GREATER MEKONG SYSTEM REGIONAL GRID CODE

Connection Code (draft)

3 of 7 Code Documents

Version 0.4

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Note: *A section titled "ANNEX: Code – History of Comments" is attached to each Code. It provides a log of every comment and subsequent consideration taken on the Code.*

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1. Introduction

(1) This code contains a set of connection conditions for *power-generator facilities*, *HVDC systems* including *DC connected power modules* and *Demand facilities*.

(2) The connection code specifies the acceptable technical, design and operational criteria which must be complied with by any Party connected to the GMS Interconnected Network.

(3) The objective of the connection conditions is to ensure that, by specifying minimum technical, design and operational criteria, the basic rules for connection to the Interconnected System are similar for all participants of an equivalent category. This will enable the maintenance, preservation and restoration of system security in order to facilitate proper functioning of the internal electricity market within and between synchronous areas, and to achieve cost efficiencies.

(4) This code was based on connection conditions stated in EU Commission Regulations 2016/631, 2016/1447 and 2016/1388 and adapted for the GMS Interconnected Network.

2. Requirements for Generators (RfG)

2.1 Size of generator facility

(1) A *power-generating facility* shall comply with the requirements on the basis of the voltage level of its connection point and its maximum capacity according to the categories set out below.

(2) *A power-generating facility* within any of the following categories shall be considered as significant:

Connection point below 110 kV and maximum capacity:

(a) greater than 0.8 kW and less than the maximum capacity threshold for a type B *power generating facility* in Table 2-1 (type A);

(b) at or above the maximum capacity threshold for a type B *power generating facility* and less than the maximum capacity threshold for type C in Table 2-1 (type B);

(c) at or above the maximum capacity threshold for a type C *power generating facility* and less than the maximum capacity threshold for type D in

(d) Table 2-1 (type C); or

(e) at or above the maximum capacity threshold for a type D *power generating facility* in

(f) Table 2-1 (type D).

A *power generating facility* with a connection point at 110 kV or above is also categorised as type D.

Table 2-1 Limits for thresholds for type B, C and D *power-generating facility*

Synchronous areas	Limit for maximum capacity threshold from which a *power-generating facility* is of type B	Limit for maximum capacity threshold from which a *power-generating facility* is of type C	Limit for maximum capacity threshold from which a *power-generating facility* is of type D
Interconnected GMS	1 MW	40 MW	75 MW

2.2 Frequency tolerance, active power and frequency control requirements

2.2.1 Frequency tolerance

(1) All *power-generating facilities* shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 2-2.

(2) The relevant *TSO* and the *power-generating facility* owner may agree on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations to ensure the best use of the technical capabilities of a *power-generating facility*, if it is required to preserve or to restore system security.

(3) Tripping times for when frequency goes outside of the normal operating range of 49.0 to 51.0 Hz shall be agreed with the relevant *TSO*. The *TSO* shall co-ordinate such settings to minimise the risk of cascade tripping and network collapse.

Table 2-2 Minimum time periods for which a *power-generating facility* must be capable of operating at different frequencies without disconnecting from the network, for specified ranges representing deviations from the nominal value.

Synchronous area	Frequency range	Minimum time period for operation of each *power generating facility* each time the system frequency is in the specified frequency ranges
Interconnected GMS	47.0 Hz-47.5 Hz	To be specified by each *TSO*, but not less than 15 seconds
	47.5 Hz-49.0 Hz	To be specified by each *TSO*, but not less than 30 minutes
	49.0 Hz-51.0 Hz	Unlimited
	51.0 Hz-51.5 Hz	30 minutes
	51.5 Hz-52.0 Hz	15 minutes

2.2.2 Active power and frequency control requirements

(1) Type B, C and D *power-generating facilities* shall be capable of continuous operation, at up to 100% active power output, within a frequency range of 49.0 to 51.0 Hz and voltage range of 0.05 pu either side of nominal voltage.

(2) Type B, C and D *power-generating facilities* shall be capable of continuous operation at any point between the limits of 0.85 power factor leading and 0.95 power factor lagging, when supplying 100% active power output.

(3) The active power output from Type B, C and D *power-generating facilities* shall not decrease by more than a proportionate decrease in frequency when the frequency varies within the range of 47.5 to 49.0 Hz.

(4) Type B, C and D *power-generating facilities* shall remain connected to the *network* for a rate of change of frequency of up to and including 1.0 Hz per second measured over a rolling window of 500 ms, provided that the network frequency remains within the operating range specified in Table 2-2.

(5) All *power-generating facilities* shall be designed to be capable to provide power-frequency response in order to stabilise the grid *frequency*. The metering accuracy for the grid *frequency* shall be at least ±10 mHz.

