

GOVERNMENT OF INDIA

CENTRAL ELECTRICITY AUTHORITY

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Website: www.cea.nic.in

PUBLIC NOTICE

In exercise of the powers conferred under Section 177 of the Electricity Act, 2003, the Central Electricity Authority (CEA) has prepared the draft **Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2026**. The draft regulations are available on the CEA website www.cea.nic.in for inviting comments and suggestions from stakeholders and the general public.

All the stakeholders and the public are requested to send their comments and suggestions on the draft regulations through e-mail to **Chief Engineer (Grid Management Division)** at gmcea@nic.in and **Chief Engineer (Regulatory Affairs Division)** at cea-ra2017@gov.in, latest by **17th August, 2026**.

Central Electricity Authority

CENTRAL ELECTRICITY AUTHORITY

NOTIFICATION

New Delhi, the

No. 12/X/STD(CONN)/GM/CEA - In exercise of the powers conferred by clause (a) of sub-section (2) of section 177 read with section 53 of the Electricity Act, 2003, and in suppression of the earlier Central Electricity Authority (Technical Standards for connectivity to the Grid) Regulations, 2007 and its amendments thereof, except as respects things done or omitted to be done before such suppressions, the Central Electricity Authority hereby makes the following regulations, namely: –

1. **Short title and commencement: -**

- (1) These Regulations may be called the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2026.
- (2) These Regulations shall come into force on the date of their publication in the Official Gazette.

2. **Definitions: -**

- (1) In these regulations, unless the context otherwise requires: -
 - (i) "Act" means the Electricity Act, 2003 (No. 36 of 2003);
 - (ii) "Active Current Priority Mode" means a mode in which the active current output (I_p) is given priority and has the full current rating of the generating station available to it (i.e., maximum current ac, I_{max}), while the reactive current output (I_q) is constrained.
 - (iii) "Appropriate Load Despatch Centre" means the National Load Despatch Centre (NLDC), Regional Load Despatch Centre (RLDC) or State Load Despatch Centre (SLDC) or Area Load Despatch Centre as the case may be;
 - (iv) "Area Load Despatch Centre" means the centre as established by the state for load despatch and control in a particular area of the state;
 - (v) "Appropriate Transmission Utility" means the Central Transmission Utility or State Transmission Utility as the case may be;
 - (vi) "Asynchronous Generating Station" means a generating station comprising of asynchronous generating unit(s);

- (vii) "Asynchronous Generating Unit" means a Generating Unit, that is not a synchronous generating unit.
- (viii) "Automatic Generation Control (AGC)" means capability to regulate the power output of selectable Generating unit(s) in response to total power plant output, tie-line power flow, and power system frequency;
- (ix) "British Standards (BS)" means those standards and specifications approved by the British Standards Institution;
- (x) "Bulk consumer" means a consumer who avails supply at voltage of 33 kV or above;
- (xi) "Co-located generating station" means two or more generating stations, including energy storage systems, that are operated and controlled as separate facility and are connected behind a single PoI;
- (xii) "Collector system" means equipment and systems utilized in the aggregation of generating unit(s). This includes switch-gear, cables, transmission lines, transformers, and reactive compensating devices etc. between the generating unit(s) and the PoI;
- (xiii) "Earth Fault Factor" at a location in a three-phase system means the ratio of the highest root mean square (r.m.s.) phase-to-earth power frequency voltage on a sound phase during a fault to earth (affecting one or more phases) to the r.m.s. phase-to-earth power frequency voltage which would be obtained at the selected location without the fault;
- (xiv) "Energy Management System" (EMS) means a complete system comprising software for facilitating operation of a power system, maintaining safety, reliability and economy;
- (xv) "Event Logging Facilities" means a device provided to record the chronological sequence of operations of the relays and other equipment;
- (xvi) "Energy Storage System (ESS)" in relation to the electricity system, means a facility where electrical energy is converted into any form of energy which can be stored, and subsequently reconverted into electrical energy and injected back into the grid such as Battery Energy Storage System (BESS) and Pumped Storage Plant (PSP);
- (xvii) "Energy Storage System (ESS) Unit" means
 - (a) an electrical generator coupled to a prime mover within a power station together with all plant and apparatus at the power station which relate exclusively to operation of that generator in case of Pumped Storage Plants (PSP);

Or

- (b) battery module(s) connected under an inverter along with other equipment in respect of Battery Energy Storage System (BESS);
- (xviii) “Facility” means a specific type of equipment or installation that plays a role in power generation, transmission, or distribution;
- (xix) “Fast Frequency Response” means active power injected to the grid in response to changes in measured or observed frequency during the arresting phase of a frequency excursion event to improve the frequency nadir or initial rate-of-change of frequency;
- (xx) “First Time Energisation” means the initial energisation of a new or modified power-system element (for testing, commissioning and/or integration with the grid), carried out as per the procedure prepared by appropriate load despatch centre;
- (xxi) Flexible AC Transmission Systems (FACTS)” means alternating current transmission systems incorporating power electronic-based and other static controllers to enhance controllability and increase power transfer capability;
- (xxii) "Frequency" means the number of alternating cycles per second [expressed in Hertz (Hz);
- (xxiii) “Generating Unit” means
 - (c) a unit of a generating station having electrical generator coupled to a prime mover within a power station together with all plant and apparatus at the power station which relate exclusively to operation of that generator;
- Or
- (d) an inverter along with associated photovoltaic modules and other equipment in respect of generating station based on solar photovoltaic technology;
- Or
- (e) a wind turbine generator with associated equipment, in respect of generating station based on wind energy;
- (xxiv) “Grid Forming (GFM)” means a control that maintains an internal voltage phasor that is constant or nearly constant in the sub-transient to transient time frame;
- (xxv) ‘HVDC system’ means an electrical power system which transfers energy in the form of high-voltage direct current between two or more alternating current (AC) buses;
- (xxvi) “HVDC Converter Station” is a part of an HVDC System which consists of one or more HVDC Converters installed in a single location together with buildings, reactors, filters,

reactive power devices, control, monitoring, protective, measuring and auxiliary equipment;

- (xxvii) “Hybrid Generating Station” means a generating station comprising of a combination of synchronous and asynchronous generating unit(s), with or without energy storage systems, controlled and operated as a single generating station behind a single PoI;
- (xxviii) “IEC Standard” means a standard published by the International Electrotechnical Commission;
- (xxix) "Indian Standards" (IS) means standards specified by Bureau of Indian Standards;
- (xxx) “Installed capacity”
 - (a) in case of coal, lignite, gas engines and hydro stations, means the summation of the name plate capacities of all the unit(s) of the generating station or Maximum Continuous Rating of the generating station;
 - Or
 - (b) in case of wind generating stations and generating stations using inverters, means the summation of the name plate capacities of wind turbines or solar generating unit(s), as the case may be;
 - Or
 - (c) in case of ESS means the rated Peak Capacity (MW) and energy capacity (MWh) to be delivered to the connected load;
- (xxxi) "Inverter" means a device that changes direct current power into alternating current power;
- (xxxii) “Inverter based resource (IBR)” means any source of electric power that is connected to the grid via power electronic interface, and consists of one or more IBR unit(s) capable of exporting active power from a primary energy source or energy storage system and a collector system or a supplemental device may also be part of an IBR;
- (xxxiii) IBR continuous rating (ICR): The steady-state, continuous active power rating of an IBR plant guaranteed by the IBR owner at the PoI;
- (xxxiv) “Inverter-based resource plant (IBR plant)” means a grouping of one or more IBR unit(s) and possibly supplemental device(s) operated by a common facility-level controller along with a collector system to achieve the performance requirements at the PoI;

- (xxxv) “Inverter based resource unit (IBR unit)” means an individual inverter device or a grouping of multiple inverters connected together behind a single PoI and for type III wind turbine generators, the wind turbine itself, the doubly-fed generator, the rotor-circuit inverter, and the three-winding unit transformer, if present, make up an IBR unit;
- (xxxvi) “Inverter-Interfaced Bulk Consumer” means a bulk consumer who receives power through electronic based converters for feeding the loads;
- (xxxvii) "Isolator" means a device for achieving isolation of one part of an electrical system from the rest of the system;
- (xxxviii) “Line – Commutated Converter (LCC)” based HVDC converter means a converter that relies on the line voltage of the ac system to which the converter is connected in order to affect the commutation from one switching device to its neighbor and it uses switching devices that are either uncontrolled (such as diodes) or that can only be turned on (not off) by control action, such as thyristors;
- (xxxix) “Operating mode” means mode of IBR or IBR plant operation that determines the performance during normal or abnormal conditions;
- (xl) “Overshoot” means the maximum system output minus the final steady state value, divided by the actual change in system output (i.e., from its initial value to the final settled value), when the final settled value is within the defined settling band, expressed as a percentage of final steady state value;
- (xli) " Point of Interconnection (PoI)" means a point on the grid, including a sub-station or a switchyard, where the interconnection is established between the facility of the requester /user and the grid and where electricity injected into or drawn from the grid can be measured unambiguously for the requester/user;
- (xlii) "Power Factor" means the cosine of the electrical angle between the voltage and current complex in an AC electrical circuit;
- (xliii) "Primary energy source” means energy sources like solar irradiance in the case of a photovoltaic IBR, instantaneous wind energy (determined by wind speed at a given moment) in case of a wind turbine generator, stored chemical energy in case of a Battery Energy Storage System (BESS), and stored potential energy in case of Pumped Storage Plants (PSP);
- (xliv) “Primary frequency response (PFR)” means the immediate and automatic adjustment of power generation based on droop characteristics to stabilize the frequency deviations;

- (xlv) "Protection System" means the equipment by which abnormal conditions in the grid are detected and fault clearance, actuating signals or indications are initiated without the intervention by the operator;
- (xlvi) "Reactive Current Priority Mode" means a mode in which the reactive current output (I_q) is given priority and has the full current rating of the generating station available to it (i.e, maximum current ac, I_{max}), while the active current output (I_p) is constrained;
- (xlvii) "Reaction time (T_{react})" means the duration from a step change in a system quantity measured at a defined location until the output of the system at the same defined location measurably changes in the direction of the control effort;
- (xlviii) "Reactive Power" means in relation to an AC electrical system, the product of root mean square (r.m.s.) voltage, root mean square (r.m.s.) current and the sine of the electrical phase angle between the voltage phasor and current phasor, as measured in volt-amperes reactive (VAr);
- (xlix) "Requester" includes a generating company, captive generating plant, energy storage system, transmission licensee (other than Central Transmission Utility and State Transmission Utility), distribution licensee, or bulk consumer seeking connection to the grid for its new or expanded electrical plant or Substation or Transmission line or any power system element at voltage level of 33 kV and above;
 - (l) "Ride-through" means ability to withstand voltage or frequency disturbances within the specified limits and to continue operating as specified;
 - (li) "Rise time (T_{rise})" means the time for the output of a system to go from 10% to 90% of required output change;
 - (lii) "SCADA" means Supervisory Control and Data Acquisition System that acquires data from remote locations over communication links and processes it at centralised control location for monitoring, supervision, control as well as decision support;
 - (liii) "Settling band" means the region around the value change where the system output is required to settle in after a step change in a system quantity measured at a defined location;
 - (liv) "Settling time" means the duration from a step change in a system quantity measured at a defined location until the output of the system settles to within a specified settling band around its final value change at the same defined location;
 - (lv) "Site Common Drawing" means a drawing prepared for a connection site, which depicts layout of connection site, electrical layout, common protection and control drawings and common services;

- (lvi) "Site Responsibility Schedule" (SRS) means a Schedule for demarcating the ownership, responsibility for control, operation and maintenance of the equipment at the PoI;
- (lvii) "Step response" means the output of a system as a function of time when the input is a step function of time also;
- (lviii) "Step response time" means the time between the step change in a system quantity measured at a defined location and when the output of the system reaches 90% of required output change, before any overshoot;
- (lix) "Supplemental device: means any equipment within a facility, that is only used to obtain compliance with some or all of the technical requirements specified in these regulations;
- (lx) "Synchronous Generating Station" means a generating station comprising of synchronous generating unit(s);
- (lxi) "Synchronous Generating Unit" means a generating unit which can generate electrical energy such that the frequency of the generated voltage, the generator speed and the network voltage are in a constant ratio and thus in synchronism;
- (lxii) "Synchronous Condenser Unit" means a unit similar in construction to a Synchronous Generating Unit which operates at the equivalent speed of the frequency of the power system to dynamically generate or absorb reactive power to regulate voltage, improve the power factor, and provide essential mechanical inertia, and, when operating in steady state conditions, neither generates nor consumes active power other than consumption for losses within the unit;
- (lxiii) "Total Harmonic Distortion" (THD) means a measure of distortion of the voltage or current wave form (which shall ideally be sinusoidal) and is the square root of the sum of squares of all voltage or current harmonics expressed as a percentage of the magnitude of the fundamental;
- (lxiv) "Transmission System" means a network of transmission lines and sub-stations;
- (lxv) "Type test" means a test of one or more devices manufactured to a certain design to demonstrate, or provide information that can be used to verify, that the design meets the requirements specified in this standard;
- (lxvi) "Under Frequency Relay" means a relay which operates when the system frequency falls below a preset value;

- (lxvii) “user” includes a generating company, captive generating plant, energy storage system, transmission licensee (other than the Central Transmission Utility and State Transmission Utility), distribution licensee, or bulk consumer whose electrical plant or Substation or Transmission line or any power system element is connected to the Grid at voltage level of 33 kV and above;
- (lxviii) “Voltage Source Converters (VSC)” means a converter that has a forced commutated device (for example, IGBT) based self-commutated converter that is capable of generating ac voltage from dc capacitor voltages;
- (lxix) "Voltage Unbalance" means the deviation between highest and lowest line voltage divided by Average Line Voltage of the three phases;
- (lxx) “Wind turbine generator (WTG)” means an IBR unit which converts the kinetic wind energy into electric energy;
- (2) Any other words, terms, definitions and symbols which are used herein and not defined in these regulations shall have the same meanings respectively as assigned in the Act or any other regulation published by the Authority.

3. **Applicability of the Regulations:-**

These regulations shall be applicable to all the users, requesters, Central Transmission Utility, appropriate Load Despatch Centre and State Transmission Utility.

Chapter – I General Connectivity Requirements

4. The requester/user shall be responsible for the planning, design, construction, reliability, protection and safe operation of its own equipment subject to the regulations for construction, operation and maintenance, connectivity, and other statutory provisions.
5. The new connection shall not cause any adverse effect on the grid. The grid shall continue to perform with specified reliability, security and quality as per the Central Electricity Authority (Grid Standards) Regulations in force. However, these regulations are not to be relied upon to protect the plant and equipment of the requester/-user.
6. A requester is required to be aware, in advance, of the standards and conditions his system has to meet for being integrated into the grid.
7. The requester/user shall participate in contingency operations such as load shedding, increasing or reducing generation, islanding, black start, providing start-up power and restoration as per the procedure decided by the Appropriate Load Despatch Centre.
8. The requester/ user shall carryout modifications in his equipment with respect to short circuit level, protection coordination and other technical reasons considered necessary due to operational requirements.
9. Site Responsibility Schedule:
 - (1) A Site Responsibility Schedule (SRS) for every connection point shall be filled by the requester/user operating the facility at which connection is taking place.
 - (2) The appropriate transmission utility or distribution licensee shall publish the proforma for Site Responsibility Schedule (SRS) to be filled by the requester/user.
 - (3) Following information shall be included in the Site Responsibility Schedule, namely, —
 - (i) Schedule of electrical apparatus services and supplies;
 - (ii) Schedule of telecommunications and measurement apparatus; and
 - (iii) Safety rules applicable to each plant and apparatus.
 - (4) Following information shall also be furnished in the Site Responsibility Schedule for each item of equipment installed at the connection site, namely: —
 - (i) the ownership of equipment;
 - (ii) the responsibility for control of equipment;
 - (iii) the responsibility for maintenance of equipment;
 - (iv) the responsibility for operation of equipment;
 - (v) the manager of the site;
 - (vi) the responsibility for all matters relating to safety of persons at site; and

- (vii) the responsibility for all matters relating to safety of equipment at site.
10. Access at Connection Site:
The requester or user, as the case may be owning the electrical plant shall provide reasonable access and other required facilities to the licensee or Appropriate Transmission Utility or Appropriate Load Despatch Centre, whose equipment is installed or proposed to be installed at the Connection Site for installation, operation and maintenance, etc. of the equipment.
11. Site Common Drawings:
Site Common Drawings shall be prepared for each connection point by the owner of the Sub-station where connection is taking place.
12. Cyber security:
(1) The requester/user shall comply with cyber security guidelines, regulations and the technical standards for communication system in power sector laid down by the Authority.
(2) The requester/user shall also comply with cyber security guidelines/orders issued by the Central Government, CERT-In, NSCS, NCIIPC from time to time.
13. The requester/user shall prepare single line schematic diagrams in respect of its facility and make the same available to the Appropriate Load Despatch Centre, Appropriate Transmission Utility or licensee through which his system is connected.
14. The requester/user shall follow the industry best practices and applicable industry standards in respect of the equipment installation and its operation and maintenance.
15. The equipment including overhead lines and cables shall comply with the relevant Indian Standards and in absence of Indian Standard, International Electrotechnical Commission Standard, Institute of Electrical and Electronic Engineers Standard, European Norms Standard in the sequence of their appearance unless stated otherwise:

Provided that whenever an International Electrotechnical Commission Standard, Institute of Electrical and Electronic Engineers Standard, European Norms Standard is followed, necessary corrections or modifications shall be made for nominal system frequency, nominal system voltage, ambient temperature, humidity and other conditions prevailing in India before actual adoption of the said Standard.
16. The equipment shall meet the requirements in accordance with the provisions specified in these regulations and other technical regulations published by the Authority.

17. The effects of wind, storms, floods, lightening, elevation, temperature extremes, icing, contamination, pollution and earthquakes must be considered in the design and operation of the connected facilities for compliance of the provisions specified in these regulations.
18. All the provisions contained in these regulations shall be complied and met by the facility at the PoI.
19. The name plate rating, at specified environmental conditions, of various equipment including transformers within the facility shall be used while assessing the compliance at PoI with the provisions specified in these regulations.
20. There shall be no collector system limitation, internal network limitation, control system limitation, protection system, environmental conditions or other limiting device in operation that would prevent the facility from meeting the technical requirements at PoI specified in these regulations.

