ENTSO-E Draft Requirements for Grid Connection Applicable to all Generators

22 March 2011

Notice

This draft represents the conclusion of the informal preparatory work initiated in summer 2009 by ENTSO-E in the context of the "pilot network code for requirements for grid connection applicable to all generators". The contents of this draft, organised in a manner similar to the anticipated structure of a formal network code, reflect the status of ongoing work by TSO experts as of 22 March 2011, based on the ERGEG framework guidelines on grid connection published on 7 December 2010, as well as the input of an extensive informal dialogue with stakeholders that took place during the period prior to 3 March 2011, i.e. before the application of Regulation (EC) 714/2009.

It is distributed with the sole purpose to provide stakeholders with all the information necessary to assess the results of the informal preparatory work, combining the policy option choices in ERGEG's framework guidelines and the resulting connection requirements for generators. It is therefore expected to be a useful instrument for assisting the debate around the ACER framework guidelines currently under formal consultation which will be the definitive basis of ENTSO-E's future network code.

Disclaimer

This draft does not represent a firm, binding and definitive ENTSO-E position on the contents, the structure, or the prerogatives of the "network code for requirements for grid connection applicable to all generators" and on which a formal public consultation will be organised by ENTSO-E according to Regulation (EC) 714/2009.

PURPOSE AND OBJECTIVES

Having regard to Directive 2009/72/CE of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/CE;

Having regard to Regulation 714/2009 of the European parliament and of the Council of 13 July 2009 and especially Article 6;

Having regard to the priority list issued by the European Commission on 22 December 2010;

Having regard to the Pilot Framework Guidelines on Electricity Grid Connection issued by ERGEG on 7 December 2010;

Whereas :

(1) Directive 2009/72/CE of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/CE and Regulation 714/2009 of the European parliament and of the Council of 13 July 2009 (whereas section 6) underline the need for an increased cooperation and coordination among transmission system operators within a European network of transmission system operators for electricity (ENTSO-E) to create network codes for providing and managing effective and transparent access to the transmission networks across borders, and to ensure coordinated and sufficiently forward-looking planning and sound technical evolution of the transmission system in the Community, including the creation of interconnection capacities, with due regard to the environment ;

(2) Transmission system operators (TSOs) are according to Article 12 of Directive 2009/72/CE responsible for providing and operating high and extra-high voltage networks for long-distance transmission of electricity as well as for supply of lower-level regional distribution systems and directly connected customers. Besides this transmission and supply task it is also the TSOs' responsibility to ensure the system security with a high level of reliability and quality;

(3) Distribution system operators (DSOs) are responsible for providing and operating low, medium and high voltage networks for regional distribution of electricity as well as for supply of lower-level distribution systems and directly connected customers. Besides the regional distribution and supply task it is also the DSOs' responsibility to ensure the security of their networks with a high level of reliability and quality.

(4) Secure system operation is only possible by close cooperation between owners of Power Generating Facilities and the Network Operators. In particular, the system behavior in disturbed operating conditions depends upon the response of Power Generating Facilities to deviations from nominal values of voltage and frequency. In context of system security the transmission Network and the Power Generating Facilities need to be considered as one entity from a systems engineering approach. It is therefore of crucial importance that Power Generating Facilities are obliged to meet

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the relevant technical requirements concerning system security as a prerequisite for network connection. Appropriate dynamic behavior of Power Generating Facilities and their protection and control facilities are necessary in normal operating conditions and in a range of disturbed operating conditions in order to preserve or to re-establish system security. The close cooperation between owners of Power Generating Facilities and the Network Operators shall take place in due compliance with the principle of confidentiality, such as further detailed in Article 16.1 of Directive 2009/72/CE.

(5) ENTSO-E has drafted this Network Code for grid connection requirements ("Requirements for Grid Connection Applicable to all Generators") aiming at setting out clear and objective requirements for generators for network connection in order to contribute to non-discrimination, effective competition and the efficient functioning of the internal electricity market and to ensure system security.

(6) EC Regulation 714/2009 Article 8 (7) defines that "the network codes shall be developed for cross-border network issues and market integration issues and shall be without prejudice to the Member States' right to establish national network codes which do not affect cross-border trade".

The term "cross-border network issue" itself is not defined by this EC Regulation. Therefore for the purposes of this document a definition needs to derived from the targets of the EC 3rd legislative package for the internal electricity market, which are:

- supporting the completion and functioning of the internal market in electricity and cross-border trade
- facilitating the targets for penetration of renewable generation
- Maintaining security of supply

The interconnected transmission system establishes the wholesale platform for the internal electricity market. TSOs are responsible for maintaining, preserving and restoring security of the interconnected system with a high level of reliability and quality, which in this context is the essence in facilitating cross-border trading.

As indicated in (4) above, TSOs cannot ensure the system security regardless of the technical capabilities of power generating facilities, TSOs call for a regular coordination at the level of generation and for an adequate performance of equipment connected to their networks with robustness to face disturbances and to help to prevent any large disturbance or to facilitate restoration of the system after the collapse.

Also as stated in (4) above, Secure system operation is only possible by close cooperation of power generating facilities connected at all voltage levels with the network operators in an appropriate way. Consequently, the transmission system and the generating units need to be considered as one entity from a systems engineering approach. It is therefore of crucial importance that generating units are obliged to meet the requirements and to provide the technical capabilities with relevance to system security.

To ensure system security within the interconnected transmission system and to provide adequate security level a common understanding on these requirements to power generating facilities is esssential. All requirements that contribute to maintaining, preserving and restoring system security in order to facilitate proper functioning of the internal electricity market shall be regarded as "cross-border network issues".

Pursuant to Article 6 of Regulation 714/2009, ENTSO-E shall submit this Network Code to ACER.

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Title 1

GENERAL PROVISIONS

Article 1

DEFINITIONS (glossary)

For the purpose of this Network Code, the following definitions shall apply:

Active Power - Active Power is the real component of the apparent power, expressed in watts or multiples thereof (e.g. kilowatts (kW) or megawatts (MW)).

Active Power Frequency Response - automatic response of Active Power output from a Power Generating Facility, in response to a change in System Frequency from the Nominal System Frequency.

Apparent Power - is the product of voltage (in volts) and current (in amperes). It is usually expressed in kilovolt-amperes (kVA) or megavolt-amperes (MVA) and consists of a real component (Active Power) and an imaginary component (Reactive Power),.

Automatic Voltage Regulator (AVR) - the continuously acting automatic equipment controlling the terminal voltage of a Synchronous Generating Unit by comparing the actual terminal voltage with a reference value and controlling by appropriate means the output of an Exciter, depending on the deviations.

Black Start Capability - the capability of recovery of a Power Generating Facility from a total Shutdown through a dedicated auxiliary power source without any external energy supply.

Block Loading – maximum step Active Power loading of reconnected demand during system restoration after black-out .

Connection Agreement - a contract between the Network Operator and the Power Generating Facility which includes site specific requirements for the Power Generating Facility complementary to requirements defined in the applicable Network Code.

Connection Point - refers to:
- the location at which the network user is connected to the network; and
- the border marking the division of responsibility between the network operator on the one hand and network users on the other..

Control Area - is a coherent part of a synchronous area (usually coinciding with the territory of a company, a country or a geographical area, physically demarcated by the position of points for measurement of the interchanged power and energy to the remaining interconnected network), operated by a single TSO, with physical loads and controllable generation units connected within the Control Area.

Current – unless stated otherwise, current refers to the root-mean-square value of phase current.

Derogation - a time limited or indefinite (as specified) acceptance in writing of a non-compliance of a Power Generating Facility with regard to identified Network Code requirements.

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Droop - the ratio of the steady state change of speed or in Frequency to the steady state change in power output.

Distribution System Operator (DSO) - means a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.

Energisation Operational Notification (EON) - a notification issued by the Relevant Network Operator to a Power Generating Facility operator prior to energisation of its internal network. EON entitles the Power Generating Facility operator to energise its internal network by using the network connection.

Excitation System - the equipment providing the field current of an electrical machine, including all regulating and control elements, as well as field discharge or suppression equipment and protective devices.

Exciter - the source of the electrical power (static or rotating) providing the field current for the excitation of an electrical machine.

Fast Valving - the ability to provide fast changes in mechanical power by acting on both main governor and control valves.

Final Operational Notification (FON) - a notification issued by the Relevant Network Operator to a Power Generating Facility operator confirming that the Power Generating Facility operator is entitled to operate the Generating Unit by using the network connection because compliance with the technical design and operational criteria has been demonstrated as referred to in this Network Code and in national legislation, Connection Agreement or any other bilateral contracts.

Frequency Response Deadband - Deadband is used intentionally to make the power-frequency regulation not responsive. In contrast to (in)sensitivity, deadband has a artificial nature and basically is adjustable.

Frequency Response Sensitivity - The sensitivity of the frequency response is the inherent feature of control system defined as the minimum magnitude of the frequency (input signal) which results in a change of output power (output signal).

Frequency Sensitive Mode (FSM) - a Generating Unit operating mode which will result in Active Power output changing, in response to a change in System Frequency, in a direction which assists in the recovery to Target Frequency, by operating so as to provide Frequency Response.

Generating Unit - a Generating Unit is an indivisible set of installations which can generate electrical energy. If there is more than one unit generating power within a Power Generating Facility that cannot be operated independently from each other then each of the combinations of these units shall be considered as one Generating Unit. This includes more than one Generating Unit in a CCGT and multiple units in a Power Park Module.

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Houseload Operation – In case of network failures resulting in disconnection of Generating Units from the network and being tripped onto their auxiliary supplies, house-load operation ensures that Power Generating Facilities are able to continue to supply their in-house loads.

Interim Compliance Statement - itemized statement of compliance provided by the Power Generating Facility operator to the Relevant Network Operator as established in this Network Code and as additionally required by national legislation including the national codes.

Interim Operational Notification (ION) - a notification issued by the Relevant Network Operator to a Power Generating Facility operator confirming that the Power Generating Facility operator is entitled to operate the Generating Unit by using the network connection for a limited period of time and to undertake compliance tests to meet the technical design and operational criteria of the Network Code and of national legislation, Connection Agreement or any other bilateral contracts.

Instruction - a command given orally, manually or by automatic remote control facilities, e. g. a setpoint, from a Network Operator to a Power Generating Facility Operator in order to perform an action requested by such a command

Isolated Network Operation - independent operation of a part of the Network that is isolated after its disconnection from the interconnected system, having at least one Generating Unit in operation with ability to speed control.

Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) - a genset operating mode which will result in Active Power output reducing, in response to a change in System Frequency above a certain value. For Gensets also providing LFSM-U, both LFSM-O and LFSM-U will be operational together.

Limited Frequency Sensitive Mode – Underfrequency (LFSM-U) - a genset operating mode which will result in Active Power output increasing, in response to a change in System Frequency below a certain value. LFSM-U and LFSM-O are operational together.

Limited Operational Notification (LON) - a notification issued by the Relevant Network Operator to a Power Generating Facility operator which has previously reached FON status, but is temporarily subject to either a significant modification or loss of capability which has resulted in non-compliance to the Network Code and/or in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts .

Manufacturer's Data and Performance Type Certificate (MD&PTC)
Certificates registered with Network Operators defining verified data and performance which can include models and testing for the purpose of replacing specific parts of the compliance process. Only for types A and B Generating Units there is the potential for these MD&PTCs to be accepted as the sole evidence of compliance. For types C and D Generating Units the MD&PTC verify specific parts of data and performance. They do not indicate not total compliance.

Maximum Capacity - the maximum continuous Active Power which a Generating Unit can feed into the Network as defined in the Connection Agreement or as agreed between the Relevant Network Operator and the Power Generating Facility operator.

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Minimum Operating Level - the level at which the Generating Unit can be operated continuously electrically, mechanically and/or thermally (as the case may be) in a stable manner.

Minimum Regulating Level – is the minimum Active Power that the Generating Unit can regulate down to.

Network - plant and apparatus connected together in order to transmit or distribute electrical power.

Network Operator - the network operator is any kind of entity that operates a Network. These represent either a TSO, a DSO or an industrial customers network.

Offshore Grid Connection System – has the meaning given in Article 18 paragraph 5.

Onshore Grid Interconnection Point – has the meaning given in Article 18 paragraph 6.

Over Excitation Limiter - is a control device within the AVR which prevents the rotor of a generator from overload by limiting the excitation current.

Power Factor - the ratio of Active Power to Apparent Power.

Power Generating Facility - is a facility to convert primary energy to electrical energy which consists of one or more Generating Units or Power Park Modules connected to a Network by one or more Connection Points

Power Park Module (PPM) - multiple interconnected power producing units which are not synchronous and have a common CP to the Network. Examples are wind farms, solar, wave and tidal Power Generating Facilities.

P-Q-Capability Diagram - describes the Reactive Power capability of a Generating Unit in context of varying Active Power at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point taking into account its full tap-changing range.

Power System Stabilizer (PSS) - is an additional functionality of the AVR with the purpose of damping power oscillations.

Reactive Power - Reactive Power is the imaginary component of the apparent power, usually expressed in kilovar (kvar) or megavar (Mvar).

Relevant TSO – is the TSO in whose Control Area a Generating Unit is or will be connected to the Network

Relevant DSO – is the DSO to whose network a Generating Unit is or will be connected.

Relevant Network Operator – is the operator to the network to which a Generating Unit is or will be connected.

Secured Fault - a Secured Fault is defined as a fault, which the network is required to withstand without loss of demand or generation according to the planning criteria, when this fault is cleared according to the primary protection scheme.

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Setpoint - a target value for any parameter typically used in control schemes.

Short-Circuit Ratio - for the synchronous generator is the ratio of the field current required for the rated voltage at open circuit to the field current required for the rated generator terminal current at short circuit.

Slope - the percentage change in voltage, based on nominal, that results in a change in Reactive Power from 0 to maximum Reactive Power.

Speed Control - capability of a generating unit to contribute to control speed by adjusting the Active Power Output in order to maintain stable system frequency.

Statement of Compliance - a document provided by the Power Generating Facility Operator to the Network Operator stating the current status with respect to compliance itemised for each element of Network Code and in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

Steady-State Stability - if the Network or a synchronous machine previously in the steady state reverts to this state again following a sufficiently minor disturbance, it has Steady-State Stability.

Synchronous Generating Unit - a Generating unit that is synchronously connected to the network.

Synthetic Inertia - a facility provided to replicate the effect of inertia of a Synchronous Generating Unit to a prescribed level of performance.

System User - any natural or legal person supplying to, or being supplied by, or both supplying and being supplied by a transmission or distribution system.

Transmission System Operator (TSO) - means a natural or legal person responsible for operating, ensuring the /maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity;

Transient Stability - should a Network which has suffered a major disturbance progress through decaying transient phenomena to its steady state; it demonstrates Transient Stability with regard to the nature, location and duration of this disturbance (e.g. a fault).

U-Q/P_{max}-profile - a profile representing the Reactive Power capability of a Power Generating Facility in context of varying voltage at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point.

Under Excitation Limiter - is a control device within the AVR, the purpose of which is to prevent the rotor of a generator from loosing synchronism due to lack of excitation.

Voltage – unless stated otherwise, voltage refers to the root-mean-square value of phase-to-phase voltages

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Article 2

SUBJECT MATTER

This Network Code defines a common set of requirements for Power Generating Facilities, including Synchronous Generating Units, Power Park Modules and Offshore Generation Facilities, to be connected to the Network and sets up a common framework for Network Connection Agreements between Network Operators and the Power Generating Facility Operators.

Article 3

SCOPE

1. The requirements set forth by this Network Code apply to Generating Units connected to the Network. The extent of the requirements depends on the voltage level of their Connection Point and their MW capacity according to the categories defined in paragraph 2 below.

2. Generating Units within the scope of this Network Code are categorized as follows:

   a) A Synchronous Generating Unit or Power Park Module is of Type A if its Connection Point is below 110 kV and its Maximum Capacity is 400 W or more;

   b) A Synchronous Generating Unit or Power Park Module is of Type B if its Connection Point is below 110 kV and its Maximum Capacity is at or above the threshold according to table 1;

   c) A Synchronous Generating Unit or Power Park Module is of Type C if its Connection Point is below 110 kV and its Maximum Capacity is at or above the threshold according to table 1;

Synchronous Area	capacity threshold Type B	capacity threshold Type C
Continental Europe	0.1 MW	10 MW
Nordic	1.5 MW	10 MW
Great Britain	1 MW	10 MW
Ireland	0.1 MW	5 MW
Baltic	1 MW	5 MW

Table 1: Thresholds for Type B and C Synchronous Generating Units or Power Park Modules

   d) A Synchronous Generating Unit or Power Park Module is of Type D if its Connection Point is at 110 kV or above;

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e) Offshore Power Park Modules are of Type D. The categories to be taken into account for the purpose of this Network Code are defined in Article 18 paragraph 7; and

f) Pump-storage variable speed Generating Units shall fulfill all requirements applicable to Type D synchronous Generating Units and in addition those set forth in Article 15 paragraph 2 (a).

g) For the avoidance of doubt, CHP generators will be assessed on their electrical Active Power output.

Article 4

NON-DISCRIMINATION AND TRANSPARENCY

1. The requirements established in this Network Code and their applications are based on the principle of non-discrimination and transparency as well as the principle of optimisation between the highest overall efficiency and lowest total cost for all involved parties.

2. Notwithstanding the above, the application of non-discrimination principle shall be balanced with the aim of achieving the maximum transparency and the assignment to the real originator of the costs.

   This shall be reflected in objective differences in treatment of different generation technologies with different inherent characteristics as well as by avoiding unnecessary investments in some Regions so that their respective regional specificities are appropriately taken into account. TSOs shall have the right to take into account these marginal differences when defining requirements, in compliance with the provisions of this Network Code and their national law.

   TSOs and DSOs shall not include more onerous requirements related to aspects covered by this Network Code than those defined or allowed for herein.

Article 5

CONFIDENTIALITY OBLIGATIONS

1. Each Relevant Network Operator, Relevant TSO or Relevant DSO shall preserve the confidentiality of the information and data submitted to them in implementation of the Network Code and shall use them exclusively for the purpose they have been submitted in compliance with the Network Code, notably to verify the compliance of requirements set forth in this Network Code.

2. Notwithstanding the above, disclosure of such data may occur in case a Relevant Network Operator, a Relevant TSO or a Relevant DSO is compelled under relevant EU or national law to disclose it, under the conditions set forth in the relevant legislation.

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Article 6

RELATIONSHIP WITH NATIONAL LAW PROVISIONS

This Regulation shall be without prejudice to the rights of Member States to maintain or introduce measures that contain more detailed provisions than those set out herein.

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Title 2

REQUIREMENTS

Chapter 1

GENERAL REQUIREMENTS

Article 7

GENERAL REQUIREMENTS FOR TYPE A UNITS

1. Type A units shall fulfill the following requirements referring to frequency stability**:**

a) With regard to frequency ranges:

1) In case of deviation of the Network frequency from its nominal value, any automatic disconnection of a Generating Unit from the Network shall be prohibited due to a deviation within the frequency ranges and time periods specified by table 2.

Frequency Range	Minimum time period for operation
47.5 Hz – 48.5 Hz	90 minutes
48.5 Hz – 49.0 Hz	To be determined by each TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts , but not less than 90 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	90 minutes

Table 2: This table shows the minimum time periods each Generating Unit has to be able to operate for different frequencies deviating from a nominal value without disconnecting from the network.

2) Wider frequency ranges or longer minimum times for operation can be agreed between the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts to ensure the best use of the technical capabilities of a Generating Unit if needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are technically feasible, the consent of the Power Generating Facility Operator shall not be unreasonably withheld.

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3) Notwithstanding the provisions of point 1) a Generating Unit shall be capable of automatic disconnection at specified frequencies, if required by the Relevant Network Operator. The terms and settings for automatic disconnection shall be agreed, if not regulated by the respective national grid code or by the TSO, with the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

b) With regard to the rate of change of frequency withstand capability, the Generating Unit shall not disconnect from the network due to rates of change of frequency up to 2Hz/s. Any rate of change of frequency above 2 Hz/s shall be withstood by Generating Units for at least 1.25 seconds without disconnection from the network.

c) With regard to the Limited Frequency Sensitive Mode - Overfrequency (LFSM-O):

1) Each Generating Unit shall be capable of providing Active Power Frequency Response according to figure 1 when not operating in Frequency Sensitive Mode as defined in Article 9 paragraph 2 (c).

2) The Generating Unit shall in the Limited Frequency Sensitive Mode - Overfrequency be capable of activating Active Power Frequency Response with a Droop in a range of 2 - 12%. The actual Droop setting shall be determined by the Relevant TSO. The Active Power Frequency Response shall be activated as fast as technically feasible with an initial delay that shall be as short as possible and reasonably justified if greater than 2 seconds.