(6) All *power-generating facilities* shall be capable of providing primary frequency response to meet the requirements shown in Figure 2-1:

(a) The default settings for f_{min}, f_{max}, $f_4$and f_5 shall be as shown in Table 2-3, unless otherwise agreed upon between RPCC, the relevant *TSO* and *power-generating facilities*.

(b) The droop settings shall be between 2% and 12%.

(c) The purpose of frequency points f_1 to f_4 is to form a dead band and a control band for *power-generating facilities* contracted for primary frequency response. The purpose of frequency points f_4 to f_6 is to supply mandatory critical power/frequency response.

(d) A Type A *power-generating facility* is not required to provide any positive response to a low frequency, $P_{Delta} = 0$, unless otherwise agreed by the relevant *TSO* and the *power-generating facilities.*

(e) Type B, C & D *power-generating facilities* shall be designed with the capability to provide a P_{Delta} of not less than 5% of $P_{available.}$ P_{Delta} is the setpoint to which the *available active power* has been reduced in order to provide frequency stabilisation (primary frequency response) in the case of falling grid frequency.

(f) Type B, C & D *power-generating facility* settings for $P_{Delta,}$ f_1, f_2 and f_3 shall be as agreed between RPCC, the relevant *TSO* and *power-generating facilities*.

Figure 2-1 Frequency response requirements for power generation facilities

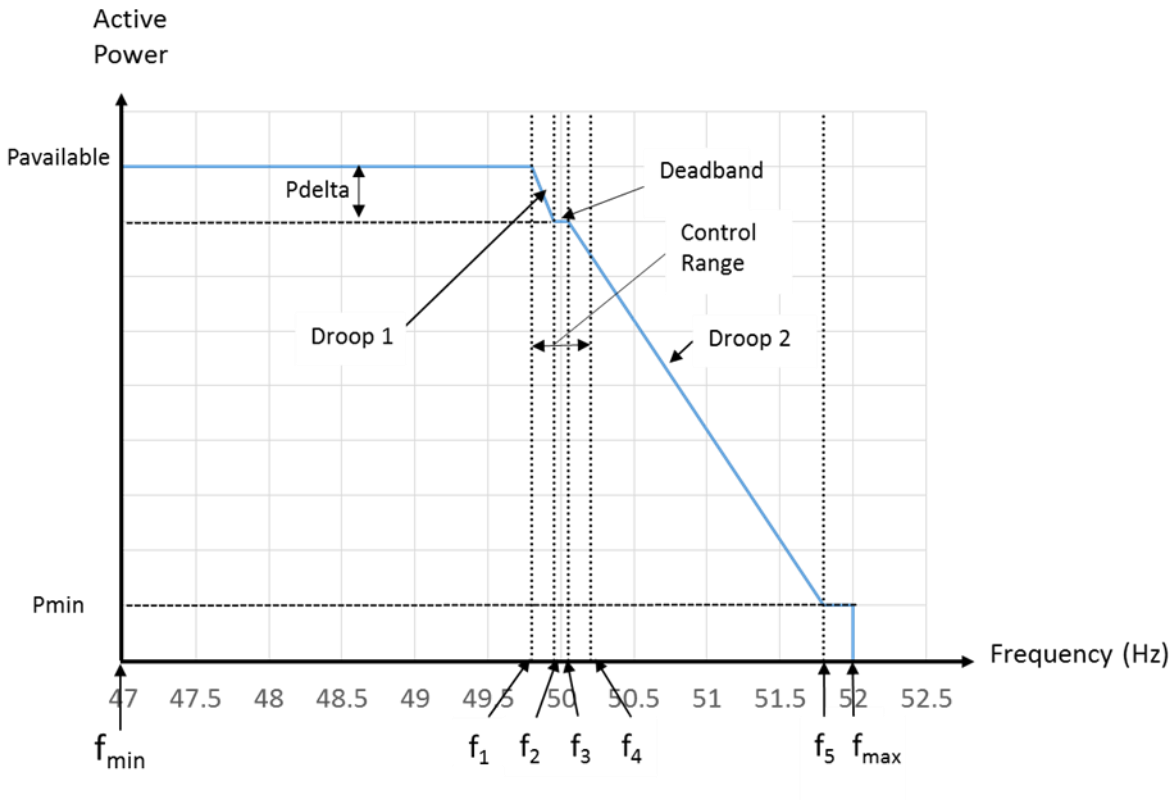


Table 2-3 Frequency response default settings for Type A, B, C & D *power-generating facilities*

***Power-generating facility* Type**	**Type A**	**Type B**	**Type C & D**	**Unit**
f_{min}	47.0	47.0	47.00	Hz
f_{max}	52.0	52.0	52.00	Hz
f_1	47.0	As agreed with *TSO*	≥49.80	Hz
f_2	47.0	As agreed with *TSO*	49.98	Hz
f_3	50.5	As agreed with *TSO*	50.02	Hz
f_4	50.5	50.5	≤50.50	Hz
f_5	52.0	52.0	52.00	Hz
P_{Delta}	0	As agreed with *TSO*	➢ 5%	%

