (Hz)	System Voltage (HV Side) kV	HV side (After GT)		Auxiliary Bus voltage (kV)	Stator Temp Min / Max	H2 Pressure	Load angle	pf	MVAR Capability as per the Generator capability curve (MVAR)	Remarks
		Gross Real Power (MW)	Gross Reactive Power (MVAr)	Voltage (kV)	Current (kA)	Voltage (V)	Current (A)			Net Ex Bus Real Power (MW)	Net Ex Bus Reactive Power (MVAr)							
INITITAL CONDITIONS																		
1																		

- Active and reactive power plot with generator capability curve.

Test Results to be submitted:

- Test report along with active power vs reactive power plot w.r.t the reactive power capability curve of the generator to be submitted to the SLDC/RLDC.
- All the recording parameters (such as active power, Generator terminal voltage, bus voltage and reactive power)data of 1 sec resolution for the testing period to be submitted in excel format.
- Comparison of OEM supplied capability curve and capability curve as per onsite testing alongwith various limiters shall be submitted.
- From the test results the compliance to CEA technical standards for connectivity is verified by using the extreme power factors recorded.
- Reaching up to 0.85 lagging power factor depends on the real time grid conditions.

Primary Frequency Response Test procedure

Primary Response Test Procedure

Basic Data

1	Turbine	Speed (in RPM)	
2	Generator	Make	
3	Capacity	MW	
4	DCS	Make	
5	Governor	Make	
6	Type	Model	
7	Pmax	MW	
8	Pmin	MW	

S.No 10 & 11, reference IEEE Technical report (PES-TR1)- Dynamic Models for Turbine Governors in Power System Studies.

9	Droop	% of MCR	
10	Maximum permissible deadband	Hz	**0.03**
12	Governor Reference frequency set to 50.000 Hz	Yes/No	

- **Turbine-Governor information**

- Type of turbine (Tandem/Cross compound),
- Model of turbine and boiler (including details of boiler controls, technology, valves, valve characteristics),
- Model of speed governor and turbine load (if applicable) control system (including details of technology, valves, valves characteristics) ,
- Mode of operation and control, ramp rates, turbine inertia, details of control mode (boiler-follow, turbine-follow, or coordinated control),
- Commissioning report of turbine-governor system or recent governor testing report to be furnished.

- **Signals to be Recorded**

Signals need to be recorded with resolution of 10Hz

- Simulated frequency
- Active power, Pgen, corresponding to turbine power
- FGMO Output
- EHTC O/P (Electro Hydraulic Turbine Controller)
- Steam Pressure
- HPCV Opening (HP control valve positions)
- Pressure correction

S.No	Load Level	Test Signal
1	Full Load & Technical	• -/+0.03HZ from 50 Hz
	Minimum (Ripple factor Test)	• +/-0.03HZ from 50 Hz
2	a) Technical Minimum	• -0.05 & +0.05 Hz from 50 Hz • +0.05 & -0.05 Hz from 50 Hz
	b) 60% of MCR c) 75% of MCR	• -0.10 & +0.10 Hz from 50 Hz • +0.10 & -0.10 Hz from 50 Hz
	d) 100% of MCR	• -0.13 & +0.13 Hz from 50 Hz • +0.13 & -0.13 Hz from 50 Hz

Note: For Hydro & Gas units above tests shall be done at various loadings within the operating zone

Simulated frequency (Hz)	MW at test start t_0	MW change at t_0+45 seconds	MW change at t_0+100 seconds	Droop (%) Actual implemented droop	Droop (%) Calculated** at t_0+45 seconds	Droop (%) Calculated at t_0+100 seconds

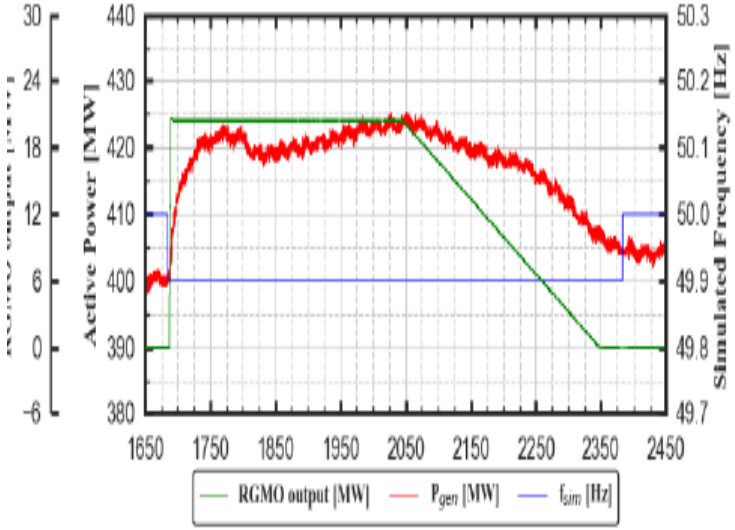
Results

Turbine -Governor Model Validation:

a. Turbine – governor model development- IEEE equivalent Model need to be submitted.

b. Simulation scenarios

1. Governor validation – Developed IEEE model need to be validated with the test response of the machines.
2. Past event simulation- Developed IEEE model need to be validated with the past event data/response of the machines.