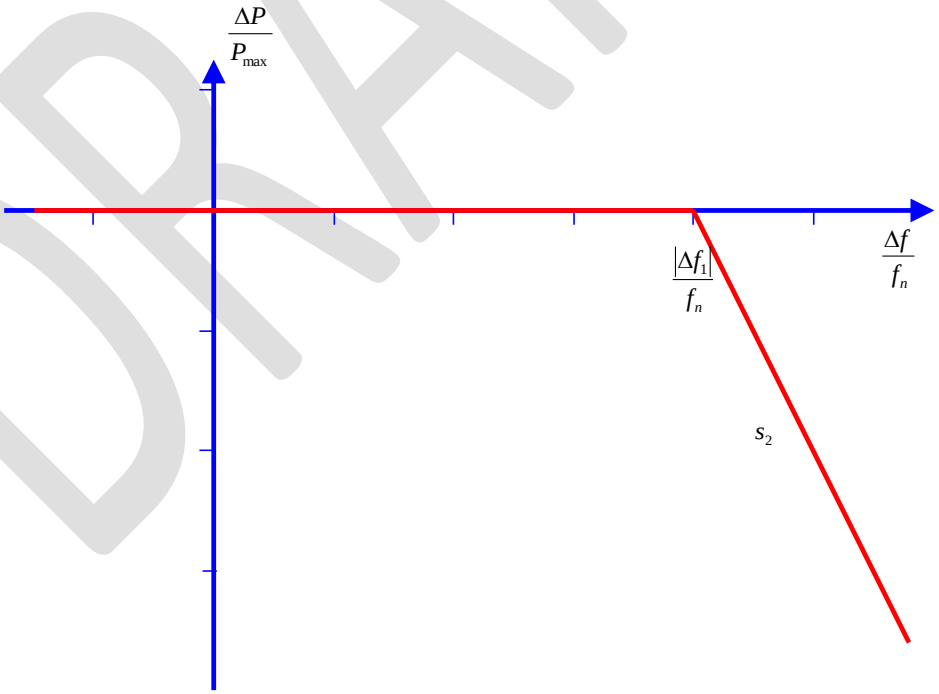

Figure 1: Active Power Frequency Response of Generating Units in Limited Frequency Sensitive Mode - Overfrequency. P_{max} is the Maximum Capacity to which ΔP is related. ΔP is the change in Active Power output from the generator. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency change in the network. At overfrequencies where Δf is above Δf_1 the generator has to provide a negative Active Power output change according to the Droop S_2.

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3) Stable operation of the generating unit during LFSM-O operation shall be ensured. Any contradiction between LFSM-O speed control and power control during LFSM-O operation shall be avoided.

d) In order to be able to cease Active Power output, the Generating Unit shall be equipped with a logic interface capable of switching it off and on. The Relevant Network Operator shall have the right to determine the requirement for further equipment to make this facility operable remotely in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

2. Type A units shall fulfill the following requirements referring to voltage stability:

a) With regard to voltage ranges a Generating Unit shall be capable of automatic disconnection of the Generating Unit at specified voltages, if required by the Relevant Network Operator. The terms and settings for automatic disconnection shall be agreed with the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

3. Type A units shall fulfill the following general system management requirements:

a) With regard to earthing arrangement of the neutral-point of step-up transformers, it shall be in accordance with the specifications of the Relevant Network Operator.

b) With regard to power/ voltage quality rapid voltage changes:

1) Power Generating Facilities shall ensure that their connection to the Network does not result in a level of distortion or fluctuation of the supply voltage on the Network, at the Connection Point, exceeding that allocated to them in accordance with the conditions set forth by national legislation, Connection Agreement or any other bilateral contract.

2) Power Generating Facilities shall also operate in a manner which will not breach the requirements of CENELEC Standard EN 50160 as amended from time to time and any other relevant standard in this context, defined by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO. These may include International Electrotechnical Commission (IEC) standards "Electromagnetic Compatibility-Limits-Limitation of emission of harmonic currents for equipment connected to medium and high voltage power supply systems" (IEC/TR3 61000-3-6) as amended from time to time and "Electromagnetic Compatibility-Limits-Limitation of voltage fluctuation and flicker for equipment connected to medium and high voltage power supply systems" (IEC/TR3 61000-3-7) as amended from time to time

Article 8

GENERAL REQUIREMENTS FOR TYPE B UNITS

1. In addition to fulfilling the general requirements applicable to type A units and listed in Article 7, type B units shall fulfill the following requirements referring to frequency stability, robustness of generating units, system restoration and to general system management through the Network.

2. Type B units shall fulfill the following requirements referring to frequency stability:

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a) With regard to controllability of Active Power, the Generating Unit shall be capable of reducing Active Power output in steps not bigger than 20% of the Maximum Capacity by an interface. The Relevant Network Operator shall have the right to determine the requirement for further equipment to make this facility operable remotely.

3. Type B units shall fulfill the following requirements referring to robustness of Generating Units:

a) With regard to auto-reclosures, Network Operators shall have the right to request single-phase auto-reclosures on generator supply lines (radial connection of one or more generators to the public network) and single-phase or three-phase auto-reclosures on meshed Network lines to be withstood by Generating Units without tripping.

4. Type B units shall fulfill the following requirement referring to system restoration:

a) With regard to capability of reconnection after an incidental disconnection due to a network disturbance, the TSO shall define, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, the conditions under which a Generating Unit is entitled to reconnect to the network after an incidental disconnection has taken place due to a network disturbance. Installation of automatic reconnection systems shall be subject to prior authorisation by the Relevant TSO.

5. Type B units shall fulfill the following general system management requirements:

a) With regard to synchronization, when starting a Generating Unit, synchronisation shall be performed by the Power Generating Facility Operator after authorization by the Relevant Network Operator. The Generating Unit shall be equipped with the necessary synchronisation facilities. Synchronisation of Generating Units shall be possible for frequencies within the ranges set out by table 2. The Network Operator and the Power Generating Facility Operator shall agree on the settings of synchronisation devices in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO concluded prior to operation of the Generating Unit. This agreement shall cover the following matters: voltage, frequency, phase angle range, deviation of voltage and frequency.

b) With regard to electrical protection schemes and settings:

1) The Relevant Network Operator shall define the settings necessary to protect the Network taking into account the characteristics of the Power Generating Facility. Protection schemes relevant for the Power Generating Facility and the Network and settings relevant for the Power Generating Facility shall be coordinated and agreed between the Network Operator and the Power Generating Facility Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

2) Electrical protection of the Generating Unit shall take precedence over operational controls taking into account system security, health and safety of staff and the public and mitigation of the damage to the Generating Unit.

3) Protection schemes can include the following technical components:

- external and internal short circuit;
- asymmetric load (Negative Phase Sequence);

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- stator and rotor overload;
- over-/under-excitation;
- over-/under-voltage at the Connection Point;
- over-/under-voltage at the generator terminals;
- inter-area oscillations;
- robustness against power swings (for example, angle and voltage stability);
- over- and underfrequency;
- asynchronous operation (pole slip);
- protection against subsynchronous resonance (shaft torsions);
- generator line protection;
- unit transformer protection;
- backup schemes against protection and switchgear malfunction;
- overfluxing (U/f);
- inverse power;
- rate of change of frequency; and
- neutral voltage displacement.

4) Any changes to the protection schemes relevant for the Power Generating Facility and the Network and to the setting relevant for the Power Generating Facility shall be coordinated and agreed between the Network Operator and the Power Generating Facility Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO concluded prior to the introduction of changes.

c) With regard to control schemes and settings:

1) Schemes and settings of the different control devices of the Power Generating Facility relevant for system stability shall be coordinated and agreed between the Relevant TSO, Network Operator and the Power Generating Facility Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, especially in case of the following circumstances :

- isolated (Network) operation;
- damping of oscillations; and
- disturbances to the system.

2) Any changes to the schemes and settings of the different control devices of the Power Generating Facility, relevant for system stability, shall be coordinated and agreed between the Relevant TSO, Network Operator and the Power Generating Facility Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, especially if they concern the circumstances referred to above under point 1.

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d) With regard to priority ranking of protection and control, the Power Generating Facility shall organize their protections and control devices in compliance with the following priority ranking, organized in decreasing order of importance:

- Network system and generating unit protection;
- Synthetic Inertia, if applicable;
- Frequency control (Active Power adjustment);
- Power Restriction; and
- Power gradient constraint.

e) With regard to information exchange:

1) Power Generating Facilities shall be equipped according to the standard defined by the Relevant Network Operator pursuant to national legislation to transfer information between the Relevant Network Operator and the Power Generating Facility in real time or periodically with time stamping.

2) The Relevant Network Operator in coordination with the Relevant TSO shall define pursuant to national legislation the information exchanges standards and the precise list of data to be facilitated.

f) With regard to changes to / modernization or replacement of equipment of Generating Units, any Power Generating Facility Operator intending to change plant and equipment of the Power Generating Facility that may have an impact on the network connection and on the interaction, such as turbines, generators, converters, high-voltage equipment, protection and control systems (hardware and software), shall notify in advance (to agreed national timescales) the Relevant Network Operator in case it is reasonable to foresee that these intended changes may be affected by the requirements of this network code and shall agree on these requirements before the proposals are implemented with the Relevant Network Operator in coordination with the Relevant TSO. In case of modernisation/ replacement of equipment in existing Power Generating Facilities the new installations shall comply with the respective requirements which are relevant to the planned work. The use of existing spare components that do not comply with the requirements has to be agreed with the Relevant Network Operator in coordination with the Relevant TSO in each single case.

Article 9

GENERAL REQUIREMENTS FOR TYPE C UNITS

1. In addition to fulfilling the general requirements applicable to type A and B units, listed respectively in Articles 7 and 8, except for Article 7 paragraph 1 (d) and 8 paragraph 2 (a), type C units shall fulfill the following requirements referring to the frequency stability, voltage stability, robustness of generating units, system restoration and to general system management through the Network.

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2. Type C units shall fulfill the following requirements referring to frequency stability:

a) With regard to Active Power controllability and control range**:**

1) The Active Power output of any Generating Unit connected to the Network shall be controllable. For this purpose, the Power Generating Facility control system shall be capable of receiving an Instruction containing a required Setpoint, given orally, manually or by automatic remote control facilities by the Relevant Network Operator and shall implement the Setpoint within a period specified in the above Instruction. Manual measures shall be possible in the case that any automatic remote control devices are out of service.

2) Unless advised by the Relevant Network Operator, the deviation between the scheduled value and the actual value of load at steady-state load (period specified by the Relevant Network Operator) shall not exceed a percentage of the Generating Unit capacity (subject to the availability of the prime mover resource), that will also be specified in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

b) With regard to inertia, all Power Generation Facilities may be required to provide inertia. In case a Power Generation Facility does not provide this inherently, the Relevant Network Operator in coordination with the Relevant TSO shall have the right to require a Power Generating Facility to deliver an equivalent performance by an increase of Active Power related to the rate of change of frequency.

c) With regard to Frequency Sensitive Mode:

1) Each Generating Unit shall be capable of providing Active Power Frequency Response with respect to figure 2 and in accordance with the parameters specified by each TSO within the ranges shown in table 3. In case of overfrequency each TSO shall have the right to determine whether the Active Power decrease shall stop when reaching the Minimum Operating Level and stay at this level or whether it shall be further decreased in case of further increasing frequency.

2) The TSO will specify whether a Generating Unit stays connected at the Minimum Regulating Level, or continues to regulate down accepting the risk of disconnection, below the Minimum Regulating Level.

3) For operation between the Minimum Regulating Level and the Minimum Operating Level, the Relevant Network Operator is entitled to permit or require regulation capability from Power Generating Unit.

4) In case of underfrequency the Active Power Frequency Response is limited by Maximum Capacity.

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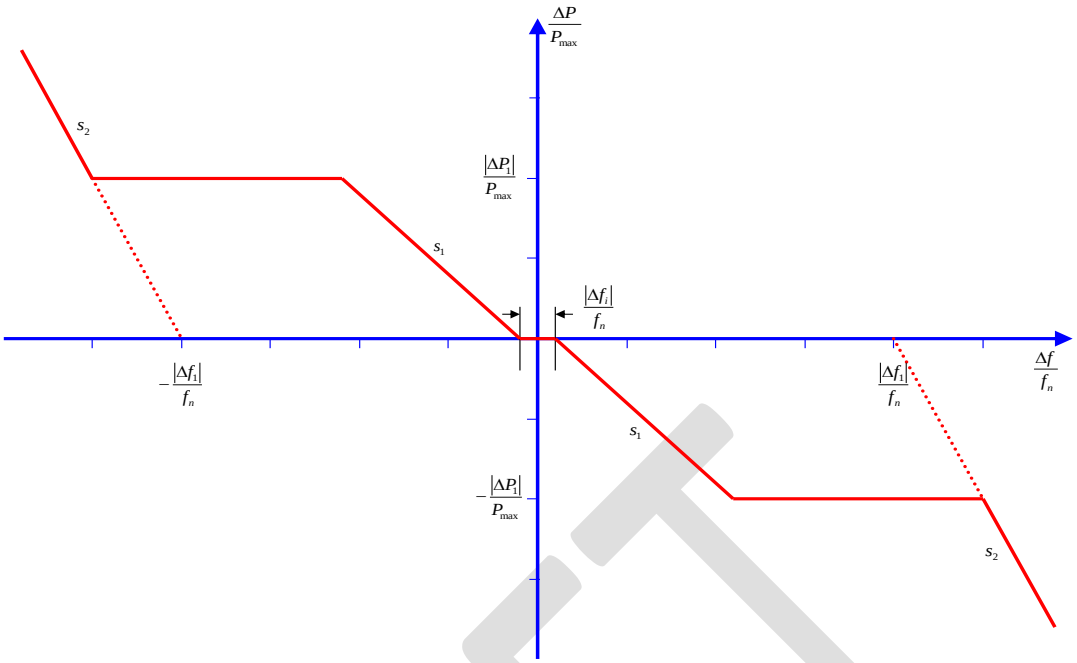

Figure 2: Active Power Frequency Response of Generating Units in Frequency Sensitive Mode. P_{max} is the Maximum Capacity to which ΔP is related. ΔP is the change in Active Power output from the generator. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At overfrequencies where Δf is above Δf_1 the generator has to provide a reduction in Active Power according to the Droop S_2. At underfrequencies where Δf is below $-\Delta f_1$ the generator has to provide an increase in Active Power according to the Droop S_2. Δf_i is the dead band where there is no requirement for an Active Power Frequency Response from the Generating Unit. The horizontal line between S_1 and S_2 defines the Δf when no further Active Power Frequency Response is required from the Generating Unit.

Parameters	**Ranges in mHz**	**Ranges in %**
Active Power range related to Maximum Capacity $\frac{\lvert\Delta P_1\rvert}{P_{max}}$	-	2 – 10 %
Frequency Response Deadband of frequency deviation from nominal frequency $\frac{\lvert\Delta f_1\rvert}{f_n}$	10 – 500 mHz	0.02 – 1.0 %
Frequency sensitivity range $\frac{\lvert\Delta f_i\rvert}{f_n}$	20 – 30 mHz	0.04 – 0.06 %
Droop S_1	-	2 – 20 %
Droop S_2	-	2 – 12 %

Table 3: Parameters for Active Power Frequency Response in frequency sensitive mode (explanation for figure 2)

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5) The accuracy of frequency measurements for Active Power Frequency Response must be better than 10 mHz.

6) The Frequency Response Deadband of frequency deviation and droop are selected by the TSO and must be able to be reselected subsequently (without requiring to be online or remote) within the given frames in the Table 3.

7) Each Generating Unit shall be capable of activating full Active Power Frequency Response at least according to figure 3 in accordance with the parameters specified by each TSO within the ranges according to table 4. The initial delay shall be as short as possible and reasonably justified by the Power Generating Facility Operator to the TSO, by providing technical evidence for why a longer time is needed, if greater than 2 seconds.

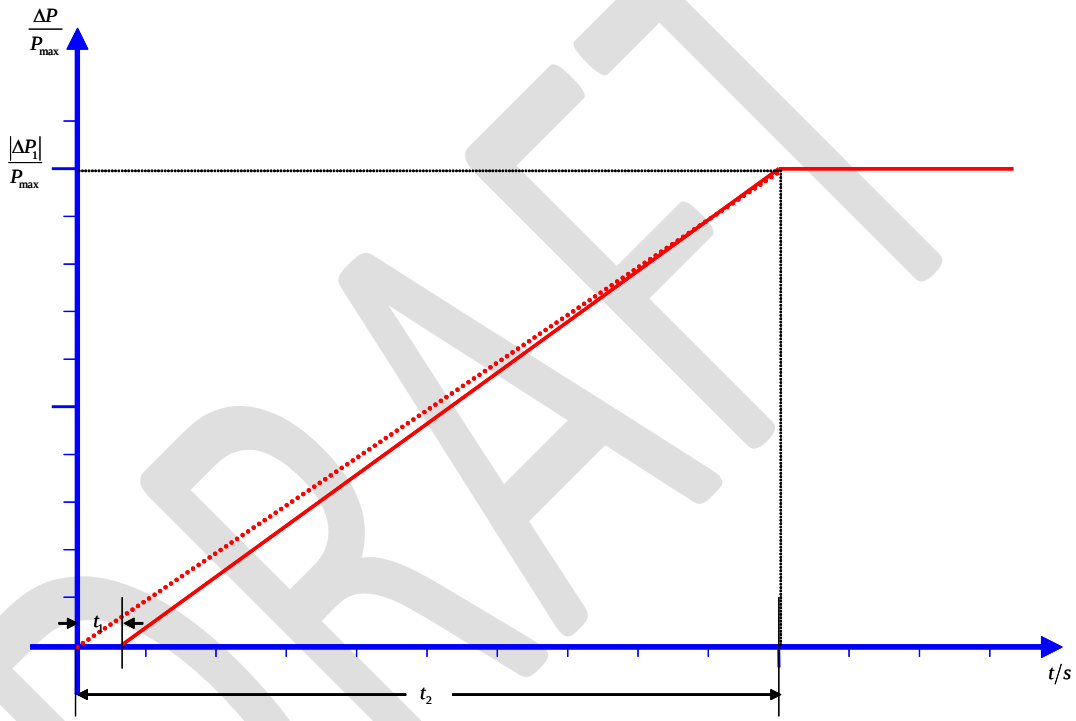

Figure 3: Active Power Frequency Response. P_{max} is the Maximum Capacity to which ΔP is related. ΔP is the change in Active Power output from the generator. The Generating Units have to provide Active Power Output ΔP up to the point ΔP_1 in accordance with the times t_1 and t_2 with the values of ΔP_1 and t_2 being specified by the Relevant TSO from within the ranges specified in Table 4. t_1 is the initial delay which is allowed to be 2 seconds as maximum. t_2 is the time for full activation.

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Parameters	Ranges
Active Power range related to Maximum Capacity $\frac{\lvert\Delta P_1\rvert}{P_{max}}$	2 – 10 %
Initial delay t_1	≤ 2 seconds
Full activation time t_2	6 – 30 seconds

Table 4: Parameters for full activation of Active Power Frequency Response resulted from frequency step change (explanation for figure 3).

8) Each Generating Unit shall be capable of providing full Active Power Frequency Response for a period specified by the TSOs for each Synchronous Area between 15 min and 30 min if inherently available considering the Active Power headroom and energy source of the Power Generating Facility.

9) While a frequency deviation persists power target regulation shall not have any adverse impact on the frequency response.

10) For stable operation of a Generating Unit during network operation and island operation it is necessary that both a proportional speed controller and the power controller are always in operation. The speed controller determines the dynamic behaviour, whereas a slower power controller adapts the steady state operating point.

d) With regard to Limited Frequency Sensitive Mode - Underfrequency:

1) Each Generating Unit shall be capable of providing Active Power Frequency Response according to figure 4 when not operating in Frequency Sensitive Mode as defined in Article 9 paragraph 2 (c).

2) The Generating Unit shall be capable of activating Active Power Frequency Response with a Droop in a range of 2 - 12% by providing a power increase up to its maximum power Pmax, taking account of limitations for some generation technologies from operation near Pmax with frequencies below 49.0Hz. The actual Droop setting shall be determined by the Relevant TSO. The Active Power Frequency Response shall be activated as fast as technically feasible with an initial delay that shall be as short as possible and reasonably justified if greater than 2 seconds.