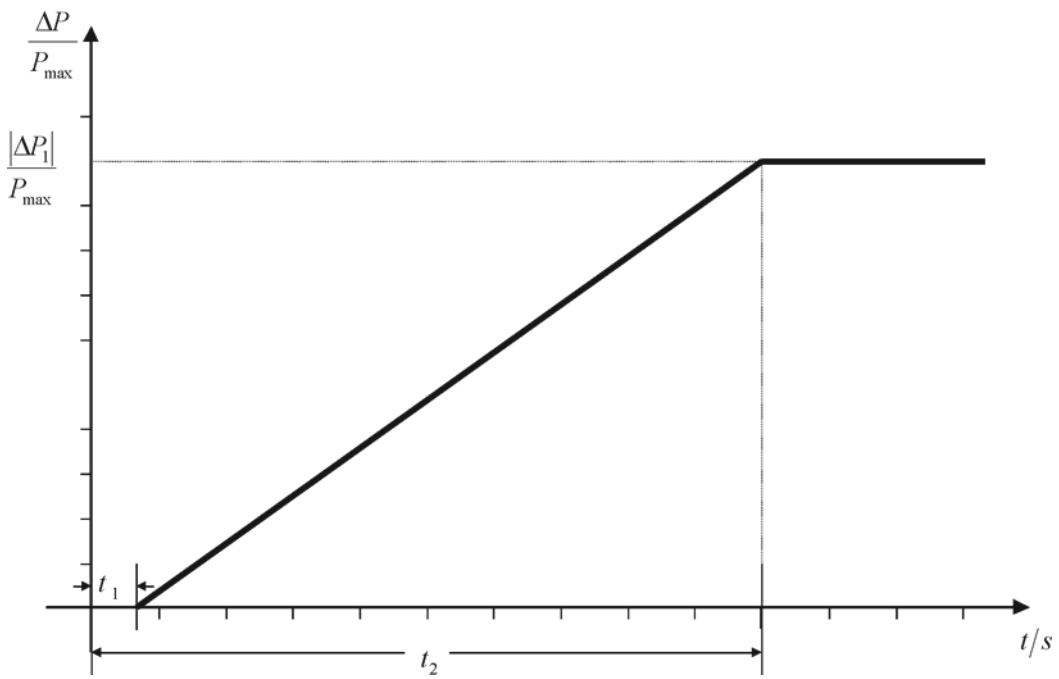
(7) For Type B, C & D *power-generating facilities* the delay time for the start of the activation of P_{Delta}, in response to a step in the frequency, shall be designed to be less than 2 seconds or as agreed between RPCC, the relevant *TSO* and *power-generating facilities*. The delay time is shown as time t_1 in Figure 2-2. If the delay to activation of the active power frequency response is greater than 2 seconds then the *power-generating facility* owner shall provide technical evidence to demonstrate why a longer time is needed.

(8) For Type B, C & D *power-generating facilities* the full response time for provision of P_{Delta}, in response to a step in the frequency, shall be designed to be less than 30

seconds or as agreed between RPCC, the relevant *TSO* and *power-generating facilities* owners. The full activation time is shown as time t_2 in **Error! Reference source not found.**

(9) For Type B, C & D *power-generating facilities* the sustained time for provision of P_{Delta} active power frequency response, shall be designed to be at least 15 minutes or as agreed between RPCC, the relevant *TSO* and *power-generating facilities* owners.

Figure 2-2 Active power frequency response capability to a step in frequency



(10) Type C and D *power-generating facilities* shall be equipped with appropriate plant controllers enabling the Automatic Generation Control functions to provide the required Secondary Reserve for the Control Area. Signals will be sent by the Automatic Generation Control system of the relevant *TSO* to the plant controllers to automatically adjust the generation output. The amount of AGC capacity shall not be not less than 40% of the range of the generator.

(11) Type C and D *power-generating facilities* shall be equipped with PMU (Phasor Measurement Unit) where type C and D generators connected to system above 230kV.

(12) Type C and D the nuclear generator shall be able to decrease power to 80% of nominal capacity in 3 hours and decrease to 50% of nominal capacity in 6 hours.

(13) Type C and D active power vibration zone of hydro generator shall be less than 45% of its nominal capacity.

2.3 Voltage tolerance, voltage control and reactive power provision

(1) *Power-generating facilities* shall be designed and capable of staying connected to the network and operating within the range of 0.9 to 1.1 pu of the nominal network voltage at the connection point.