Conclusion & Recommendations:

- On site observations during the test alongwith frequency step vs output plots
- Model validation need to be done for dead band, below 50 Hz, above 50 Hz
- details of tuning carried out(if any)

PSS tuning of the generating units

Testing methodology

- To be carried out in line with Clause 29(8) Power System Stabilizers (PSSs), *AVRs of generating units and reactive power controllers shall be properly tuned by the generating station as per the plan and the procedure prepared by the concerned RPC*
- The procedure for PSS tuning is under discussion at NPC level
- The submission of test reports and Models to respective RLDC as per this procedure

Modelling of power plant before performing PSS Testing

- SMIB approach shall be used in the RMS simulation software
- To account varying network conditions at the generator bus, the equivalent reactance of the transmission line to the infinite bus to be varied and checked
- The Developed Generator+ Excitation system + PSS Model needs to be validated, before using the tuning results from the model
- SMIB is to be developed using IEEE Models, if User Defined Model (UDM) are considered, source code of UDM to be shared)
- Model Validation may be done by validation of the local mode of frequency during the step test.

Signals to be recorded during the PSS testing

1. Real Power
2. Field Current
3. PSS Output
4. Field Voltage
5. Reactive current
6. Generator Voltage

Following test reports to be shared

1. Gain Margin Test

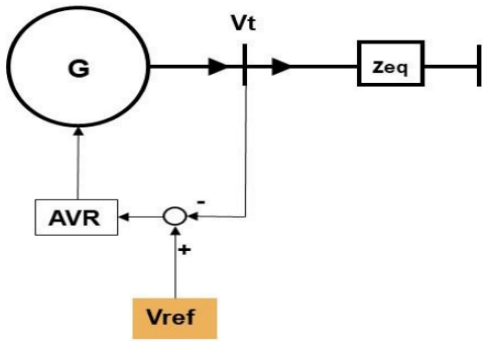
- After setting the tuned parameters in the PSS, the gain margin test should be performed
- Increase the gain step-by-step gradually without applying the step input
- Continue the test until any one of the output signals become oscillatory or unstable.

Sl.No	Gain	Active Power (stable or oscillatory)	Field voltage (stable or oscillatory)	Remarks (Final Implemented Gain / Maximum Gain)

Following test reports to be shared

2. AVR Step response test with Partial and Full Load (After Tuning)

The step change is given to Vref of AVR and the machines performance (Real Power Oscillation time duration & Magnitude) with PSS in-service against PSS out-service is to be checked.



Step Response Test	Channel 1 &2	± 2-3% Step	PSS-ON	Around Technical Minimum Load
			PSS-OFF	
			PSS-ON	80 % - MCR Loading
			PSS-OFF	
	Channel 1 &2	± 5% Step	PSS-ON	Around Technical Minimum Load
			PSS-OFF	
			PSS-ON	80 % - MCR Loading
			PSS-OFF	

Following test reports to be shared

3. Simulated Disturbance Test on model

- PSS performance and this will ensure the conformance of PSS testing in the real-time.
- Disturbance like the opening of transmission lines/switching of reactors after consultation with the system operator (SLDC / RLDC) can be applied
- During this test, the PSS of all other units of the plant shall be made OFF

Following test reports to be shared

4. Impulse Test

- A low magnitude impulse signal super-imposed over the AVR reference set-point needs to be given for the generator
- Machine behavior shall be observed with and without PSS
- This test involves typically higher magnitude of the V_{ref} (10% impulse)
- However, the duration of the impulse signal will be very less in the order of 0.1 sec.

Following test reports to be shared

5. Validation of PSS Performance during Under-Excitation/Over-Excitation:

- The Step Response Test needs to be done at MCR with maximum leading/lagging reactive power output as per the capability curve
- Machine is excited until the Over Excitation Limiter/ Under Excitation Limiter becomes active.
- This is to be checked for the inter-action of the PSS with OEL/UEL

Contents of the PSS testing report

- Improved damping for
  - Step change in voltage from 2% -5%.
  - Tuned for Frequency band 0.02 Hz – 4 Hz.
  - Reduction in No. of Cycles & Amplitude of Oscillation
- No appreciable instability at 3 times proposed gain.
- Improved Damping under variable system operating condition (Real and Reactive Power and Terminal voltage) and network.
- Procedure adopted for simulation model validation after PSS Tuning.
- Changes made on filed during the PSS tuning Activity.