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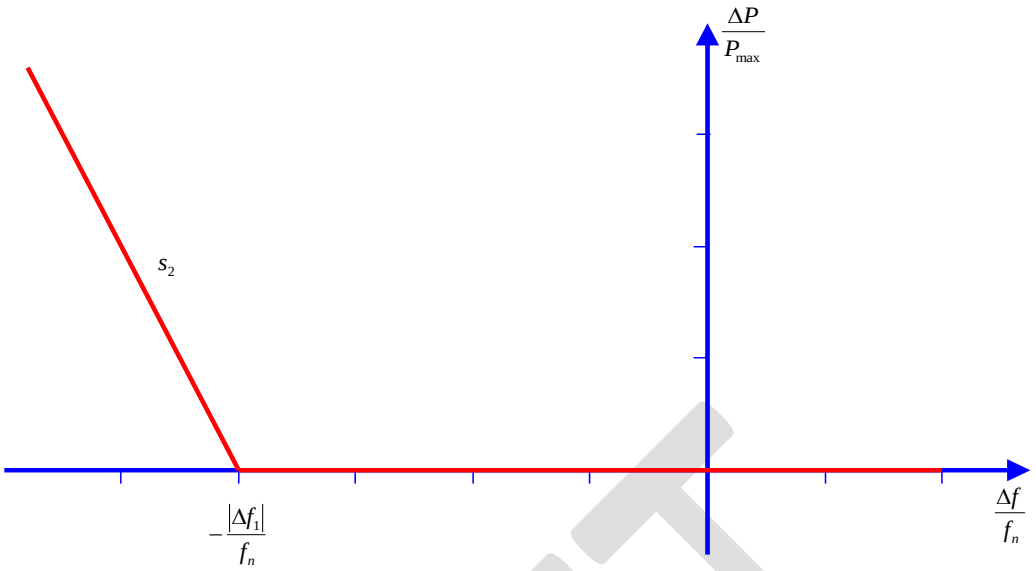

Figure 4: Active Power Frequency Response of Generating Units in Limited Frequency Sensitive Mode - Underfrequency. P_{max} is the Maximum Capacity to which ΔP is related. ΔP is the change in Active Power output from the generator. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency change in the network. At under frequencies where Δf is below Δf_1 the generator has to provide a positive Active Power output change according to the Droop S_2.

3) Stable operation of the generating unit during Limited Frequency Sensitive Mode (Underfrequency) operation shall be ensured.

4) Any contradiction between power and speed control during Limited Frequency Sensitive Mode (Underfrequency) shall be prohibited.

5) When in Limited Frequency Sensitive Mode (Underfrequency) operation, the Generating Set will simultaneously also be in LFSM-O mode.

e) With regard to frequency restoration control, the Power Generating Facility shall provide facilities, compliant to specifications defined by the Relevant TSO, aiming at restoring frequency to its nominal value and/ or maintain power exchange flows between control areas at their scheduled values.

f) With regard to disconnection due to underfrequency, any Power Generating Facility being capable of acting as a load, including hydro pump-storage Power Generating Facilities, shall be capable of disconnecting its load in case of under-frequency.

g) With regard to monitoring of frequency response:

1) To monitor the operation of frequency response the communication interface shall be equipped to transfer between the Power Generating Facility and the Network control centre of the Relevant Network Operator and/or the Relevant TSO on request by the Relevant Network Operator and/or the Relevant TSO the following signals:

- status signal of frequency response;
- scheduled Active Power output;
- actual value of the Active Power output;

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- actual Setpoint value for frequency response;
- range of frequency response; and
- for Power Park Modules available power reflecting maximum unrestricted power, taking into account variable source, such as wind or sun.

2) The Relevant Network Operator transmits the Setpoint value for automatic generation from the load-frequency controller in the system control centre to the communication interface of the Power Generating Facility.

3) The Relevant Network Operator and/or the Relevant TSO and the Power Generating Facility Operator can agree, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, on additional signals to by provided by Power Generating Facility for monitoring and/or recording devices in order to verify the performance of the frequency response provision of participating generating units.

3. Type C units shall fulfill the following requirements referring to robustness of generating units

a) Steady-state stability of a generating Unit is required for any operating point in the P-Q-Capability Diagram in case of power oscillations. Tripping and power reduction shall be prohibited.

b) With regard to torsional stress, the Generating Units shall be designed in a way that shaft torsional stress which may be excited by Transient Active Power steps up to 50% of its Maximum Capacity are considered a routine part of normal operation and shall be taken into account when specifying the shaft characteristics.

4. Type C units shall fulfill the following requirements referring to system restoration:

a) With regard to Black Start Capability:

1) Black Start Capability is not mandatory. If the Relevant TSO deems system security to be at risk due to a lack of Black Start Capability in a Control Area, the Relevant TSO shall have the right to impose Black Start Capability on a Power Generating Facility. Black Start Capability shall be agreed between the TSO and the Power Generating Facility in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts. The consent of the Power Generating Facility Operator shall not be withheld if the requested Black Start Capability is inherently available in the major technology of the facility. Black Start Capability shall be requested by the TSO pursuant to its national legislation and shall be compulsory for the Power Generating Facility Operator where such capability is technically feasible.

2) A Generating Unit with Black Start Capability shall be able to start from shut down within a timeframe specified by the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, without any external energy supply. The Generating Unit shall be able to energise a part of the Network upon instruction from the Relevant Network Operator and shall be able to synchronise with another Network within the frequency limits defined in Article 7 paragraph 1 and voltage limits defined in Article 10 paragraph 2.

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3) The generator voltage regulation shall be enabled to assure that load connections causing dips of voltage, are automatically regulated. The Generating Unit protection shall be stabilized against in-rush currents.

The Generating Unit shall:

- be capable of regulating load connections in block load in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.
- control frequency in case of overfrequency and underfrequency within the whole Active Power output range as well as at houseload level;
- be capable of parallel operation of a few generating units within one isolated network;
- control voltage automatically during the system restoration phase; and

b) With regard to capability to take part in isolated network operation:

1) The capability to take part in Isolated Network Operation, if required by the Relevant Network Operator in coordination with the Relevant TSO, shall be possible within the frequency limits defined in Article 7 paragraph 1 and voltage limits defined in Article 10 paragraph 2.

2) If required, each Generating Unit shall be able to operate in frequency sensitive mode during Isolated Network Operation, as defined in Article 9 paragraph 2 (c). In the case of a power surplus, it shall be possible to reduce the loading of the Generating Unit from its previous operating point to any new operating point within the P-Q-Capability Diagram as much as inherently technically feasible, but at least a load reduction of 45% of its Maximum Capacity shall be possible. This load reduction shall prevent the disconnection of the Generating Unit from the Isolated Network due to overfrequency.

3) The Generating Unit shall perform the required behaviour when changing from interconnected system operation to Isolated Network Operation without using any switchgear position signals for identifying an Isolated Network.

c) With regard to trip to houseload:

1) Tripping to houseload is required in case of disconnection of the Generating Unit from the Network in line with protection strategy agreed between the Relevant Network Operator and the Power Generation Facility Operator in the event of disturbances to the system.

2) The Generating Unit whose minimum start-up time exceeds 30 minutes shall be designed for tripping to houseload from any operating point in the P-Q-Capability Diagram without using any swichtgear position signals for identifying houseload operation.

3) Generating Units shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be defined by the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

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4) All Power Generating Facility control systems shall remain in automatic mode. Manual intervention by the Power Generating Facility Operator is prohibited within the first 3 minutes after tripping.

d) With regard to reconnection after tripping onto auxiliary supply, it shall be performed by a circuit breaker on the voltage level of the Connection Point after a synchro-check.

5. Type C units shall fulfill the following general system management requirements**:**

a) With regard to loss of stability of a single Generating Unit, it should automatically disconnect from the Network in order to support preservation of system security and/or to prevent damage from the Generating Unit. The Power Generating Facility Operator shall comply with the criteria established by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO to recognize loss of stability and the subsequent automatic disconnection.

b) With regard to instrumentation:

1) Power Generating Facilities shall be equipped with a facility to provide fault recording, dynamic system behaviour monitoring and of the following parameters:

- Voltage;
- Active Power;
- Reactive Power;
- Frequency; and
- Harmonics.

The Relevant Network Operator shall have the right to add other quality of supply parameters requirements to be complied with provided a reasonable prior notice is given.

2) The settings of the fault recording equipment, including triggering criteria and the sampling rates shall be agreed with the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3) The dynamic system behaviour monitoring shall include an oscillation trigger, specified by the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, detecting poorly damped power oscillations.

4) The facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the Network Operator and/or the Relevant TSO to access the information. The communications protocols for recorded data shall be agreed with the Relevant Network Operator and/or Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

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c) With regard to the simulation models:

1) Each Network Operator in coordination with the Relevant TSO shall have the right, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts including confidentiality or by the TSO, to require simulation models for the purpose of verification of the requirements of this Network Code and for the use in all types of studies for continuous evaluation of system performance.

2) The models shall be provided in the format required by the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts and shall show the behaviour of the generating unit in both steady-state simulations and dynamic simulations (long term, short term, and electromagnetic transient) at the Connection Point.

3) For the purpose of dynamic simulations, the model provided shall contain the following sub-models:

- Speed and power control;
- Voltage control, including PSS, and excitation system and limiters;
- Generator protection models; and
- Converter models for Power Park Modules.

4) The structure and block diagrams of the model shall be fully documented, according the requirements of the Relevant Network Operator agreed in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

5) The Relevant Network Operator or Relevant TSO shall have the right to require, in the conditions set forth by national legislation, Connection Agreement or bilateral contracts, generator recordings in order to compare the response of the model with these recordings.

d) With regard to the installation of devices for system operation and/or security, if the Relevant Network Operator in co-ordination with the TSO considers additional devices necessary to be installed in a Power Generating Facility site in order to preserve or restore system operation or security, the Relevant Network Operator/TSO and the Power Generating Facility Operator shall investigate this request and agree by means of bilateral contracts on an appropriate solution.

Article 10

GENERAL REQUIREMENTS FOR TYPE D UNITS

1. In addition to fulfilling the general requirements applicable to type A, B and C units, listed respectively in Articles 7, 8 and 9, except for Article 7 paragraph 1 (d), Article 7 paragraph 2 (a) and 8 paragraph 2 (a), type D units shall fulfill the following requirement referring to voltage stability through the Network.

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2. Type D units shall fulfill the following requirements referring to voltage stability:

a) With regard to voltage ranges:

1) In case of a deviation of the Network voltage at the Connection Point from its nominal value, any automatic disconnection from the Network of a Generating Unit, with a Connection Point at 110 kV or above, shall be prohibited due to the deviation within the voltage ranges, expressed by the voltage at the Connection Point related to nominal voltage (per unit), and within the time periods specified by tables 5.1 and 5.2. Note the reference PU voltage at each TSO in the same synchronous area may differ i.e. the voltage range in kV for all TSOs within a synchronous are may not be the same.

Synchronous Area	**Voltage Range**	**Time period for operation**
Continental Europe	0.80 pu – 0.85 pu	30 minutes
	0.85 pu – 0.90 pu	180 minutes
	0.90 pu – 1.0875 pu	Unlimited
	1.0875 pu – 1.10 pu	60 minutes
Nordic	0.90 pu – 1.05 pu	Unlimited
	1.05 pu – 1.10 pu	60 minutes
Great Britain	0.90 pu – 1.05 pu 1.05 pu – 1.10 pu	Unlimited 60 minutes
Ireland	0.90 pu – 1.05 pu	Unlimited
Baltic	0.88 pu – 0.90 pu	20 minutes
	0.90 pu – 1.10 pu	Unlimited
	1.10 pu – 1.15 pu	20 minutes

Different equipment ratings may apply for permanent operation above 1.05 pu (420 kV).

Table 5.1: This table shows the minimum time periods each Generating Unit has to operate for voltages deviating from the nominal value at the Connection Point without disconnecting from the network. (The voltage base for pu values is between 300 kV and 400 kV)

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Synchronous Area	Voltage Range	Time period for operation
Continental Europe	0.80 pu – 0.85 pu	30 minutes
	0.85 pu – 0.90 pu	180 min
	0.90 pu – 1.115 pu	Unlimited
	1.115 pu – 1.15 pu	60 minutes
Nordic	0.90 pu – 1.05 pu	Unlimited
	1.05 pu – 1.10 pu	60 minutes
Great Britain	0.90pu–1.10pu	Unlimited
Ireland	0.90 pu – 1.118 pu	Unlimited
Baltic	0.80 pu – 0.90 pu	30 minutes
	0.90 pu – 1.12 pu	Unlimited
	1.12 pu – 1.15 pu	20 minutes

Table 5.2: This table shows the minimum time periods each Generating Unit has to operate for voltages deviating from the nominal value at the Connection Point without disconnecting from the network. (The voltage base for pu values is between 110 kV and 300 kV)

2) Notwithstanding the provisions of point 1) a Generating Unit shall be capable of automatic disconnection of the Generating Unit at specified voltages, if required by the Relevant Network Operator. The terms and settings for automatic disconnection shall be agreed with the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

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Chapter 2

REQUIREMENTS FOR SYNCHRONOUS GENERATING UNITS

Article 11

REQUIREMENTS FOR TYPE B SYNCHRONOUS GENERATING UNITS

1. In addition to fulfilling the general requirements listed in Articles 7 and 8, type B Synchronous Generating Units shall fulfill the following requirement referring to voltage stability and to the robustness of generating units.

2. Type B Synchronous Generating Units shall fulfill the following requirements referring to voltage stability:

   a) With regard to Reactive Power capability the Relevant DSO shall have the right, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO, to determine the capability of a Synchronouos Generating Unit to provide Reactive Power at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point.

   b) With regard to the voltage control system:

      1) Each Synchronous Generating Unit shall be equipped with a permanent automatic excitation control system in order to provide constant generator terminal voltage without instability over the entire operating range of the Synchronous Generating Unit.

3. Type B Synchronous Generating Units shall fulfill the following requirements referring to robustness of generating units:

   a) With regard to fault ride through capability of Synchronous Generators connected below 110 kV:

      1) Each TSO shall have the right to define, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a voltage-against-time-profile at the Connection Point for fault conditions which describes the conditions in which the Synchronous Generating Unit shall stay connected to the network and shall continue stable operation after the power system has been disturbed by Secured Faults on the network unless the protection scheme requires the disconnection of a Generating Unit from the network.

      2) This voltage-against-time-profile shall be expressed by a lower limit of the course of the one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, irrespective of the voltage drop of the other two phase-to-phase voltages, as a function of time before, during and after the fault. This lower limit shall remain above the red lines or inside the shaded area delimited by the red lines in figure 5.

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3) Each TSO shall define the pre-fault and post-fault conditions for the fault ride through capability in terms of:

   - conditions for the calculation of the pre-fault minimum short circuit capacity at the Connection Point;
   - conditions for pre-fault active and Reactive Power operating point of the Generating Unit at the Connection Point and voltage at the Connection Point; and
   - conditions for the calculation of the post-fault minimum short circuit capacity at the Connection Point.

4) Each Relevant Network Operator shall define the pre-fault and post-fault parameters for the fault ride through capability as an outcome of the calculations at the Connection Point as defined in point 3) regarding:

   - pre-fault minimum short circuit capacity at each Connection Point expressed in MVA;
   - pre-fault operating point of the Generating Unit expressed in Active Power output and Reactive Power output at the Connection Point and voltage at the Connection Point; and
   - post-fault minimum short circuit capacity at each Connection Point expressed in MVA.

5) The Generating Unit shall stay connected to the network and continue stable operation when the actual course of one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, given the pre-fault and post-fault conditions according to points 3) and 4), remains above the lower limit defined in point 2).

6) Under voltage protection, respecting the appropriate operating voltage ranges, should be set to the widest possible technical capability of the generator and the settings applied by generators shall be justified by the Power Generating Facility Owner in accordance with this principle.

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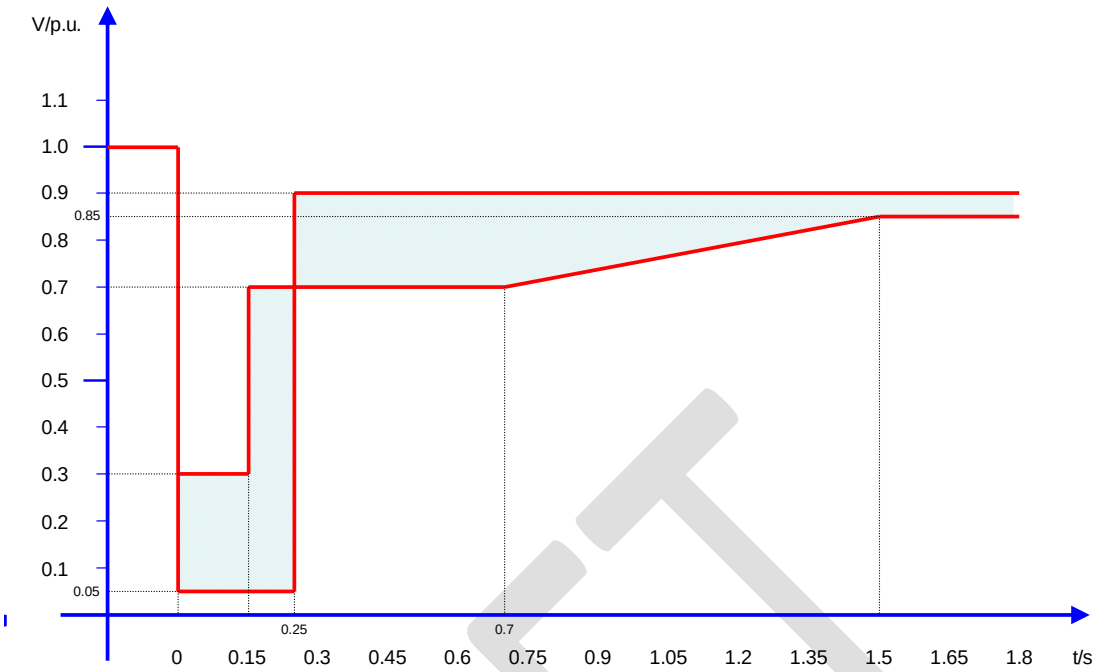

Figure 5 – Fault ride through profile of a Synchronous Generating Unit connected at voltage levels below 110 kV. The diagram represents the boundaries for a voltage-against-time profile by the voltage at the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit before, during and after a fault.

7) Fast Valving is prohibited unless permitted by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

b) With regard to post fault Active Power recovery, the Relevant TSO shall specify in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a maximum recovery period for the Active Power to reach at least the level of 90% of the pre-fault nominal voltage value. The maximum recovery period shall be equal to or greater than 0.5 seconds and shorter than 15 seconds.

Article 12

REQUIREMENTS FOR TYPE C SYNCHRONOUS GENERATING UNITS

1. In addition to fulfilling the general requirements listed in Articles 7, 8 and 9 as well as the specific type B Synchronous Generating Units requirements listed in Article 11, except paragraph 2 (a), type C Synchronous Generating Units shall fulfill the following requirement referring to frequency stability, voltage stability and to general system management through the Network.

2. Type C Synchronous Generating Units shall fulfill the following requirements referring to frequency stability:

a) The Power Generating Facility shall maintain constant output at its target Active Power value regardless of changes in frequency, subject to the following limitations:

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1) For the purpose of Article 9 paragraph 2 c) Frequency Sensitive Mode, in the context of Article 9 paragraph 2 d) Limited Sensitive Mode – Underfrequency and in the context of Article 7 paragraph 1 c) Limited Sensitive Mode – Overfrequency output shall follow the defined changes in output.

b) With regard to underfrequency maximum power capability reduction for some generation technologies, some synchronous generation technologies deliver falling mechanical power with falling frequency. The TSO shall define a Maximum Capacity with falling frequency. The value chosen by the TSO shall be within the boundaries of:

- Below 49 Hz falling up to a maximum reduction rate of 10% of maximum capability per 1Hz frequency drop below 49 Hz.

- Below 49.5 Hz up to a maximum reduction rate of 2% of Maximum Capacity per 1 Hz frequency drop below 49.5 Hz.

Acceptance of this reduction is limited to selection of affected generation technologies specified by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3. Type C Synchronous Generating Units shall fulfill the following requirements referring to voltage stability:

a) With regard to the voltage control system:

1) The Excitation System of a Synchronous Generating Unit shall include:

- an Excitation System complying with the characteristics defined in Article 12 paragraph 3 (c) and (d) ; and

- a continuously acting Automatic Voltage Regulator (AVR) complying with the characteristics defined in Article 12 paragraph 2 (b).

2) Control scheme characteristics, parameters and settings of the voltage control system components shall be agreed between the Power Generating Facility Operator and the Relevant Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3) Power Generating Facility Operators shall provide to the Relevant Network Operator all data, models and studies required by this Network Code and in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO including the national codes in order to evaluate and agree on the voltage control system.

b) With regard to steady-state voltage control, the Automatic Voltage Regulator shall limit the change at the Generating Unit terminal to not more than a percentage of rated terminal voltage specified by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO, when the output signal is gradually changed from zero to rated Apparent Power at rated voltage, Active Power and frequency.