(2) Type B *power-generating modules* shall fulfil the following additional requirements relating to voltage stability:

(a) The relevant system operator shall have the right to specify the capability of a synchronous *power-generating module* to provide reactive power;

(b) The synchronous *power-generating facilities* shall be equipped with a permanent automatic excitation control system that can provide constant alternator terminal voltage at a selectable setpoint without instability over the entire operating range of the synchronous *power-generating module*.

(3) Type C & D *power-generating facilities* shall fulfil the following additional requirements relating to voltage stability:

(a) The relevant system operator shall have the right to specify the capability of a synchronous *power-generating module* to provide reactive power;

(b) The relevant system operator may specify supplementary reactive power to be provided if the connection point of a synchronous *power-generating facility* is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous *power-generating module* or its alternator terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.

(c) The *power-generating facilities* shall provide the following reactive power capability at maximum capacity:

(i) the relevant system operator, in coordination with the relevant *TSO*, shall specify the reactive power provision capability requirements in the context of varying voltage. For that purpose, the relevant system operator shall specify a U-Q/P_{max}-profile within the boundaries of which the synchronous *power-generating module* shall be capable of providing reactive power at its maximum capacity. The specified U-Q/P_{max} profile may take any shape, having regard to the potential costs of delivering the capability to provide reactive power production at high voltages and reactive power consumption at low voltages;

(ii) the U-Q/P_{max}-profile shall be specified by the relevant system operator, in coordination with the relevant *TSO*, in conformity with the following principles:

— the U-Q/P_{max}-profile shall not exceed the U-Q/P_{max}-profile envelope, represented by the inner envelope in Figure 2-3,

— the dimensions of the U-Q/P_{max}-profile envelope (Q/P_{max} range and voltage range) shall be within the range in Table 2-4, and

— the position of the U-Q/P_{max}-profile envelope shall be within the limits of the fixed outer envelope in Figure 2-3;

Figure 2-3 U-Q/P_{max}-profile of a synchronous *power-generating facility*

The diagram represents the boundaries of the U-Q/P_{max}-profile with the voltage at the connection point, expressed in pu, against the ratio of the reactive power (Q) to the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.

Table 2-4 Parameters for the inner envelope in Figure 2-3

Synchronous area	Maximum range of Q/P_{max}	Maximum range of steady- state voltage level in PU
Interconnected GMS	0.95	0.225

(iii) the reactive power provision capability requirement applies at the connection point. For profile shapes other than rectangular, the voltage range represents the highest and lowest values and the full reactive power range is therefore not expected to be available across the range of steady-state voltages;

(iv) the synchronous *power-generating module* shall be capable of moving to any operating point within its U-Q/P_{max} profile in appropriate timescales to target values requested by the relevant system operator;

(d) with regard to reactive power capability below maximum capacity, when operating at an active power output below the maximum capacity ($P < P_{max}$) the synchronous *power-generating facilities* shall be capable of operating at every possible operating point in the P-Q-capability diagrams of the alternators of those synchronous *power-*

generating facilities, at least down to minimum stable operating level. Therefore, even at reduced active power output, reactive power supply at the connection point shall correspond fully to the P-Q-capability diagram of the alternator of that synchronous *power-generating module*, taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account.

(4) Type D *power-generating facilities* shall fulfil the following additional requirements relating to voltage stability:

(a) The *power-generating facilities* shall be capable of staying connected to the network and operating within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to the reference 1 pu voltage, and for the time periods specified in Table 2-5;

(b) The relevant *TSO* may specify shorter periods of time during which *power-generating modules* shall be capable of remaining connected to the network in the event of simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency;

Table 2-5 Minimum voltage range capabilities for *power-generating facilities*

Synchronous area	Voltage range	Minimum time period for operation
Interconnected GMS	0.85 pu - 0.90 pu	60 minutes
	0.900 pu - 1.118 pu	Unlimited
	1.118 pu - 1.150 pu	To be specified by each *TSO*, but not less than 20 minutes and not more than 60 minutes

(5) the parameters and settings of the components of the voltage control system shall be agreed between the *power-generating facility* owner and the relevant system operator, in coordination with the relevant *TSO*;

(6) the agreement in the previous paragraph shall cover the specifications and performance of an automatic voltage regulator ('AVR') with regard to steady-state voltage and transient voltage control and the specifications and performance of the excitation control system. The latter shall include:

(a) bandwidth limitation of the output signal to ensure that the highest frequency of response cannot excite torsional oscillations on other *power-generating modules* connected to the network;

(b) an underexcitation limiter to prevent the AVR from reducing the alternator excitation to a level which would endanger synchronous stability;

(c) an overexcitation limiter to ensure that the alternator excitation is limited to less than the maximum value that can be achieved whilst ensuring that the synchronous *power-generating module* is operating within its design limits;

(d) a stator current limiter; and

(e) a PSS function to attenuate power oscillations, for synchronous *power-generating facilities* whose size is above a value of maximum capacity specified by the relevant *TSO*.