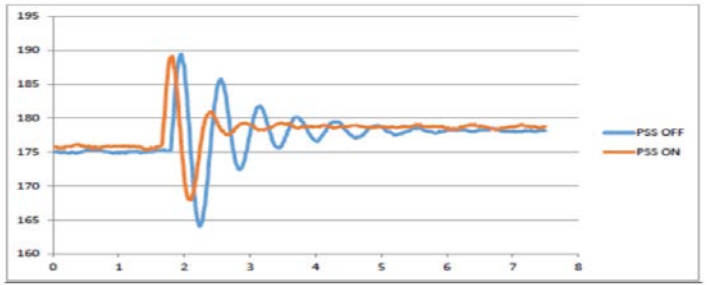
Contents of the PSS testing report

- Proposed changes / suggestions for the PSS
- Static details of the generator like OCC, SCC characteristics, P-Q capability curves, datasheets of the turbine and governor.
- Damping torque calculation shall be submitted as per the procedure
- Make, Model, transfer function - IEEE equivalent models along-with the final Implemented settings of
  - Generator
  - Excitation system
  - PSS
  - Governor

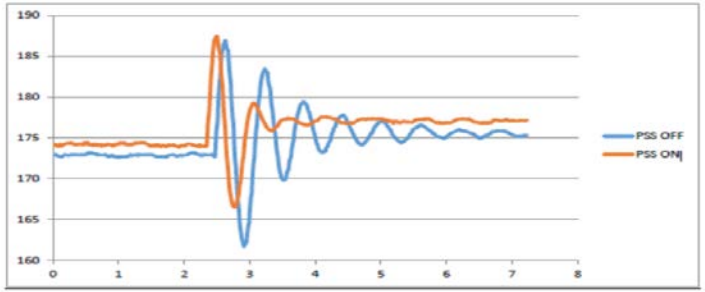
Contents of the PSS testing report

- A graphical representation of the Real Power Output with and without PSS shall be attached.

Channel-1 :



Channel-2 :



Power plant controller functionality test including active, reactive set point, frequency response and voltage control

For non-synchronous generating plants

Data submission:

1	Power plant name	Name	
2	WTG/ PV Inverter	Make & Model	
3	Plant Installed Capacity	MW	
4	Plant Peak Capacity	MW	
5	Master PPC	Make	
6	Auxiliary PPCs	Number and Make	

The power plant controller user manual covering details of various control functions of PPC shall be submitted.

Procedure:

- The active power and reactive power control tests shall be carried out at a generation level as mentioned in the test procedure.
- However if the weather conditions are conducive for conducting the tests at the maximum generation level as specified for each test during commissioning phase, tests may be carried at available generation level.
- Subsequently the developer has to carryout the tests at more than 70% generation level and submit the reports within one year after plant commissioning.
- For each test **1 sec data** of all the recording parameters shall be shared in **excel/csv** format along with relevant graphs showing the compliance.
- Each test shall verify the compliance to CEA connectivity standards and reaching the set points provided.

1.Inverter communication test:

- This test will be carried out through IP ping test for all the inverters.
- The inverters IP addresses will be pinged from the PPC server.
- The ping response time will be recorded and it shall be less than the expected time.
- The status of commands writing and reading also to be checked.

Inverter Number	Inverter Name	Ping response Expected (ms)	Ping response Actual (ms)	Commands Writing (Ok)	Commands Reading (Ok)

2.PQ Meter communication test

- This test verifies whether communication and reading from PQ meter is proper or not.
- Various parameter values shown on the PQ meter display and the parameters received at PPC from PQ meter will be compared and checked for correctness

Parameters	Value shown at PPC monitoring station	PQ meter display
Active power (MW)		
Reactive Power (MW)		
Power factor		
Voltage (Kv)		
Frequency (Hz)		

3. Active Power Set Point change test

This test is performed to check whether active power is generated as per the set point given to PPC complying to CEA (Technical Standards for Connectivity to the Grid) Regulations (amendment, 2019) clause B2(4):

"i) Shall be equipped with the facility to control active power injection in accordance with a set point, capable of being revised based on directions of the State Load Dispatch Centre or Regional Load Dispatch Centre, as the case may be;

iv) shall be equipped with the facility for controlling the rate of change of power output at a rate not more than ± 10% per minute"

This test shall be carried out at a power not less than 70% of rated capacity.

[Note: It is preferable to carry out the test during peak solar hours (11:00 Hrs to 13:00Hrs) under clear sky conditions for solar plants and maximum wind generation period for wind plant.]