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c) With regard to transient voltage control:

1) For a step change from 90 to 100% of the nominal voltage at the Generating Unit terminal, with the Generating Unit on open circuit, the Excitation System response shall have a damped oscillatory characteristic. For this characteristic, the time for the Generating Unit terminal voltage to reach 100% shall be less than a value specified by the Relevant Network Operator. The time to settle within 5% of the voltage change shall be specified by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

2) To ensure that adequate synchronising power is maintained, when the Generating Unit is subject to a large voltage disturbance, the Exciter whose output is varied by the AVR shall be capable of providing its achievable upper and lower limit ceiling voltages to the Generating Unit field in a time not exceeding that specified by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO. The achievable upper and lower limit ceiling voltages may be dependent on the voltage disturbance. The Exciter shall be capable of attaining an Excitation System on Load Positive Ceiling Voltage specified by the Relevant Network Operator for at least 10 seconds when responding to a sudden drop in voltage of 10% or more.

3) The field voltage of a synchronous generator with a static Excitation System should be capable of attaining a negative ceiling level specified by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO after the removal of the step when responding to a sudden drop in voltage of 10% or more at the Generating Unit terminals.

4) Depending of the circumstances, the Relevant Network Operator shall have the right to require in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO that the Exciter:

- shall be capable of maintaining free firing when the Generating Unit terminal voltage is depressed to a level which may be 25% of rated terminal voltage; and

- shall be capable of attaining a positive ceiling voltage not less than 80% of the Excitation System On Load Positive Ceiling Voltage upon recovery of the Generating Unit terminal voltage to 80% of rated terminal voltage following fault clearance.

d) With regard to Excitation System specification:

1) The Excitation System shall be equipped with the following elements:

- elements that limit the bandwidth of the output signal. The bandwidth shall be limited to and ensure that the highest frequency of response cannot excite torsional oscillations on other Generating Units connected to the network. The bandwidth limit shall be specified by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts to be consistent with the speed of response required;

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- an Under Excitation Limiter. The Under Excitation Limiter shall prevent the Automatic Voltage Regulator reducing the generator excitation to a level which would endanger synchronous stability. The Under Excitation Limiter shall operate when the Excitation System is providing automatic control. The Under Excitation Limiter shall respond to changes in the Active Power and the Reactive Power, and to the square of the generator voltage in such a direction that an increase in voltage will permit an increase in leading Reactive Power. The characteristic of the Under Excitation Limiter shall be substantially linear from no-load to the Maximum Capacity output of the Generating Unit at any setting and shall be readily adjustable.

  The resulting maximum overshoot in response to a step injection which operates the Under Excitation Limiter shall not exceed 4% of the Generating Unit Maximum Capacity. The operating point of the Generating Unit shall return to a steady-state value at the limit line and the final settling time shall not be greater than 5 seconds. When the step change AVR reference voltage is reversed, the field voltage should begin to respond without any delay and should not be held down by the Under Excitation Limiter. Operation into or out of the preset limit levels shall ensure that any resultant oscillations are damped so that the disturbance is within 0.5% of the Generating Unit rated Apparent Power within a period of 5 seconds.

  The under excitation limiter shall also prevent the Generating Unit excitation from being reduced to a level which would endanger synchronous stability when the Excitation System is under manual control; and

- an Over Excitation Limiter, if may either be provided by choice of the Power Generator Facility Operator or requested by the Relevant Network Operator. The settings of the Over Excitation Limiter shall ensure that the generator excitation is not limited to less than the maximum value that can be achieved whilst ensuring the Generating Unit is operating within its design limits. Any operation beyond the over excitation limit shall be controlled by the Over Excitation Limiter without tripping the Generating Unit.

  The Generator over excitation limiter shall also not restrict any over-excitation of the generator when the Excitation System is under manual control, other than what is necessary to ensure the Generating Unit is operating within its design limits.

e) With regard to Reactive Power capability at Maximum Capacity:

1) Each Network Operator shall define, in accordance with the conditions set forth in national legislation, Connection Agreement or any other bilateral contracts or by the TSO, the Reactive Power provision capability requirement in the context of varying voltage for Synchronous Generating Units. For doing so, it shall define a U-Q/P_{max}-profile that shall take any shape and within the boundaries of which the Synchronous Generating Unit shall be capable to provide Reactive Power at its Maximum Capacity if required to do so by the Relevant Network Operator.

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2) The U-Q/P_{max}-profile is defined by each Network Operator for each Synchronous Generating Unit by means of national legislation, Connection Agreement or any other bilateral contract or by the TSO and in compliance with the following principles:

- the U-Q/Pmax-profile shall be inside the U-Q/Pmax-profile envelope, represented by the inner envelope in figure 6;
- the dimensions of the U-Q/Pmax-profile envelope (Reactive Power Factor range and voltage range) are defined for each Synchronous Area in table 6;
- the position of the U-Q/Pmax-profile envelope is defined by each Network Operator;
- the U-Q/Pmax-profile envelope cannot be positioned outside the fixed outer envelope in figure 6; and
- in case a Synchronous Generating Unit has a Reactive Power capability beyond the voltage range specified by figure 6, the Reactive Power capability shall not be deliberately limited.

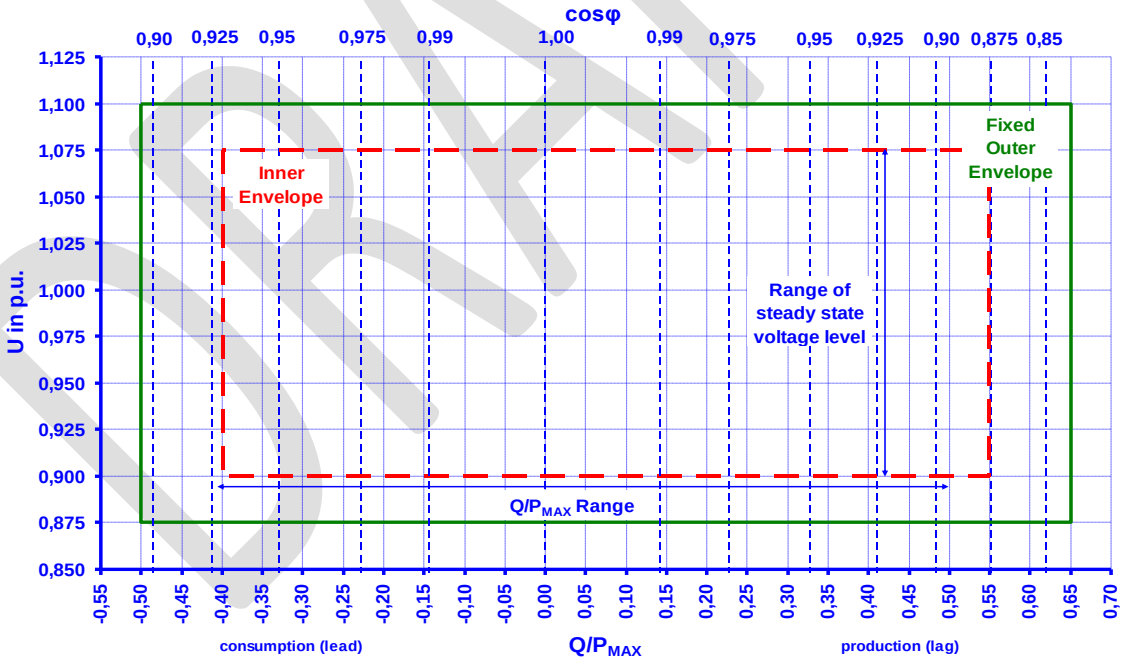

Figure 6 – U-Q/P_{max}-profile of a Synchronouos Generating Unit. The diagram represents a U-Q/P_{max}-profile by the voltage at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit, against the ratio of the Reactive Power (Q) and the Maximum Capacity (P_{max}) of a Generating Units, respectively the Power Factor (cos φ).

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Synchronous Area	Range of Q/P_{max}	Range of steady state voltage level in PU
Continental Europe	0.95	0.225
Nordic	0.95	0.150
Great Britain	0.95	0.100
Ireland	1.08	0.218
Baltic States	1.0	0.220

Table 6: Parameters for figure 6

3) The Reactive Power provision capability requirement applies at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point. Beyond the voltage range specified by the figure 6 the Reactive Power capability shall not be deliberately limited. For Synchronous Generating Units where the Connection Point is remote from the high-voltage terminals of this step-up transformer, supplementary Reactive Power may be required by the Network Operator to compensate for the Reactive Power demand of the HV line, or cable, between these two points from the responsible owner of this line or cable.

4) The Synchronous Generating Unit shall be capable of moving to any operating point within its P-Q/Pmax profile in timescales determined by the requirements of reactive power control. The Relevant Network Operator shall have the right at any time to change the Reactive Power target value within the agreed Reactive Power range. Where part of the P-Q/Pmax range is unavailable until tapping of generation transformer(s) has been completed, the Relevant Network Operator shall not require more than 15 tap movements within 4 minutes.

5) The Relevant Network Operator shall have the right to require from the Synchronous Power Generating Facility that additional facilities are installed on the Synchronous Power Generating Facility in order to be able to carry out voltage and Reactive Power control within its area. The mode of operation is determined by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

f) With regard to Reactive Power capability below Maximum Capacity, when operating at an Active Power output below the Maximum Capacity (P<Pmax), the Synchronous Generating Units of the Synchronous Power Generating Facility shall be able to be operated in every possible operating point in the P-Q Capability Diagram of the generator of this Synchronous Generating Unit. Even at reduced Active Power output, Reactive Power supply at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point shall fully correspond to the P-Q-Capability Diagram of the generator of this Synchronous Generating Unit, taking the auxiliary service power and the losses of the generator transformer into account.

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g) With regard to stator current limiter:

1) The operation of the Stator Current Limiter and the Over Excitation Limiter shall be coordinated. The Stator Current Limiter shall act delayed to the Over Excitation Limiter to fully utilise the transient over excitation capability of the Generating Unit. The operation of the Stator Current Limiter shall not result in a reduction of the generator terminal voltage which leads to possible failure from the auxiliary supply system due to low voltage.

2) If the stator current does not reach the admissible range when the generator voltage is at its minimum admissible value which prevents failure from the auxiliary supply system due to low voltage, the Stator Current Limiter shall either reduce the Active Power output automatically until the stator is in the admissible range or, alternatively, the Active Power output shall be reduced manually after an alarm signal from the Stator Current Limiter.

4. Type C Synchronous Generating Units shall fulfill the following general system management requirements:

a) With regard to coordination of speed and power control of Synchronous Generating Units:

1) Generating Units shall be equipped with a proportional speed controller to determine the dynamic behaviour and a slower power controller which adapts the steady-state operating point.

2) Generating Units shall ensure that both the proportional speed controller and the power controller are always in operation to ensure stable operation during network operation and island operation.

Article 13

REQUIREMENTS FOR TYPE D SYNCHRONOUS GENERATING UNITS

1. In addition to fulfilling the general requirements listed in Articles 7, 8, 9 and 10 as well as the specific type B and C Synchronous Generating Units requirements listed in Articles 11 and 12, type D Synchronous Generating Units shall fulfill the following requirements referring to to voltage stability and the robustness of generating units.

2. Type D Synchronous Generating Units shall fulfill the following requirements referring to voltage stability:

a) With regard to the voltage control system the Excitation System of a Synchronous Generating Unit shall include a Power System Stabiliser (PSS) to prevent or attenuate power oscillations, if the Synchronous Generating Unit size is above a value of Maximum Capacity specified by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

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b) With regard to power oscillations damping control:

1) The arrangements for the supplementary control signal shall ensure that the PSS output signal relates only to changes in the supplementary control signal and not the steady-state level of the signal. Additionally the PSS shall not react to non-oscillatory power changes.

2) The output signal from the PSS shall be limited to not more than ±10% of the Generating Unit terminal voltage signal at the AVR input. The gain of the PSS shall be such that an increase in the gain by a factor of 3 shall not cause instability.

3) The PSS shall include elements that limit the bandwidth of the output signal. The bandwidth limiting shall ensure that the highest frequency of response cannot excite torsional oscillations on other Generating Units connected to the network. The bandwidth limit shall be specified by the Relevant TSO.

4) The PSS shall be active within the Excitation System at all times when synchronised including when the Under Excitation Limiter or Over Excitation Limiter are active. When synchronising or de-synchronising a Generating Unit or when operating at less than 10% of Maximum Capacity, the PSS may be out of service.

5) Where a PSS is fitted to a pumped storage unit it shall function when the pumped storage unit is in both generating and pumping modes.

6) A facility to inject a band limited random noise signal into the AVR voltage reference shall be provided for demonstrating the frequency domain response of the Power PSS. The tuning of the PSS shall result in improved damping of corresponding Active Power response of the AVR in combination with the PSS compared to the Active Power response of the AVR alone over a frequency range specified by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3. Type D Synchronous Generating Units shall fulfill the following requirements referring to robustness of generating units:

a) With regard to fault ride through capability of Synchronous Generators connected at 110 kV or above:

1) Each TSO shall have the right to define, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a voltage-against-time-profile at the Connection Point for fault conditions which describes the conditions in which the Synchronous Generating Unit shall stay connected to the network and shall continue stable operation after the power system has been disturbed by Secured Faults on the network, unless the protection scheme requires the disconnection of a Generating Unit from the network.

2) This voltage-against-time-profile shall be expressed by a lower limit of the course of the one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, irrespective of the voltage drop of the other two phase-to-phase voltages, as a function of time before, during and after the fault. This lower limit shall remain on the red lines or inside the shaded area delimited by the red lines in figure 7.

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3) Each TSO shall define the pre-fault and post-fault conditions for the fault ride through capability in terms of:

- conditions for the calculation of the pre-fault minimum short circuit capacity at the Connection Point;
- conditions for pre-fault active and Reactive Power operating point of the Generating Unit at the Connection Point and voltage at the Connection Point; and
- conditions for the calculation of the post-fault minimum short circuit capacity at the Connection Point.

4) Each Network Operator shall define the pre-fault and post-fault parameters for the fault ride through capability as an outcome of the calculations at the Connection Point as defined in point 3) regarding:

- pre-fault minimum short circuit capacity at each Connection Point expressed in MVA;
- pre-fault operating point of the Generating Unit expressed in Active Power output and Reactive Power output at the Connection Point and voltage at the Connection Point; and
- post-fault minimum short circuit capacity at each Connection Point expressed in MVA.

5) The Generating Unit shall stay connected to the network and continue stable operation when the actual course of one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, given the pre-fault and post-fault conditions according to points 3) and 4), remains above the lower limit defined in point 2).

6) Under voltage protection, respecting the appropriate operating voltage ranges, should be set to the widest possible technical capability of the generator and the settings applied by generators shall be justified by the Power Generating Facility Owner in accordance with this principle.

7) Fast Valving under fault conditions in order to aid angular stability shall be implemented if allowed or requested by the responsible TSO. Specifications shall be agreed between the TSO and the Power Generating Facility Operator.

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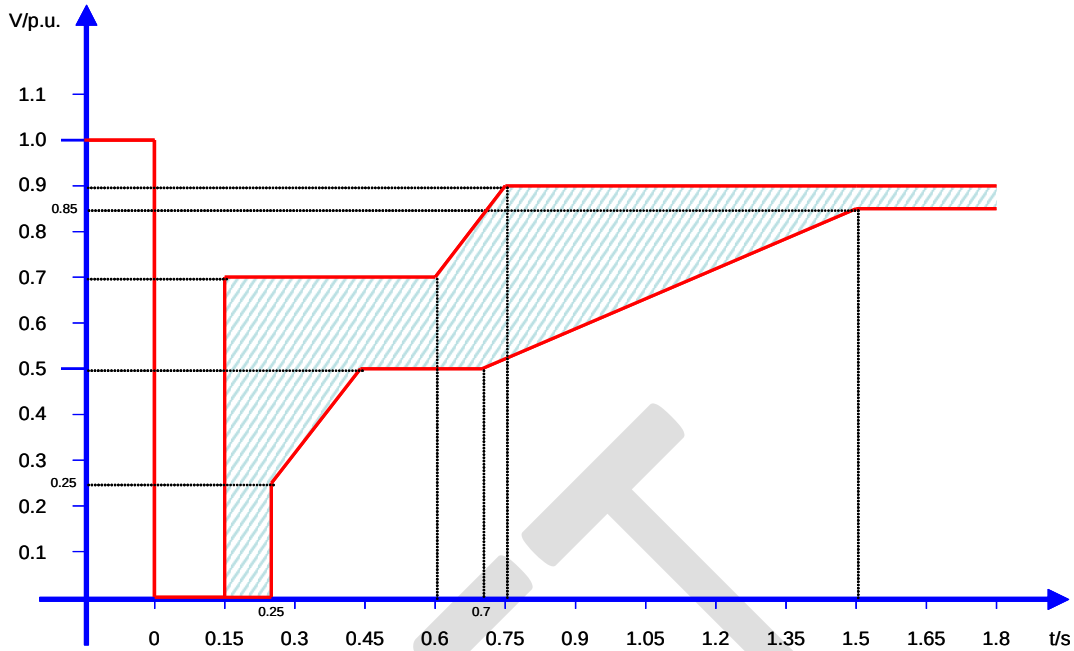

Figure 7 – Fault ride through profile of a Synchronous Generating Unit connected at voltage levels at 110kV or above. The diagram represents the boundaries for a voltage-against-time profile by the voltage at the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit before, during and after a fault.

Chapter 3

REQUIREMENTS FOR POWER PARK MODULES

Article 14

REQUIREMENTS FOR TYPE A POWER PARK MODULES

1. In addition to fulfilling the general requirements listed in Articles 7, type A Power Park Modules shall fulfill the following requirement referring to voltage stability.

   a) With regard to Reactive Power capability the Relevant DSO shall have the right, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO, to determine the capability of a Power Park Module to provide Reactive Power at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point.

   b) With regard to Reactive Power control modes:

      1) The Power Park Module shall be capable of providing Reactive Power automatically by either Voltage Control mode, Reactive Power Control mode or Power Factor Control mode.

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2) For the purposes of Voltage Control mode, the Power Park Module shall be capable of controlling the voltage at the Connection Point by provision of Reactive Power exchange with the System with a Setpoint voltage covering at least 0.95 to 1.05pu in steps no greater than 0.01pu with a Slope with a range of at least 2 to 7% in steps no greater than 0.5%.

The Setpoint may be operated with or without a deadband selectable in a range from 0 to +-10% of nominal network voltage in steps no greater than 0.5% (figure 8 illustrates a choice of zero deadband).

Following a step change in voltage 90% of the change in Reactive Power output shall be achieved within 1 second and settle at the value defined by the operating Slope within 5 seconds with a steady state reactive tolerance no greater than 5%. The Slope is the percentage change in voltage based on nominal, that results in a change of reactive power from 0 to Qmax.

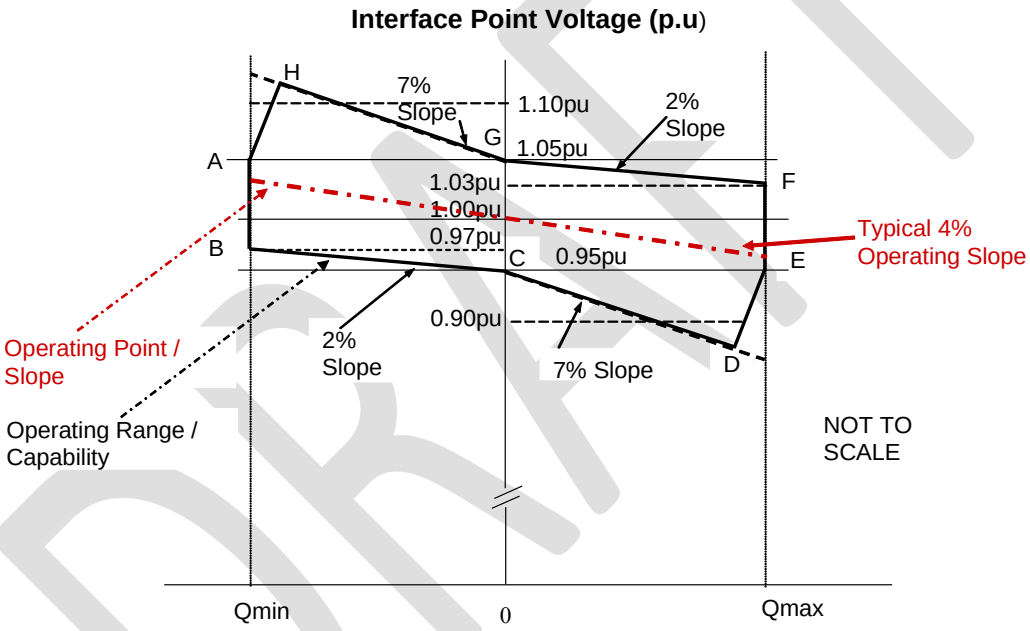

Figure 8 – Steady-state voltage control of Power Park Modules The enclosed area within points ABCDEFGH is the required capability range within which the Slope and Setpoint Voltage shall be achieved.