(7) *Power-generating facility* owners shall ensure that voltage unbalance is less than 1%.

2.4 Fault ride through capability

(1) Fault-ride-through capability of Type B, C & D synchronously connected *power-generating facilities* is required as follows:

(a) each *TSO* shall specify a voltage-against-time-profile in line with Figure 2-4 at the connection point for fault conditions, which describes the conditions under which the *power-generating facilities* shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults on the transmission system;

(b) the voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault;

(c) the lower limit referred to in point (b) above shall be specified by the relevant *TSO* using the parameters set out in Figure 2-4, and within the ranges set out in Table 2-7;

(d) each *TSO* shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of:
   (i) the calculation of the pre-fault minimum short circuit capacity at the connection point,
   (ii) the pre-fault active and reactive power operating point of the *power-generating facility* at the connection point and voltage at the connection point, and
   (iii) calculation of the post-fault minimum short circuit capacity at the connection point;

(e) The short circuit current levels shall not exceed the limits specified in Table 2-6

Table 2-6 Short Circuit Current Level

Requirements	GMS
Short Circuit Current Levels: ▪ **500 kV**	50 kA
▪ **220-230 kV**	40 kA
▪ **115-132 kV**	31.5 kA

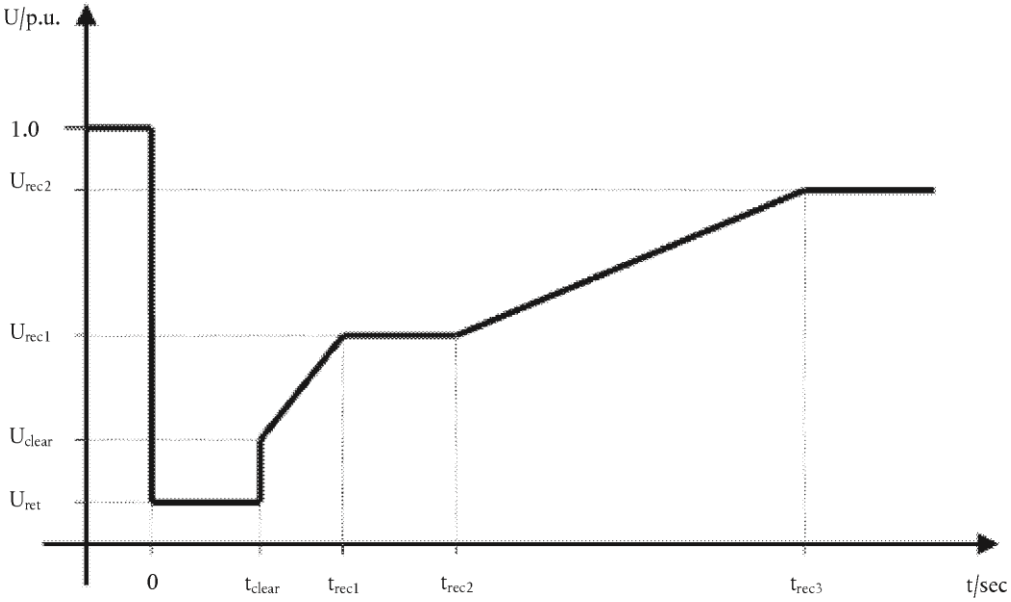
(f) at the request of a *power-generating facility* owner, the relevant system operator shall provide the pre-fault and post-fault conditions to be considered for fault-ride-through capability as an outcome of the calculations at the connection point as specified in point (d) above regarding:
   (i) pre-fault minimum short circuit capacity at each connection point expressed in MVA,

(ii) pre-fault operating point of the *power-generating facility* expressed in active power output and reactive power output at the connection point and voltage at the connection point, and

(iii) post-fault minimum short circuit capacity at each connection point expressed in MVA.

Alternatively, the relevant system operator may provide generic values derived from typical cases;

Figure 2-4 Fault-ride-through profile of a *power-generating facility*



The diagram represents the lower limit of a voltage-against-time profile for the voltage at the connection point, expressed in pu, during and after a fault. U_{ret} is the retained voltage at the connection point during a fault; t_{clear} is the instant when the fault has been cleared; and U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} specify certain points of lower limits of voltage recovery after fault clearance.