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Chapter – II

Requirements for Generators and ESS

Synchronous Generating Station

Active Power Capability

21. The generating station shall be capable of providing the summation of Maximum Continuous Rating (MCR) capacity of generating unit(s) minus the declared auxiliary consumption at PoI.
22. Automatic facilities shall be provided in the generating station.

Reactive Power Capability

23. The generating station shall be capable of supplying and absorbing dynamically varying reactive power compensation at the PoI commensurate to 61.97% (0.85 pf) of summation of MCR capacity of generating unit(s) in lagging (over-excited) condition to 32.87% (0.95 pf) of summation of MCR capacity of generating unit(s) in leading (under-excited) condition of generating station:

Provided further that the above performance shall also be provided on a continuous basis with voltage variation of $\pm 10\%$ of nominal, frequency variation of (+) 4% and (-) 5% and combined voltage and frequency variation of $\pm 5\%$. However, for gas turbines, the above performance shall be provided on a continuous basis for voltage variation of $\pm 5\%$.

Voltage Disturbance Ride Through

24. The generating station shall be able to operate for Short Circuit Ratio as per IEC 60034.
25. The generating station shall operate continuously in the voltage range 0.9 p.u to 1.1 p.u at the PoI and be able to deliver the summation of MCR capacity of generating unit(s).
26. Voltage disturbances of any duration, for which the applicable voltage remains within the continuous operation region, shall not cause the generating station or unit(s) to trip. The generating station or unit(s) shall remain in operation during any such disturbance, and shall continue to deliver pre-disturbance level of active power or available active power, whichever is less.
27. All instantaneous under / over voltage protection used within the generating station shall use filtered quantities to reduce the possibility of mis-operation while providing protection to the desired equipment and system. Any instantaneous under /over voltage protection(s) that has the possibility of disrupting the power output of the entire generating station shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the grid.

Low Voltage Ride Through (LVRT)

28. The generating station connected to the grid, shall remain connected to the grid for the duration corresponding to the under voltage at the PoI on any or all phases (symmetrical or asymmetrical under voltage conditions) as depicted by the thick line in the curve in Fig. 1

Vt : Actual Voltage; Vn: Nominal Voltage—

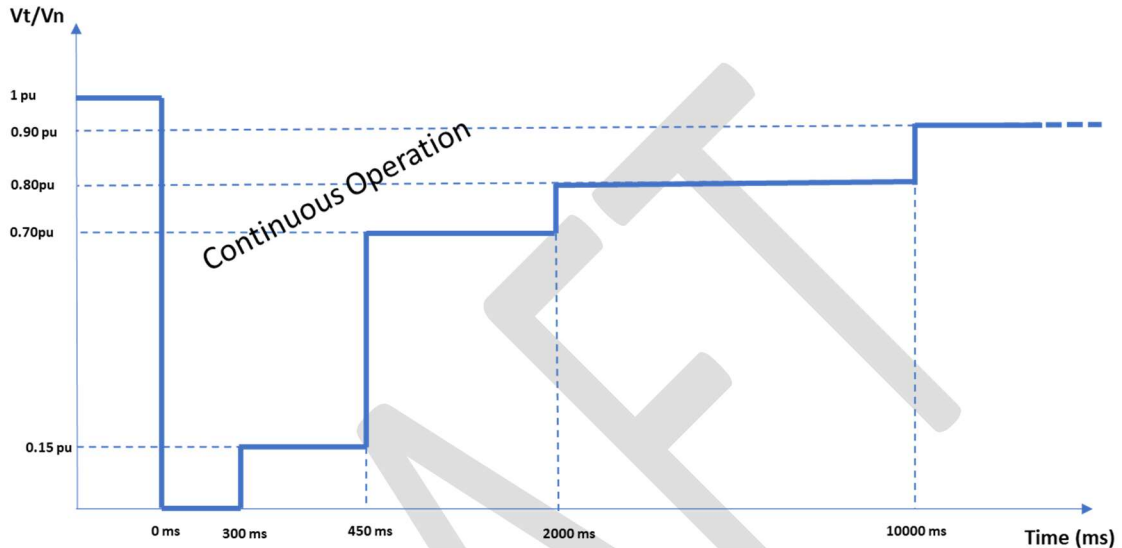


Fig 1. Low Voltage Ride Through requirements for Synchronous Generating station

Note: The relevant voltage shall be the lowest magnitude fundamental frequency phasor component of the phase-to-phase or phase-to ground voltages, whichever is less, at the PoI relative to the corresponding nominal voltage.

The response of the generating station shall be stable if the voltage is outside the continuous operation limits indicated in the Fig. 1. above:

Provided that during the low voltage ride through conditions, Generating Station shall have the overload (current) capability as per IEC 60034.

High Voltage Ride Through (HVRT)

29. The generating station connected to the grid, shall remain connected to the grid for the duration corresponding to the overvoltage at the PoI, on any or all phases (symmetrical or asymmetrical overvoltage conditions) as depicted by the thick line in the curve in Fig. 2

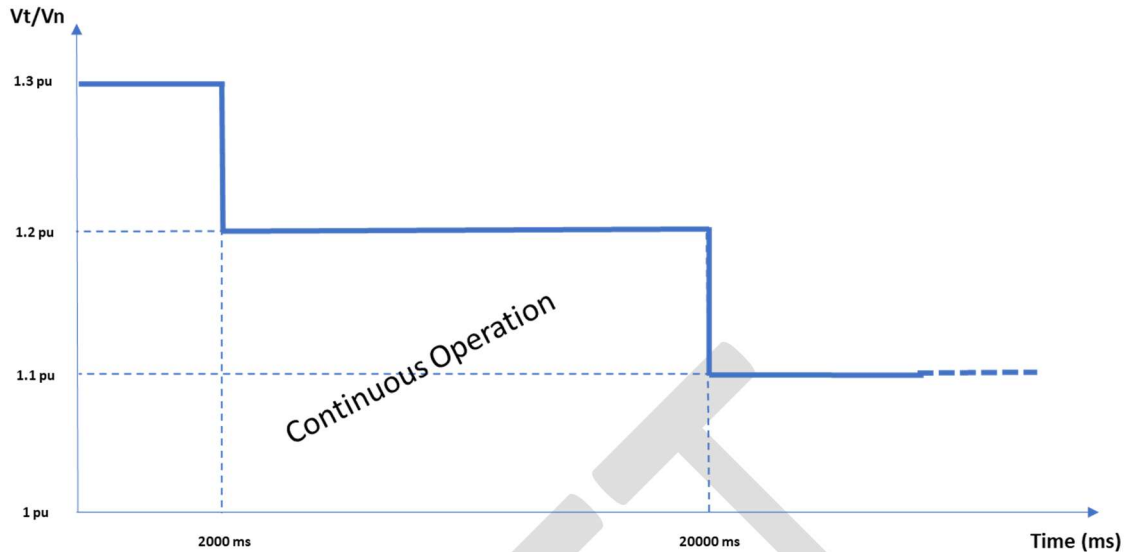


Fig. 2. High Voltage Ride through requirements for synchronous generating station

Note: The relevant voltage shall be the greatest magnitude fundamental frequency phasor component of the phase-to-phase and phase-to ground voltages, whichever is high, at the PoI relative to the corresponding nominal voltage.

The response of the generating station shall be stable if the voltage is outside the continuous operation limits indicated in the Fig. 2 above.

Multiple Fault Ride Through (MFRT)

30. The generating station connected to the grid, shall remain connected to the grid for a series of up to 15 voltage disturbance below 0.9 p.u within any 5-minute period as per the LVRT capability:

Provided that during such period generating station shall remain connected for at least 06 voltage disturbance below 0.5 p.u:

Provided further that during the multiple LVRT conditions, the generating station shall meet the performance requirements specified in LVRT conditions.

31. While assessing multiple voltage disturbances, a fault that is re-established following operation of automatic re-close Protection Scheme shall be counted as a separate voltage disturbance.

Frequency Ride through

32. The generating station shall be capable of operating in the frequency range 47.5 to 52 Hz and be able to deliver the summation of MCR capacity of generating unit(s) in the frequency range of 49.5 Hz to 50.5 Hz on a continuous manner:

Provided that the generating station shall be able to maintain its performance contained in this sub-clause even with voltage variation of up to (+/-) 10%:

Provided further that there shall be a provision of keeping over-frequency settings above 52 Hz in case of hydro generating stations.

Active Power Control

- 33. The generating unit(s) of aggregate capacity of 100 MW and above at PoI shall have the provision to receive the signal from the State Load Despatch Centre or Regional Load Despatch Centre, as the case may be, for varying active power output.
- 34. All generating unit(s) irrespective of capacity shall have electronically controlled governing systems with appropriate speed/load characteristics to regulate frequency. The governors of thermal generating unit(s) shall have a droop of 3 to 6% of MCR and hydro generating unit(s) including PSP shall have a droop of 0 to 10% of MCR.
- 35. The governor shall be set with respect to a reference frequency of 50.00 Hz and response outside the dead band shall be with respect to a total change in frequency. The inherent dead band of the generating unit or frequency controller shall not exceed (+/-) 0.03 Hz.
- 36. The primary response requirement shall be as mentioned in Table 1 below:

Table 1. Primary response requirements

Type	Response range
Coal, Lignite & Gas based thermal generating unit	(+/-) 5% of MCR
Hydro generating unit and On-stream PSP unit	(+/-) 10% of MCR (subject to rated head being available)
Off-stream PSP unit	(+/-) 10% of MCR (subject to rated head being available) for short duration

- 37. The generating unit shall give primary response instantaneously as per the capability upto (+/-) 5% or (+/-) 10% of their operating level/MCR, when the frequency deviates from the reference frequency:

Provided that ramping down is limited to the minimum technical level of the generating unit/station.

- 38. The ramp rate of the generating unit shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations in force.

Reactive Power Control

- 39. The generating unit(s) of aggregate capacity of 100 MW and above at PoI shall have the provision to receive the signal from the State Load Despatch Centre or Regional Load Despatch Centre, as the case may be, for varying reactive power output.

40. The excitation system for every generating unit:
- (1) shall have state of the art excitation system;
 - (2) shall have Automatic Voltage Regulator (AVR).

Provided that a generating unit of 100 MW rating and above shall have Automatic Voltage Regulator with digital control and two separate channels having independent inputs and automatic changeover; and

- (3) must have must have excitation control system that is capable of operating the stator continuously at 110% of nominal voltage when operating at the MCR capacity.
41. Hydro generating unit having rated capacity of 50 MW and above shall be equipped with facility to operate in synchronous condenser mode.
42. The Automatic Voltage Regulator of generating unit of 100 MW and above shall include Power System Stabilizer (PSS) with the following capabilities:
- (1) two washout filters for each input, with ability to bypass one of them if necessary;
 - (2) sufficient (and not less than two) lead-lag transfer function blocks (or equivalent number of complex poles and zeros) with adjustable gain and time-constants, to compensate fully for the phase lags due to the Generating Unit;
 - (3) monitoring and recording equipment for key variables including inputs, output and the inputs to the lead-lag transfer function blocks;
 - (4) equipment to permit testing of the power system stabilizer in isolation from the power system by injection of test signals, sufficient to establish the transfer function of the power system stabilizer;
 - (5) measurements of rotor speed/voltage and Active Power/reactive power output of the Generating Unit as inputs;
 - (6) an output limiter, which is continually adjustable over the range of (-)10% to (+)10% of stator voltage; and
 - (7) sufficient flexibility to enable damping performance to be maximised, with the stabilising circuit responsive and adjustable over a frequency range.
43. The Generating Station must have equipment capabilities and Control Systems sufficient to ensure that:

- (1) power system oscillations, for the frequencies of oscillation of the Generating Station against any other Generating Station or device, are adequately damped;
- (2) operation of the Generating Station does not degrade the damping of any critical mode of oscillation of the power system; and
- (3) operation of the Generating Station does not cause instability (including hunting of Tap-Changing Transformer Control Systems) that would adversely impact other Equipment connected to the grid.

Synchronous Condenser

44. Synchronous condenser unit shall comply with the voltage disturbance ride-through, frequency ride-through, and multiple fault ride-through and reactive power control requirements applicable to synchronous generating stations as specified in these regulations.

Asynchronous Generating Station

Active Power Capability

45. The generating station shall be capable of providing its ICR capacity at PoI as per the maximum and minimum ambient temperature determined as per the procedure given in **Schedule I**.

Reactive Power Capability

46. The capability is to be provided in compliance with the maximum and minimum ambient temperature determined as per the procedure given in **Schedule I**.
47. The generating station shall be able to provide minimum dynamic reactive power capability for all active power levels (Including at zero) as per the PQ curve in Fig. 3. The generating station shall be capable of absorbing or supplying dynamically varying reactive power continuously when operating anywhere inside the PQ curve in Fig. 3

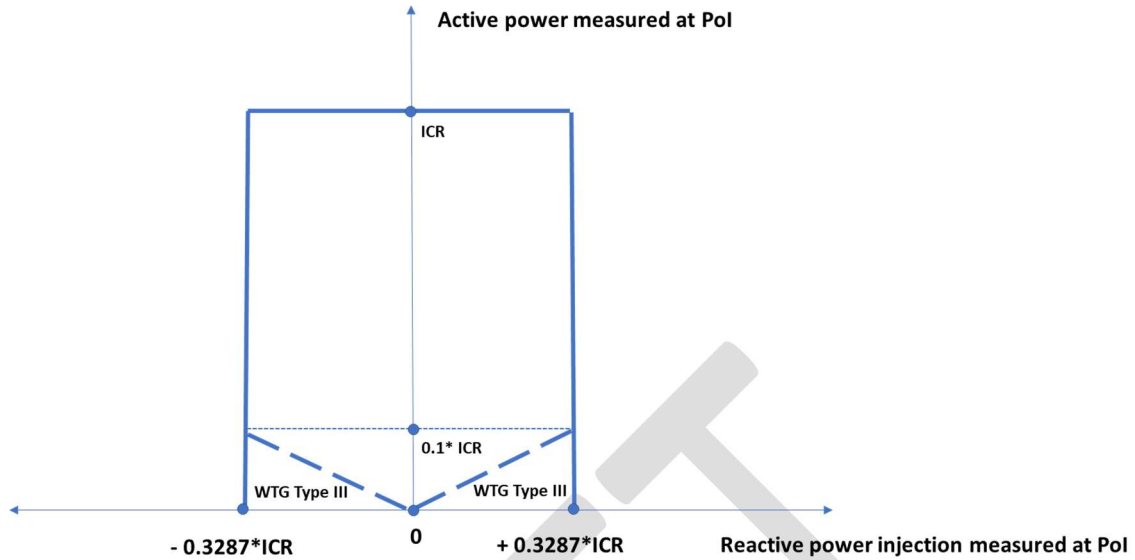


Fig. 3. Minimum Reactive power capability of generating station in terms of active power and reactive power injection measured at PoI.

NOTE — 1) Exchange of reactive power may require the generating station to consume active power from the grid due to losses when there is no available primary energy source.

2) The figure shows the minimum range for the reactive power capability required by this clause. The actual capability of generating station may be higher.

3) WTG Type-III machines shall provide reactive power support as per dotted line below $0.1 \cdot ICR$ active power output

PQ Curve to be followed in case of BESS during charging (absorption of active power, -P) and discharging (injection of active power, +P) as well as in case of variable speed PSP during motoring (absorption of active power, -P) and generating (injection of active power, +P), shall be the same as above.

48. The minimum dynamic Reactive Power Capability may be varied as shown in the QV curve when the voltage at the PoI varies between 0.9 per unit and 1.1 per unit, where the generating station shall be capable of absorbing or supplying Reactive Power continuously when operating anywhere inside the QV curve in Fig. 4

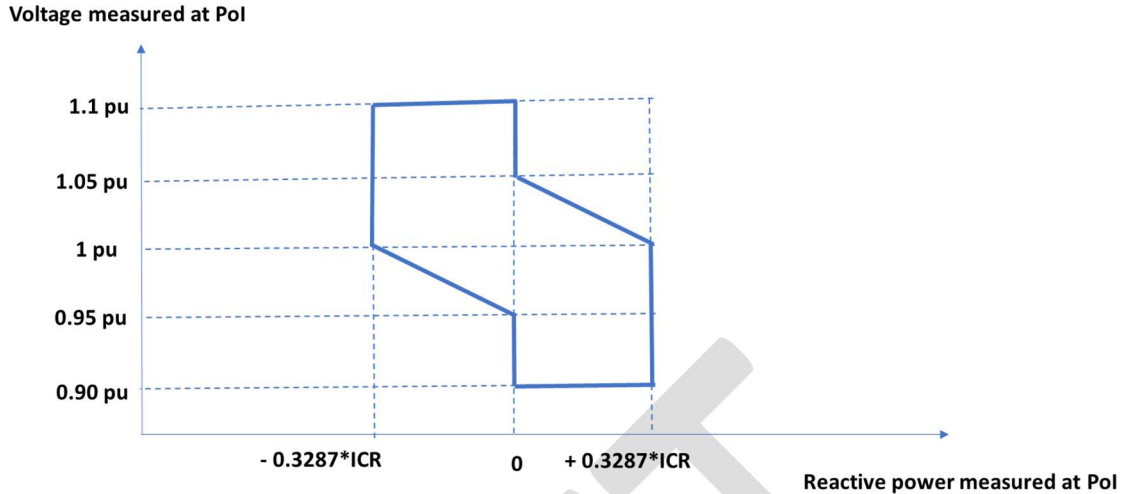


Fig. 4. Minimum Reactive power capability of generating station in terms of Voltage and reactive power measured at PoI

QV Curve to be followed in case of BESS during charging (absorption of active power, +P) and discharging (injection of active power, -P) as well as in case of variable speed PSP during motoring (absorption of active power, -P) and generating (injection of active power, +P), shall be the same as above:

Provided that the generating station should coordinate their LVRT and HVRT activation limits so as to achieve the above QV curve requirements.