3.Active Power Set Point change test

i) Change the active power set point from 100% (maximum available active power) to 10% in steps of 20% with hold time of 5minutes for each step with frequency control disable.
ii) Subsequently increase the active power set point from 10% to 100% of maximum available active power in steps of 20% with hold time of 5minutes for each step with frequency control disable.
iii) Record the parameters as per the following format. The active power set point vs actual generation to be plotted.

Test format for WTG/ PV Inverter plant:

Set point Given time (hh:mm:ss)	Given Set Point in MW at PPC	Solar Irradiance / Wind speed @ time of set point given	Active power (MW) at the time of set point reached (At POI)	Set Point Reached time (hh:mm:ss)	Time taken to reach set point (in seconds)	Frequenct at the toime of set point given (Hz)	Implemented Ramp rate (% per minute) at the PPC	Achieved Ramp rate (% per minute)	Remarks

4.Frequency response test

This test is performed to check whether the RE plant is providing frequency response as specified in CEA (Technical Standards for Connectivity to the Grid) Regulations (amendment, 2019) clause B2(4):

"(ii) shall have governors or frequency controllers of the units at a droop of 3 to 6% and a dead band not exceeding ±0.03 Hz: Provided that for frequency deviations in excess of 0.3 Hz, the Generating Station shall have the facility to provide an immediate (within 1 second) real power primary frequency response of at least 10% of the maximum Alternating Current active power capacity;

Frequency response test

(iii) shall have the operating range of the frequency response and regulation system from 10% to 100% of the maximum Alternating Current active power capacity, corresponding to solar insolation or wind speed, as the case may be;"

This test shall be carried out at different power generation level as given below, At the time of testing the maximum available active power generation as per the prevailing weather conditions shall not be less than 70% of rated capacity.

[Note: It is preferable to carry out this test during peak solar hours (11:00 Hrs to 13:00Hrs) under clear sky conditions for solar plants and maximum wind generation period for wind plant.]

Frequency response test

Sl.No	Load Level	Test Signal
1	At 90% (or maximum of active power capacity	-0.03 & +0.03 Hz from 50 Hz
		-0.10 & +0.10 Hz from 50 Hz
		-0.15 & +0.15 Hz from 50 Hz
		- 0.35Hz & +0.35Hz from 50Hz
2	At 50% of active power capacity	-0.03 & +0.03 Hz from 50 Hz
		-0.10 & +0.10 Hz from 50 Hz
		-0.15 & +0.15 Hz from 50 Hz
		- 0.35Hz & +0.35Hz from 50Hz
3	At 25% of active power capacity	-0.03 & +0.03 Hz from 50 Hz
		-0.10 & +0.10 Hz from 50 Hz
		-0.15 & +0.15 Hz from 50 Hz
		- 0.35Hz & +0.35Hz from 50Hz

Frequency response test

Following shall be recorded for each testing step.

Simulated frequency signal (Hz)	Initial Active power generation (MW)	Initial Irradiance / Wind speed	Implemented Droop setting (%)	Expected frequency response (MW)	Expected final active power generation (MW)	Final Settled active power (MW)	Time taken for providing response (Sec)	Droop calculated based on frequency response (%)	Remarks
50 -> 50.03									

5.Reactive Power control test

Three types of reactive power control i.e, Fixed reactive power control (Q control), Power factor (PF) control and voltage control tests shall be performed when the plant is generating active power. Fixed Q and Voltage control tests shall be performed during no generation period.

a. Fixed Q-control mode

When Plant is generating active power:

This test is required to check whether the plant generates reactive power as per the given set-point. The following set point changes shall be performed.

a) 20%,50%,100% of maximum Reactive power at the point of interconnection at full generation and 50% of full generation.

b) -25%, -50%, -100% of maximum Reactive power at the point of interconnection at full generation and 50% of full generation.

This test is to be carried out at maximum available generation at the time of testing (shall not be less than 70% of rated capacity) and 50% of rated capacity. Q Set point test of 100% shall be carried out based on the grid voltage with prior permission of RLDC/SLDC as the case may be.

Start Time	End Time	MVAR Set point given	MVAR at start time	MVAR at End time	POI Voltage at start time	POI Voltage at end time	PF at end time	Response Time (Sec)

*Maximum reactive power is 33% of the active power generation at POI.

Reactive power set point vs actual reactive power shall be plotted.

(ii) Test during no generation period:

This test is to check whether the plant generates a Reactive power as per the set-point during no generation period (For PV inverters during night time and for WTGs no wind period). The following set-point changes 0%, 50%, 100%, -50% & -100% of maximum Reactive power at the point of connection. The testing steps may vary based on real time grid conditions.