3) For the purposes of Reactive Power Control mode, the Power Park Module shall be capable of setting the Reactive Power target anywhere in the full Reactive Power range (applicable at full Active Power) with setting steps no greater than 5Mvar or 5% (whichever is smaller) of full Reactive Power, controlling the Reactive Power at the Connection Point to an accuracy within +-5Mvar or +-5% (whichever is smaller) of the full Reactive Power.

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4) For the purposes of Power Factor Control mode, the Power Park Module shall be capable of controlling the Power Factor at the Connection Point within the required Reactive Power range, defined by Article 14 paragraph 1 (a) and by Article 16 paragraph 3 (a) and (b), with a target Power Factor in steps no greater than 0.01. The Relevant Network Operator will determine, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts or by the TSO, the target Power Factor value and the tolerance expressed in Mvar or % within a period of time, following a sudden change of Active Power output or step change in voltage at the Connection Point.

5) The control mode, parameter settings and the operating point for steady-state Reactive Power exchange at the Connection Point shall be determined by the Relevant Network Operator in coordination with the Relevant TSO, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, and shall relate to either Voltage Setpoint, Reactive Power Setpoint or Power Factor Setpoint.

6) The Relevant Network Operator in coordination with the Relevant TSO will determine which of the above three reactive power control modes options shall apply.

Article 15

REQUIREMENTS FOR TYPE B POWER PARK MODULES

1. In addition to fulfilling the general requirements listed in Articles 7 and 8, as well as type A Power Park Modules specific requirements listed in Article 14, type B Power Park Modules shall fulfill the following requirement referring to voltage stability and to robustness of generating units.

2. Type B Power Park Modules shall fulfill the following requirement referring to voltage stability:

a) With regard to fast acting reactive current injection in case of symmetrical (3-phase) faults:

1) Reactive current injection according to figure 9 shall be activated in the event of a voltage deviation of no more than X % of the effective value of the generator voltage where X is a value equal or bigger than 0 and equal or smaller than ±10 % of the effective value of the generator voltage. This voltage control shall ensure the supply of a reactive current at the low-voltage terminals of the step-up transformer from the voltage level of the generator with a contribution of at least 2 % of the rated current per percent of the voltage deviation (figure 9). The Power Park Module shall be capable of feeding the required reactive current no later than 40 milliseconds after the fault inception into the network (control response time).

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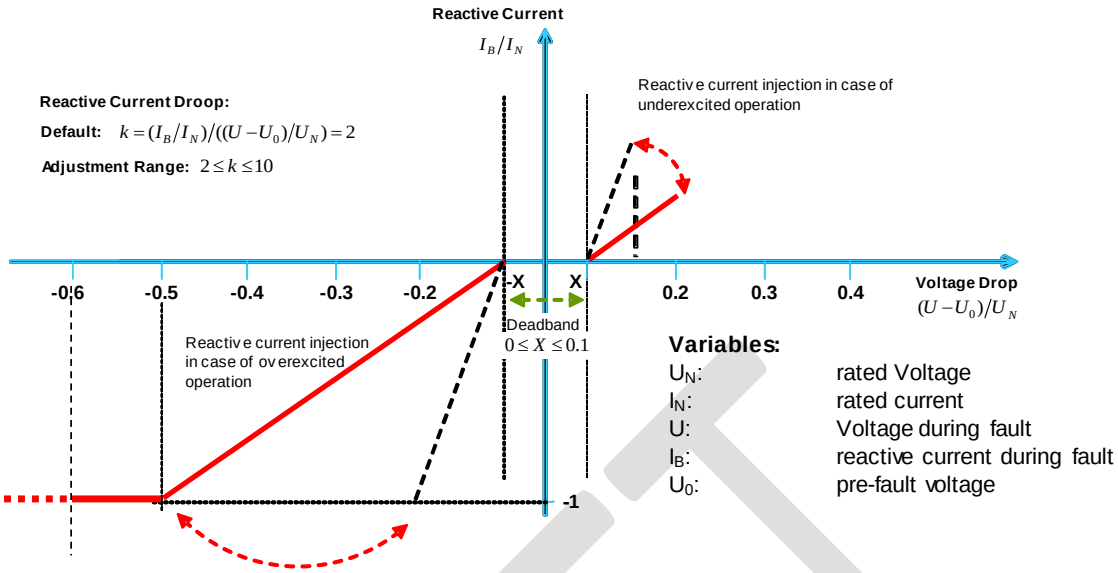

Figure 9 – Principle of voltage support by fast reactive current injection during faults. The red line represents the required minimum reactive current, expressed by the ratio of the reactive current and the nominal reactive current in per unit, against the voltage drop, expressed by the ratio of the actual voltage value and its nominal value in per unit at the network Connection Point.

2) Reactive current supply during the fault duration shall not be less than 1pu of the short term dynamic rating of the equipment (>=1.0pu) between 50% and 40% retained voltage (respectively in case of a voltage drop between 50% and 60%) at the Connection Point. Below 40% retained voltage reactive current shall be supplied as far as technically feasible.

3) The Relevant Network Operator shall define in coordination with the Relevant TSO, and in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, the parameter settings and the operating point for the fast acting reactive current injection.

4) The Relevant Network Operator shall define in coordination with the Relevant TSO, and in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, the maximum period of time after fault clearances within which uncontrolled production of Reactive Power is allowed.

b) With regard to fast acting reactive current injection in case of asymmetrical (1-phase or 2-phase) faults the Relevant Network Operator in coordination the Relevant TSO is allowed to introduce a requirement for asymmetrical current injection.

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c) With regard to failure to provide voltage support by current injection:

1) If required by the Relevant TSO, the Power Park Module causing a Network disturbance shall be disconnected from the network, after a time delay of 0.5 seconds if both of the following two conditions occur simultaneously:

- the voltage (positive sequence system) at the network Connection Point falls and remains at a value of 85 % or below of the reference voltage, with the voltage value referring to the highest value of the three phase-to-phase network voltages based on a resetting ratio of 0.98; and

- at the same time the direction of the Reactive Power is into the Power Park Module (under-excited operation).

3. Type B Power Park Modules shall fulfill the following requirement referring to robustness:

a) With regard to fault ride through capability of Power Park Modules below 110 kV**:**

1) Each TSO shall have the right to define, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a voltage-against-time-profile at the Connection Point for fault conditions which describes the conditions in which the Power Park Module shall stay connected to the network and shall continue stable operation after the power system has been disturbed by Secured Faults on the network, unless the protection scheme requires the disconnection of a Power Park Module from the network.

2) This voltage-against-time-profile shall be expressed by a lower limit of the course of the one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, irrespective of the voltage drop of the other two phase-to-phase voltages, as a function of time before, during and after the fault. This lower limit shall remain on the red lines or inside the shaded area delimited by the red lines in figure 10.

3) Each TSO shall define the pre-fault and post-fault conditions for the fault ride through capability in terms of:

- conditions for the calculation of the pre-fault minimum short circuit capacity at the Connection Point;

- conditions for pre-fault active and Reactive Power operating point of the Power Park Module at the Connection Point and voltage at the Connection Point; and

- conditions for the calculation of the post-fault minimum short circuit capacity at the Connection Point.

4) Each Network Operator shall define the pre-fault and post-fault parameters for the fault ride through capability as an outcome of the calculations at the Connection Point as defined in point 3) regarding:

- pre-fault minimum short circuit capacity at each Connection Point expressed in MVA;

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- pre-fault operating point of the Power Park Module expressed in Active Power output and Reactive Power output at the Connection Point and voltage at the Connection Point; and

- post-fault minimum short circuit capacity at each Connection Point expressed in MVA.

5) The Power Park Module shall stay connected to the network and continue stable operation when the actual course of one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, given the pre-fault and post-fault conditions according to points 3) and 4), remains above the lower limit defined in point

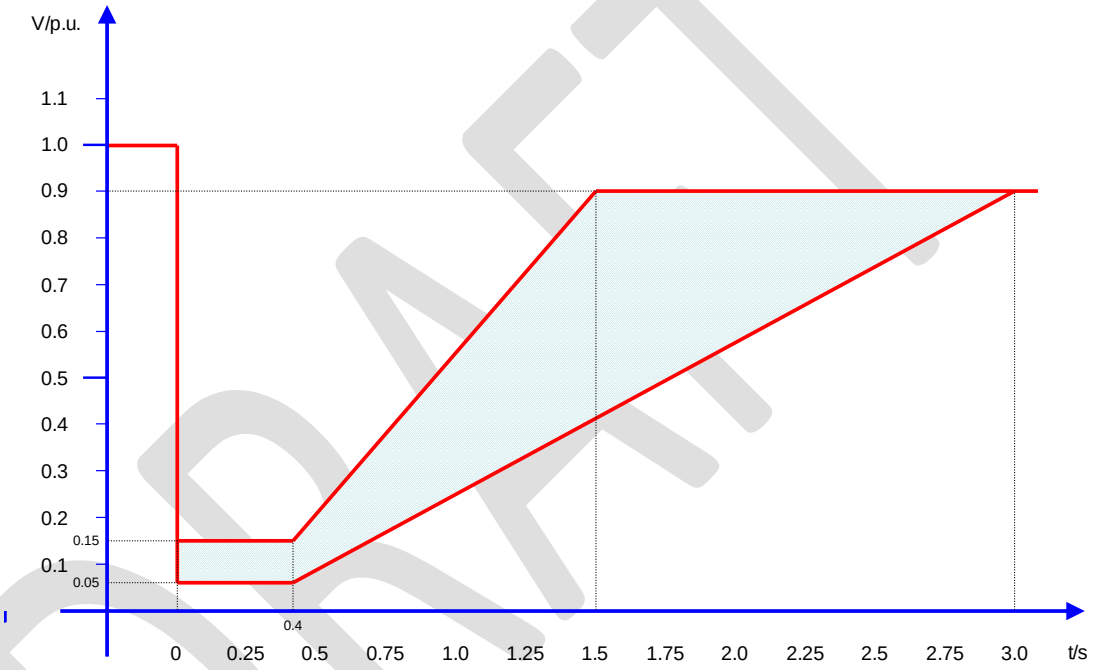

Figure 10 – Fault ride through profile of a Power Park Module connected at voltage levels below 110 kV. The diagram represents the boundaries for a voltage-against-time profile by the voltage at the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit before, during and after a fault.

6) Under voltage protection, respecting the appropriate operating voltage ranges, should be set to the widest possible technical capability of the generator and the settings applied by generators shall be justified by the Power Generating Facility Owner in accordance with this principle.

b) With regard to post fault Active Power recovery**,** the Relevant TSO shall establish, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a maximum recovery time for the Active Power to reach at least the level of 85% of the pre-fault nominal voltage value. The maximum recovery time shall be specified by the Relevant TSO to a value chosen within the range of 0.5 seconds and 10 seconds.

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Article 16

REQUIREMENTS FOR TYPE C POWER PARK MODULES

1. In addition to fulfilling the general requirements listed in Articles 7, 8 and 9, as well as type A and B Power Park Modules specific requirements listed in Articles 14 and 15, type C Power Park Modules shall fulfill the following requirement referring to frequency stability, voltage stability and robustness of generating units.

2. Type C Power Park Modules shall fulfill the following requirements referring to frequency stability:

   a) With regard to synthetic inertial capability to a low frequency event:

      1) The Relevant TSO shall have the right, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts and determined in co-operation with other TSOs in the relevant Synchronous Area, to require each Power Park Module, which does not inherently have a capability to supply additional Active Power to the Network by its inertia and which is greater than a MW size to be specified by the Relevant TSO, to install a control system which operates the Power Park Module so as to supply additional Active Power to the Network in order to limit the rate of change of frequency following a sudden generation loss.

      2) The operating principle of this control system and the associated performance parameters shall be defined by the Relevant TSO, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3. Type C Power Park Modules shall fulfill the following requirements referring to voltage stability:

   a) With regard to Reactive Power Capability, for Power Park Modules where the Connection Point is remote from the high-voltage terminals of this step-up transformer, supplementary Reactive Power may be required by the DSO to compensate for the Reactive Power demand of the HV line, or cable, between these two points from the responsible owner of this line or cable.

   b) With regard to Reactive Power capability at Maximum Capacity**:**

      1) Each Relevant Network Operator shall define for each Power Park Module, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, the Reactive Power provision capability requirements in the context of varying voltage. With this purpose, it shall define a U-Q/P_{max}-profile which specifies the Reactive Power capability at the Maximum Capacity of the Power Park Module with respect to varying voltage at the Connection Point.

      2) The U-Q/P_{max}-profile is defined in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, by each Network Operator for Power Park Module in compliance with the following principles:

         - the U-Q/Pmax-profile shall be inside the U-Q/Pmax-profile envelope, represented by the inner envelope in figure 11, its shape does not need to be rectangular;

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- the dimensions of the U-Q/Pmax-profile envelope (Reactive Power Factor range and voltage range) are defined for each Synchronous Area in table 7;
- the position of the U-Q/Pmax-profile envelope in terms of bias towards consumption (lead) or production (lag) is defined by each Network Operator;
- the U-Q/Pmax-profile envelope cannot be positioned outside the fixed outer envelope in figure 11; and
- in case a Power Park Module has a Reactive Power capability beyond the voltage range specified by figure 11, the Reactive Power capability shall not be deliberately limited.

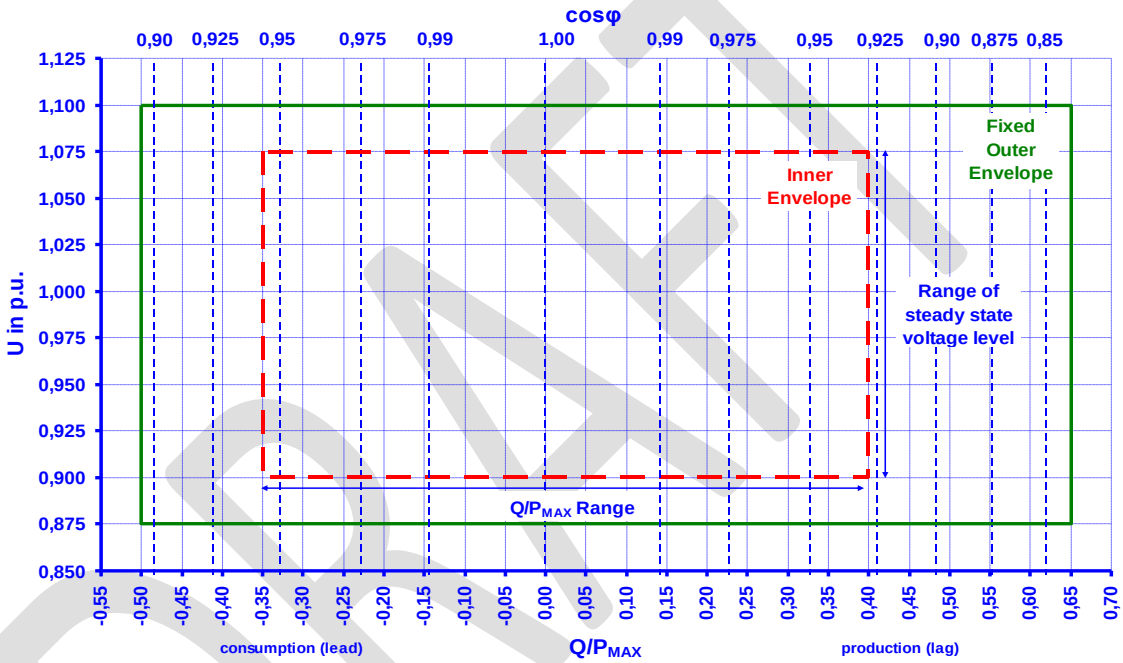

Figure 11 – U-Q/P_{max}-profile of a Power Park Module. The diagram represents a U-Q/P_{max}-profile by the voltage at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point, expressed by the ratio of its actual voltage value U and its nominal value of U in per unit, against the ratio of the Reactive Power (Q) and the Maximum Capacity (P_{max}) of a Generating Units (in the scale at the bottom of the figure), respectively the Power Factor (cos φ) (in the scale at the top of the figure).

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Synchronous Area	Range of Q/P_{max}	Range of steady state voltage level in PU
Continental Europe	0.75	0.225
Nordic	0.95	0.150
Great Britain	0.60	0.100
Ireland	0.66	0.218
Baltic States	0.80	0.220

Table 7: Parameters for figure 11

3) The Reactive Power provision capability requirement applies at the high-voltage terminals of the last step-up transformer to the voltage level of the Connection Point. Beyond the voltage range specified by the figure 7 the Reactive Power capability shall not be deliberately limited. For profile shapes other than rectangular, the voltage range represents the highest and lowest values. The full Reactive Power range is therefore not expected to be available across the range of steady state voltages. For Power Generating Facilities where the Connection Point is remote from the high-voltage terminals of this step-up transformer, supplementary Reactive Power may be required by the Relevant Network Operator to compensate for the Reactive Power demand of the HV line, or cable, between these two points from the responsible owner of this line or cable.

c) With regard to Reactive Power capability below Maximum Capacity:

1) When operating at an Active Power output below the Maximum Capacity ($P<P_{max}$), each Power Park Module shall be able to be operated in every possible operating point inside the outer envelope defined by the P-Q-Capability diagram in figure 12.

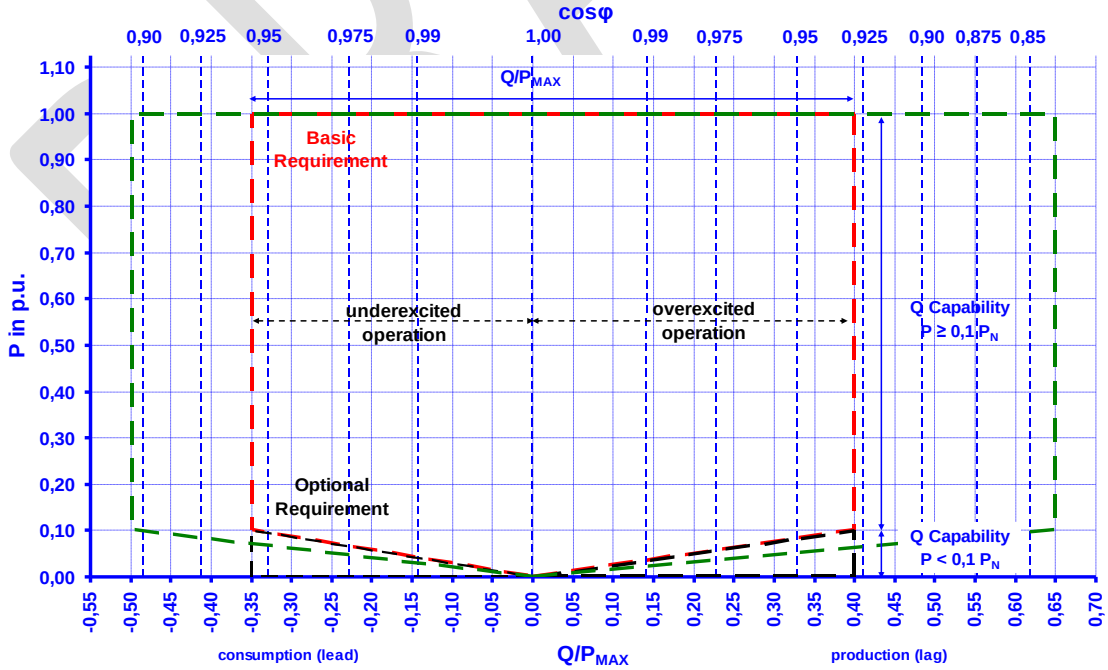

Figure 12 - $P-Q/P_{max}$-profile of a Power Park Module. The diagram represents a $P-Q/P_{max}$-profile by the Active Power, expressed by the ratio of its actual value and the Maximum Capacity in per unit, against the ratio of the Reactive Power (Q) and the Maximum Capacity (P_{max}) of a Generating Units, respectively the Power Factor ($\cos \varphi$).

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2) The Power Park Module shall be capable of providing Reactive Power at any operating point inside the inner envelope in figure 12. In this controlled mode it is allowed to operate the Power Park Module outside the specified range of Reactive Power.

3) The Relevant Network Operator shall have the right to require, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, the Power Park Module to install additional facilities at the Power Park Module in order to be capable of providing Reactive Power at any operating point inside the outer envelope in figure 12.