Voltage Disturbance Ride Through

49. The Short Circuit Ratio at the PoI where the generating station is proposed to be connected shall in general not be less than 5. However, the generating station shall stably operate at minimum SCR of 5 or the actual SCR at the PoI, whichever is lower.
50. The generating station shall be capable of operating continuously in the voltage range 0.9 p.u to 1.1 p.u at the PoI and be able to deliver ICR capacity.
51. The generating station shall have configurable low and high voltage ride through activation & deactivation settings, the range of which shall be decided based on system studies to ensure stable plant operation during voltage ride through conditions.
52. Voltage disturbances of any duration, for which the applicable voltage remains within the continuous operation region, shall not cause the generating station or unit(s) to trip. The generating station or unit(s) shall remain in operation during any such disturbance, and shall continue to deliver pre-disturbance level of active power or available active power, whichever is less.

53. All instantaneous under / over voltage protection used within the generating station shall use filtered quantities to reduce the possibility of mis-operation while providing protection to the desired equipment and system. Any instantaneous under /over voltage protection(s) that has the possibility of disrupting the power output of the entire generating station shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the grid.
54. The generating station reactive current response during voltage disturbance ride through shall meet the following performance specifications as given in Table 2 below:

Table 2. Reactive Current Response Target range for asynchronous generating station

Parameter	Generating Station with Type-III WTGs	All other Asynchronous Generating Stations
Step response time	NA	≤ 30 ms
Settling time	≤ 120 ms	≤ 100 ms
Settling band	(-)2.5%/(+)10% of generating station maximum current	(-)2.5%/(+)10% of generating station maximum current

Note: 1) The time delay required for the measurements is included in the step response time and settling time specified in this table.

2) System conditions may require a slower response time. If so, the generating station shall have the necessary flexibility in the settings to increase the response time as per the directions of the appropriate load despatch centre.

Low Voltage Ride Through (LVRT)

55. The generating station connected to the grid, shall remain connected to the grid for the duration corresponding to the under voltage at the PoI on any or all phases (symmetrical or asymmetrical under voltage conditions) as depicted by the thick line in the curve in Fig. 5

V_t : Actual Voltage; V_n: Nominal Voltage—

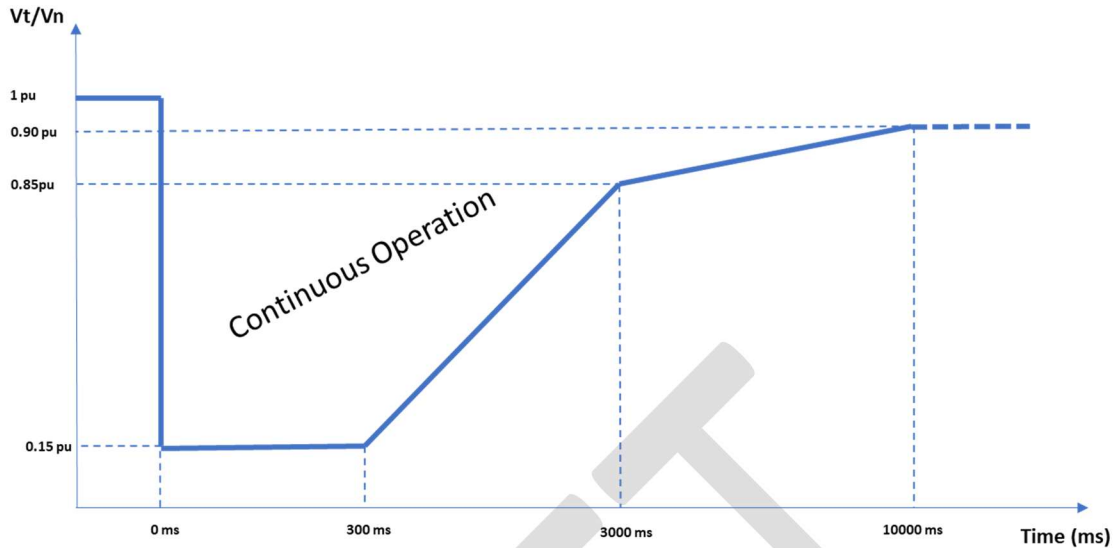


Fig. 5. Low Voltage Ride Through requirements for Asynchronous Generating station

Note: The relevant voltage shall be the lowest magnitude fundamental frequency phasor component of the phase-to-phase or phase-to ground voltages, whichever is less, at the PoI relative to the corresponding nominal voltage.

56. The generating station shall have the capability to select operation in either active current priority mode or reactive current priority mode during low voltage ride through events. The mode during real-time operations shall be selected as per the directions of appropriate load despatch centre. The generating station shall operate in reactive current priority mode by default:

Provided that in the reactive current priority mode, the generating station shall provide incremental reactive current:

Provided further that the reactive current priority mode does not necessarily mean that active power (or active current) is reduced to zero. It means that the reactive current output (I_q) is given first priority and has the full current rating of the generating station available to it while the active current output (I_p) is constrained. The active current I_p range varies from a maximum of $\sqrt{(I_{max}^2 - I_q^2)}$ to a minimum of zero for asynchronous generating stations and to $(-)\sqrt{(I_{max}^2 - I_q^2)}$ for energy storage systems, where I_q is the present value of reactive current:

Provided also that, active power be restored to at least 90% of the pre-fault level within 1 second of restoration of voltage. The active power recovery time shall be adjustable within a configurable range of 1.0 to 10 seconds.

57. During LVRT condition, the generating station shall have the overload (current) capability of minimum 1.1pu of the rated capacity and the reactive/active current shall be supplied considering apparent current rating of 1.1pu.

58. The step response time for LVRT conditions shall be maximum 30 ms i.e. the generating station shall be capable of injecting the incremental reactive current within 30 ms into the network. The injection of the incremental reactive current shall also be withdrawn within 30 ms of the return of the voltage within the continuous operating range. The response of the generating station shall be adequately damped.

59. For balanced faults and symmetrical over-voltage conditions, the generating station shall provide incremental positive sequence reactive current support dependent on the PoI voltage:

Provided that the quantum of positive sequence reactive current injection shall be dependent on the reactive current gain i.e. LVRT “K+” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and appropriate LDC based on the system strength and network stability in the complex. The LVRT “K+” factor shall typically be in the range of 0 to 10.

60. For unbalanced faults and unsymmetrical over-voltage conditions, in addition to the incremental positive sequence reactive current, the generating station shall inject negative sequence current dependent on PoI negative sequence voltage:

Provided that the quantum of negative sequence reactive current injection shall be dependent on the reactive current gain i.e. LVRT “K-” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and load despatch centre based on the system strength and network stability in the complex. The LVRT “K-” factor shall typically be in the range of 0 to 10:

Provided further that incremental negative sequence current from generating stations with Type-III WTG may not be completely controllable and shall be governed as per machine dynamics & converter control.

61. In the event the generating Station apparent current limit of 1.1pu is reached, either positive or negative sequence current shall be reduced with a preference to be given to equal reduction of both currents.

High Voltage Ride Through (HVRT)

62. The generating station connected to the grid, shall remain connected to the grid for the duration corresponding to the overvoltage at the PoI, on any or all phases (symmetrical or asymmetrical overvoltage conditions) as depicted by the thick line in the curve in Fig 6:

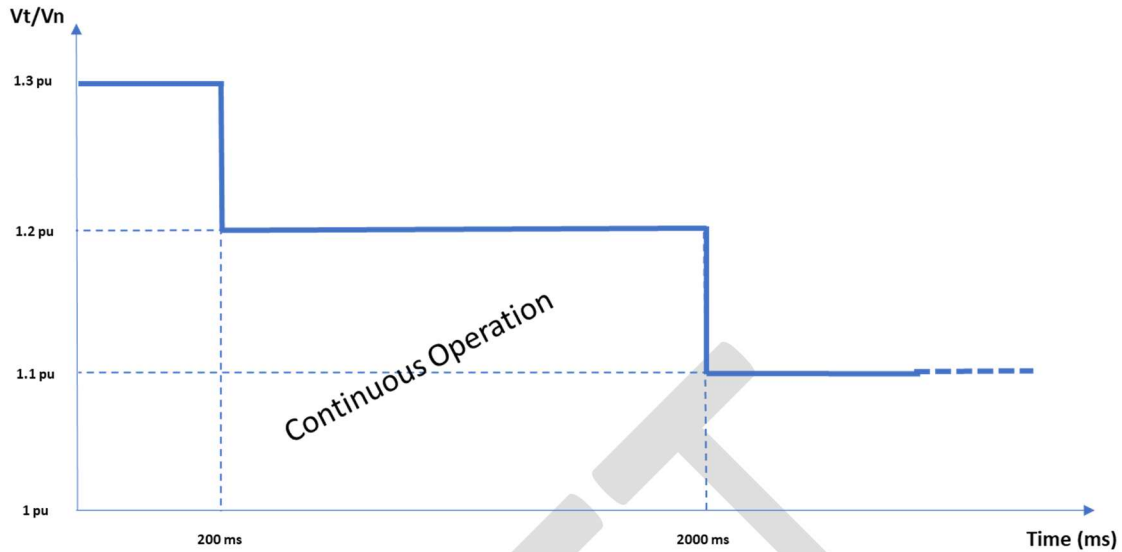


Fig. 6. High Voltage ride-through requirements for asynchronous generating station.

Note: The relevant voltage shall be the greatest magnitude fundamental frequency phasor component of the phase-to-phase and phase-to ground voltages, whichever is high, at the PoI relative to the corresponding nominal voltage.

63. The generating station shall have the capability to select operation in either active current priority mode or reactive current priority mode during high voltage ride through events. The mode during real-time operations shall be selected as per the directions of appropriate load despatch centre. The generating station shall operate in reactive current priority mode by default:

Provided that, in the reactive current priority mode, the generating station shall provide incremental reactive current:

Provided further that the reactive current priority mode does not necessarily mean that active power (or active current) is reduced to zero. It means that the reactive current output (I_q) is given first priority and has the full current rating of the generating station available to it while the active current output (I_p) is constrained. The active current I_p range varies from a maximum of $\sqrt{(I_{max}^2 - I_q^2)}$ to a minimum of zero for asynchronous generating stations and to $(-)\sqrt{(I_{max}^2 - I_q^2)}$ for energy storage systems, where I_q is the present value of reactive current:

Provided also that, active power be restored to at least 90% of the pre-fault level within 1 second of restoration of voltage. The active power recovery time shall be adjustable within a configurable range of 1.0 to 10 seconds.

64. During HVRT condition, the generating station shall have the overload (current) capability of minimum 1.1pu of the rated capacity and the reactive/active current shall be supplied considering apparent current rating of 1.1pu.

65. The step response time for HVRT conditions shall be maximum 30 ms i.e. the generating station shall be capable of absorbing the incremental reactive current within 30 ms from the network. The absorption of the incremental reactive current shall also be withdrawn within 30 ms of the return of the voltage within the continuous operating range. The response of the generating station shall be adequately damped.

66. For balanced faults and symmetrical over-voltage conditions, the generating station shall provide incremental positive sequence reactive current support dependent on the PoI voltage:

Provided that the quantum of positive sequence reactive current absorption shall be dependent on the reactive current gain i.e. HVRT “K+” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and appropriate Load Despatch Centre based on the system strength and network stability in the complex. The HVRT “K+” factor shall typically be in the range of 0 to 10.

67. For unbalanced faults and unsymmetrical over-voltage conditions, in addition to the incremental positive sequence reactive current, the generating station shall absorb negative sequence current dependent on PoI negative sequence voltage:

Provided that the quantum of negative sequence reactive current absorption shall be dependent on the reactive current gain i.e. HVRT “K-” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and load despatch centre based on the system strength and network stability in the complex. The HVRT “K-” factor shall typically be in the range of 0 to 10:

Provided further that incremental negative sequence current from generating stations with Type-III WTG may not be completely controllable and shall be governed as per machine dynamics & converter control.

68. In the event the generating Station apparent current limit of 1.1pu is reached, either positive or negative sequence current shall be reduced with a preference to be given to equal reduction of both currents.

Multiple Fault Ride Through

69. The generating station connected to the grid, shall remain connected to the grid for a series of up to 15 voltage disturbance below 0.9 p.u within any 5-minute period as per the LVRT capability:

Provided that during such period generating station shall remain connected for at least 06 voltage disturbance below 0.5 p.u:

Provided further that during the multiple LVRT conditions, the generating station shall meet the performance requirements specified in LVRT conditions.

70. While assessing multiple voltage disturbances, a fault that is re-established following operation of automatic re-close Protection Scheme shall be counted as a separate voltage disturbance.

Frequency Ride Through

71. The generating station shall be capable of operating in the frequency range 47.5 to 52 Hz and be able to deliver its ICR capacity in the frequency range of 49.5 Hz to 50.5 Hz on a continuous basis:

Provided that the generating station shall be able to maintain its performance contained in this sub-clause even with voltage variation of up to (+/-) 5% subject to availability of commensurate primary energy source.

72. Within the specified frequency range of operation, the generating station shall ride through and shall not trip for frequency excursions having an absolute rate of change of frequency (ROCOF) magnitude less than or equal to 5.0 Hz/second. ROCOF shall be the average rate of change of frequency over an averaging window of at least 0.1 second.
73. The rate of change of frequency (ROCOF) protection shall not impede the generating station from meeting the voltage and frequency ride-through requirements specified in these regulations inclusive of ROCOF ride-through requirements.

Voltage Phase Angle Change Ride Through

74. The generating unit shall ride through positive-sequence phase angle changes within a sub-cycle-to-cycle time frame of the applicable voltage of less than or equal to (+/-) 25 electrical degrees. In addition, the generating unit shall remain in operation for any change in the phase angle of individual phases caused by occurrence and clearance of unbalanced faults, provided that the positive-sequence angle change does not exceed the forestated criterion.

Active Power Control

75. The generating station with installed capacity of more than 10 MW connected at voltage level of 33 kV and above:
- (1) 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 Despatch Centre or Regional Load Despatch Centre, as the case may be;
 - (2) The frequency controller shall be set with respect to a reference frequency of 50.00 Hz and the response outside the dead band shall be with respect to a total change in frequency.
 - (3) shall have frequency controller with a settable droop of 1 to 6% of ICR. The inherent dead band of the of the frequency shall not exceed (+/-) 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.

- (4) 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;
 - (5) shall be equipped with the facility for controlling the rate of change of power output at a ramp rate not more than $\pm 10\%$ per minute at PoI.
76. The primary response requirement shall be as mentioned in Table 3 below:

Table 3. Primary response requirements

Type	Response range
Solar, Wind and Battery Energy Storage System (BESS)	(+/-) 10% of ICR

- 77. The generating unit shall give primary response instantaneously as per the capability upto (+/-) 10% of their operating level/ICR, when the frequency deviates from the reference frequency.
- 78. The overall dynamic primary frequency response capability of the generating station for a step change in applicable frequency shall be within the ranges specified in **Schedule II**.

Reactive Power Control

- 79. The generating station of aggregate capacity of 10 MW and above shall have the provision to receive the signal from the State Load Despatch Centre or Regional Load Despatch Centre, as the case may be, for varying reactive power output.
- 80. The generating station shall provide voltage regulation capability by changes in reactive power output whenever the PoI voltage is in the continuous operation region for voltage.
- 81. The generating station shall provide the capabilities of the following mutually exclusive operating modes of reactive power control functions:
 - (1) Voltage control
 - (2) Power factor control
 - (3) Reactive power set point control

The generating station shall be capable of activating each of these modes one at a time. The generating station shall be responsible for implementing setting modifications and mode selections, as specified by the appropriate system operator within a time acceptable to the appropriate system operator.

The dynamic response of the generating station in all the control modes shall be stable and any oscillations shall be positively damped.

Black Start Capability

- 82. BESS of aggregate capacity of 50 MW and above shall be capable of providing Black Start support. This capability shall be utilized by appropriate load despatch centre based on system requirements.
- 83. The black start functionality shall be demonstrated during commissioning and verified periodically through testing in accordance with these standards and other requirements as specified by the appropriate Load Despatch Centre.

Grid Forming Control

- 84. The generating station with Grid Forming control shall comply with all regulations applicable to asynchronous generating station.
- 85. The generating station with Grid Forming control shall independently provide near-instantaneous frequency and voltage support. The primary control objective shall be to maintain the voltage phasor of the internal voltage source, established through control strategies, as constant during the sub-transient time frame, utilizing the converter’s full available current capacity.
- 86. The generating station with Grid Forming converters shall be capable of seamless transition to and from islanded operation, ensuring stable reconnection to the main grid.
- 87. The generating station with Grid Forming control shall also be capable of injecting negative-sequence currents for the purpose of maintaining voltage symmetry under unbalanced conditions, both during steady-state and fault conditions.
- 88. The generating station with Grid Forming control shall be capable of riding through positive-sequence phase angle variations of up to ± 60 electrical degrees within a sub-cycle to one-cycle timeframe, relative to the applicable voltage.

Energy Storage System (ESS)

- 89. The requirements applicable to ESS are as specified in Table 4 below:

Table 4. Requirements for ESS

Fixed Speed PSP	Regulation 21 to 44
BESS	Regulation 45 to 88
Variable Speed PSP	Regulation 21 to 23, 32 to 44, 49 to 55 and 62

Chapter – III

Requirements for HVDC Systems and FACTS (Flexible AC Transmission System) Devices

General Requirements

90. The HVDC system and FACTS devices shall be designed to meet all performance requirements specified in these regulations and shall be compatible with the existing power system.
91. HVDC links can either be used to connect asynchronous grids with each other or can be embedded within a single synchronous AC grid.
92. The HVDC system shall be capable of finding stable operation points with a minimum change in active power flow and voltage level, during and after any planned or unplanned change in the HVDC system or AC network to which it is connected.
93. The HVDC system owner shall ensure that the tripping or disconnection of an HVDC converter station, as part of any multi-terminal or embedded HVDC system, does not result in transients at the PoI.
94. The HVDC system and FACTS devices shall withstand transient faults on HVAC lines in the network adjacent or close to the HVDC system, and shall not cause any of the equipment in the HVDC system to disconnect from the network due to auto-reclosure of lines in the network.
95. HVDC systems, including DC overhead lines, shall be capable of fast recovery from transient faults within the HVDC system.
96. The appropriate transmission utility and distribution licensee shall specify and make available the method and the pre-fault and post-fault conditions for the calculation of the minimum and maximum short circuit power at the PoI. The ratio of fault level in MVA at any of the converter station (for conventional current source type), to the power flow on the LCC based HVDC bipole shall not be less than 3.0.
97. The HVDC system and FACTS shall be capable of operating within the range of short circuit power and network characteristics specified by the appropriate transmission utility and distribution licensee.
98. The appropriate transmission utility and distribution licensee shall provide the network equivalents describing the behavior of the network at the PoI, enabling the requester/user to design their system with regard to at least, but not limited to, harmonics and dynamic stability over the lifetime of the HVDC system and FACTS device.