Start Time	End Time	MVAR Set point given	MVAR at start time	MVAR at End time	POI Voltage at start time	POI Voltage at end time	Response Time (Sec)

*Maximum reactive power is 33% of the rated capacity at POI

b. Voltage control mode

- This test is required for checking whether the plant generates an amount of reactive power, proportionally to the error between the voltage set-point and the actual voltage value.
- Details of droop and dead band of voltage control mode to be submitted.
- This test shall be carried out at maximum available active power generation (not less than 70% of rated capacity) and during no generation period.

Simulated Voltage %	Simulated Voltage (kV)	Active Power (MW)	Initial Reactive Power (MVAr)	Expected MVAr as of V-Control settings	Final MVAr	Start Time	End Time	Duratuion (Sec)	Remarks

c. Power Factor Control mode

This test is to check that the plant is operating with a power factor equal to the set-point value.

i) The testing needs to be carried out in coordination with RLDC/SLDC in real time based on POI voltage.

ii) Change the power factor set points from 0.95 pf lead to 0.95lag in steps of 0.02 and tabulate the results as below.

This test needs to be carried out at 100% power generation (or maximum possible generation not less than 70% of rated capacity) and 50% generation level.

Reactive Power control test

Power Factor Set-point Change	Active Power at POI (MW)	Reactive Power at POI (MVAR)	Power Factor at POI	POI Voltage (kV)	Start Time	End Time	Duration	Remarks
--								Initial conditions
Lagging power factor test								
1.00→0.98								
0.98→0.96								
0.96→0.95								
0.95→1.00								
Leading power factor test								
1.00→0.98								
0.98→0.96								
0.96→0.95								
0.95→1.00								

6.Test to check the ability to receive signals from control center (for plants having capacity more than 500 MW)

- Active and reactive power set points sent from SLDC/RLDC needs to be validated for correctness and corresponding change in active reactive powers needs to be recorded.
- *"The generating stations of aggregate capacity of 500 MW and above shall have the provision to receive the signal from the State Load Dispatch Centre or Regional Load Dispatch Centre, as the case may be, for varying active and reactive power output."*

Test to check the ability to receive signals from control center

Sl.No	Active power Set Point sent from RLDC/SLDC	Same Set point received at Site (Yes/No)	Starting generation (MW)	End Generation (MW)	Time taken (Sec)

Sl.No	Reactive power Set Point sent from RLDC/SLDC	Same Set point received at Site (Yes/No)	Starting MVAr	End MVAr	Time taken (Sec)

7.PPC redundancy test

- PPC system provides automatic switch over from primary to back-up processor when a fault occurs in the primary.
- Normally, the primary PLC processor controls the logic execution while the other performs standby operation.
- It is important to ensure normal operation of the plant in the event of communication failure/ PPC failure.

Testing method:

1: Stop the primary processor (power off / stop mode)
2. Check the PPC Status whether the data is synchronizing. In order to check whether the secondary PPC is able to control the plant. This can be validated by changing the setpoints from UI.
3.Remove the communication cable to PPC and check the plant active power and reactive power at POI. If master and slave PPCs are available the testing needs to be carried out for failure of master PPC and slave PPCs.

Sl. No	Active power (MW) before PPC failure	Active power (MW) after PPC failure	Reactive power (MW) before PPC failure	Reactive power (MW) after PPC failure	Remarks

Model Validation:

- The plant model submitted by the developer shall be validated with the test results and validation report with appropriate plot showing the validation to be submitted.

Data Submission:

1. All the recording parameters for each test shall be submitted in csv/excel format with 1 sec resolution (or lesser) for testing period and 5 minutes before & after the testing.
2. Test report covering all the tests performed, recording tables, relevant plots and conclusion on the compliance to CEA technical standards to Connectivity as applicable.

Conclusion & Recommendations:

a. Observations on the field testing of PPC

b. Observations model validation with respect to the field testing

Procedure for Carrying Out all ISTS HVDC as well as Intra-State HVDC/FACTS testing

Reactive Power Controller (RPC) Capability for HVDC/FACTS

Purpose of RPC in HVDC

- to facilitate the switching of alternating current (ac) filters with changing power order
- ensure that the required ac filters are connected to prevent harmonics from entering into the AC system

Modes of RPC in operation

- **AC bus voltage control**
  - Auto mode : to fulfil minimum filter conditions
  - Manual mode: to fulfil the absolute minimum filter conditions

- **Constant reactive power mode**
  - No switching of any reactive element takes place