4) The Power Park Module shall be capable of moving to any operating point within its P-Q/Pmax profile (see figure 12) in timescales determined by the requirements of reactive power control. The Relevant Network Operator shall have the right at any time to change the Reactive Power target value within the agreed Reactive Power range. Where part of the P-Q/Pmax range is unavailable until tapping of generation transformer(s) has been completed, the Relevant Network Operator shall not require more than 15 tap movements within 4 minutes.

d) With regard to priority to Active or Reactive Power contribution, the Relevant TSO shall have the right to determine, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, whether Active Power contribution or Reactive Power contribution has priority during faults. If priority is given to Active Power contribution, its provision shall be established no later than 150ms from the fault inception.

4. Type C Power Park Modules shall fulfill the following requirement referring to robustness:

With regard to power oscillations damping control, if required by the Relevant TSO, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a Power Park Module shall be capable of contributing to damping power oscillations as prescribed.

Article 17

REQUIREMENTS FOR TYPE D POWER PARK MODULES

1. In addition to fulfilling the general requirements listed in Articles 7, 8, 9 and 10, as well as type A, B and C Power Park Modules specific requirements listed in Articles 14, 15 and 16 type D Power Park Modules shall fulfill the following requirement referring to robustness of generating units.

a) With regard to fault ride through capability of Power Park Modules connected at 110 kV or above

1) Each TSO shall have the right to define, in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts, a voltage-against-time-profile at the Connection Point for fault conditions which describes the conditions in which the Power Park Module shall stay connected to the network and shall continue stable operation after the power system has been disturbed by Secured Faults on the network, unless the protection scheme for internal Power Park Module faults requires the disconnection of a Power Park Module from the network.

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2) This voltage-against-time-profile shall be expressed by a lower limit of the course of the one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, irrespective of the voltage drop of the other two phase-to-phase voltages, as a function of time before, during and after the fault. This lower limit defined by the TSO shall be selected on the red lines or a specific line inside the shaded area delimited by the red lines in figure 13.

3) Each TSO shall define the pre-fault and post-fault conditions for the fault ride through capability in terms of:

- pre-fault minimum short circuit fault level at the Connection Point expressed in MVA;
- pre-fault active and Reactive Power operating point of the Power Park Module at the Connection Point and voltage at the Connection Point; and
- post-fault minimum short circuit fault level at the Connection Point expressed in MVA.

4) The Power Park Module shall stay connected to the network and continue stable operation when the actual course of one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault, given the pre-fault and post-fault conditions according to point 3), remains above the lower limit defined in point 2).

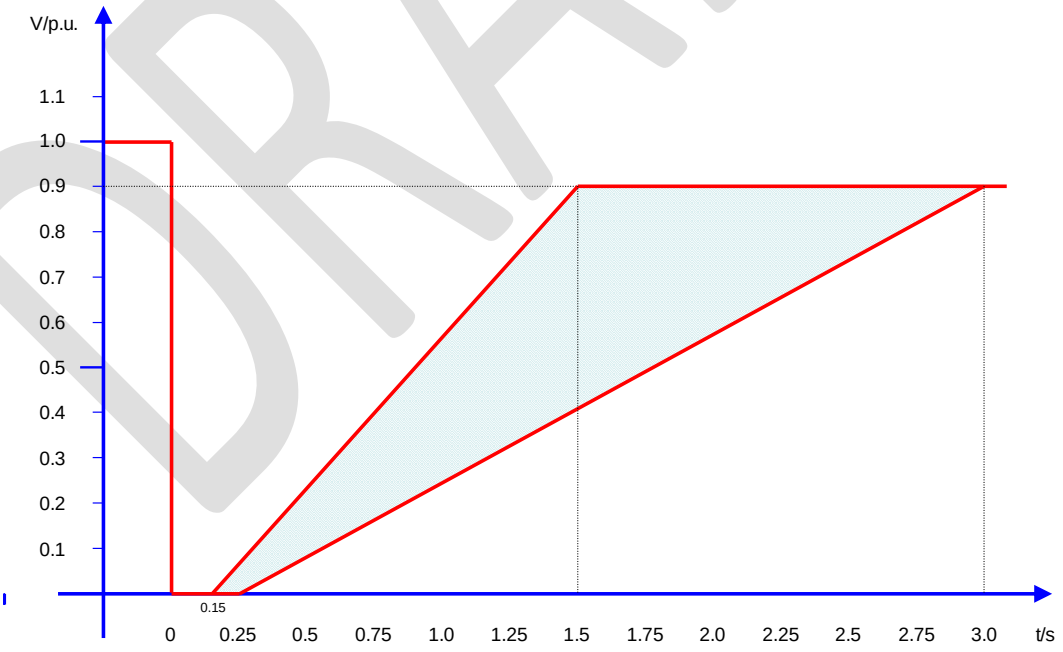

Figure 13 – Fault ride through profile for a Power Park Module connected at voltage levels at 110 kV or above. The diagram represents the boundaries for TSOs to determine a unique line for a voltage-against-time profile by the voltage at the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit before, during and after a fault.

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6) Under voltage protection, respecting the appropriate operating voltage ranges, should be set to the widest possible technical capability of the generator and the settings applied by generators shall be justified by the Power Generating Facility Owner in accordance with this principle.

Chapter 4

REQUIREMENTS FOR OFFSHORE POWER PARK MODULES

Article 18

GENERAL PROVISIONS

1. The requirements set for in this Chapter apply to the connection to the network of Power Park Modules located offshore. For the purpose of this Chapter, Offshore Connection Point shall mean a Connection Point located offshore. A Power Park Module located offshore which does not have an Offshore Connection Point shall be considered as an Onshore Power Park Modules and thus shall be compliant with the requirements set forth for the Power Park Modules situated onshore.

2. The Offshore Connection Point of an Offshore Power Park Module shall be agreed between the Relevant Network Operator and the Offshore Power Park Module in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3. Offshore Power Park Modules shall be considered type D units.

4. An Offshore Power Park Module may comprise of one or more Generating Units. All associated auxiliary system and secondary equipments shall be considered as parts of the Offshore Power Park Module.

5. The Offshore Grid Connection System shall contain the complete interconnection between the Offshore Connection Point and the connection to the Interconnected Onshore System at the Onshore Grid interconnection Point.

6. For the purpose of this Chapter, Onshore Grid Interconnection Point is the point at which the Offshore Grid Connection System for the Offshore Power Park Module for the Offshore Power Park Modules is connected to the onshore Network of the Responsible Network Operator.

7. Offshore Power Park Modules within the scope of this Network Code are categorized in accordance to the following Offshore Grid Connection System Configurations:

a) Configuration 1: Radial AC Connection

One or more Offshore Power Park Modules are interconnected offshore to form an Offshore AC System. The Offshore AC System is connected to the Onshore System with one or more ac radial connection(s) to the same Onshore Grid Interconnection Point.

b) Configuration 2: Meshed AC Connection

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A number of Offshore Power Park Modules are interconnected offshore to form an Offshore AC System. The Offshore AC System is connected to the Onshore System at two or more Onshore Grid Interconnection Point locations.

c) Configuration 3: Radial DC Connection and AC Connection

One or more Offshore Power Park Modules are interconnected offshore to form an Offshore AC System. The Offshore AC System is connected to the Onshore System with a radial DC connection or parallel DC connections at one Onshore Grid Interconnection Point location.

d) Configuration 4: Hybrid AC/DE Solution

A number of Offshore Power Park Modules are interconnected offshore to form an Offshore AC System. The Offshore AC System is connected to the Onshore System with radial AC and DC connections at two or more Onshore Grid Interconnection Point locations.

e) Configuration 5: Meshed Multiterminal DC, AC Collection

A number of Offshore Power Park Modules are interconnected offshore to form an Offshore AC System. The Offshore AC System is connected to the Onshore System with multiple DC connections at two or more Onshore Grid Interconnection Point locations. The DC connections may be combined in a multi-terminal system and may also have a connection to an offshore system of another country.

f) Configuration 6: Meshed DC, DC Collection

An Offshore Power Park Module consisting of DC generators and DC collection network. The Offshore Power Park Module connected by DC to an Offshore DC System. The Offshore DC connection is connected to the Onshore system with one or more DC link(s).

Article 19

FREQUENCY STABILITY REQUIREMENTS APPLICABLE TO OFFSHORE POWER PARK MODULES

1. The frequency stability requirements defined respectively in Article 9 paragraph 2 (a), (b), (e) and (g) shall apply to any Offshore Power Park Module, irrespective of its configuration.

2. The frequency ranges as defined in Article 7 paragraph 1 (a) shall apply to Offshore Power Park Modules of Configurations 1, 2 and 4. For Configuration 3 and 5 in anticipation to temporarily extreme system disturbances, such as transient oscillations or HVDC controller failures, wider frequency ranges may apply in the range of 46.5 Hz to 53 Hz for at most 10 seconds. The precise frequency ranges are to be determined in accordance with the conditions set forth in national legislation, Connection Agreement or any other bilateral contracts.

3. The rate of change of frequency withstand capability requirement as defined in Article 7 paragraph 1 (b) shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5.

4. The frequency stability requirements as defined in Article 7 paragraph 1 (c), Article 9 paragraph 2 (c) and (d) and Article 16 paragraph 2 (a) shall apply to any Offshore Power Park

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Modules, irrespective of its configuration. Nevertheless, for Configurations 3, 5 and 6 Offshore Frequency or alternatively Onshore Frequency Signal shall be used as reference.

Article 20

VOLTAGE STABILITY REQUIREMENTS APPLICABLE TO OFFSHORE POWER PARK MODULES

1. The voltage ranges set forth in table 8 shall apply to any Offshore Power Park Module, irrespective of its configuration within the time periods specified by table 8. For Configuration 6 the voltage range shall be defined individually.

Synchronous Area	Voltage Range	Time period per event
Continental Europe	0.85 pu – 0.875 pu	30 minutes
	0.875 pu – 0.90 pu	180 minutes
	0.90 pu – 1.0875 pu	Unlimited
	1.0875 pu – 1.10 pu	60 minutes
Nordic	0.90 pu – 1.05 pu	Unlimited
	1.05 pu – 1.10 pu	60 minutes
Great Britain	0.90 pu – 1.10 pu	Unlimited
Ireland	0.90 pu – 1.118 pu	Unlimited
Baltic	0.88 pu – 0.90 pu	20 minutes
	0.90 pu – 1.10 pu	Unlimited
	1.10 pu – 1.15 pu	20 minutes

Table 8: This table shows the minimum period each Offshore Power Park Module has to operate for different voltage ranges deviating from a nominal value without disconnecting.

2. The Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5 shall apply the voltage stability requirements defined respectively in Article 9 paragraph 3 (a), Article 15 paragraph 2 (a) and (b) as well as in Article 16 paragraph 3 (b), (c) and(d).

3. The Reactive Power control modes as defined in Article 14 paragraph 1 (b) shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5. For Configuration 6 only voltage control option shall apply.

4. The Reactive Power capability at maximum Active Power as defined in Article 16 paragraph 3 (b) shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5 except for Table 7, which shall be replaced by Table 9.

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Synchronous Area	Range of Q/P_{max}	Range of steady state voltage level in PU
Continental Europe	0.75	0.225
Nordic	0.95	0.150
Great Britain	¥	0.100
Ireland	0.66	0.218
Baltic States	Not defined yet	Not defined yet

¥ 0.60 at the **Onshore GIP** and at the **Offshore CP** 0 for Configuration 1 & 6 and 0.30 for Configuration 2, 3, 4 & 5.

Table 9: Parameters for figure 11

Article 21

ROBUSTNESS OF GENERATING UNITS REQUIREMENTS APPLICABLE TO OFFSHORE POWER PARK MODULES

1. The steady-state stability requirement as defined in Article 9 paragraph 4 (a) shall apply to Offshore Power Park Modules of Configurations 1, 2, 4 and 6.

2. The torsional stress requirement defined in Article 9 paragraph 4 (b) shall apply to Offshore Power Park Modules of Configurations 1, 2 and 4.
3. The power oscillation damping control requirement as defined in Article 16 paragraph 4 (a) shall apply to Offshore Power Park Modules of Configurations 1, 2, 4 and 5.

4. The fault ride through capability of Power Park Modules connected at 110 kV or above requirement as defined in Article 17 paragraph 1 (a) shall apply to any Offshore Power Park Module, irrespective of its configuration.

Article 22

SYSTEM RESTORATION REQUIREMENTS APPLICABLE TO OFFSHORE POWER PARK MODULES

1. The system restoration requirements defined respectively in Article 8 paragraph 4 (a), Article 9 paragraph 4 (a), (b), and (d) shall apply to any Offshore Power Park Modules, irrespective of its configuration.

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Article 23

GENERAL SYSTEM MANAGEMENT REQUIREMENTS APPLICABLE TO OFFSHORE POWER PARK MODULES

1. The general system management requirements defined respectively in Article 7 paragraph 3 (b), Article 8 paragraph 5 (b), (c), (d), (e) and (f) and Article 9 paragraph 6 shall apply to any Offshore Power Park Module, irrespective of its configuration.

2. The synchronization requirement as defined in Article 8 paragraph 5 (a) shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5.

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Title 3

OPERATIONAL NOTIFICATION PROCEDURE

Article 24

GENERAL PROVISIONS

1. Each Power Generating Facility Operator shall confirm to the Relevant Network Operator its ability to satisfy the technical design and operational criteria as referred to in Title 2 of this Network Code and as additionally required by national legislation, Connection Agreement or any other bilateral contracts or by the TSO.

2. The operational notification procedure for connection of new Power Generating Facilities shall comprise the following successive phases:

   a) Energisation Operational Notification (EON);

   b) Interim Operational Notification (ION);and

   c) Final Operational Notification (FON).

3. The Manufacturer's Data and Performance Type Certificate (MD&PTC) registered with the Relevant Network Operators defining verified data and performance for a specific type of generator can, where relevant, be used to verify specific parts of data and performance in place of part of this Operational Notification Procedure.

   a) For types A and B only, these MD&PTCs might be accepted as the sole evidence of compliance.
   b) For types C and D the MD&PTC cannot indicate total compliance, but can be used as validated information about components of the Power Generating Facility.

   The Power Generating Facility Owner is advised to check with the Relevant Network Operator (or its declared agent authorized to fulfill this function on its behalf) at an early stage of a project what parts, if any, are acceptable in lieu of the full compliance process and how to proceed to make use of this facility.

Article 25

ENERGISATION OPERATIONAL NOTIFICATION (EON)

1. Energisation Operational Notification (EON) shall entitle the Power Generating Facility Operator to energise its internal network by using the network connection.

2. Energisation Operational Notification (EON) shall be issued by the Relevant Network Operator, subject to prior establishment of network connection facilities including the protection and control interfaces between the Relevant Network Operator and the Power Generating Facility Operator \and the fulfillment of the requirements of the Relevant Network Operator on operational procedures and responsibilities.

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Article 26

INTERIM OPERATIONAL NOTIFICATION (ION)

1. Interim Operational Notification (ION) shall entitle the Power Generating Facility Operator to operate the Generating Unit by using the network connection for a limited period of time.

2. Interim Operational Notification (ION) shall be issued by the Relevant Network Operator, subject to the completion of data and study review process as required by this Network Code and in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts.

3. With respect to data and study review the following must be submitted to the Relevant Network Operator:

   a) Itemized Statement of compliance in the conditions set forth in Title 4 Chapter 5, 6 and 7 of this Network Code (Interim Compliance Statement);

   b) Detailed technical data of the Power Generating Facility with relevance to the network connection as specified by the Relevant Network Operator;

   c) Manufacturer capability type certificates of Generating Units, where these are relied upon as part of the evidence of compliance;

   d) Simulation Models as specified by Article 9 paragraph 5 (c) and as required by the Relevant Network Operator in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts for its own steady-state and dynamic system studies;

   e) Studies demonstrating expected steady-state and dynamic performance as required by Title 4 Chapter 5, 6 or 7 of this Network Code; and

   f) Details of intended practical compliance tests.

4. The maximum period for the Power Generating Facility Operator to remain in the Interim Operational Notification (ION) status shall not exceed 24 months. The Relevant Network Operator is entitled to specify a shorter ION validity period (e.g. 6 months) with ION extensions granted only if the Power Generating Facility owner has made substantial progress towards full compliance. At the time of ION extension, the outstanding issues should be explicitly identified.

5. A prolongation of the maximum period for the Power Generating Facility Operator to remain in the Interim Operational Notification (ION) status (beyond a total of 24 months) may be granted upon request for derogation made to the Relevant Network Operator, before the expiry of that period, in accordance with the derogation procedure defined in the Code.

Article 27a

FINAL OPERATIONAL NOTIFICATION (FON)

1. Final Operational Notification (FON) shall entitle the Power Generating Facility Operator to operate the Generating Unit by using the network connection.

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2. Final Operational Notification (FON) shall be issued by the Relevant Network Operator, upon prior removal of all incompatibilities identified for the purpose of the Interim Operational Notification (ION) status and subject to the completion of data and study review process as required by this Network Code and in the conditions set forth by national legislation, Connection Agreement or bilateral contracts.

3. With respect to data and study review the following must be submitted to the Relevant Network Operator:

   a) Confirmation of compliance in the conditions set forth in Title 4 Chapter 2, 3, 4, 5, 6 and 7 of this Network Code (Statement of Compliance); and

   b) Update of applicable technical data, simulation models and studies as referred to in Article 26 paragraph 3 (b), (c), (d) and (e), including use of actual measured values during testing.

4. In case of incompatibility identified for the purpose of the granting of the Final Operational Notification (FON), a derogation may be granted upon request made to the Relevant Network Operator, in accordance with the derogation procedure defined in this Network Code. Final Operational Notification (FON) shall be issued by the Relevant Network Operator, if the Power Generating Facility is compliant with the provisions of the derogation. The Power Generating Facility Operator, whose request for derogation was rejected, shall not be connected, until a resolution which is agreed by the Power Generating Facility Operator and the Relevant Network Operator is expected to be compliant. The outstanding issues shall be implemented under a ION (for a new PGF) or a LON (for a failure in service or a change or modification) as appropriate.

Article 27b

LIMITED OPERATIONAL NOTIFICATION (LON)

1. Power Generating Facility Operator in the Final Operational Notification (FON) status shall apply for a Limited Operational Notification (LON) in the following circumstances:

   a) it is temporarily subject to either a significant modification or loss of capability, due to implementation of one or more modifications of significance to its performance; or

   b) in case of equipment failures leading to non compliance with some relevant requirements.

2. The Limited Operational Notification (LON) shall be issued if the circumstances justifying its granting to remain for a consecutive period exceeding 3 months.

3. Limited Operational Notification (LON) shall be issued by the Relevant Network Operator with a clear identification of:

   a) the unresolved issues justifying the granting of the Limited Operational Notification (LON);

   b) the responsibilities and timescales for expected solution; and

   c) a maximum period of validity which shall not exceed 12 months. The initial period granted may be shorter, with possibility for extension if evidence to the satisfaction of

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the Relevant Network Owner has been made which demonstrates that substantial progress has been made in terms of achieving full compliance.

4. A further prolongation of the period of validity of the Limited Operational Notification (LON) may be granted upon request for derogation made to the Relevant Network Operator, before the expiry of that period, in accordance with the derogation procedure defined in the Code.

Article 28

COMPLIANCE OF EXISTING AND UNDER CONSTRUCTION POWER GENERATING FACILITIES

1. Operators of existing Power Generating Facilities of types C and D shall provide, within five years following the entry into force of this Network Code, all data, studies, results of both practical and simulation test procedures and compliance statements required for the purpose of issuing the Final or Limited Operational Notification (FON or LON) in the conditions as referred to in Articles 27a and 27b to the extent these data, studies and test results are available or can reasonably be procured or performed and in such a manner that Article 56 paragraph 5 of this Code can be complied with .

2. New Power Generating Facilities in development or under construction, which can demonstrate to the Relevant Network Operator that a final and financially binding contract exists for the main part of the facility at the time of this Network Code entry into force, shall for the purposes of technical requirements be considered as an existing Power Generating Facility. Its compliance process shall however be pursued in line with the process defined in this Network Code.

3. There is no requirement to examine compliance for existing Power Generation Facilities of type A and B.

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Title 4

COMPLIANCE

Chapter 1

COMPLIANCE MONITORING

Article 29

RESPONSIBILITY OF THE POWER GENERATING FACILITY OPERATOR

1. The Power Generating Facility Operator shall ensure that the Power Generating Facility is compliant with the requirements under this Network Code or national legislation including the national codes. This compliance shall be maintained throughout the lifetime of the facility.

2. The Power Generating Facility Operator may, irrespective of its continued responsibility and under the conditions provided for by national legislation, Connection Agreement or any other bilateral contracts or by the TSO, partially or totally delegate to third parties the task of gathering relevant documentation evidencing compliance provision. The final statement from the Power Generating Facility Operator confirming full compliance shall be made by an authorized person representing the Power Generating Facility Operator.

3. Any intention to modify the technical capabilities of the Power Generating Facility with possible impact on its compliance to the requirements under this Network Code or national legislation including the national codes shall be subject to notification to the Relevant Network Operator in due time and prior to pursuing such modification.