99. The requester/user shall maintain a complete HVDC system and FACTS Devices control and protection replica system without redundancy along with a real time simulator based on project specification at its premises.
100. HVDC System and FACTS devices should have the feature of active filtering to manage the background harmonics. The order and magnitude of harmonics to be attenuated at PoI may be decided by appropriate transmission utility.
101. Performance of HVDC and FACTS devices shall be tested by a third-party accredited testing agency before getting connected to the Grid.
102. System studies for evaluating dynamic performance testing of HVDC and FACTS devices during EMT modelling stage and Real time Simulation shall be carried out considering at least two network cases i.e Peak and Off-peak.
103. System studies for interaction between nearby HVDC systems, FACTs devices, Generating Stations (Asynchronous and synchronous) and Conventional AC equipment should be carried out in line with CIGRE Technical Brochure (TB-934) (Interaction between nearby VSC-HVDC converters, FACTs devices, HV power electronic devices and conventional AC equipment).

Reactive Power Capability

104. The VSC based HVDC system (at both converter ends) shall be capable of supplying and absorbing dynamically varying reactive power at the PoI commensurate to 32.87% of rated power capacity of the HVDC system. The capability is to be provided in compliance with the maximum and minimum ambient temperature determined as per the procedure given in **Schedule I**.
105. The VSC HVDC system shall be able to provide minimum dynamic reactive power capability for all active power levels (including at zero) as per the PQ curve in Fig.7. The VSC HVDC system shall be capable of absorbing or supplying dynamically varying reactive power continuously when operating anywhere inside the PQ curve in Fig. 7:

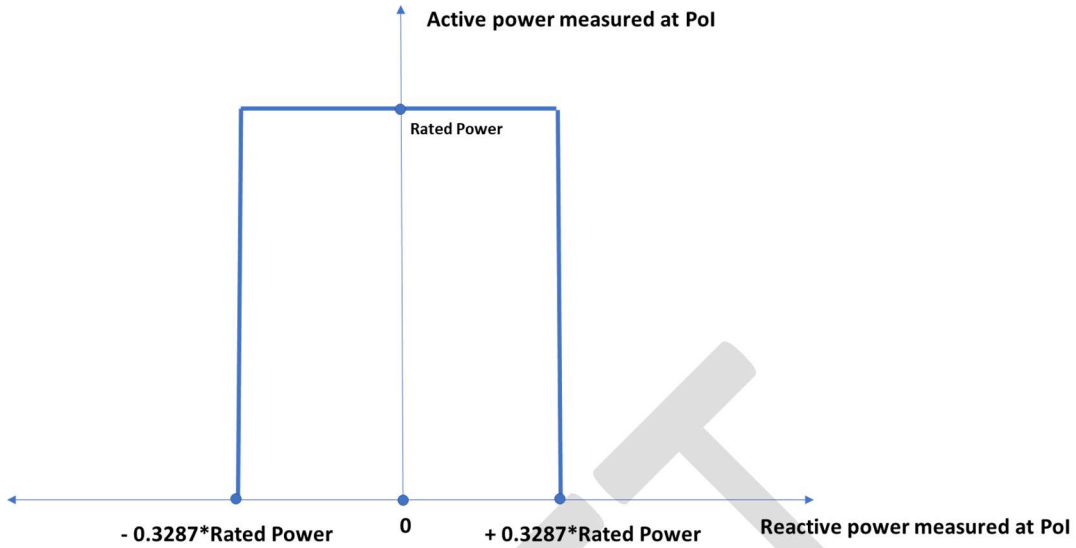


Fig. 7. Minimum Reactive power capability of HVDC system in terms of active power and reactive power measured at PoI.

NOTE — 1) Exchange of reactive power may require the VSC HVDC system to consume active power from the grid due to losses when there is no transfer of active power.

2) The figure shows the minimum range for the reactive power capability required by this clause. The VSC HVDC system actual capability may be higher.

Provided that the PQ curve to be followed during charging (absorption of active power, -P) and discharging (injection of active power, +P) shall be the same as above.

106. The minimum dynamic Reactive Power Capability may be varied as shown in the QV curve when the voltage at the PoI varies between 0.9 per unit and 1.1 per unit, where the VSC HVDC system shall be capable of absorbing or supplying Reactive Power continuously when operating anywhere inside the QV curve in Fig. 8:

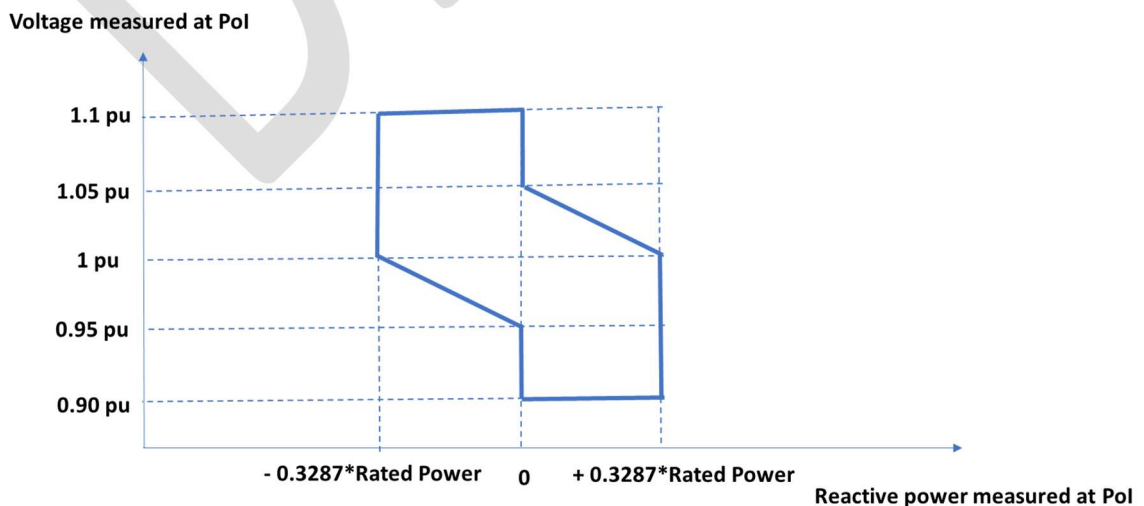


Fig. 8. Minimum Reactive power capability of VSC HVDC system in terms of Voltage and reactive power measured at PoI.

Provided that the QV Curve to be followed during charging (absorption of active power, - P) and discharging (injection of active power, +P) shall be the same as above.

Voltage Disturbance Ride through

- 107. The HVDC system and FACTS devices shall operate continuously in the AC voltage range 0.9 p.u to 1.1 p.u at the PoI and be able to deliver rated output.
- 108. The HVDC station and FACTS devices shall have configurable low and high voltage ride through activation & deactivation settings, the range of which shall be decided based on system studies to ensure stable plant operation during voltage ride through conditions.
- 109. All instantaneous under / over voltage protection used within the HVDC system and FACTS device shall use filtered quantities to reduce the possibility of mal-operation while providing protection to the desired equipment and system. Any instantaneous under /over voltage protection(s) which have the possibility of disrupting the power output of the entire HVDC system shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the grid.
- 110. The VSC HVDC system and FACTS device reactive current response shall meet the following performance specifications as given in Table 5 below:

Table 5. Reactive Current Response Target range for HVDC System and FACTS

Parameter	VSC HVDC System and FACTS
Step response time	≤ 30 ms
Settling time	≤ 100 ms
Settling band	(-)2.5%/(+)10% of HVDC System and FACTS maximum current

Note: 1) The time delay required for the measurements is included in the step response time and settling time specified in this Table.

(b) System conditions may require a slower response time. If so, the HVDC System and FACTS shall have the necessary flexibility in the settings to increase the response time as per the directions of the appropriate load despatch centre.

Low Voltage Ride Through (LVRT)

- 111. The VSC HVDC System and FACTS Devices connected to the grid, shall remain connected to the grid for the duration corresponding to the under voltage at the PoI on any or all phases (symmetrical or asymmetrical under voltage conditions) as depicted by the thick line in the curve in Fig. 9

Vt : Actual Voltage; Vn: Nominal Voltage—

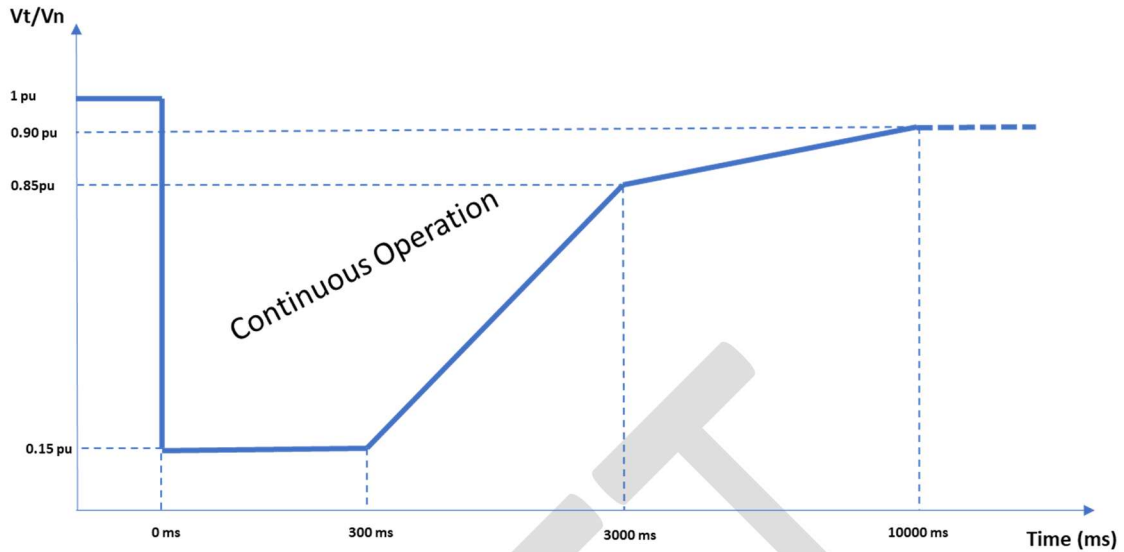


Fig. 9. Low Voltage Ride Through requirements for VSC HVDC system and FACTS devices

Note: The relevant voltage shall be the lowest magnitude fundamental frequency phasor component of the phase-to-phase or phase-to ground voltages, whichever is less, at the PoI relative to the corresponding nominal voltage.

High Voltage Ride Through (HVRT)

112. The VSC HVDC System and FACTS Devices connected to the grid, shall remain connected to the grid for the duration corresponding to the overvoltage at the PoI, on any or all phases (symmetrical or asymmetrical overvoltage conditions) as depicted by the thick line in the curve in Fig 10:

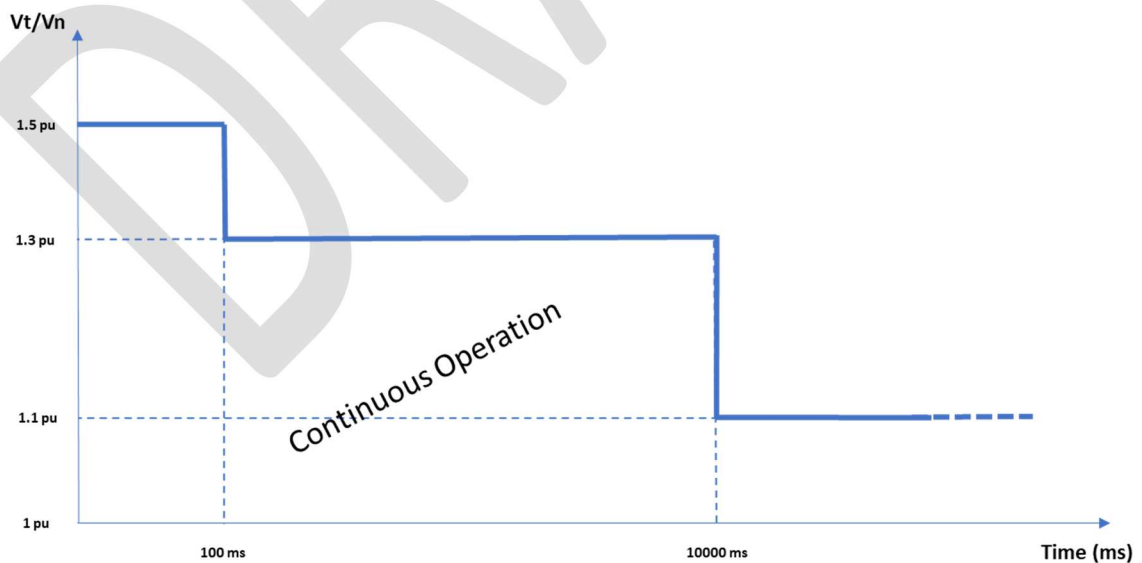


Fig. 10: High Voltage ride-through requirements for VSC HVDC system and FACTS devices.

Note: The relevant voltage shall be the greatest magnitude fundamental frequency phasor component of the phase-to-phase and phase-to ground voltages, whichever is high, at the PoI relative to the corresponding nominal voltage.

Multiple Fault Ride Through (MFRT)

113. The HVDC System and FACTS devices connected to the grid, shall remain connected to the grid for a series of up to 15 voltage disturbance below 0.9 p.u within any 5-minute period as per the LVRT capability:

Provided that during such period HVDC System and FACTS devices shall remain connected for at least 06 voltage disturbance below 0.5 p.u:

Provided further that during the multiple LVRT conditions, the HVDC System and FACTS devices shall meet the performance requirements specified in LVRT conditions.

114. While assessing multiple voltage disturbances, a fault that is re-established following operation of automatic re-close Protection Scheme shall be counted as a separate voltage disturbance.

Frequency Ride through

115. HVDC system and FACTS shall be capable of operating in the frequency range 47.5 to 52.5 Hz and be able to deliver rated output in the frequency range of 48.5 Hz to 51 Hz:

Provided that the HVDC system and FACTS shall be able to maintain its performance contained in this sub-clause even with voltage variation of up to (+/-) 5%.

116. Within the frequency range of operation specified, the HVDC system and FACTS devices shall ride through and shall not trip for frequency excursions having an absolute rate of change of frequency (ROCOF) magnitude less than or equal to 5.0 Hz/second. ROCOF shall be the average rate of change of frequency over an averaging window of at least 0.1 second:

Provided that during black start operation using HVDC, the ROCOF withstand capability may be higher.

117. The rate of change of frequency (ROCOF) protection shall not impede the HVDC system and FACTS devices from meeting the voltage and frequency ride-through requirements specified in these regulations inclusive of ROCOF ride-through requirements.

Voltage Phase Angle Change Ride Through

118. The VSC HVDC system and FACTS shall ride through positive-sequence phase angle changes within a sub-cycle-to-cycle time frame of the applicable voltage of less than or equal to (+/-) 25 electrical degrees. In addition, it shall remain in operation for any change in the phase angle of individual phases caused by occurrence and clearance of unbalanced

faults, provided that the positive-sequence angle change does not exceed the forestated criterion.

Active Power Control

119. The VSC HVDC system shall be capable of adjusting the transmitted active power up to its maximum HVDC active power transmission capacity in each direction following an instruction from the appropriate load despatch centre. The minimum step size for change in power shall be 1% of the maximum rated power.
120. The power reversal in LCC based HVDC links shall be possible from the maximum active power transmission capacity in one direction to the maximum active power transmission capacity in the other direction within 60 minutes. For LCC based HVDC Back-to-back stations, this duration shall be 30 minutes. The VSC HVDC shall be designed for minimum 02 reversal operations per day. VSC based HVDC System shall have the capability to transfer the maximum active power transmission capacity in one direction to the maximum active power transmission capacity in the other direction on immediate basis.
121. The HVDC system shall be capable of adjusting the ramping rate of active power variations by at least 10% per minute of active power order in upwards/downwards direction under all conditions.
122. The continuous and transient overload capability per pole shall be specified in the technical specifications.
123. The HVDC system designed for locations where low inertia/islanding situations are possible shall be capable of providing synthetic inertia in response to frequency changes, activated in low or high-frequency conditions by rapidly adjusting the active power to limit the rate of change of frequency.
124. The HVDC system shall be equipped with an independent control mode to modulate the active power output of the HVDC converter station depending on the frequencies at all connection points of the HVDC system to maintain stable system frequencies. The settings of frequency control shall be returnable to be changed on recommendation of appropriate load despatch centre.

Reactive Power Control

125. The VSC HVDC system and FACTS devices shall provide voltage regulation capability by changes in reactive power output whenever the PoI voltage is in the range for continuous operation.
126. The VSC HVDC system and FACTS devices shall provide the capabilities of the following mutually exclusive operating modes of reactive power control functions:
 - (1) Voltage control

(2) Reactive power set point control

The VSC HVDC system and FACTS devices shall be capable of activating each of these modes one at a time. The VSC HVDC system and FACTS devices shall be responsible for implementing setting modifications and mode selections, as specified by the appropriate system operator within a time acceptable to the appropriate system operator.

The dynamic response of the VSC HVDC system and FACTS devices in all the control modes shall be stable and any oscillations shall be positively damped.

127. VSC HVDC system and FACTS devices shall be capable of operating in additional control modes as specified by the appropriate transmissions utility and load despatch centre.

Power Oscillation Damping

128. HVDC and FACTS devices shall implement a power oscillation damping (POD) function in their controls, which can be tuned to reduce the power system oscillations.
129. The HVDC system shall be capable of contributing to electrical damping of torsional frequencies with regard to sub synchronous torsional interaction (SSTI) damping control. The appropriate transmission utility shall provide input parameters, to the extent available, related to the equipment and relevant system conditions in its network. The SSTI studies shall be carried out by the requester/user.

Black Start Capability

130. The Black start capability shall be possible for both the converter stations of the VSC HVDC system. Transmission Service Provider (TSP) shall determine and provide any additional equipment that is required to be able to carry out black start in both directions. This shall include any hardware and all the necessary control functions to perform the black start.