Format to record the test output

Set Point MW	Active power (MW) at time of set point given	Active power (MW) at time of set point reached	REACTIVE POWER (MVAR) AT TIME OF SET POINT GIVEN	REACTIVE POWER (MVAR) AT TIME OF SET POINT Reached	Voltage(kV)	Total Filter injection prior to power order change (MVAR)	Total Filter injection after power order change (MVAR)

Validated Models based on onsite testing results to be submitted

Filter bank adequacy assessment

- Purpose of this test
  - analyse the impact of filter bank switching on the system voltages
  - filter bank switching shall not cause any unwanted or a major rise or fall in the voltages
  - filter bank sizing shall factor the granularity aspect

- Test Procedure:
  - Review the filter switching sequence table and note the various power orders where filter switching may take place.
  - Set HVDC at minimum power order.
  - Increase HVDC power order in steps
  - Record the change in voltage with each step rise in power order
  - Plot the voltage vs Power order characteristics with the recorded values

Validation of response by FACTS devices as per settings.

Purpose of this test

- verify that the FACTS device is capable of operating up to its specified limits in the continuous operating mode, from maximum Mvar capacitive to maximum Mvar inductive
- Validate the implemented settings in voltage control of FACTS with actual settings

Test Procedure

- simulated system disturbances to be applied
  - Transmission line(s) switched into and out of service
  - energization of nearby capacitor banks
- Record the change in reactive exchange by FACTS after change in operating state
  - high-resolution (kHz range) recorders that can trace the actual transients
  - Measuring the rise time and settling time of the response
  - Measuring the stability of dynamic response
- Validated Models based on onsite testing need to be submitted

Procedure
on
Automatic Generation Control (AGC) Testing

Grid Controller of India Limited (Grid-India)
formerly known as POSOCO

Background

- Indian power system has developed into a large synchronous grid
  - Gradual improvement in resource adequacy and power reserves
- Tertiary frequency control introduced since April 2016
- Secondary frequency control through AGC as a pilot project in 2017-18
- Implemented on 70 power plants covering 67337 MW installed capacity
  - 57.7 GW is coal-based generation, 6.4 GW is hydro and 3.2 GW is gas-based
  - 24x7 operation of AGC commenced from 20th July 2021
- AGC implementation in India is a multistakeholder project
- Details regarding AGC implementation
  - Architecture
  - Practical cases
  - Settlement aspects
  - Performance, simulations

Secondary Reserve Ancillary Services (SRAS)

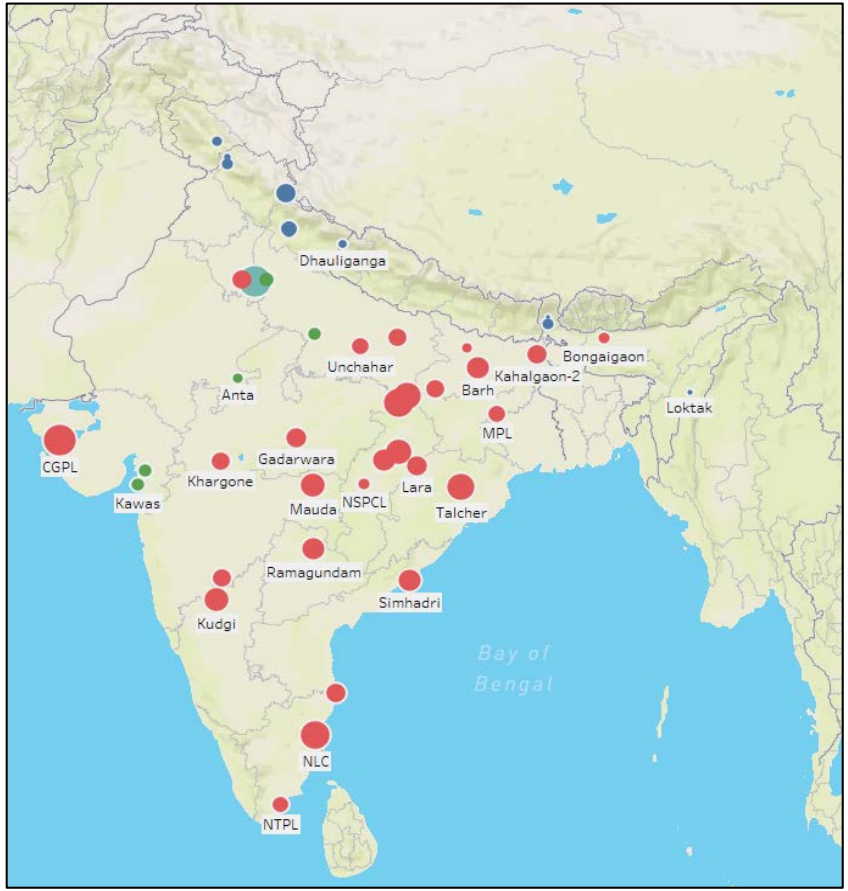
- **Eligible entities connected to Inter-state or Intra-State grid:**
  - Generating stations
  - Entities having energy storage resource