4. Any operational incidents or failures of the Power Generating Facility that have impact on its compliance to the requirements of this Network Code or national legislation including the national codes shall be subject to notification to the Relevant Network Operator as soon as possible without any intentional delay after the occurrence of such an incident.

   Any foreseen test schedules and procedures to verify compliance of the Power Generating Facility to the requirements of this Network Code or national legislation including the national codes, shall be subject to notification and approval by the Relevant Network Operator in due time and prior to their launch. The purpose of this is to allow the Relevant Network Operator to evaluate and mitigate where necessary the consequential risks to the Network and its Users.

5. The Relevant Network Operator shall be facilitated to participate to such test and may record the performance of the Power Generating Facility.

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Article 30

TASKS OF THE NETWORK OPERATOR

1. The Relevant Network Operator shall be allowed to monitor compliance of the Power Generating Facility to the requirements under this Network Code, national legislation including national codes throughout the lifetime of the Power Generating Facility.

2. The Relevant Network Operator shall have the right to request compliance tests to be carried out, in particular after any failure, modification or replacement of any equipment with possible impact on its compliance to the requirements under this Network Code or national legislation or contractual agreement.

3. The Relevant Network Operator shall make publicly available the requirements for its compliance process to be fulfilled by the Power Generating Facility Operator, in particular:

   a) All documentation and certificates to be provided by the Power Generating Facility Operator;

   b) Details of the technical data of the Power Generating Facility with relevance to the network connection;

   c) Requirements for models for steady-state and dynamic system studies;

   d) Studies by the Power Generating Facility Operator for demonstrating expected steady-state and dynamic performance referring to the requirements set forth in Title 4 Chapter 4 and 5 of this Network Code; and

   e) Conditions and procedures including scope for registering manufacturer's data and performance type certificates.

   f) Conditions and procedures for use by the Power Generating Facility Operator of relevant manufacturers' data and performance type certificates in lieu of part of the activity for compliance as described in this Network Code. Only for type A and B can such type certificates be accepted as the total required evidence of Compliance.

4. The Relevant Network Operator shall make publicly available the allocation of responsibilities to the Power Generating Facility Operator and to the Network Operator for compliance testing, certification and monitoring.

5. The Relevant Network Operator may, irrespective of its continued responsibility and under the conditions provided for by national legislation, partially or totally delegate the performance of its compliance monitoring to third parties.

6. The Relevant Network Operator shall not withhold unreasonably any Operational Notification as per Article 25, 26, 27a or 27b, if compliance tests or simulations cannot be performed as agreed between the Relevant Network Operator and the Power Generating Facility Operator due to reasons which are in the sole control of the Relevant Network Operator.

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Article 31

COMMON PROVISIONS ON COMPLIANCE TESTING

1. The testing of the individual Generating Units within the Power Generating Facility shall aim at demonstrating the fulfillment of the requirements of this Network Code.

2. Notwithstanding the minimum requirements relating to the compliance testing laid down by the provisions of this Network Code, the Relevant Network Operator is entitled to:

   a) allow the Power Generating Facility Operator to carry out an alternative set of tests, provided that those tests are efficient and sufficient to demonstrate compliance of the Power Generating Facility to the requirements under this Network Code or national legislation including national codes;

   b) require the Power Generating Facility Operator to carry out an additional or alternative set of tests in case information supplied to the Relevant Network Operator by the Power Generating Facility Operator in relation to compliance testing under the provisions of Title 4 Chapter 2, 3 or 4 of this Network Code are not sufficient to demonstrate compliance to the requirements under this Network Code; and

   c) require the Power Generating Facility Operator to carry out appropriate tests in order to demonstrate the Power Generating Facility performance when operating on alternative fuels or fuel mixes. The Relevant Network Operator and the Power Generating Facility Owner shall agree on which types of fuel are tested.

3. The Power Generating Facility Operator is responsible for carrying out the tests in accordance with the conditions laid down in Title 4 of this Network Code.

4. The Power Generating Facility Operator is responsible for the safety of the personnel and the plant during the tests.

5. The costs of the tests including necessary deviation from the commercially preferred operating point in order to facilitate the tests shall be covered by the Power Generating Facility Operator.
6. The Relevant Network Operator shall be facilitated to participate to the test either on site or remotely from the Network Operator's control centre. For that purpose, The Power Generating Facility Operator shall provide suitable monitoring equipment to record all relevant test signals and measurements as well as ensure that the relevant representatives from both the Power Generating Facility and the manufacturer are available on site for the entire testing period. Signals specified by the Relevant Network Operator shall be provided if the Relevant Network Operator wishes for selected tests to use own equipment to record the performance during tests. The decision as regards the participation of the Relevant Network Operator to the test and the form of this participation remains at the sole and exclusive discretion of the Relevant Network Operator.

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Article 32

COMMON PROVISIONS ON COMPLIANCE SIMULATIONS

1. The simulation of the individual Generating Units within the Power Generating Facility shall aim at demonstrating the fulfillment of the requirements of this Network Code.

2. Notwithstanding the minimum requirements relating to the compliance simulations laid down by the provisions of this Network Code, the Relevant Network Operator is entitled to:

   a) allow the Power Generating Facility Operator to carry out an alternative set of simulations, provided that those simulations are efficient and sufficient to demonstrate compliance of the Power Generating Facility to the requirements under this Network Code or national legislation including national codes;

   b) require the Power Generating Facility Operator to carry out an additional or alternative set of simulations in case information supplied to the Relevant Network Operator by the Power Generating Facility Operator in relation to compliance simulation under the provisions of Title 4 Chapter 5, 6 or 7 of this Network Code are not sufficient to demonstrate compliance to the requirements under this Network Code; and

3. The Power Generating Facility Operator shall provide simulation results relevant to each and any individual Generating Units within the Power Generating Facility in a report form in order to demonstrate the fulfillment of the requirements of this Network Code. The Power Generating Facility Operator shall produce and provide a validated simulation model for each Generating Unit. The coverage and the format of the Simulation Models are described in Article 9 paragraph 5 (c).

4. The Relevant Network Operator shall have the right to check the compliance of the Power Generating Facility with the requirements of this Network Code by carrying out its own compliance simulations based on the provided simulation reports, Simulation Models and compliance test measurements.

Chapter 2

COMPLIANCE TESTING FOR SYNCHRONOUS GENERATING UNITS

Article 33

COMPLIANCE TESTS FOR TYPE A SYNCHRONOUS GENERATING UNITS

1. The Manufacturer's Data and Performance Type Certificate (MD&PTC) may be used in lieu of part or all of the tests below, provided that they are registered with the Relavant Network Operator.

2. With regard to type A Synchronous Generating Units the Overfrequency Limited Frequency Sensitive Mode Response test shall be carried out.

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a) For the purpose of this test, the Generating Unit shall demonstrate its technical capability to cotinuously modulate Active Power to contribute to frequency control in case of large increase of frequency in the system and shall verify the steady state parameters of regulations, such as insensitivity, Droop, dead band, range of regulation, and dynamic parameters, including frequency step change response.

b) The test shall be carried out by simulating frequency steps and ramps big enough to activate at least 10% of Maximum Capacity change in Active Power, taking into account the Droop settings and the dead band. Simulated frequency deviation signals shall be injected simultaneously at both the speed governor and the load controller references if required, taking into account speed governor and load controller scheme.

c) The test is deemed passed, provided that the following conditions are both fulfilled:

1) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Article 7 paragraph 1 (c); and

2) undamped oscillations do not occur after the step change response.

Article 34

COMPLIANCE TESTS FOR TYPE B SYNCHRONOUS GENERATING UNITS

1. In addition to carrying out the compliance tests for type A Synchronous Generating Units in the conditions as referred to in Article 33, type B Synchronous Generating Units are subject to the following compliance tests.

2. With regard to the Open and Short Circuit Saturation Characteristics test:

a) The Generating Unit shall demonstrate its open circuit running and short circuit characteristics to verify its Short-Circuit Ratio.

b) The test is deemed passed, provided that the Short-Circuit-Ratio of the Generating Unit is not less than 0.5.or a lower value specified by the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contract.

Article 35

COMPLIANCE TESTS FOR TYPE C SYNCHRONOUS GENERATING UNITS

1. In addition to carrying out the compliance tests for type A and B Synchronous Generating Units in the conditions as referred to in Articles 33 and 34, type C Synchronous Generating Units are subject to the following compliance tests. The Manufacturer's Data and Performance Type Certificate (MD&PTC) may be used as part of verified component performance data, provided that they are registered with the Relevant Network Operator, these.

2. With regard to the Frequency Sensitive Mode Response test:

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a) The Generating Unit shall demonstrate its technical capability to continuously modulate Active Power over the full operating range to contribute to frequency control and shall verify the steady state parameters of regulations, such as insensitivity, Droop, dead band, range of regulation, as well as dynamic parameters, including robustness through frequency step change response and large, fast frequency changes.

b) The test shall be carried out by simulating frequency steps and ramps big enough to activate the whole Active Power frequency response range, taking into account the Droop settings, the dead band and the Real Power headroom or deload (margin to Maximum Capacity in operational timescale). Simulated frequency deviation signals shall be injected simultaneously into both the speed governor and the load controller references if required, taking into account the speed governor and load controller scheme.

c) The test is deemed to be passed, provided that the following conditions are all fulfilled:

1) activation time of whole full Active Power frequency response range as result of a step frequency change has been no longer than required by Article 9 paragraph 2 (c);

2) undamped oscillations do not occur after the step change response;

3) the initial delay time has been as small as possible and no higher than 2 seconds according to Article 9 paragraph 2 (c);

4) minimum time to achieve the Active Power frequency response is no longer than that defined for t_2 according to Article 9 paragraph 2 (c);

5) the Droop settings is adjustable to the value required by the Relevant TSO within the range defined in Article 9 paragraph 2 (c) and dead band (thresholds) is less than the value in Article 9 paragraph 2 (c); and

6) insensitivity of Active Power frequency response at any relevant operating point does not exceed the requirements set forth in Article 9 paragraph 2 (c).

3. With regard to the Limited Frequency Sensitive Mode - Underfrequency Response test:

a) The Generating Unit shall demonstrate its technical capability to continuously modulate Active Power at operating points below Maximum Capacity to contribute to frequency control in case of large drop of frequency in the system.

b) The test shall be carried out by simulating at appropriate Active Power load points (e.g. 80%) the low frequency steps and ramps big enough to activate at least 10% of Maximum Capacity Active Power change, taking into account the Droop settings and the dead band. Simulated frequency deviation signals shall be injected simultaneously into both the speed governor and the load controller references if required, taking into account the speed governor and the load controller scheme.

c) The test is deemed passed, provided that the following conditions are both fulfilled:

1) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Article 9 paragraph 2 (d); and

2) undamped oscillations do not occur after the step change response.

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4. With regard to the Frequency Restoration Control test:

   a) The Generating Unit shall demonstrate its technical capability to participate in frequency restoration control. The cooperation of Frequency Sensitive Mode and Frequency Restoration Control shall be checked.

   b) The test is deemed passed, provided that the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Article 9 paragraph 2 (c) and (e).

5. With regard to the Excitation System Open Circuit Step Response test:
   a) The Generating Unit shall demonstrate its small signal performance of the excitation system. The open circuit step response of the Excitation System will be tested by applying a voltage step change from 90% to 100% of the nominal Generating Unit terminal voltage, with the Generating Unit on open circuit and at rated speed.

   b) The test is deemed passed, provided that the following conditions are both fulfilled:

      - for a step change from 90% to 100% of the nominal Generating Unit terminal voltage, with the Generating Unit on open circuit, the Excitation System response has a damped oscillatory characteristic; and

      - the time of getting the voltage to the rated value by the voltage regulator is in line with the requirements as referred to Article 12 paragraph 3 (d).

6. With regard to the Excitation System On-Load Response test:

   a) The Generating Unit shall demonstrate the steady-state and dynamic stability of the Excitation System.

   b) The test is deemed passed, provided that the following conditions are both fulfilled:

      1) the Excitation System demonstrates performance in accordance with the requirements referred to in Article 12 paragraph 3 (c) and (d); and

      2) the continuously-acting automatic excitation control system provides constant terminal voltage control of the Generating Unit without instability over the entire operating range.

7. With regard to the Under Excitation Limiter Performance test:

   a) The Generating Unit shall demonstrate its performance of the Under Excitation Limiter at low load points and subsequently at, or near, full load by testing its response to a step change corresponding to a 2% decrease in AVR reference voltage an initial position in Reactive Power clear of the Under Excitation Limit, but close to it. The Under Excitation Limiter shall be active when the AVR is in both auto and manual modes and its settings shall be readily adjustable.

   b) The test is deemed passed, provided that the following conditions are all fulfilled:

      1) the resulting maximum Reactive Power overshoot (in Mvar) does not exceed 4% of the Generating Unit's Maximum Capacity (in MW);

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2) the operating point of the Generating Unit returns to a steady state value within 5 seconds;

3) the control of generator terminal voltage presents a damped characteristic;

4) the automatic excitation control acts continuously and without instability; and

5) the Under Excitation Limiter demonstrates performance in accordance with the requirements as referred to in Article 12 paragraph 3 (d).

8. With regard to the Over Excitation Limiter Performance test:

a) The Generating Unit shall demonstrate its performance of the Over Excitation Limiter and shall provide evidence that the Over Excitation Limiter is set as high as the design limit of the generator allows by testing its response to a steep increase in the AVR reference voltage that results in operation of the Over Excitation Limiter when operating at Maximum Capacity and within its continuous Reactive Power capability range. The size of the step shall be determined by the minimum value necessary to operate the Over Excitation Limiter and shall be agreed by Network Operator and the Power Generating Facility Operator. To reduce the risk of tripping, this test may initially be carried out with a reduced Over Excitation Limit setting proving its function, before it is repeated at the intended setting.

b) The test is deemed passed, provided that the following conditions are cumulatively fulfilled:

1) the resulting operation beyond the over excitation limit is controlled by the Over Excitation Limiter without tripping the Generating Unit;

2) the Over Excitation Limiter operation demonstrates an appropriate time delay to avoid over excitation protection tripping;

3) the Over Excitation Limiter is set close to the machine design limit; and

4) the Over Excitation Limiter action does not produce any apparent or Active Power oscillations and demonstrates performance in accordance with the requirements as referred to in Article 12 paragraph 3 (d).

9. With regard to the Black Start Capability test:

a) Relevant Generating Units specified to have Black Start capability shall demonstrate their technical ability to start from shut down without any external energy supply.

b) The test is deemed passed, provided that the start-up time is not longer than the timeframe according to Article 9 paragraph 4 (a) point 2).

10. With regard to the Tripping to Houseload test:

a) Generating Unit shall demonstrate their technical capability to trip to and stably operate on house load.

b) The test shall be carried out at the maximum Active and nominal Reactive Power of the Generating Unit before load shedding.

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c) Further conditions for this test shall be determined by the Relevant Network Operator, taking into account the operating point of the Generating Unit, speed control mode as well as the point of disconnection from the network as referred to in Article 9 paragraph 4 (c).

d) The test is deemed passed, provided that the following conditions are all fulfilled:

1) the Excitation System response shall present a damped oscillatory characteristic;

2) after tripping, the voltage or speed controller has kept generator voltage or frequency in the permissible range where the time for the generator terminal voltage to reach the target value of the voltage regulator within an admissible tolerance shall be shorter than;

- 0.5 s – for thyristor static exciters; and
- 1.5 s – for electromechanical exciters.

3) all Generating Unit control systems remain in automatic mode;

4) manual intervention by the Power Generating Facility Operator within the first 3 minutes after tripping does not occur; and

5) the minimum houseload operation time according to Article 9 paragraph 4 (c) has been demonstrated.

11. With regard to the Reactive Power Capability test:

a) The Generating Unit shall demonstrate its technical capability to provide leading and lagging Reactive Power capability according to Article 12 paragraph 3 (e) and (f).

b) The test is deemed passed, provided that the following conditions are all fulfilled:

1) the Generating Unit has been operating no shorter than 1 hour at maximum Reactive Power, both leading and lagging, for each of:

- minimum Active Power;
- maximum Active Power; and
- an Active Power operating point between those maximum and minimum ranges; and

2) the Generating Unit demonstrates its capability to change to any Reactive Power target value within the agreed Reactive Power range within the specified performance targets of the relevant Reactive Power control scheme.
Where part of the P-Q/Pmax range is unavailable until tapping of generation transformer(s) has been completed, achieving the complete movement in the time allowed by the Relevant Network Operator, which shall not be less than 4 minutes or cover more than 15 tap movements.

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Article 36

COMPLIANCE TESTS FOR TYPE D SYNCHRONOUS GENERATING UNITS

1. In addition to carrying out the compliance tests for type A, B and C Synchronous Generating Units in the conditions as referred to in Articles 33, 34 and 35 for type D Synchronous Generating Units the PSS compliance test shall be carried out.

2. For the purpose of this PSS test, the Generating Unit shall demonstrate the capability of the PSS control system to contribute positive Active Power damping of power oscillations over the frequency range specified by the TSO when compared with damping with the PSS being switched out.

3. The test is deemed passed, provided that the PSS demonstrates performance in accordance with the requirements referred to in Article 13 paragraph 2 (b).

Chapter 3

COMPLIANCE TESTING FOR POWER PARK MODULES

Article 37

COMPLIANCE TESTS FOR TYPE A POWER PARK MODULES

1. The Manufacturer's Data and Performance Type Certificate (MD&PTC) may be used in lieu of part or all of the tests below, provided that they are registered with the Relavant Network Operator.

2. With regard to type A Power Park Modules the Limited Frequency Sensitive Mode - Overfrequency Response, Voltage Control Mode or the Reactive Power Control Mode or the Power Factor Control Mode tests shall be carried out reflecting the choice of control scheme selected by the Relevant Network Operator.

3. With regard to the Limited Frequency Sensitive Mode - Overfrequency Response test:

   a) The Power Park Module shall demonstrate its technical capability to continuously modulate Active Power to contribute to frequency control in case of increase of frequency in the system and shall verify the steady state parameters of regulations, such as insensitivity, Droop, dead band, range of regulation, as well as dynamic parameters, including frequency step change response.

   b) The test shall be carried out by simulating frequency steps and ramps big enough to activate at least 10% of Maximum Capacity change in Active Power, taking into account the Droop settings and the dead band. Simulated frequency deviation signals shall be injected to perform this test.

   c) The test is deemed passed, provided that the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Article 7 paragraph 1 (c)

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4. With regard to the Voltage Control Mode test:

   a) The Power Park Module shall demonstrate its capability to operate in voltage control mode in the conditions set forth in Article 14 paragraph 1 (b).

   b) The Voltage Control Mode test shall apply concerning the verification of the following parameters:

      1) the implemented Droop and dead band of the static characteristic;

      2) the accuracy of the regulation;

      3) the insensitivity of the regulation; and

      4) the time of Reactive Power activation.

   c) The test is deemed passed, provided that the following conditions are cumulatively fulfilled:

      1) the implemented Droop and dead band of the static characteristic;

      2) the time of Reactive Power activation as result of step voltage change has been no longer than required, according to Article 14 paragraph 1 (b);

      3) the range of regulation and adjustable the Droop and dead band is compliant with agreed characteristic parameters, according to Article 14 paragraph 1 (b);

      4) the insensitivity of Voltage Control is not higher than 0.01 pu, according to Article 14 paragraph 1 (b); and

      5) following a step change in voltage 90% of the change in Reactive Power output has been achieved within 1 second and settled at the value defined by the operating Slope within 5 seconds with a steady state reactive tolerance no greater than 5%.

5. With regard to the Reactive Power Control Mode test:

   a) The Power Park Module shall demonstrate its capability to operate in Reactive Power control mode, according to the conditions referred to in Article 14 paragraph 1 (b).

   b) The Reactive Power Control Mode test shall be complementary to the Reactive Power Capability test.

   c) The Reactive Power Control Mode test shall apply concerning the verification of the following parameters:

      1) the Reactive Power Setpoint range and step;

      2) the accuracy of the regulation; and

      3) the time of Reactive Power activation.

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d) The test is deemed passed, provided that the following conditions are cumulatively fulfilled:

1) the Reactive Power Setpoint range and step is ensured according to Article 14 paragraph 1 (b); and

2) the accuracy of the regulation is compliant with the conditions as referred to in Article 14 paragraph 1 (b).