Chapter – IV Requirements for Bulk Consumers and Distribution Systems

General Requirements

131. The bulk consumer(s) shall not energize transmission or distribution system by injecting supply from his generators or any other source either by automatic controls or manually unless specifically provided for in the connection agreement with the Transmission or Distribution Licensee.
132. The Short Circuit Ratio at the PoI where the Inverter-interfaced bulk consumer is proposed to be connected shall in general be not less than 5. The Inverter-interfaced bulk consumer shall stably operate at minimum SCR of 5 or the actual SCR at the PoI, whichever is lower.
133. The Voltage-disturbance ride-through, frequency ride through and Voltage Phase-angle ride through requirements shall be applicable to Inverter-interfaced bulk consumers having capacity of 50 MW or above at PoI.

Reactive Power Capability

134. The inverter-interfaced bulk consumers shall be capable of supplying and absorbing dynamically varying reactive power at the PoI commensurate to 32.87% (0.95pf lagging/leading) of rated power capacity of inverter-interfaced bulk consumers. The capability is to be provided in compliance with the maximum and minimum ambient temperature determined as per the procedure given in **Schedule I**.
135. The inverter-interfaced bulk consumers shall be able to provide minimum dynamic reactive power capability for all active power levels (including at zero power being drawn by the inverter-interfaced bulk consumers) as per the shown PQ curve in Fig. 11. The inverter-interfaced bulk consumers must be capable of absorbing or supplying Reactive Power continuously when operating anywhere inside the PQ curve in Fig. 11.

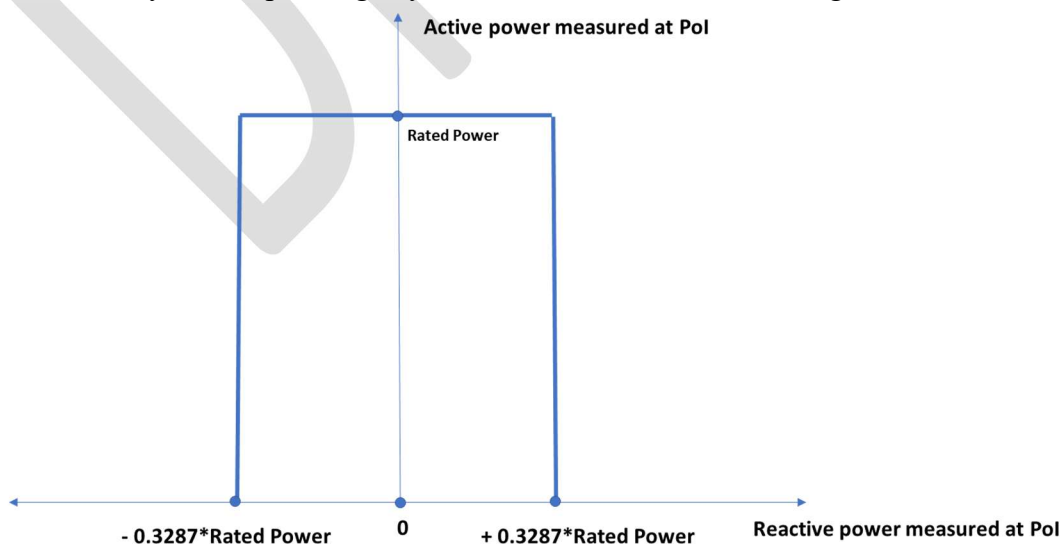


Fig. 11. Minimum Reactive power capability of inverter-interfaced bulk consumer in terms of active power and reactive power drawal measured at PoI.

NOTE – 1) Exchange of reactive power may require the inverter-interfaced bulk consumers to consume active power from the grid due to losses.

2) The figure shows the minimum range for the reactive power capability required by this standard. The inverter-interfaced bulk consumers' actual capability may be higher.

136. The minimum dynamic Reactive Power Capability of the inverter-interfaced bulk consumer may be varied as shown in the QV curve in Fig. 12. when the voltage at the PoI varies between 0.9 per unit and 1.1 per unit, where the inverter-interfaced bulk consumer must be capable of absorbing or supplying Reactive Power continuously when operating anywhere inside the QV curve.

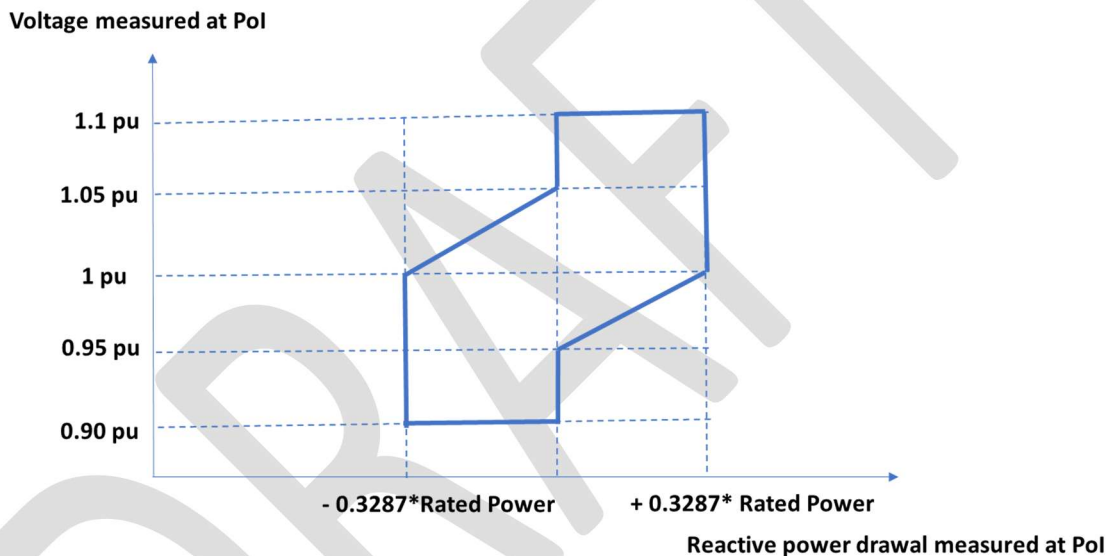


Fig. 12. Minimum Reactive power capability of inverter-interfaced bulk consumer in terms of voltage and reactive power measured at PoI.

137. The distribution licensee shall provide adequate reactive compensation to meet the reactive power requirement in their system so that power factor is maintained within ± 0.95 .
138. The bulk consumer other than inverter-interfaced bulk consumer shall provide adequate reactive compensation in their system so as maintain unity power factor at PoI:

Provided that the bulk consumer other than inverter-interfaced bulk consumer shall have the capability to maintain power factor in the range of ± 0.95 as per the directions of appropriate load despatch centre.

Voltage Disturbance Ride Through

- 139. The inverter-interfaced bulk consumers shall be capable of operating continuously in the voltage range 0.9 p.u to 1.1 p.u at the PoI and be able to draw rated power.
- 140. The inverter-interfaced bulk consumer shall have configurable low and high voltage ride through activation & deactivation settings, the range of which shall be decided based on system studies to ensure stable plant operation during voltage ride through conditions.
- 141. All instantaneous under / over voltage protection used within the inverter-interfaced bulk consumer shall use filtered quantities to reduce the possibility of mal-operation while providing protection to the desired equipment and system. Any instantaneous under /over voltage protection(s) which has the possibility of disrupting the power drawl of the entire inverter-interfaced bulk consumer shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the grid.
- 142. The inverter-interfaced bulk consumer’s current response shall meet the following performance specifications as given in Table 6 below:

Table 6: Reactive Current Response Target range for inverter-interfaced bulk consumer

Parameter	Inverter-interfaced bulk consumers
Step response time	≤ 30 ms
Settling time	≤ 100 ms
Settling band	(-)2.5%/(+)10% of inverter-interfaced bulk consumer’s maximum current

Note: 1) The time delay required for the measurements is included in the step response time and settling time specified in this table.

2) System conditions may require a slower response time. If so, the inverter-interfaced bulk consumer shall have the necessary flexibility in the settings to increase the response time as per the directions of the appropriate load despatch centre.

Low Voltage Ride Through (LVRT)

- 143. The inverter-interfaced bulk consumer connected to the grid, shall remain connected to the grid for the duration corresponding to the under voltage at the PoI on any or all phases (symmetrical or asymmetrical under voltage conditions) as depicted by the thick line in the curve in Fig. 13

Vt: Actual Voltage; Vn: Nominal Voltage—

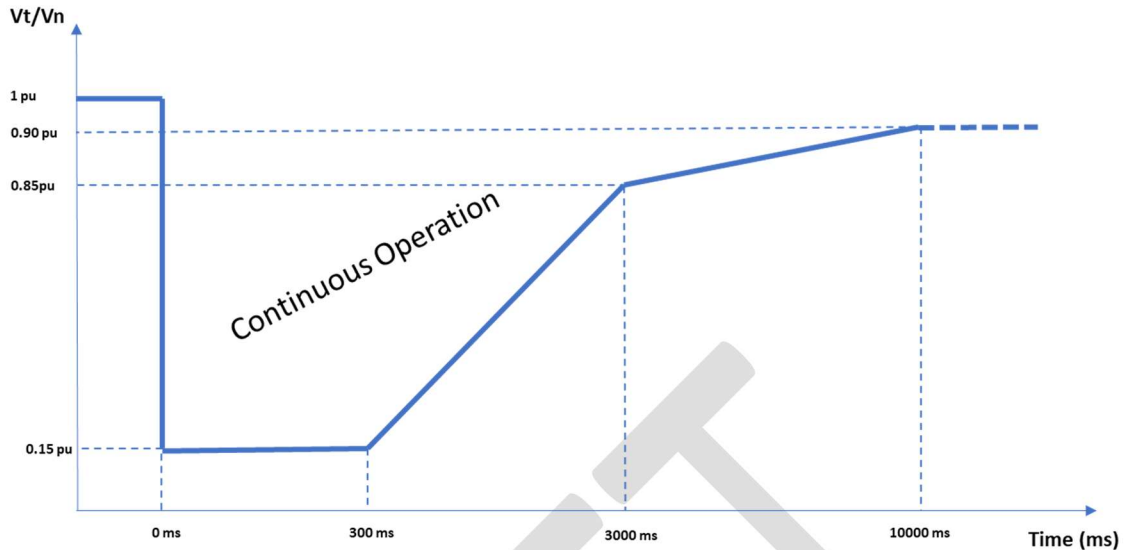


Fig. 13. Low Voltage Ride Through requirements for inverter-interfaced bulk consumer

Note: The relevant voltage shall be the lowest magnitude fundamental frequency phasor component of the phase-to-phase or phase-to ground voltages, whichever is less, at the PoI relative to the corresponding nominal voltage.

144. The inverter-interfaced bulk consumer shall have the capability to select operation in either active current priority mode or reactive current priority mode during low voltage ride through events. The mode during real-time operations shall be selected as per the directions of appropriate load despatch centre. The inverter-interfaced bulk consumer shall operate in reactive current priority mode by default:

Provided that, in the reactive current priority mode, the inverter-interfaced bulk consumer shall deliver incremental reactive current:

Provided further that the reactive current priority mode does not necessarily mean that active power (or active current) is reduced to zero. It means that the reactive current output (I_q) is given first priority and has the full current rating of the inverter-interfaced bulk consumer available to it while the active current output (I_p) is constrained. The active current I_p range varies from zero to $(-) \sqrt{(I_{max}^2 - I_q^2)}$ for inverter-interfaced bulk consumer, where I_q is the present value of reactive current:

Provided also that, active power be restored to at least 90% of the pre-fault level within 1 second of restoration of voltage. The active power recovery time shall be adjustable within a configurable range of 1.0 to 10 seconds.

145. During LVRT condition, the inverter-interfaced bulk consumer shall have the overload (current) capability of minimum 1.1pu of the rated capacity and the reactive current shall be supplied considering apparent current rating of 1.1pu.

146. The step response time for LVRT conditions shall be maximum 30 ms i.e. the inverter-interfaced bulk consumer shall be capable of injecting the incremental reactive current within 30 ms into the network. The injection of the incremental reactive current shall also be withdrawn within 30 ms of the return of the voltage within the continuous operating range. The response of the inverter-interfaced bulk consumer shall be adequately damped.

147. For balanced faults and symmetrical over-voltage conditions, the inverter-interfaced bulk consumer shall provide incremental positive sequence reactive current support dependent on the PoI voltage:

Provided that the quantum of positive sequence reactive current injection shall be dependent on the reactive current gain i.e. LVRT “K+” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and appropriate Load Despatch Centre based on the system strength and network stability in the complex. The LVRT “K+” factor shall typically be in the range of 0 to 10.

148. For unbalanced faults and unsymmetrical over-voltage conditions, in addition to the incremental positive sequence reactive current, the inverter-interfaced bulk consumer shall inject negative sequence current dependent on PoI negative sequence voltage:

Provided that the quantum of negative sequence reactive current injection shall be dependent on the reactive current gain i.e. LVRT “K-” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and load despatch centre based on the system strength and network stability in the complex. The LVRT “K-” factor shall typically be in the range of 0 to 10.

149. In the event the inverter-interfaced bulk consumer apparent current limit of 1.1pu is reached, either positive or negative sequence current shall be reduced with a preference to be given to equal reduction of both currents.

High Voltage Ride Through (HVRT)

150. The inverter-interfaced bulk consumer connected to the grid, shall remain connected to the grid for the duration corresponding to the overvoltage at the PoI, on any or all phases (symmetrical or asymmetrical overvoltage conditions) as depicted by the thick line in the curve in Fig 14

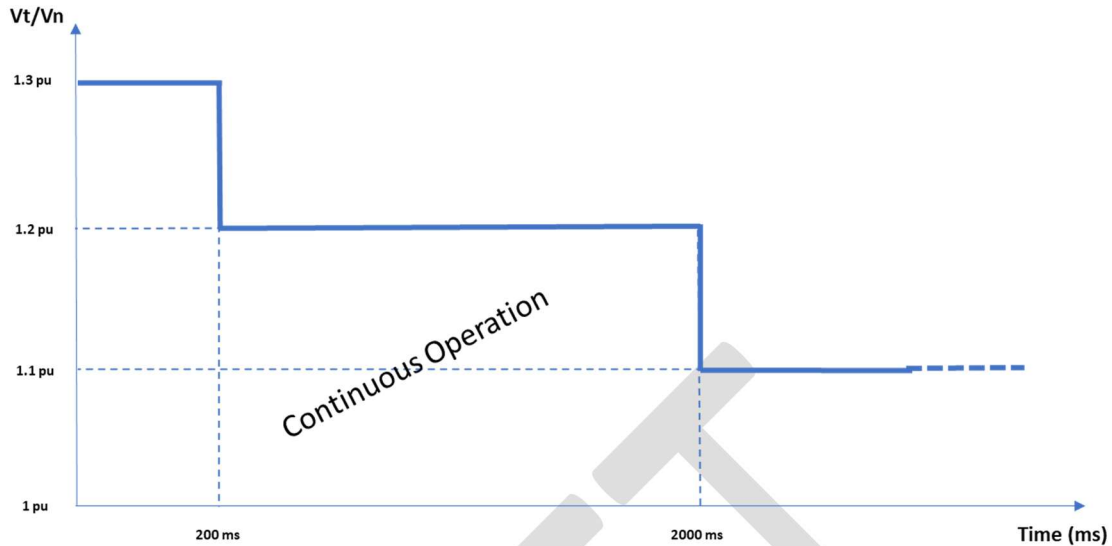


Fig. 14. High Voltage ride-through requirements for inverter-interfaced bulk consumer.

Note: The relevant voltage shall be the greatest magnitude fundamental frequency phasor component of the phase-to-phase and phase-to ground voltages, whichever is high, at the PoI relative to the corresponding nominal voltage.

151. The inverter-interfaced bulk consumer shall have the capability to select operation in either active current priority mode or reactive current priority mode during high voltage ride through events. The mode during real-time operations shall be selected as per the directions of appropriate load despatch centre. The inverter-interfaced bulk consumer shall operate in reactive current priority mode by default:

Provided that, in the reactive current priority mode, the inverter-interfaced bulk consumer shall provide incremental reactive current:

Provided further that the reactive current priority mode does not necessarily mean that active power (or active current) is reduced to zero. It means that the reactive current output (I_q) is given first priority and has the full current rating of the inverter-interfaced bulk consumer available to it while the active current output (I_p) is constrained. The active current I_p range varies from zero to $(-)\sqrt{(I_{max}^2 - I_q^2)}$ for inverter-interfaced bulk consumer, where I_q is the present value of reactive current:

Provided also that, active power be restored to at least 90% of the pre-fault level within 1 second of restoration of voltage. The active power recovery time shall be adjustable within a configurable range of 1.0 to 10 seconds.

152. During HVRT condition, the inverter-interfaced bulk consumer shall have the overload (current) capability of minimum 1.1pu of the rated capacity and the reactive current shall be absorbed considering apparent current rating of 1.1pu.

153. The step response time for HVRT conditions shall be maximum 30 ms i.e. the inverter-interfaced bulk consumer shall be capable of providing the incremental reactive current within 30 ms to the network. The absorption of the incremental reactive current shall also be withdrawn within 30 ms of the return of the voltage within the continuous operating range. The response of the inverter-interfaced bulk consumer shall be adequately damped.

154. For balanced faults and symmetrical over-voltage conditions, the inverter-interfaced bulk consumer shall provide incremental positive sequence reactive current support dependent on the PoI voltage:

Provided that the quantum of positive sequence reactive current absorption shall be dependent on the reactive current gain i.e. HVRT “K+” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and appropriate LDC based on the system strength and network stability in the complex. The HVRT “K+” factor shall typically be in the range of 0 to 10.

155. For unbalanced faults and unsymmetrical over-voltage conditions, in addition to the incremental positive sequence reactive current, the inverter-interfaced bulk consumer shall absorb negative sequence current dependent on PoI negative sequence voltage:

Provided that the quantum of negative sequence reactive current absorption shall be dependent on the reactive current gain i.e. HVRT “K-” factor, value of which shall be decided through simulation studies by the appropriate transmission utility and load despatch centre based on the system strength and network stability in the complex. The HVRT “K-” factor shall typically be in the range of 0 to 10.