Table 2-7 Parameters for fault-ride-through capability of Type B, C & D synchronous *power-generating facilities*

Voltage parameters (pu)		Time parameters (seconds)	
Type B & C synchronous *power-generating facilities*			
U_{ret}:	0.05 – 0.20	t_{clear}:	0.15 (or 0.25 if system protection and secure operation so require)
U_{clear}:	0.70 – 0.90	t_{rec1}:	t_{clear}
U_{rec1}:	U_{clear}	t_{rec2}:	t_{rec1}-0.7
U_{rec2}:	0.85 – 0.90 and ≥ U_{clear}	t_{rec3}:	t_{rec2}-1.5
Type D synchronous *power-generating facilities*			
U_{ret}:	0	t_{clear}:	0.15 (or 0.25 if system protection and secure operation so require)
U_{clear}:	0.25	t_{rec1}:	t_{clear}-0.45

U_{rec1}:	0.5 – 0.7	t_{rec2}:	t_{rec1}-0.7
U_{rec2}:	0.85 – 0.9	t_{rec3}:	t_{rec2}-1.5

(g) the *power-generating facility* shall be capable of remaining connected to the network and continuing to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, given the pre-fault and post-fault conditions in points (d) and (e) above, remain above the lower limit specified in point (b) above, unless the protection scheme for internal electrical faults requires the disconnection of the *power-generating facility* from the network. The protection schemes and settings for internal electrical faults must not jeopardise fault-ride-through performance;

(h) without prejudice to point (f) above, undervoltage protection (either fault-ride-through capability or minimum voltage specified at the connection point voltage) shall be set by the *power-generating facility* owner according to the widest possible technical capability of the *power-generating facility*, unless the relevant system operator requires narrower settings. The settings shall be justified by the *power-generating facility* owner in accordance with this principle;

(2) Fault-ride-through capabilities in case of asymmetrical faults shall be specified by each *TSO*.

2.5 Protection requirements

(1) Type A *power-generating facilities* shall have loss of mains protection as specified by the relevant *TSO*

(2) Type B, C & D *power-generating modules* shall fulfil the following additional control schemes and settings:

(a) the schemes and settings of the different control devices of the *power-generating module* that are necessary for transmission system stability and for taking emergency action shall be coordinated and agreed between the relevant *TSO*, the relevant system operator and the *power-generating facility* owner;

(b) any changes to the schemes and settings of the different control devices of the power-generating module shall be coordinated and agreed between the relevant *TSO*, the relevant system operator and the *power-generating facility* owner;

(3) Type C & D *power-generating modules* shall fulfil the following additional control schemes and settings:

(a) the relevant system operator shall specify the schemes and settings necessary to protect the network, taking into account the characteristics of the *power-generating module*. The protection schemes needed for the *power-generating module* and the network, as well as the settings relevant to the *power-generating module*, shall be coordinated and agreed between the relevant system operator and the *power-generating facility* owner. The protection schemes and settings for internal electrical faults must not jeopardise the performance of a power-generating module, in line with the requirements set out in this code;

(b) electrical protection of the *power-generating module* shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the *power-generating module*;

(c) protection schemes may cover the following aspects:
- external and internal short circuit,
- asymmetric load (negative phase sequence),
- stator and rotor overload,
- over-/underexcitation,
- over-/undervoltage at the connection point,
- over-/undervoltage at the alternator terminals,
- inter-area oscillations,
- generator shedding;
- inrush current,
- asynchronous operation (pole slip),
- protection against inadmissible shaft torsions (for example, subsynchronous resonance),
- *power-generating module* line protection,
- unit transformer protection,
- back-up against protection and switchgear malfunction,
- overfluxing (U/f),
- inverse power,
- rate of change of frequency, and
- neutral voltage displacement.

(d) changes to the protection schemes needed for the *power-generating module* and the network, and to the settings relevant to the *power-generating module*, shall be agreed between the system operator and the *power-generating facility* owner, and agreement shall be reached before any changes are made.

(4) the *power-generating facility* owner shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest):

(i) network and *power-generating module* protection;

(ii) synthetic inertia, if applicable;

(iii) frequency control (active power adjustment);

(iv) power restriction; and

(v) power gradient constraint;

(5) -For the case that the relay protection of power-generating facility owner need to connect with Grid relay protection, the relay protection of power-generating facility owner must satisfy the TSO requirement and have the acceptance of SO. The requirements for the relay is at least the following:

(i) The reliability of relay protection must not less than 99%

(ii) There shall be at least 2 separate communication channel for relay protection

(6) Type D *power-generating modules* shall fulfil the following recording devices, as specified by the relevant TSO:

(i) Fault recorder with GPS

(ii) Phasor Measurement Unit (PMU)

2.6 System Restoration, Islanding and Black start capability

(1) Type C & D *power-generating modules* shall fulfil the following requirements relating to system restoration, black start and quick re-synchronisation capability.