6. With regard to the Power Factor Control Mode test:

a) The Power Park Module shall demonstrate its capability to operate in Power Factor control mode according to the conditions referred to in Article 14 paragraph 1 (b).

b) The Power Factor Control Mode test shall apply concerning the verification of the following parameters:

1) the Power Factor Setpoint range;

2) the accuracy of the regulation; and

3) the response of Reactive Power due to step change of Active Power.

c) The test is deemed passed, provided that the following conditions are cumulatively fulfilled:

1) the Power Factor Setpoint range and step is ensured according to Article 14 paragraph 1 (b);

2) the time of Reactive Power activation as result of step Active Power change does not exceed the requirements set forth in Article 14 paragraph 1 (b); and

3) the accuracy of the regulation is compliant with the value, as referred to in Article 14 paragraph 1 (b).

7. With regard to test the tests identified in Article 37 paragraphs 4, 5 and 6 the Relevant Network Operator may select only of the three control options for testing.

Article 38

COMPLIANCE TESTS FOR TYPE B POWER PARK MODULES

The tests for type A Power Park Modules as referred to in Article 37, shall be carried out with regard to type B Synchronous Generating Units.

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Article 39

COMPLIANCE TESTS FOR TYPE C POWER PARK MODULES

1. In addition to carrying out the compliance tests for type A and B Power Park Modules in the conditions as referred to in Articles 37 and 38, type C Power Park Modules are subject to the following compliance tests. For installations for which relevant Manufacturer's Data and Performance Type Certificate (MD&PTC) exists which are registered with the Relevant Network Operator, these may be used as part of verified component performance data.

2. With regard to the Limited Active Power Control Mode test:

   a) The Power Park Module shall demonstrate its technical capability to operate at a load level no higher than the Setpoint sent by the Relevant Network Operator.

   b) The test is deemed passed, provided that the following conditions are all fulfilled:

      1) the load level of the Power Park Module is kept below the Setpoint;

      2) the Setpoint is implemented according to the requirements as referred to in Article 9 paragraph 2 (a); and

      3) the accuracy of the regulation is compliant with specified value according to Article 9 paragraph 2 (a).

3. With regard to the Frequency Sensitive Mode Response test:

   a) The Power Park Module shall demonstrate its technical capability to continuously modulate Active Power over the full operating range to contribute to frequency control and shall verify the steady state parameters of regulations, such as insensitivity, Droop, dead band and range of regulation, as well as dynamic parameters, including frequency step change response.

   b) The test shall be carried out by simulating frequency steps and ramps big enough to activate whole Active Power frequency response range, taking into account the Droop settings and the dead band. Simulated frequency deviation signals shall be injected to perform this test.

   c) The test is deemed passed, provided that the following conditions are cumulatively fulfilled:

      1) the activation time of the start of the required Active Power frequency response as result of a step frequency change has been no longer than that required by Article 9 paragraph 2 (c);

      2) undamped oscillations do not occur after the step change response;

      3) the initial delay time has been as small as possible and no longer than 2 seconds according to Article 9 paragraph 2 (c);

      4) minimum time to achieve the Active Power frequency response is no longer than that defined for t_2 according to Article 9 paragraph 2 (c);

      5) the Droop settings are available within the ranges defined in Article 9 paragraph 2 (c) and dead band (thresholds) is no more than the value chosen by the TSO; and

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6) the insensitivity of Active Power frequency response does not exceed the requirements set forth in Article 9 paragraph 2 (c) .

4. With regard to the Limited Frequency Sensitive Mode - Underfrequency response test:

a) The Power Park Module shall demonstrate its technical capability to continuously modulate Active Power to contribute to frequency control in case of large drop of frequency in the system.

b) The test shall be carried out by simulating the frequency steps and ramps big enough to activate at least 10% of Maximum Capacity Active Power change with a starting point of no more than 80% of Maximum Capacity, taking into account the Droop settings and the dead band. Simulated frequency deviation signals shall be injected simultaneously at both speed governor and load controller references if required, taking into account speed governor and load controller scheme.

c) The test is deemed passed, provided that the following conditions are all fulfilled:

1) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Article 9 paragraph 2 (d); and

2) undamped oscillations after the step change response does not occur.

5. With regard to the Frequency Restoration Control test:

a) The Power Park Module shall demonstrate its technical capability to participate in frequency restoration control. The cooperation of both Frequency Sensitive Mode and Frequency Restoration Control shall thus be verified.

b) The test is deemed passed, provided that the test results for both dynamic and static parameters are in line with the requirements as referred to in Article 9 paragraph 2 (c) and (e).

6. With regard to the Reactive Power Capability test:

a) The Power Park Module shall demonstrate its technical capability to provide leading and lagging Reactive Power capability in the conditions set forth in Article 16 paragraph 3 (b) and (c).

b) The Reactive Power Capability test shall be carried out at maximum Reactive Power, both leading and lagging, and concerning the verification of the following parameters:

1) operation in excess of 60% of maximum capacity for 30 min;

2) operation within the range of 30 – 50 % of maximum capacity for 30 min; and

3) operation within the range of 10 – 20 % of maximum capacity for 60 min.

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c) The test is deemed passed, provided that the following criteria are cumulatively fulfilled:

1) the Power Park Module has been operated no shorter than requested duration at maximum Reactive Power, both leading and lagging, in each parameter as referred to in Article 39 paragraph 6 (b);

2) the Power Park Module has demonstrated its capability to change to any Reactive Power target value within the agreed Reactive Power range within the specified performance targets of the relevant Reactive Power control scheme;

3) Where part of the P-Q/Pmax range is unavailable until tapping of generation transformer(s) has been completed, achieving the complete movement in the time allowed by the Relevant Network Operator, which shall not be less than 4 minutes or cover more than 15 tap movements; and

4) no action of any protection within the operation limits defined by Reactive Power capacity diagram occurs.

Article 40

COMPLIANCE TESTS FOR TYPE D POWER PARK MODULES

The tests that must be carried out by a type D Power Park Modules are those provided for type A, B and C Power Park Modules as described respectively in Articles 37, 38 and 39 of this Network Code.

Chapter 4

COMPLIANCE TESTING FOR OFFSHORE POWER PARK MODULES

Article 41

COMPLIANCE TESTING APPLICABLE TO OFFSHORE POWER PARK MODULES IN ALL CONFIGURATIONS

The Compliance tests as defined in Article 35 paragraph 3 and 4, Article 37 paragraph 4, as well as in Article 39 paragraph 2 and 3 shall apply to any Offshore Power Park Module, irrespective of its configuration.

Article 42

COMPLIANCE TESTING APPLICABLE TO OFFSHORE POWER PARK MODULES of CONFIGURATIONS 1-5

The Compliance tests as defined in Article 35 paragraph 7 and in Article 37 paragraph 5 and 6 shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5.

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Chapter 5

COMPLIANCE SIMULATIONS FOR SYNCHRONOUS GENERATING UNITS

Article 43

COMPLIANCE SIMULATIONS FOR TYPE A SYNCHRONOUS GENERATING UNITS

1. For installations for which relevant Manufacturer's Data and Performance Type Certificate (MD&PTC) exists which are registered with the Relevant Network Operator, these may be used in lieu of part or all of the simulations below.

2. With regard to type A Synchronous Generating Units the Limited Frequency Sensitive Mode - Overfrequency Response simulation shall be carried out.

3. For the purpose of that simulation, the Generating Unit shall demonstrate its capability to simulate Active Power modulation in high frequency situations to study compliance in extreme network situations.

4. The simulation shall be carried out by simulating high frequency steps, ramps reaching Maximum Capacity, taking into account the Droop settings and the dead band.

5. The simulation is deemed passed, provided that the Generating Unit is validated against the compliance tests for Limited Frequency Sensitive Mode - Overfrequency Response as referred to in Article 33.

Article 44

COMPLIANCE SIMULATIONS FOR TYPE B SYNCHRONOUS GENERATING UNITS

1. In addition to the compliance simulations for type A Synchronous Generating Units in the conditions as referred to in Article 43, for type B Synchronous Generating Units the type B Fault Ride Through Capability of Synchronous Generating Units simulation shall be carried out.

2. The Generating Unit shall demonstrate its capability to simulate fault ride through capability in the conditions set forth in Article 11 paragraph 3 (a).

3. The simulation is deemed passed, provided that the Generating Unit demonstrates compliance with the requirements set forth in Article 11 paragraph 3 (a).

Article 45

COMPLIANCE SIMULATIONS FOR TYPE C SYNCHRONOUS GENERATING UNITS

1. In addition to carrying out the compliance simulations for type A and B Synchronous Generating Units in the conditions as referred to in Articles 43 and 44, type C Synchronous Generating Units are subject to the following compliance simulations.

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2. With regard to the Frequency Sensitive Mode Response simulation:

   a) The Generating Unit shall demonstrate its capability to simulate Active Power modulation over the full frequency range according to Article 9 paragraph 2 (c) to study compliance in extreme network situations.

   b) The simulation shall be carried out by simulating frequency steps and ramps big enough to activate whole Active Power frequency response range, taking into account the Droop settings and the dead band.

   c) The simulation is deemed passed, provided that the Generating Unit is validated against the compliance tests for Frequency Sensitive Mode Response as referred to in Article 35 paragraph 2.

3. With regard to the Underfrequency Limited Frequency Sensitive Mode Response simulation:

   a) The Generating Unit shall demonstrate its capability to simulate Active Power modulation in low frequency situations to study compliance in extreme network situations.

   b) The simulation shall be carried out by simulating low frequency steps, ramps reaching Minimum Operating Level, taking into account the Droop settings and the dead band.

   c) The simulation is deemed passed, provided that the Generating Unit is validated against the compliance tests for underfrequency Limited Frequency Sensitive Mode Response as referred to in Article 35 paragraph 3.

4. With regard to the Isolated Network Operation and Block Loading simulation:

   a) The Generating Unit shall demonstrate its performance during Isolated Network Operation in the conditions as referred to in Article 9 paragraph 4 (b).

   b) The simulation is deemed passed, provided that the following conditions are cumulatively fulfilled:

      1) the Generating Unit shall be able to change from Interconnected System Operation to Isolated Network Operation without using any switchgear position signals for identifying an Isolated Network;

      2) the Generating Unit reduces or increases the loading from its previous operating point to any new operating point within the P-Q-Capability Diagram within the limits of Article 9 paragraph 4 (b) without disconnection of the Generating Unit from the Isolated Network due to over/underfrequency; and

      3) the Generating Unit has regulated load connections in block load with a maximum size of 10% of Maximum Capacity of the Generating Unit without frequency dropping dynamically by more than 1Hz in the Isolated Network.

5. With regard to the Reactive Power Capability simulation:

   a) The Generating Unit shall demonstrate its capability to simulate leading and lagging Reactive Power capability in the conditions referred to in Article 12 paragraph 3 (e) and (f).

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b) The simulation is deemed passed, provided that the following conditions are cumulatively fulfilled:

1) the Generating Unit is validated against the compliance tests for Reactive Power Capability at the as referred to in Article 35 paragraph 7;

2) the Generating Unit demonstrates compliance with the requirements across the voltage range as referred to in Article 12 paragraph 3 (e); and

3) the Generating Unit demonstrates the level of Reactive Power capability available for the voltage range according to Article 10 paragraph 2 (a) respectively.

Article 46

COMPLIANCE SIMULATIONS FOR TYPE D SYNCHRONOUS GENERATING UNITS

1. In addition to carrying out the compliance simulations for type A and C Synchronous Generating Units in the conditions as referred to in Articles 43 and 45, type D Synchronous Generating Units are subject to the following compliance simulations.

2. With regard to the Power Oscillations Damping Control simulation:

a) The Generating Unit shall demonstrate the performance of its control system (PSS) to damp power oscillations in the conditions set forth in Article 13 paragraph 2 (b).

b) The tuning of the PSS shall result in improved damping of corresponding Active Power response of the AVR in combination with the PSS compared to the Active Power response of the AVR alone.

c) The simulation is deemed passed, provided that the following conditions are cumulatively fulfilled:

1) the PSS damps the existing power oscillations of the Generating Unit within a frequency range of 0,1Hz to 2,0Hz. This frequency range shall include the eigen frequency of the Generating Unit and the expected Network oscillations; and

2) the PSS has not reacted to non-oscillatory admissible power changes in Interconnected System Operation due to a sudden load reduction of 40% of Maximum Capacity of the Generating Unit from 1p.u. to 0,6p.u. within 3 seconds.

3. With regard to the type D Fault Ride Through Capability of Synchronous Generating Units simulation:

a) The Generating Unit shall demonstrate its capability to simulate fault ride through capability in the conditions set forth in Article 13 paragraph 3 (a).

b) The simulation is deemed passed, provided that the Generating Unit demonstrates compliance with the requirements set forth in Article 13 paragraph 3 (a).

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Chapter 6

COMPLIANCE SIMULATIONS FOR POWER PARK MODULES

Article 47

COMPLIANCE SIMULATIONS FOR TYPE B POWER PARK MODULES

1. With regard to type B Power Park Modules the type B Fault Ride Through Capability, Fast Acting Reactive and/or Active Power Contribution During Faults and Post Fault Active Power Recovery compliance simulations shall be carried out.

2. With regard to the type B Fault Ride Through Capability of Power Park Modules simulation:

   a) The model of the Generating Unit shall demonstrate its capability to simulate fault ride through capability in the conditions as referred to in Article 15 paragraph 3 (a).

   b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 15 paragraph 3 (a) respectively.

3. With regard to the Fast Acting Reactive Power Contribution During Faults simulation:

   a) The model of the Generating Unit shall demonstrate its capability to simulate fast acting reactive current injection in the conditions as referred to in Article 15 paragraph 2 (a).

   b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 15 paragraph 2 (a).

4. With regard to the Post Fault Power Recovery simulation:

   a) The model of the Generating Unit shall demonstrate its capability to simulate post fault Active Power recovery in the conditions as referred to in Article 15 paragraph 3 (b).

   b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 15 paragraph 3 (b).

Article 48

COMPLIANCE SIMULATIONS FOR TYPE C POWER PARK MODULES

1. In addition to carrying out the compliance simulations for type B Power Park Modules in the conditions as referred to in Article 47, type C Power Park Modules are subject to the following compliance simulations.

2. With regard to the Island Operation and Block Loading simulation:

   a) The Generating Unit shall demonstrate its performance during Isolated Network Operation in the conditions as referred to in Article 9 paragraph 4 (b).

   b) The simulation is deemed passed, provided that the following conditions are cumulatively fulfilled:

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1) the Generating Unit shall be able to change from Interconnected System Operation to Isolated Network Operation without using any switchgear position signals for identifying an Isolated Network;

2) the Generating Unit reduces or increases the loading from its previous operating point to any new operating point within the P-Q-Capability Diagram within the limits of Article 9 paragraph 4 (b) without disconnection of the Generating Unit from the Isolated Network due to over/underfrequency; and

3) the Generating Unit has regulated load connections in block load with a maximum size of 10% of Maximum Capacity of the Generating Unit without frequency dropping dynamically by more than 1Hz in the Isolated Network.

3. With regard to the Synthetic Inertial Capability simulation:

a) The model of the Generating Unit shall demonstrate its capability to simulate synthetic inertial capability to a low frequency event in the conditions as referred to in Article 16 paragraph 2 (a).

b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 16 paragraph 2 (a).

4. With regard to the Fast Acting Active Power Contribution During Faults simulation:

a) The model of the Generating Unit shall demonstrate its capability to simulate fast acting Active Power contribution in the conditions as referred to in Article 16 paragraph 3 (c).

b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 16 paragraph 3 (c).

5. With regard to the Power Oscillations Damping Control simulation:

a) The model of the Generating Unit shall demonstrate its capability to simulate power oscillations damping capability in the conditions as referred to in Article 16 paragraph 4 (a).

b) The simulation is deemed passed, provided that the model demonstrates compliance with the conditions of Article 16 paragraph 4 (a).

Article 49

COMPLIANCE SIMULATIONS FOR TYPE D POWER PARK MODULES

1. In addition to carrying out the compliance simulations for type B and C Power Park Modules in the conditions as referred to in Article 47 and 48, type D Power Park Modules are subject to the Type D Fault Ride Through Capability of Power Park Modules compliance simulation, which shall be carried out instead of the compliance simulation according to Article 47 paragraph (2).

2. The model of the Generating Unit shall demonstrate its capability to simulate fault ride through
capability in the conditions as referred to in Article 17 paragraph 1 (a).

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3. The simulation is deemed passed, provided that the model demonstrates compliance with the
conditions of Article 17 paragraph 1 (a) respectively.

Chapter 7

COMPLIANCE SIMULATIONS FOR OFFSHORE POWER PARK MODULES

Article 50

COMPLIANCE SIMULATIONS APPLICABLE TO OFFSHORE POWER PARK MODULES IN ALL CONFIGURATIONS

The Compliance simulations as defined in Article 47 paragraph 2 and 4 as well as in Article 48 paragraph 2 and 3 shall apply to any Offshore Power Park Module, irrespective of its configuration.

Article 51

COMPLIANCE SIMULATIONS APPLICABLE TO OFFSHORE POWER PARK MODULES of CONFIGURATIONS 1-5

The Compliance simulations as defined in Article 48 paragraph 4 and 5 shall apply to Offshore Power Park Modules of Configurations 1, 2, 3, 4 and 5.

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Title 5

DEROGATIONS

Article 52

GENERAL PROVISIONS

1. The procedure for derogation defined in this Title applies to all Power Generating Facility Operators, both existing and new Power Generating Facilities.

2. This procedure does not provide the criteria for determination of derogation, which are to be developed by each Network Operator in coordination with the Relevant TSO in the conditions set forth by national legislation, Connection Agreement or any other bilateral contracts. These criteria shall be non-discriminatory and transparent and shall comply with the principles set forth in this Code.

Article 53

REQUEST FOR DEROGATION

1. Users may apply for derogation to this Network Code by submitting a request to the Relevant Network Operator, according to the terms and conditions set in this Article.

2. The derogation application, drafted by the applicant, is to be submitted in writing to the Relevant Network Operator and must include the following information:

   a) identifying data of the applicant party, with reference contact person for any communications;
   b) the specific plant/site to which the derogation request is referred;

   c) the description of the content and of the reason for the modification;

   d) the provision/parameter of the Network Code for which a derogation is requested, specifying which option is requested among the following:

      - a derogation to a parameter set in the technical conditions for connection (exception to a parameter set in the technical conditions for connection);

      - a derogation to a provision of the Network Code (exception to a provision of the Network Code);

   e) all relevant documents supporting the derogation application.

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Article 54

EXCEPTION TO A PARAMETER SET IN THE TECHNICAL CONDITIONS FOR CONNECTION

1. Derogation to a parameter set in the technical conditions for connection may exclusively entail a variation in the value of parameters indicated in the individual provision of a connection site, without changing its prescription. The derogation may be granted provided that such variation is not significant in terms of impact on the system.

2. Further to the application submitted by the user, the Relevant Network Operator assesses the request and related documentation. No later than 6 months after the receipt of the application, the Relevant Network Operator issues a motivated decision granting or refusing the derogation and specifying the duration of the derogation.

3. The Relevant Network Operator shall communicate to the applicant the decision granting the derogation and shall keep a register of all derogations it has granted.

Article 55

EXCEPTION TO A PROVISION OF THE NETWORK CODE

1. Further to the application submitted by the user, the Relevant Network Operator assesses the request and related documentation. No later than 6 months after the receipt of the application, the Relevant Network Operator issues a motivated decision granting or refusing the derogation and specifying the duration of the derogation.

2. The Relevant Network Operator shall communicate to the applicant the decision granting the derogation and shall keep a register of all derogations it has granted.

Article 56

COMPLIANCE OF EXISTING POWER GENERATING FACILITIES

1. The procedures set in Article 54 and 55 apply also to existing Power Generating Facilities.

2. An existing Power Generating Facility which is not compliant with one or more provisions of the Network Code at the date of entry into force of the Network Code shall no later than five years after the same date, submit together with the documents according to Article 28, an application to the Relevant Network Operator requesting, for each provision to which it is not compliant the derogation to the provision or parameter, following the conditions set forth in Articles 54 and 55.

3. The application form shall be submitted to the each Network Operator no later than 6 months after the entry into force of the Network Code.

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4. Further to the request by an existing Power Generating Facility, the Relevant Network Operator shall assess the derogation application following the relevant procedure as set forth in Articles 54 and 55.

5. In any case, no later than within ten years following the entry into force of this Network Code, all existing units shall:

   a) be compliant with all provisions of the Network Code; or

   b) have received a derogation decision from the Relevant Network Operator with respect to the provisions for which they are not compliant.

Article 57

REGISTER OF DEROGATIONS TO THE NETWORK CODE

1. Each Relevant Network Operator shall keep a register of all derogations it has granted and shall provide to ENTSO-E an updated and consolidated register at least every 6 months.

2. ENTSO-E shall compile the registers received from each Relevant Network Operator to create and maintain the Register of Derogations to the Network Code.

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Title 6

FINAL PROVISIONS

Article 58

ENTRY INTO FORCE

This Network Code shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

It shall apply as from the day of expiration of a 3 year period following its publication.

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