156. If the inverter-interfaced bulk consumer apparent current limit of 1.1pu is reached, either positive or negative sequence current shall be reduced with a preference to be given to equal reduction of both currents.

Multiple Fault Ride Through (MFRT)

157. The inverter-interfaced bulk consumers connected to the grid, shall remain connected to the grid for a series of up to 15 voltage disturbance below 0.9 p.u within any 5-minute period as per the LVRT capability:

Provided that during such period inverter-interfaced bulk consumers shall remain connected for at least 06 voltage disturbance below 0.5 p.u:

Provided further that during the multiple LVRT conditions, the inverter-interfaced bulk consumers shall meet the performance requirements specified in LVRT conditions.

158. While assessing multiple voltage disturbances, a fault that is re-established following operation of automatic re-close Protection Scheme shall be counted as a separate voltage disturbance.

Frequency Ride through

159. The inverter-interfaced bulk consumers shall be capable of operating in the frequency range 47.5 to 52 Hz and be able to draw rated power in the frequency range of 49.5 Hz to 50.5 Hz on a continuous manner basis:

Provided further that the inverter-interfaced bulk consumers shall be able to maintain its performance contained in this sub-clause even with voltage variation of up to (+/-) 5%.

160. Within the frequency range of operation specified, the inverter-interfaced bulk consumers shall ride through and shall not trip for frequency excursions having an absolute rate of change of frequency (ROCOF) magnitude that is less than or equal to 5.0 Hz/second. ROCOF shall be the average rate of change of frequency over an averaging window of at least 0.1 second.
161. The rate of change of frequency (ROCOF) protection shall not impede the inverter-interfaced bulk consumers from meeting the voltage and frequency ride-through requirements specified in these regulations inclusive of ROCOF ride-through requirements.

Voltage Phase Angle Change Ride Through

162. The inverter-interfaced bulk consumers shall ride through positive-sequence phase angle changes within a sub-cycle-to-cycle time frame of the applicable voltage of less than or equal to (+/-) 25 electrical degrees. In addition, the inverter-interfaced bulk consumers shall remain in operation for any change in the phase angle of individual phases caused by occurrence and clearance of unbalanced faults, provided that the positive-sequence angle change does not exceed the forestated criterion.

Active Power Control

163. The bulk consumer shall be equipped with the facility for controlling the rate of change of power drawl at PoI at a ramp rate of not more than $\pm 10\%$ per minute. The power adjustment must be possible from any operating point:

Provided that power changes due to instructions from the grid operator must occur at a rate not exceeding $\pm 20\%$ per minute.

164. The bulk consumers with aggregated capacity of 50 MW and above at PoI shall have the provision to receive the signal from the State Load Despatch Centre or Regional Load Despatch Centre, as the case may be, for varying active power support.
165. The bulk consumers shall have flexible operation capability with minimum power level of at least forty (40) percent.

Reactive Power Control

166. The bulk consumers with aggregated capacity of 50 MW and above at PoI shall have the provision to receive the signal from the State Load Despatch Centre or Regional Load Despatch Centre, as the case may be, for varying reactive power output.
167. The bulk consumer shall provide voltage regulation capability by changes in reactive power output whenever the PoI voltage is in range for the continuous operation.
168. The bulk consumer shall provide the capabilities of the following mutually exclusive operating modes of reactive power control functions:
 - (1) Voltage control
 - (2) Power factor control
 - (3) Reactive power set point control

The bulk consumer shall be capable of activating each of these modes one at a time. The bulk consumer shall be responsible for implementing setting modifications and mode selections, as specified by the appropriate system operator within a time acceptable to the appropriate system operator.

The dynamic response of the bulk consumer in all the control modes shall be stable and any oscillations shall be positively damped.

Chapter – V

Connectivity Procedure

General Requirements

169. The State Transmission Utility shall inform the Central Transmission Utility and the Authority, within thirty days of acceptance of application of any requester for connectivity to its electricity system.
170. The requester or user, as the case may be, shall get its generating unit(s) or station, of such capacity, registered with e-GEN portal of the Authority and get an online generated Unique Registration Number:

Provided that no generating unit(s) or generating station shall be granted connectivity with the grid without the unique registration number.
171. The appropriate transmission utility or distribution licensee shall ensure that before connectivity to the grid, all the provisions with regard to the connectivity specified in these regulations are complied with by the requester
172. Hybrid generating station shall comply with the relevant regulations applicable to synchronous and asynchronous generating stations specified in these regulations for respective stations individually at PoI:

Provided that synchronous and asynchronous generating stations shall not impede each other's capability to meet the respective compliances as specified in these regulations.
173. Hybrid generating station shall submit the integrated simulation model and study of the Hybrid generating station to appropriate transmission utility or distribution licensee.
174. The qualified coordinating agency (QCA)/Lead generator/Park Developer shall act as repository for the simulation models of each generating station in co-located generating station.
175. The QCA/Lead Generator/Park Developer shall provide the simulation models of the commissioned capacity of all the generating stations existing in a co-located generating station to the requester for simulation study.
176. The appropriate transmission utility or distribution licensee in consultation with appropriate Load Despatch Centre shall publish the compliance verification guidelines from time to time under intimation to Central Electricity Authority. The compliance verification guidelines shall contain the technical data submission requirements, list of reports/certificates/models to be submitted by the requester, list of site tests, list and scenarios of compliance verification studies, model submission requirements.
177. The appropriate Load Despatch Centre shall publish a detailed procedure covering modalities for FTE and integration of new or modified power system element under

intimation to Central Electricity Authority. The procedure shall specify requirements for integration with the grid such as protection, telemetry and communication systems; metering; statutory clearances, timelines for submission of data for system study. list of site test for validation plant simulation model and post-commissioning monitoring requirements:

Provided in absence of such procedure by SLDC, NLDC procedure shall prevail.

178. The Appropriate Transmission Utility or distribution licensee shall publish a detailed procedure for the modalities of interconnection study.

Connectivity Stages

179. The requester/user, appropriate transmission utility and distribution licensee shall adhere to the connectivity stages contained in the flowchart provided in **Schedule III**.

Retirement, Up-rating and De-rating of generating unit(s)

180. The guidelines issued by the Authority from time to time shall be applicable to the conventional sources of electricity generation i.e. Coal/Lignite, Diesel, Gas based power plants and Large Hydroelectric plants (above 25 MW), for the retirement, uprating & derating of generating unit(s).
181. The grid connectivity procedure and requirements specified in these regulations shall also be followed for the up-rating and de-rating of the generating unit(s).

Chapter – VI Power Quality

General Requirements

182. The user/requester must ensure and verify that the facility is designed, constructed and configured in compliance with the Harmonic current distortion limits at the PoI.
183. Harmonic filters shall be installed before FTE of facility of requester (part or full capacity) based on the system study.

Harmonic Current distortion Limits

184. The measurement methodology shall follow IEC 61000-4-7 Class I and IEC 61000-4-30 Class A and the statistical methodology for measuring harmonic distortion contribution shall follow IEEE Std 519.
185. The measurement data for 2nd to 50th Harmonics level for every 10% of generation shall be provided by user/requester in the Table 7 below:

Table 7: Format for Harmonic current distortion data

Harmonic Order	Frequency	Harmonic current (for each phase – A,B,C)			Frequency Dependent Harmonic Impedance		Background Voltage Harmonics		Short circuit level (MVA) considered at PCC level
		Magnitude	Magnitude (in %)	Phase in degrees	G (conductance) or R (Resistance)	B (susceptance) or X (Reactance)	% of fundamental	Phase	
2	100								
3	150								
4	200								
...									

User/requester shall also submit the following information along with the measurements:

- (1) 3-phase Short circuit level (KVA) at which the test was conducted
- (2) Background voltage harmonics during testing (in % and upto 50th harmonics/THD)

Similar format may be used for inter-harmonics and high frequency harmonics also.

186. The harmonic current distortion limits at PoI shall be as per the latest IEEE 519 standard or latest IEEE 2800 as per the applicability.

Voltage Unbalance

187. The voltage Unbalance at 33 kV and above shall not exceed 3.0% at PoI.
188. The measurement methodology shall follow IEC 61000-4-7 Class I and IEC 61000-4-30 Class A and the statistical methodology for measuring voltage unbalance follow IEC 61000-3-13.

Flicker

189. The facility shall not introduce flicker beyond the limits specified in IEC 61000-3-7.
190. The measurement methodology shall follow IEC 61000-4-7 Class I and IEC 61000-4-30 Class A and the statistical methodology for measuring flicker shall follow IEC 61000-3-7.
191. The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5% and for occasional fluctuations other than step changes the maximum permissible limit is 3%.

DC Content

192. The facility shall not inject DC current greater than 0.5 % of the rated output at the PoI.
193. The measurement methodology shall follow IEC 61000-4-7 Class I and IEC 61000-4-30 Class A.

Chapter – VII
Data Communication and Exchange

194. The Authority Shall publish the Compliance Monitoring Guidelines which shall cover the requirements such as formats for data submission, site testing etc.; responsibilities and actions for non-compliance to maintain the conformity of these regulations after the facility gets connected to the power system.
195. Measurement of harmonic content distortions which includes total current distortion and individual harmonic order distortion, DC injection and flicker shall be done at least once in a year by user/requester in presence of the parties concerned and the indicative date for the same shall be mentioned in the connection agreement:

Provided that in addition to annual measurement, if distribution licensee or transmission licensee or the generating company, as the case may be, desires to measure harmonic content or DC-injection or flicker or other power quality parameters, it shall inform the other party in writing and the measurement shall be carried out within 5 working days.
196. The report of the annual measurement shall be submitted to the Appropriate Transmission Utility or distribution licensee and appropriate Load Despatch Centre.
197. The requester/user shall make arrangements for integration of the controls and tele-metering features of their system into the Automatic Generation Control, Automatic Load Shedding, Special Protection System, Energy Management Systems (EMS) and Supervisory Control and Data Acquisition System (SCADA) of the respective state or region.
198. The requester/user shall cooperate with the Regional Power Committee/ appropriate Load Despatch Centre for tuning of Power System Stabilizer provided in the excitation system/Power Plant Controller of the generating unit(s), Power Oscillation Damping Controller (POD) in HVDCs and FACTS devices.
199. The requester/user shall abide by the coordinated outage plan of the state and region in respect of generating unit(s) and transmission lines as approved by the Regional Power Committee.
200. The requester/user shall furnish data as required by appropriate Transmission Utility or Transmission Licensee, Appropriate Load Despatch Centre, appropriate Regional Power Committee, and any committee constituted by the Authority for system studies or for facilitating analysis of tripping or disturbance in power system;
201. The requester/user shall furnish data as required by the Appropriate Transmission Utility or by the licensee or generating station with whose system the inter-connection is proposed,

for permitting inter-connection with the grid; the content of information exchanges including a precise list of data shall be specified by the appropriate Transmission Utility or Distribution Licensee

202. The requester/user shall provide necessary facilities for voice and data communication and transfer of on-line operational data, such as voltage, frequency, line flows, and status of breaker and isolator position and other parameters as prescribed by the Appropriate Load Despatch Centre.
203. The requester/user shall maintain meters and communication system in its jurisdiction in good condition.
204. The data and communication systems shall be provided as per the Central Electricity Authority (Technical Standards for Communication System in Power System Operations) Regulations in force.
205. Metering shall be provided as specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations in force.
206. Periodic tests shall be carried out once every 5 years for all power system elements by the user for ascertaining the correctness of mathematical models used for simulation studies as well as for ensuring the compliance of these regulations. The test report and models shall be submitted to appropriate transmission utility and appropriate Load Despatch Centre. Any non-compliance of these regulations shall be reported to the Authority by the appropriate transmission utility and appropriate Load Despatch Centre.
207. The requester/user shall provide to the appropriate Load Despatch Centre, the fault recording and dynamic system behavior monitoring of his plant connected to the grid at 220 kV and above, as specified in Table 8 below:

Table 8: Specifications for fault recorder and dynamic behavior monitoring of plant

Sr No	Requirement	Specification
1	Pre-event buffer/pre-trigger(fault)	upto 1 second (waveform)
2	Post-event recording/post-trigger (fault)	≥10 seconds (waveform)
3	Sampling rate	≥12.8 kHz
4	Storage Memory	1 GB or more
5	Harmonics Monitoring	100 th order (magnitude)
6	Harmonic Phase Angle Measurement and Analysis	Required
7	Primary Frequency	Should provide one cycle high speed frequency reading with a frequency resolution of better than 10 mHz.
8	Response Time	10 ms or faster

All such equipment shall be provided with time synchronization facility for global common time reference.

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Chapter – VIII Protection

208. The requester/user shall cooperate with the Regional Power Committee, and appropriate Load Dispatch Centres for protection coordination and settings of its protective relays.
209. The generator transformer windings in synchronous generating stations shall have delta connection on low voltage side and star connection on high voltage side. Star point of high voltage side shall be effectively (solidly) earthed so as to achieve the Earth Fault Factor of 1.4 or less.
210. Every generating unit(s) shall have standard protections to protect the unit(s) not only from faults within the unit(s) and within the station but also from faults in transmission lines. For generating unit(s) having rated capacity greater than 100 MW, two independent sets of protections acting on two independent sets of trip coils fed from independent Direct Current (DC) supplies shall be provided. The protections shall include but not be limited to the Local Breaker Back-up (LBB) protection.
211. Basic Insulation Level and Insulation Co-ordination:
Basic Insulation Level (BIL) of various items of equipment and ratings of surge arresters for generating stations, lines and sub-stations shall be decided on the following order of priority, namely: —
- (1) ensure safety to public and operating personnel;
 - (2) avoid permanent damage to plant;
 - (3) prevent failure of costly equipment;
 - (4) minimise circuit interruptions; and
 - (5) minimise interruptions of power supply to consumers.
 - (6) Insulation co-ordination of equipment and lines on both sides of a connection point belonging to the requester/user and the grid shall be accomplished and the co-ordination shall be done by the appropriate Transmission Utility.
212. Protection system shall be designed to reliably detect faults on various abnormal conditions and provide an appropriate means and location to isolate the equipment or system automatically. The protection system must be able to detect power system faults within the protection zone. The protection system should also detect abnormal operating conditions such as equipment failures or open phase conditions.
213. Every element of the power system shall be protected by a standard protection system having the required reliability, selectivity, speed, discrimination and sensitivity. Where failure of a protective relay in the user/requester's system has substantial impact on the grid, it shall connect an additional protection as back up protection besides the main protection.

214. Notwithstanding the protection systems provided in the grid, the requester/user shall provide requisite protections for safeguarding his system from the faults originating in the Grid.
215. Protection Scheme such as under frequency relay for load shedding, voltage instability, angular instability, generation backing down or Islanding Schemes may also be required to be provided to avert system disturbances.
216. Protection co-ordination issues shall be finalized by the Regional Power Committee.
217. The requester/user shall develop protection manuals conforming to various standards for the reference and use of its personnel.
218. For Distribution Systems and Bulk Consumers, under frequency and df/dt (rate of change of frequency with time) relays shall be employed for automatic load control in a contingency to ensure grid security under conditions of falling grid frequency in accordance with the decision taken in the Regional Power Committee.
219. The transmission lines and sub-stations connected to the grid shall comply with the following in addition to the general connectivity conditions:
 - (1) Protection for the Transmission Lines and equipment at Substation shall be provided as per Schedule-V of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulation in force.
 - (2) Circuit breakers, isolators and all other current carrying equipment shall be capable of carrying normal and emergency load currents without damage. The equipment shall not become a limiting factor on the ability of transfer of power on the inter-state and intra-state transmission system.
 - (3) All circuit breakers and other fault interrupting devices shall be capable of safely interrupting fault currents for any fault that they are required to interrupt. The circuit Breakers shall have this capability without the use of intentional time delay in clearing the fault. Minimum fault interrupting requirement need be specified by the appropriate Transmission Utility. The Circuit Breaker shall be capable of performing all other required switching duties such as, but not limited to, capacitive current switching, load current switching and out-of-step switching. The Circuit Breaker shall perform all required duties without creating transient over-voltages that could damage the equipment provided elsewhere in the grid. The short circuit capacity of the circuit breaker shall be based on short-term and perspective transmission plans as finalized by the Authority.
 - (4) Earth Fault Factor for an effectively earthed system shall be not more than 1.4.
 - (5) Power Supply to Sub-Station Auxiliaries, shall:
 - (i) for alternating current (AC) supply (Applicable to new sub-station):

- (a) *220 kV and above:* Two high tension (HT) supplies shall be arranged from two independent sources. These two sources shall be such that outage of both the sources does not occur simultaneously. One of the two high tension supplies shall be standby to the other. In addition, an emergency supply from diesel generating (DG) source of suitable capacity shall also be provided:

Provided that Asynchronous Generating Station may install a second diesel generating (DG) source of suitable capacity for their auxiliary supply requirements.

- (b) *66 kV and below 220 kV:* There shall be one HT supply and one diesel generating source.
(c) *33 kV and below 66 kV:* There shall be one HT supply.
- (ii) *For direct current (DC) Supply (Applicable to new sub-stations):*
Sub-stations of transmission system for 132 kV and above and sub-stations of all generating stations: There shall be two sets of batteries, each equipped with its own charger.
For sub-stations below 132 kV: There shall be one set of battery and charger.

Chapter – IX Miscellaneous

220. Repeal and Saving:

- (1) The Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 in force are hereby repealed.
- (2) Notwithstanding such repeal, anything done or purported to have been done under the repealed regulations shall be deemed to have been done or purported to have been done under the relevant provisions of these regulations.

221. Power to remove difficulty

If any difficulty arises in giving effect to the provisions of these regulations, the Authority may, on its own or on an application made before it by any entity, by order, make such provisions not inconsistent with the provisions of the Act or provisions of other regulations specified by the Authority, as may appear to be necessary for removing the difficulty in giving effect to the objectives of these regulations.

222. Power to relax:

- (1) The Authority may, by order and for reasons to be recorded in writing, relax any of provisions of these regulations in respect of the matters referred to the Authority on case-to-case basis.
- (2) The Authority may deal with any matter or exercise any power under sub-section (9) of section 70 the Act for which no regulations have been framed, and the Authority may deal with such matters, powers and functions in accordance with the provisions of the Act.