(2) *Power-generating facilities* contracted for black start shall have the following capabilities:

(a) black start capability is not mandatory without prejudice to the GMS Member State's rights to introduce obligatory rules in order to ensure system security;

(b) *power-generating facility* owners shall, at the request of the relevant *TSO*, provide a quotation for providing black start capability. The relevant *TSO* may make such a request if it considers system security to be at risk due to a lack of black start capability in its control area;

(c) a *power-generating facility* with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a time frame specified by the relevant system operator in coordination with the relevant *TSO*;

(d) a *power-generating facility* with black start capability shall be able to synchronise within the frequency limits laid down in section 2.2 and, where applicable, voltage limits specified by the relevant system operator or in section 2.3;

(e) a *power-generating facility* with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand;

(f) a *power-generating facility* with black start capability shall:
- be capable of regulating load connections in block load,
- be capable of controlling frequency using speed or droop control modes,
- control frequency in case of overfrequency and underfrequency within the whole active power output range between minimum regulating level and maximum capacity as well as at houseload level,
- be capable of parallel operation of a few *power-generating modules* within one island, and
- control voltage automatically during the system restoration phase;

(3) *Power-generating facilities* contracted for islanding shall have the following capability to take part in island operation:

(a) *power-generating facilities* shall be capable of taking part in island operation if required by the relevant system operator in coordination with the relevant *TSO* and:
- the frequency limits for island operation shall be those established in accordance with section 2.2,
- the voltage limits for island operation shall be those established in accordance with section 2.3;

(b) *power-generating facilities* shall be able to operate in speed or droop control mode during island operation.

(c) In the event of a power surplus, *power-generating facilities* shall be capable of reducing the active power output from a previous operating point to any new

operating point within the P-Q-capability diagram. In that regard, the *power-generating module* shall be capable of reducing active power output as much as inherently technically feasible, but to at least 55% of its maximum capacity;

(d) the method for detecting a change from interconnected system operation to island operation shall be agreed between the *power-generating facility* owner and the relevant system operator in coordination with the relevant *TSO*. The agreed method of detection must not rely solely on the system operator's switchgear position signals;

(e) *power-generating facilities* shall be able to operate in speed or droop control modes during island operation;

(4) *Power-generating facilities* shall have the following quick re-synchronisation capabilities:

(a) in case of disconnection of a *power-generating facility* from the network, the *power-generating facility* shall be capable of quick re-synchronisation in line with the protection strategy agreed between the relevant system operator, in coordination with the relevant *TSO*, and the *power-generating facility*;

(b) a *power-generating facility* with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the system operator's switchgear position signals;

(c) *power-generating facilities* 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 specified by the relevant system operator in coordination with the relevant *TSO*, taking into consideration the specific characteristics of prime mover technology.

2.7 Information requirements

Need to check overlaps with requirements in telecommunications and information exchange codes

(1) Type C & D *power-generating modules* shall provide at least the data requirements to RPCC as specified in Table 2-8.

Table 2-8 RPCC Minimum Requirements for Telemetering for Type C & D *power-generating modules*

Type of Connection	Telemetering Required	Telemetered Status Indicators
Generation connected directly to Interconnected Transmission System	MW, MVArs, kV MWh, MVArh	Generator main circuit breakers
Generation not directly connected to Interconnected Transmission System	MW	None

(2) The above data requirements can be provided to RPCC via the relevant *TSO* and the relevant *TSO* shall specify the information exchange standards. The relevant *TSO* shall make publicly available the precise list of data required.

2.8 Connection, compliance and testing requirements

2.8.1 Operational notification procedure for connection

(1) The *power-generating facility* owner shall demonstrate to the relevant system operator that it has complied with the requirements set out in this code by successfully completing the operational notification procedure for connection of each *power-generating module* described below.

(2) The relevant system operator shall clarify and make publicly available the details of the operational notification procedure which shall have at least the following information:

(a) the location at which the connection is made;

(b) the date of the connection;

(c) the maximum capacity of the installation in kW;

(d) the type of primary energy source;

(e) reference to equipment certificates issued by an authorised certifier for equipment that is in the site installation;

(f) as regards equipment used for which an equipment certificate has not been received, information shall be provided as directed by the relevant system operator; and

(g) the contact details of the *power-generating facility* owner and the installer and their signatures.

(3) The *power-generating facility* owner shall ensure that the relevant system operator is notified about the permanent decommissioning of a *power-generating module* in accordance with relevant legislation.

(4) The relevant system operator shall have the right to request that Type B, C & D *power-generating facility* owners include the following in the operational notification:

(a) evidence of an agreement on the protection and control settings relevant to the connection point between the relevant system operator and the *power-generating facility* owner;

(b) itemised statement of compliance;

(c) detailed technical data of the *power-generating module* with relevance to the grid connection as specified by the relevant system operator;

(d) equipment certificates issued by an authorised certifier in respect of *power-generating modules*, where these are relied upon as part of the evidence of compliance;

(e) simulation models as required by the relevant *TSO*;

(f) compliance test reports demonstrating steady-state and dynamic performance as required by this Code, including use of actual measured values during testing, to the level of detail required by the relevant system operator; and

(g) studies demonstrating steady-state and dynamic performance as required by this Code, to the level of detail required by the relevant system operator.