- **Pre-requisites**
  - has bi-directional communication system with NLDC/RLDC
  - is AGC-enabled, in case of a generating station, storage;
  - can provide minimum response of 1 MW;
  - has metering and SCADA telemetry

- **Despatch**
  - Signals sent from NLDC automatically every 4 seconds
  - Participation considering ramp rate (speed of response) and the cost (merit order)

- **Charges for dispatch to be declared upfront on monthly basis**
  - Sec 62 Generating stations - **Energy charge as per approved tariff**
  - Other SRAS providers (including BESS, demand response etc.) - **Compensation charge as self-declared**

AGC Project Status (as on Aug 2023)



- Large size of the Indian power system
  - Pan India distributed
- 70 power plants with 67337 MW capacity under AGC
  - Coal, Gas, Hydro
- Far away plants in remote from Delhi!
  - NTPL 2760 kms
  - Loktak 2500 kms
- Robust communication infrastructure is important
- Up & Down Regulation up to 1500 - 2000 MW pan-India

Enabling Regulations for AGC Testing

- As per IEGC Regulation 40 (c) the testing of power plants operating under AGC shall be performed once every five (5) years or whenever major retrofitting is done at the power plant.
  - If any adverse performance is observed during any grid event, then the tests shall be carried out even earlier.
- During day-to-day operation of AGC, if the performance of an SRAS Provider falls below 20% for two consecutive days, the SRAS Providers have to repeat closed loop testing, as per the CERC (Ancillary Services) Regulations, 2022 and the detailed procedure for SRAS.
- Pre-commissioning activities as per the detailed procedure of SRAS, before integrating with the NLDC AGC infrastructure.
  - Communication set up, signal validation, open loop testing, and closed loop testing.
- Point to point validation of all the signals as per the predefined signal list
  - Also involves checking signal strength between the DCS and the RTU.
- Power plants shall submit the required data as specified in the SRAS detailed procedure, required by the Nodal Agency for the testing process.

New Plant Integration Process

Establish Communication

Central Transmission Utility provides wide band communication

Signal Integration

As per pre defined signal list shared by Nodal Agency

Open Loop Testing

Integration in AGC software and monitor readiness for accepting AGC signals

Closed Loop Testing

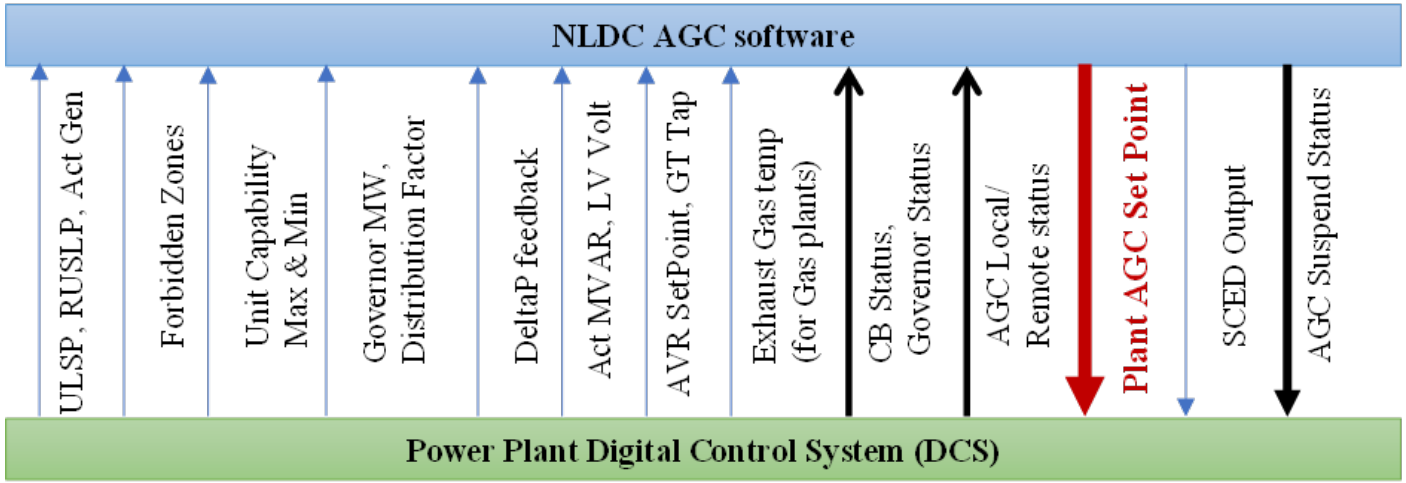
Accept AGC signals into Digital Control System

Continuous Operation

~ Total 67 GW Ready, 70 plants already on board

AGC Power Plant Signal List

Conventional Power Plant Signal List



Signal Types

Single Point Digital Status	Input Analog Point
Double Point Digital Status	Set point from Nodal Agency
Double Point Digital Command	

Open Loop Testing Procedure...(1)

- Every signal in predefined signal list may be validated through verbal confirmation with NLDC.