223. Enforcement of regulations:

- (1) The appropriate Transmission Utility and distribution licensee shall ensure compliance of these regulations before granting connectivity to any requester and shall also submit reports to the appropriate Load Despatch Centre.
- (2) The appropriate Regional Load Despatch Centre and State Load Despatch Centre shall report status of non-compliance of these regulations done by any user during the real time operation within 7 days of the grid incident/disturbance/event to Central Electricity Authority.
- (3) The user shall submit detailed report along with reasons for non-compliance to these regulations to appropriate LDC within 3 days of the grid incident/disturbance/event and planned corrective measures to address the non-compliances.

- (4) The Authority may take cognizance of any non-compliance case of these regulations by a user or requester and shall direct any officer or agency designated in this behalf to investigate and submit a report to the Authority. The Authority may direct the appropriate transmission utility to disconnect the user from the grid for non-compliance of any provision contained in these regulations until the user complies with these regulations.
- (5) The non-compliance to the provision contained in these regulations or any such order, directions in conformity with these regulations, shall be dealt as per Section 146 of the Act.

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Schedules
Schedule I

1. The following process is to be followed for assessing the maximum and minimum possible ambient temperature to be considered for design of machines in the facility:
 - (1) Obtain relevant temperature data from the India Meteorological Department (IMD), Pune (Ministry of Earth Sciences, Government of India) website. The IMD maintains the database related to monthly temperature on a pan India basis and the temperature extremum (highest maximum & minimum ever for a month) recorded by the IMD measuring station nearest to the location of the Generating Station shall be noted. In case of non-availability of IMD data, the requester may consider the temperature data from any weather service provider of repute or, any weather station of RE project in vicinity. The source of temperature data and location of the weather station, is to be indicated by requester in submission to appropriate transmission utility and LDC.
 - (2) The extreme temperature for a particular IMD station can be found using the following link:
https://cdsp.imdpune.gov.in/home_lab_2.php#extremes
 - (3) The above link gives the maximum and minimum temperature for a particular month (highest and lowest ever observed till date).
 - (4) The requester shall tabulate the maximum and minimum temperatures for each month of the year and from the table, select the highest and lowest temperature amongst the 12 months.
 - (5) For the higher extremum, a margin of 1°C shall be added to the temperature as obtained vide the above procedure and the same shall be rounded off (to the nearest higher integer) and considered for design temperature of the RE Generator at the higher extremum end.
 - (6) Similarly, for the lower extremum, a margin of 1°C shall be subtracted to the temperature as obtained vide the above procedure and the same shall be rounded off (to the nearest lower integer) and considered for the design temperature of the facility at the lower extremum end.
 - (7) The requester shall furnish the entire evaluation process & data in a stepwise manner as indicated above under Affidavit for consideration of compliance.

2. The Authority shall publish the ambient temperatures for all locations as per the procedure provided in Para 1 of this schedule. It shall be revised in first week of every financial year to reflect any updates based on the maximum temperature data to be made available by the IMD for the purpose:

Provided that till such time the new data is updated, the latest one available on the website of CEA shall be referred to by the requester for design of the machines in the facility.

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Schedule II

Response Target Range for PFR

Parameter	Response target	Ranges of available settings	
		Min	Max
Reaction time	0.5 second	0.20 (0.5 for WTG)	1
Rise Time	4.0 second	2.0 (4.0 for WTG)	20
Settling time	10 second	10	30
Damping ratio	0.3	0.2	1.0
Settling band	Max (2.5% of change or 0.5% of generating system continuous rating)	1	5

Note:- 1) Stable and damped response shall take precedence over response time. That is, if it is shown that for the applicable generating station and the given grid to which the generating station is connected, stable response requires a response time that is closer to the upper limit defined in above Table, then this is preferred to provide stable and damped response.

2) Dynamic response characteristics are defined on an open-loop basis, which is the effective case when the inertia of the system is orders of magnitude larger than the IBR rating.

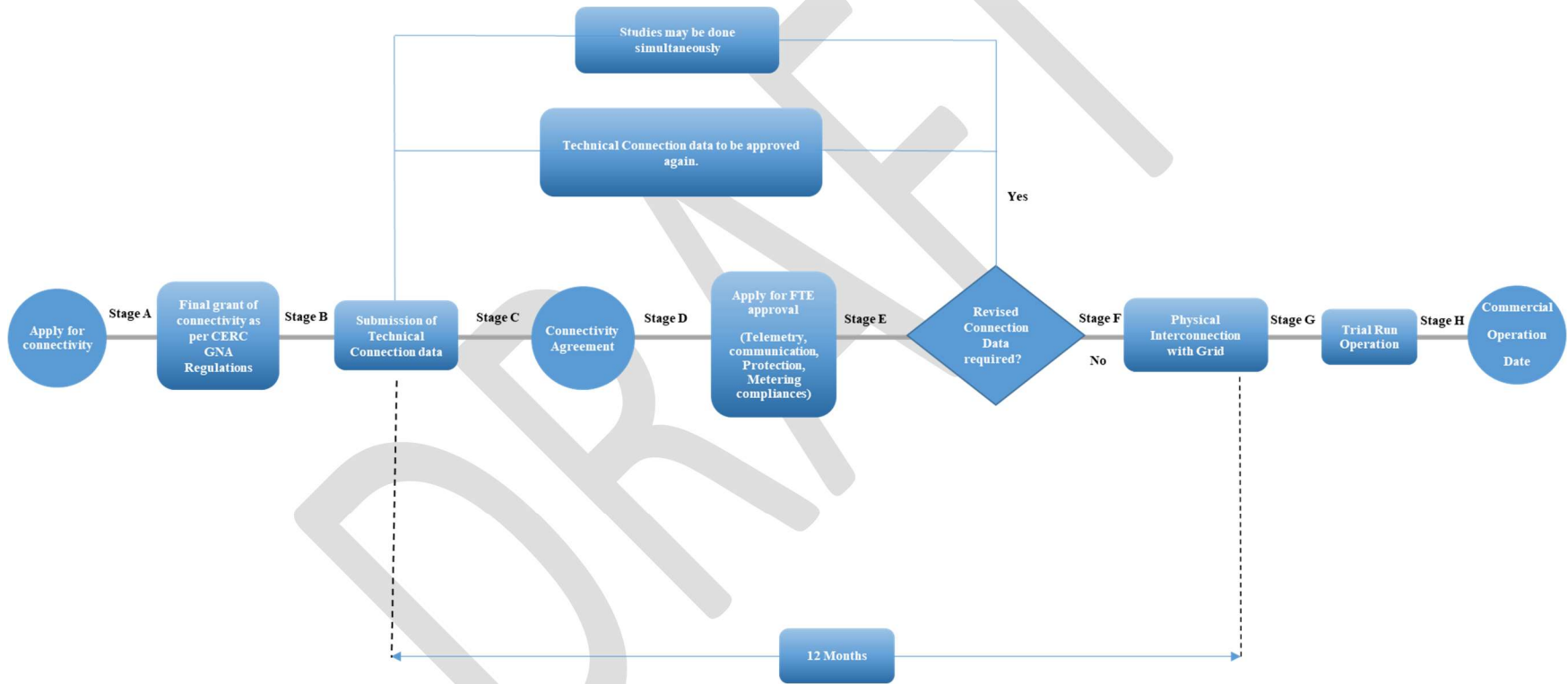
3) The reaction time starts when the applicable frequency measured at the PoI has deviated outside of the applicable PFR deadband.

4) The generating station shall be capable of sustaining PFR for as long as the primary energy source is available.

5) Refer to informative on damping ratio as per IEEE 2800 (As amended)

Schedule III

Flowchart for Connectivity Procedure



Stage A

1. The requester shall make a request for connection in the planning stage to the Appropriate Transmission Utility for inter-connection studies. In case a requester is seeking inter-connection to a distribution system such a request will be made to the distribution licensee.
2. The requester shall present the mathematical model of the equipment/facility in accordance with the requirements as stipulated by the Appropriate Transmission Utility, or distribution licensee, as the case may be.
3. The Appropriate Transmission Utility or distribution licensee shall carry out the inter-connection study to determine the point of inter-connection, required inter-connection facilities and modifications required on the existing grids, if any, to accommodate the interconnection. The study may also address the transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, machine dynamics, ferro resonance, metering requirements, protective relaying, sub-station grounding and fault duties, as the case may be.

Stage B

4. The Appropriate Transmission Utility or distribution licensee shall prepare grid information containing background Network data, background harmonic distortion levels including impedance polygons and provide it to the requester at the time of final grant of the connectivity to the requester for preparation of technical connection data by the requester.
5. The requester shall submit the complete technical connection data with the undertaking that the facility simulation model data submitted is accurate and representative of the actual facility response:

Provided that the complete technical connection data for the phase capacity of the facility only shall be submitted in case phase-wise commissioning is planned.

6. The requester shall submit following documents for each make of inverter / WTG /SVG / FACTS Devices in a facility:
 - (1) Type Test Report
 - (2) Statement of compliance (SoC)
 - (3) Measurement Report
7. The requester shall submit the facility simulation models in standard formats which are interoperable and convertible to simulation software used by appropriate transmission utility and load despatch centre. The simulation model to be submitted are as mentioned below:
 - (1) Static model

- (2) Dynamic Phasor-domain Transient (PDT) model
- (3) Dynamic Electromagnetic Transient (EMT) model
- (4) Harmonic model - For harmonic studies, frequency dependent Norton Equivalent (FDNE) model of the plant shall be provided.

The requester shall ensure that the submitted model files adhere to the model submission and compatibility requirements as mentioned in compliance verification guidelines.

8. The requester shall submit the technical connection data at least 12 months before the physical interconnection with the grid in case of asynchronous generating stations.

Stage C

9. The Appropriate Transmission Utility or distribution licensee shall share the submitted data and models with appropriate LDC and it shall, in parallel, examine the submitted data.
10. The appropriate LDC shall forward their comments to Appropriate Transmission Utility or distribution licensee and it shall convey the observations with respect to non-compliance of these regulations, to the requester.
11. The Appropriate Transmission Utility or distribution licensee shall issue the intimation of technical connection details and Connectivity Agreement shall be signed with the requester for physical interconnection with the ISTS Grid.
12. The connection agreement shall contain general and specific technical conditions, applicable to that connection.
13. Every connection of a requester's system to the grid shall be covered by a connectivity agreement between the requester and
 - (1) Appropriate Transmission Utility in case of connection to Inter-state transmission system or intra state transmission system as the case may be;
 - (2) Distribution licensee in case of inter-connection to distribution licensee's system; and
 - (3) Transmission licensee and Appropriate Transmission Utility, in case of inter-connection to a transmission licensee (tri-partite agreement).

Stage D

14. The requester shall apply for First Time Energisation (FTE) with the undertaking that the facility simulation model data submitted is accurate and there are no variations with respect to approved connection by appropriate Transmission Utility or distribution licensee.

Stage E

15. The appropriate LDC shall scrutinize the application and if there is any change in the plant network topology or simulation models as approved, the appropriate LDC shall share the submitted data and models with appropriate Transmission Utility or distribution licensee.
16. Appropriate Transmission Utility or distribution licensee and appropriate LDC shall examine the submitted data in parallel.
17. Appropriate Transmission Utility or distribution licensee shall issue Revised Connection details if compliance of all applicable provisions of contained in these Regulations are met.

Stage F

18. The appropriate LDC shall ensure compliance to CEA (Technical Standards for Connectivity to the Grid) before grant of FTE.

Stage G

19. The requester shall be allowed to inter-change power with the grid during the commissioning period, including testing and full load testing before the COD, after obtaining prior permission of the concerned RLDC/SLDC.
20. The requester shall proceed with physical interconnection with Grid for site testing validation of plant simulation models.
21. The requester shall conduct testing of the generating station as per the compliance verification guidelines:

Provided that integrated testing for the whole capacity shall be done if new capacity is added to existing capacity in a generating station.
22. The requester shall submit test results and final validated simulation model to the appropriate Load Despatch Centre.
23. The appropriate Load Despatch Centre shall examine the response of the validated simulation models against site test results and forward their comments to the requester in case of any discrepancy.
24. After validation of simulation models against site tests, the requester shall submit the following details prior to notice for trail run:

Description	Units
Installed Capacity of generating station	MW
Installed Capacity of generating station	MVA
MCR	MW

Number x unit size	No x MW
Time required for cold start	Minute
Time required for warm start	Minute
Time required for hot start	Minute
Time required for combined cycle operation under cold conditions	Minute
Time required for combined cycle operation under warm conditions	Minute
Ramping up capability	% per minute
Ramping down capability	% per minute
Minimum turndown level	% of MCR
Minimum turndown level	MW (ex-bus)
Inverter Loading Ratio (DC/AC capacity)	
Name of QCA (where applicable)	
Full reservoir level (FRL)	Meter
Design Head	Meter
Minimum draw down level (MDDL)	Meter
Water released at Design Head	M3 / MW
Unit-wise forbidden zones	MW

25. Notice of Trial Run

- (1) The requester proposing its generating station or a unit thereof for trial run or repeat of trial run shall give a notice of not less than seven (7) days to the concerned RLDC, and the beneficiaries of the generating stations, including intermediary procurers, wherever identified:

Provided that in case the repeat trial run is to take place within forty-eight (48) hours of the failed trial run, fresh notice shall not be required.

- (2) The requester proposing its transmission system or an element thereof for trial run shall give a notice of not less than seven days to the concerned RLDC, CTU, distribution licensees of the region and the owner of the inter-connecting system.
- (3) The concerned RLDC shall allow commencement of the trial run from the requested date or in the case of any system constraints, not later than seven (7) days from the proposed date of the trial run. The trial run shall commence from the time and date as decided and informed by the concerned RLDC.

Stage H

26. Trial Run of Generating Unit

- (1) Trial Run of the Thermal Generating Unit shall be carried out in accordance with the following provisions:

- (a) A Thermal Generating Unit shall be in continuous operation at MCR for seventy-two (72) hours on designated fuel:

Provided that:

- (i) short interruption or load reduction shall be permissible with the corresponding increase in duration of the test;
- (ii) interruption or partial loading may be allowed with the condition that the average load during the duration of the trial run shall not be less than MCR, excluding the period of interruption but including the corresponding extended period;
- (iii) cumulative interruption of more than four (4) hours shall call for a repeat of trial run.

- (b) Where, on the basis of the trial run, a thermal generating unit fails to demonstrate the unit capacity corresponding to MCR, the requester has the option to de-rate the capacity of the generating unit or to go for a repeat trial run. If the requester decides to de-rate the unit capacity, the de-rated capacity in such cases shall not be more than 95% of the demonstrated capacity, to cater for primary response.

- (2) Trial Run of Hydro Generating Unit shall be carried out in accordance with the following provisions:

- (a) A Hydro Generating Unit shall be in continuous operation at MCR for twelve (12) hours:

Provided that:

- (i) short interruption or load reduction shall be permissible with a corresponding increase in duration of the test;
- (ii) interruption or partial loading may be allowed with the condition that the average load during the duration of trial run shall not be less than MCR excluding period of interruption but including the corresponding extended period;
- (iii) cumulative interruption of more than four (4) hours shall call for a repeat of trial run; (iv) if it is not possible to demonstrate the MCR due to insufficient reservoir or pond level or insufficient inflow, COD may be declared, subject to the condition that the same shall be demonstrated immediately when sufficient water is available after COD:

Provided that if such a generating station is not able to demonstrate the MCR when sufficient water is available, the requester shall de-rate the capacity in terms of sub-clause (b) of this clause, and such de-rating shall be effective from COD.

- (b) Where, on the basis of the trial run, a hydro generating unit fails to demonstrate the unit capacity corresponding to MCR, the requester shall have the option to either de-rate the

capacity or go for a repeat trial run. If the requester decides to de-rate the unit capacity, the de-rated capacity in such cases shall not be more than 90% of the demonstrated capacity to cater for primary response.

(3) Trial Run of Wind / Solar / ESS / Hybrid Generating Station

- (a) Trial run of the solar inverter unit(s) shall be performed for a minimum capacity aggregating to 50 MW:

Provided that in the case of a project having a capacity of more than 50 MW, the trial run for the balance capacity shall be performed in a maximum of four instalments with a minimum capacity of 5 MW:

Provided further that the trial run for solar inverter unit(s) aggregating to less than 50 MW shall be allowed for the capacity for which Connectivity has been granted to such entity.

- (b) Successful trial run of a solar inverter unit(s) covered under sub-clause (a) of this clause shall mean the flow of power and communication signal for not less than four (4) hours on a cumulative basis between sunrise and sunset in a single day with the requisite metering system, power plant controller, telemetry and protection system in service. The requester shall record the output of the unit(s) during the trial run and shall corroborate its performance with the temperature and solar irradiation recorded at site during the day and plant design parameters:

Provided that:

- (i) the output below the corroborated performance level with the solar irradiation of the day shall call for a repeat of the trial run;
- (ii) if it is not possible to demonstrate the rated capacity of the plant due to insufficient solar irradiation, COD may be declared subject to the condition that the same shall be demonstrated immediately when sufficient solar irradiation is available after COD, within one year from the date of COD:

Provided that if such a generating station is not able to demonstrate the rated capacity when sufficient solar irradiation is available after COD, the requester shall de-rate the capacity in terms of sub-clause (h) of clause (3) of Para 26 of this Schedule.

- (c) Trial run of a wind turbine(s) shall be performed for a minimum capacity aggregating to 50 MW:

Provided that in the case of a project having a capacity of more than 50 MW, the trial run for wind turbine(s) above the capacity of 50 MW shall be performed in batch sizes of not less than 5 MW:

Provided further that the trial run for wind turbine(s) aggregating to less than 50 MW for entities covered under clause (e) of Regulation 4.1 of the GNA Regulations, shall be allowed for the capacity for which Connectivity has been granted to such an entity.