- Simulate communication failure and check if Plant DeltaP analog becomes zero
  a. Power plant to create simulated communication failure (remove cable etc.)
  b. Power plant to correct the logic if DeltaP analog does not become zero
  c. NLDC to create simulated communication failure
  d. Power plant to correct the logic if DeltaP analog does not become zero
- Simulate AGC Suspend status and check if Plant DeltaP analog becomes zero
  a. NLDC to create simulated AGC Suspend state
  b. Power Plant to correct the logic if DeltaP analog does not become zero
- Toggle AGC from Remote to Local status and check if Plant DeltaP analog becomes zero
  a. Power Plant to create simulated Local and Remote states
  b. NLDC to concur change in Local and Remote states
  c. Power Plant to correct the logic if DeltaP analog does not become zero during Local state
- Setup unit capability limits. For thermal plants, default limits shall be Max = unit's gross DC on bar. Min = 55% Max. Setup distribution factors. Default = (1/units on bar). For hydro plants P1 (min), P2 -P3 (forbidden zone) and P4 (max) may be checked.
- NLDC to explain the process for changing setting from 'Local' to 'Remote'.
  a. Local to Remote toggle is a manual process to be adopted by the power plant, only after code exchange with NLDC.
  b. Remote to Local can be done by the power plant without prior code exchange in case of emergency. But post-facto code exchange has to be done. For planned remote to local, code exchange is a must.
- Account data verification (1-week process)

i. NLDC to verify that the account data archived at NLDC and received through mail from power plant are matching.

Open Loop Testing Procedure...(2)

- Maintain max and min limits in unit DCS. Important before closed loop operation from plant safety perspective.
- Other activities as per the requirement, based on the observations during the testing process.
- In addition to the plant max, min, ramp and other limits, response of the power plant to the AGC Suspend Status and communication failure signals are also checked in the OLT.
- To familiarize the power plants with the real time operations, code exchange drill can also be conducted.
- Dummy AGC accounts may be generated by both power plant (as per LDC format) and LDC. In case of any discrepancy, suitable actions like precision adjustment at power plant may be taken up.
- An email confirmation would be provided by NLDC after the satisfactory completion of the open loop testing.

Closed Loop Testing Procedure

- NLDC shall ensure that the issues observed in the OLT have been addressed by the power plant.
- In CLT, AGC signal "DeltaP" is fed to power plant DCS.
    - Track 'AGC set point' instead of the power plant operator fed 'unit load set point'.

I. Check all the Analog and Digital signals are updating correctly before the starting of the test. ---------- NLDC & Power plant

II. Maximum allowed variation above or below RULSP shall be set at 50 MW per power plant. ---------- NLDC

III. Maintain units in 'Local' mode ---------- Power plant

IV. Inform RLDCs before the start of the test ----------NLDC

V. Alert ULDC / POWERGRID for ensuring uninterrupted communication. ---- ULDC, NLDC and Power plant.

VI. Exchange of code between NLDC and Power plant for bringing units into 'Remote' --------- code by NLDC, code & action by Power plant

VII. Allow the units to remain in 'Remote' un-interrupted for 45 minutes. Observe closely the variations of power plant. Power plants shall bear the deviations under DSM ---------- NLDC & Power plant

VIII. In case of any abnormal behaviour by AGC, the power plant is free to take the units into 'Local' without intimation. However, code may be exchanged subsequently with NLDC. ---------- Power plant

IX. Simulate AGC Suspend status and check if individual unit DeltaP analog becomes zero ---- action by NLDC

X. Simulate communication failure and check if unit DeltaP analog becomes zero ---- action by NLDC

XI. Toggle AGC from Remote to Local status and check if unit DeltaP analog becomes zero ---- action by Power plant.


THANK
YOU
GRACIAS
ARIGATO
SHUKURIA
DANKSCHEEN
BÏYAN
SHUKRIA
TASHAKKUR ATU
YAQHANYELAY
SUKSAMA
EKHMET
MEHRBANI
GRAZIE
MAAKE
KOMAPSUMNIDA
GOZAIMASHITA
EFCHARISTO
JUSPAXAR
PALDIES
BOLZÏN
MERCI
TINGKI

QUERIES