(d) Successful trial run of a wind turbine(s) covered under sub-clause (c) of this clause shall mean the flow of power and communication signal for a period of not less than four (4) hours on a cumulative basis in a single day during periods of wind availability with the requisite metering system, power plant controller, telemetry and protection system in service. The requester shall record the output of the unit(s) during the trial run and corroborate its performance with the wind speed recorded at the site(s) during the day and plant design parameters:

Provided that-

- (i) the output below the corroborated performance level with the wind speed of the day shall call for a repeat of the trial run;
 - (ii) if it is not possible to demonstrate the rated capacity of the plant due to insufficient wind velocity, COD may be declared subject to the condition that the same shall be demonstrated immediately when sufficient wind velocity is available after COD, within one year from the date of COD: Provided that if such a generating station is not able to demonstrate the rated capacity when sufficient wind velocity is available after COD, the requester shall de-rate the capacity in terms of sub-clause (h) of clause (3) of Para 26 of this Schedule.
- (e) Successful trial run of a standalone Energy Storage System (ESS) shall mean one (1) cycle of charging and discharging of energy as per the design capabilities with the requisite metering, telemetry and protection system being in service.
- (f) Successful trial run of a pumped storage plant shall mean one (1) cycle of turbo-generator and pumping motor mode as per the design capabilities up to the rated water drawing levels with the requisite metering, telemetry and protection system being in service:

Provided that if it is not possible to demonstrate the design capabilities up to the rated water drawing levels due to insufficient reservoir levels, the COD may be declared after demonstrating the capabilities at available water drawing levels, subject to the condition that design capabilities up to the rated water drawing levels shall be demonstrated immediately when sufficient reservoir level is available after COD:

Provided further that if such a generating station is not able to demonstrate the design capabilities when sufficient water is available, the requester shall have the option to either go for a repeat trial run or de-rate the capacity. If the requester decides to de-rate the unit capacity in terms of sub-clause (b) of Clause (2) of Para 22 of this Schedule, such de-rating shall be effective from the COD.

- (g) Successful trial run of a hybrid system shall mean successful trial run of each individual source of the hybrid system in accordance with the applicable provisions of these regulations.
- (h) Where, on the basis of the trial run, solar / wind / storage / hybrid generating station fails to demonstrate its rated capacity, the requester shall have the option to either go for a repeat trial run or de-rate the capacity subject to a minimum aggregated de-rated capacity of 50 MW or 5 MW, as the case may be.
- (i) Notwithstanding the provisions contained in these Regulations, where Power purchase Agreement provides for a specific capacity that can be declared COD, trial run shall be allowed for such capacity in terms of such Power purchase agreement.

27. Trial Run of Transmission System, HVDC System and FACTS

- (1) Trial run of a transmission system or an element thereof shall mean successful energisation of the transmission system or the element thereof at its nominal system voltage through interconnection with the grid for a continuous twenty-four (24) hours flow of power and communication signal from the sending end to the receiving end and with the requisite metering system, telemetry and protection system:

Provided that under exceptional circumstances and with the prior approval of Authority, a transmission element can be energized at lower nominal system voltage level:

Provided further that the appropriate LDC may allow anti-theft charging where the transmission line is not carrying any power.

28. Trial Run of Bulk Consumer

- (1) Trial run of the Bulk Consumer facility shall be performed for a minimum capacity aggregating to 50 MW:

Provided that in the case of a project having a capacity of more than 50 MW, the trial run for the balance capacity shall be performed in a maximum of four instalments with a minimum capacity of 5 MW:

Provided further that the trial run for Bulk Consumer unit aggregating to less than 50 MW shall be allowed for the capacity for which Connectivity has been granted to such entity.

- (2) Successful trial run of a Bulk Consumer facility covered under sub-clause (a) of this clause shall mean the flow of power and communication signal for not less than four (4) hours on a cumulative basis in a single day with the requisite metering system, power bulk consumer controller, telemetry and protection system in service. The requester shall record the output of the unit(s) during the trial run and shall corroborate its performance with the temperature and solar irradiation recorded at site during the day and bulk consumer design parameters:

Provided that the output below the corroborated performance level shall call for a repeat of the trial run.

29. Documents and Tests Prior to Declaration of Commercial Operation

- (1) The tests as specified in the following clauses shall be scheduled and carried out in coordination with NLDC and the concerned RLDC by the requester and relevant reports and other documents as specified shall be submitted to NLDC and the concerned RLDC before a certificate of successful trial run is issued to such a requester.
- (2) All thermal generating stations having a capacity of more than 200 MW and hydro generating stations having a capacity of more than 25 MW shall submit documents confirming the enablement of automatic operation of the plant from the appropriate load despatch centre by integrating the controls and telemetering features of their system into the automatic generation control in accordance with the CEA Regulation(s).
- (3) Documents and Tests Required for Thermal (coal/lignite) Generating Stations:
 - (4) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance with clause (1) of Para 31 of this schedule.
 - (a) The requester shall submit the following OEM documents, namely
 - (i) startup curve for boiler and turbine including starting time of unit in cold, warm and hot conditions,
 - (ii) capability curve of generator,
 - (iii) design ramp rate of boiler and turbine.
 - (b) The following tests shall be performed:
 - (i) Operation at a load of fifty-five (55) percent of MCR as per the CEA Technical Standards for Construction for a sustained period of four (4) hours.
 - (ii) Ramp-up from fifty-five (55) percent of MCR to MCR at a ramp rate of at least one (1) percent of MCR per minute, in one step or two steps (with stabilization

period of 30 minutes between two steps), and sustained operation at MCR for one (1) hour.

- (iii) Demonstrate overload capability with the valve wide open as per the CEA (Technical Standards for Construction of Electrical Plants and electrical Lines) Regulations and sustained operation at that level for at least five (5) minutes.
 - (iv) Ramp-down from MCR to fifty-five (55) percent of MCR at a ramp rate of at least one (1) percent of MCR per minute, in one or two steps (with stabilization period of 30 minutes between two steps).
 - (v) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz at 55%, 60%, 75% and 100% load.
 - (vi) Reactive power capability as per the generator capability curve as provided by OEM considering over-excitation and under-excitation limiter settings and prevailing grid condition.
- (5) Documents and Tests Required for Hydro Generating Stations including Pumped Storage Hydro Generating Station:
- (a) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance with clause (2) of Para 31 of this schedule.
 - (a) The requester shall submit OEM documents for the turbine characteristics curve indicating the operating zone(s) and forbidden zone(s). In order to demonstrate the operating flexibility of the generating unit, it shall be operated below and above the forbidden zone(s).
 - (b) The following tests shall be performed considering the water availability and head:
 - (i) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz for various loadings within the operating zone.
 - (ii) Reactive power capability as per the generator capability curve considering over-excitation and under-excitation limiter settings.
 - (iii) Black start capability, wherever feasible.
 - (iv) Operation in synchronous condenser mode wherever designed.
- (5) Documents and Test Required for Gas Turbine based Generating Stations:
- a) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance clause (1) of Para 31 of this schedule.
 - b) The requester shall submit OEM documents for (i) starting time of the unit in cold, warm and hot conditions (ii) design ramp rate.
 - c) The following tests shall be performed:
 - (i) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz for various loadings within the operating zone.
 - (ii) Reactive power capability as per the generator capability curve considering over-excitation and under-excitation limiter settings.
 - (iii) Black start capability up to 100 MW capacity, wherever feasible.

- (iv) Operation in synchronous condenser mode wherever designed.
- (6) Documents and Tests Required for the Generating Stations based on wind and solar resources:
 - (a) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance clause (4) of Para 31 of this schedule.
 - (b) Type test report for Fault Ride through Test (LVRT and HVRT) for units commissioned after the specified date as per CEA (Technical Standards for Connectivity to the Grid) Regulations mandating LVRT and HVRT capability shall be submitted.
 - (c) The following tests shall be performed at the point of interconnection:
 - (i) Frequency response of machines as per the CEA (Technical Standards for Connectivity to the Grid) Regulations.
 - (ii) Reactive power capability as per OEM rating at the available irradiance or the wind energy, as the case may be:

Provided that the requester may submit offline simulation studies for the specified tests, in case testing is not feasible before COD, subject to the condition that tests shall be performed within a period of one year from the date of achieving COD.

- (7) Documents and Tests Required for Energy Storage Systems:
 - (a) The ESS shall submit a certificate confirming compliance with the CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance with clause (4) of Para 31 of this schedule.
 - (b) The following tests shall be performed at the point of interconnection:
 - (i) Power output capability in MW and energy output capacity in MWh.
 - (ii) Frequency response of ESS.
 - (iii) Ramping capability as per design.
- (8) Documents and Tests Required for HVDC Transmission System:
 - (a) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance with clause (3) of Para 31 of this schedule.
 - (b) The transmission licensee shall submit technical details including operating guidelines such as filter bank requirements at various operating loads and monopolar/ or bipolar configuration, reactive power controller, run-back features, frequency controller, reduced voltage mode of operation, circuit design parameters and power oscillation damping, as applicable.
 - (c) The following tests shall be performed:
 - (i) Minimum load operation.

- (ii) Ramp rate.
 - (iii) Overload capability, subject to grid condition.
 - (iv) Black start capability in the case of Voltage source convertor (VSC) HVDC wherever feasible.
 - (v) Dynamic Reactive Power Support (in the case of VSC based HVDC)
- (9) Documents and Tests Required for the bulk consumer (as per applicability of tests specified in these regulations):
- (a) The requester shall submit a certificate confirming compliance with CEA (Technical Standards for Connectivity to the Grid) Regulations in accordance with clause (5) of Para 31 of this schedule.
 - (b) Type test report for Fault Ride through Test (LVRT and HVRT) for units commissioned after the specified date as per CEA (Technical Standards for Connectivity to the Grid) Regulations mandating LVRT and HVRT capability shall be submitted.
 - (c) The following tests shall be performed at the point of interconnection:
 - (i) Reactive power capability as per OEM rating at the available irradiance or the wind energy, as the case may be:

Provided that the requester may submit offline simulation studies for the specified tests, in case testing is not feasible before COD, subject to the condition that tests shall be performed within a period of one year from the date of achieving COD.

- (10) Documents and Tests Required for FACTS
- a. The transmission licensee shall submit technical particulars including a single line diagram, V/I characteristics, the rating of coupling transformer, the rating of each VSC, MSR and MSC branch, different operating modes, the IEEE standard Model, Power Oscillation Damping (POD) enabled and tuned (if not, then reasons for the same) and the results of an Offline simulation-based study to validate the performance of POD.
 - b) The following tests shall be performed to validate the full reactive power capability of FACTS in both directions i.e. absorption as well as injection mode:
 - (i) POD performance test.
 - (ii) dynamic performance testing:

Provided that the transmission licensee may submit offline simulation studies for the specified tests, in case the conduct of tests is not feasible before COD, subject to the condition that tests shall be performed within a period of one year from the date of achieving COD.

30. Certificate of Successful Trial Run

- (1) In case any objection is raised by a beneficiary in writing to the concerned RLDC with a copy to all concerned regarding the trial run within two (2) days of completion of such trial run, the concerned RLDC shall, within five (5) days of receipt of such objection, in coordination with the concerned entity and the beneficiaries, decide if the trial run was successful or if there is a need for a repeat trial run.
- (2) After completion of a successful trial run and receipt of documents and test reports as per Schedule II of these regulations, the concerned RLDC shall issue a certificate to that effect to the concerned generating station, ESS or transmission licensee, as the case may be, with a copy to their respective beneficiary(ies) and the respective RPC, within three days.

31. Declaration by requester

(1) Thermal Generating Station

- (a) The requester shall certify that:
 - (i) The generating station or unit thereof meets the relevant requirements and provisions of the CEA Regulation(s), as applicable.
 - (ii) The main plant equipment and auxiliary systems including the balance of the plant such as the fuel oil system, coal handling plant, DM plant, pre-treatment plant, fire-fighting system, ash disposal system and any other site-specific system have been commissioned and are capable of full load operation of the units of the generating station on a sustained basis.
 - (iii) Permanent electric supply system including emergency supplies and all necessary instrumentation, control and protection systems and auto loops for full load operation of the unit has been put into service.
- (b) The certificates required under sub-clause (a) of this clause shall be signed by the authorized signatory not below the rank of CMD or CEO or MD of the requester and shall be submitted to the concerned RLDC and to the Member Secretary of the concerned RPC before the declaration of COD.

(2) Hydro Generating Station

- (a) The requester shall certify that:
 - (i) The generating station or unit thereof meets the requirement and relevant provisions of the CEA regulation(s), as applicable.
 - (ii) The main plant equipment and auxiliary systems including the drainage de-watering system, primary and secondary cooling system, LP and HP air compressor and firefighting system have been commissioned and are capable of full load operation of units on a sustained basis.
 - (iii) Permanent electric supply systems including emergency supplies and all necessary Instrumentations Control and Protection Systems and auto loops for full load operation of the unit are put into service.

- (b) The certificates required under sub-clause (a) of this clause shall be signed by the authorized signatory not below the rank of CMD or CEO or MD of the requester and shall be submitted to the concerned RLDC and to the Member Secretary of the concerned RPC before the declaration of COD.
 - (3) Transmission system
The requester shall submit a certificate signed by the authorized signatory not below the rank of CMD or CEO or MD of the company to the concerned RLDC and to the Member Secretary of the concerned RPC before declaration of COD that the transmission line, sub-station and communication system conform to the CEA regulation(s), as applicable and are capable of operation to their full capacity.
 - (4) Wind, Solar, Storage, and Hybrid Generating Station
The generating station based on wind and solar resources, the ESS and the hybrid generating station shall submit a certificate signed by the authorized signatory not below the rank of CMD or CEO or MD to the concerned RLDC and to the Member Secretary of the concerned RPC before declaration of COD, that the said generating station or the ESS as the case may be, including main plant equipment such as wind turbines or solar inverters or auxiliary systems, as the case may be, has complied with all relevant provisions of CEA regulation(s), as applicable.
 - (5) Bulk Consumer
The Bulk Consumer facility shall submit a certificate signed by the authorized signatory not below the rank of CMD or CEO or MD to the concerned RLDC and to the Member Secretary of the concerned RPC before declaration of COD, that the said Bulk Consumer facility, including main bulk consumer equipment has complied with all relevant provisions of CEA regulation(s), as applicable.
- 32. Declaration of Commercial Operation (DOCO) And Commercial Operation Date (COD)**
- (1) A generating station or unit thereof or a transmission system or an element thereof or ESS may declare commercial operation as follows and inform CEA, the concerned RLDC, the concerned RPC and its beneficiaries:
 - (a) Thermal Generating Station or a unit thereof
 - (i) The commercial operation date in the case of a unit of the thermal generation station shall be the date declared by the requester after a successful trial run at MCR or de-rated capacity, as the case may be, and submission of a declaration.
 - (ii) In the case of the generating station, the COD of the last unit of the generating station shall be considered as the COD of the generating station.
 - (b) Hydro Generating Station
 - (i) The commercial operation date in the case of a unit of the hydro generating station including a pumped storage hydro generating station shall be the date declared by

the generating station after a successful trial run at MCR or de-rated capacity, as the case may be, and submission of a declaration.

- (ii) In the case of the generating station, the COD of the last unit of the generating station shall be considered as the COD of the generating station.

(c) Transmission System

- (i) The commercial operation date in the case of an Inter-State Transmission System or an element thereof shall be the date declared by the transmission licensee on which the Transmission System or an element thereof is in regular service at 0000 hours after successful trial operation for transmitting electricity and communication signals from the sending end to the receiving end and submission of a declaration:

Provided that the commercial operation date of a transmission element that is a part of the Associated Transmission System (ATS) shall be declared only after a successful trial run of the last element of the said ATS:

Provided further that where only some of the transmission elements of the ATS have achieved a successful trial run and the Connectivity grantee seeks commercial operation of such elements for utilization by such grantee and is agreed upon by the appropriate Transmission Utility, the commercial operation date of such transmission elements of the ATS may be declared by the requester as per this Regulation:

Provided also that where only some of the transmission element(s) of the ATS have achieved a successful trial run and if the operation of such transmission elements is certified by the concerned Regional Power Committee(s) for improving the performance, safety and security of the grid, the commercial operation date of such transmission element(s) of the ATS may be declared by the transmission licensee as per this Regulation:

Provided also that in case a transmission system or an element thereof executed under regulated tariff mechanism is prevented from regular service on or after the scheduled COD for reasons not attributable to the transmission licensee or its supplier or its contractors but is on account of the delay in commissioning of the concerned generating station or in commissioning of the upstream or downstream transmission system of other transmission licensee, the transmission licensee shall approach the Commission through an appropriate petition along with a certificate from the appropriate transmission utility to the effect that the transmission system is complete as per the applicable CEA Regulation(s), for approval of the commercial operation date of such transmission system or an element thereof:

Provided also that in the case of inter-State Transmission System executed through Tariff Based Competitive Bidding, the transmission licensee may declare deemed

COD of the ISTS in accordance with the provisions of the Transmission Service Agreement after obtaining (a) a certificate from the appropriate Transmission Utility to the effect that the transmission system is complete as per the specifications of the bidding guidelines and applicable CEA Regulation(s) and (b) no load charging certificate from the respective RLDC, where no load charging is possible.

- (ii) The COD of a transmission element of the transmission system under Tariff Based Competitive Bidding shall be declared only after the declaration of the COD of all the pre-required transmission elements as per the Transmission Services Agreement:

Provided that in case any transmission element is required in the interest of the power system as certified by the concerned RPC(s), the COD of the said transmission element may be declared prior to the declaration of the COD of its pre-required transmission elements.

- (d) Communication System

Date of commercial operation in relation to a communication system or an element thereof shall mean the date declared by the requester from 0000 hours of which a communication system or element thereof shall be put into service after completion of the site acceptance test including transfer of voice and data to the respective control centres as certified by the respective Regional Load Despatch Centre.

- (e) Generating Stations based on Wind and Solar resources; ESS and Hybrid Generating Station

- (i) The commercial operation date in the case of units of a renewable generating station aggregating to 50 MW and above or such other limit as specified Schedule II of these regulations, shall mean the date declared by the generating station after undergoing a successful trial run, submission of declaration, and subject to fulfilment of other conditions, if any, as per PPA.
- (ii) In the case of a generating station as a whole, the commercial operation date of the last unit of the generating station shall be considered as the COD of the generating station.

- (f) Bulk Consumer

- (i) The commercial operation date in the case of a Bulk Consumer facility aggregating to 50 MW and above or such other limit as specified Schedule II of these regulations, shall mean the date declared by the generating station after undergoing a successful trial run, submission of declaration, and subject to fulfilment of other conditions, if any, as per PPA.

- (ii) In the case of a Bulk Consumer facility as a whole, the commercial operation date of the last unit of the Bulk Consumer facility shall be considered as the COD of the Bulk Consumer facility.

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