(5) The operational notification procedure for connection of each new type C & D *power-generating module* shall comprise an energisation operational notification ('EON'), an interim operational notification ('ION'), and a final operational notification ('FON').

(a) An EON shall entitle the *power-generating facility* owner to energise its internal network and auxiliaries for the *power-generating modules* by using the grid connection that is specified for the connection point.

(b) An EON shall be issued by the relevant system operator, subject to completion of preparations including agreement on the protection and control settings relevant to the connection point between the relevant system operator and the *power-generating facility* owner.

(c) An ION shall entitle the *power-generating facility* owner to operate the *power-generating module* and generate power by using the grid connection for a limited period of time.

(d) An ION shall be issued by the relevant system operator, subject to completion of the data and study review process as required by this Code.

(e) The maximum period during which the *power-generating facility* owner may maintain ION status shall be 24 months. The relevant system operator is entitled to specify a shorter ION validity period. An extension of the ION shall be granted only if the *power-generating facility* owner has made substantial progress towards full compliance. Outstanding issues shall be clearly identified at the time of requesting an extension.

(f) A FON shall entitle the *power-generating facility* owner to operate a *power-generating module* by using the grid connection.

(g) A FON shall be issued by the relevant system operator, upon prior removal of all incompatibilities identified for the purpose of ION status and subject to completion of the data and study review process as required above.

(h) The relevant system operator, on acceptance of a complete and adequate notification, shall issue a final operational notification to the *power-generating facility* owner.

(i) If incompatibility is identified in connection with the issuing of the FON, a derogation may be granted upon a request made to the relevant system operator, in accordance with the derogation procedure in this Code. A FON shall be issued by the relevant system operator if the *power-generating module* complies with the provisions of the derogation.

2.8.2 Limited operational notification procedure for connection

(1) The *power-generating facility* owner to whom a FON has been granted shall inform the relevant system operator immediately in the following circumstances:

(a) the *power-generating facility* 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 *power-generating facility* owner shall apply to the relevant system operator for a limited operational notification (LON) if the *power-generating facility* owner reasonably expects the circumstances detailed in paragraph (1) above to persist for more than three months.

(3) A LON shall be issued by the relevant system operator with a clear identification of:

(a) the unresolved issues justifying the granting of the 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 the possibility for extension if evidence to the satisfaction of the relevant system operator demonstrates that substantial progress has been made towards achieving full compliance.

(4) The FON shall be suspended during the period of validity of the LON with regard to the subjects for which the LON has been issued.

(5) A further prolongation of the period of validity of the LON may be granted upon request for a derogation made to the relevant system operator before the expiry of that period.

(6) The relevant system operator may refuse the operation of the *power-generating facility* if the LON terminates and the circumstance which caused it to be issued remains. In such a case the FON shall automatically be invalid.

(7) If the relevant system operator does not grant an extension of the period of validity of the LON or if it refuses to allow the operation of the *power-generating facility* once the LON is no longer valid, the *power-generating facility* owner may refer the issue to the regulatory authority within six months after the notification of the decision of the relevant system operator.

2.8.3 Compliance testing process

(1) The *power-generating facility* owner shall ensure that each *power-generating module* complies with the requirements applicable under this Code throughout the lifetime of the facility.

(2) The *power-generating facility* owner shall notify the relevant system operator of any planned modification of the technical capabilities of a *power-generating module* which may affect its compliance with the requirements applicable under this Code, before initiating that modification.

(3) The *power-generating facility* owner shall notify the relevant system operator of any operational incidents or failures of a *power-generating module* that affect its compliance with the requirements of this Code, without undue delay, after the occurrence of those incidents.

(4) The *power-generating facility* owner shall notify the relevant system operator of the planned test schedules and procedures to be followed for verifying the compliance of a *power-generating module* with the requirements of this Code, in due time and prior to their launch. The relevant system operator shall approve in advance the planned test schedules and procedures. Such approval by the relevant system operator shall be provided in a timely manner and shall not be unreasonably withheld.

(5) The relevant system operator may participate in such tests and record the performance of the *power-generating modules*.

(6) The relevant system operator shall assess the compliance of a *power-generating module* with the requirements applicable under this Code, throughout the lifetime of the *power-generating facility*. The *power-generating facility* owner shall be informed of the outcome of this assessment.

(7) The relevant system operator shall have the right to request that the *power-generating facility* owner carry out compliance tests and simulations according to a repeat plan or general scheme or after any failure, modification or replacement of any equipment that may have an impact on the *power-generating module*'s compliance with the requirements of this Code. The *power-generating facility* owner shall be informed of the outcome of those compliance tests and simulations.

(8) The relevant system operator shall make publicly available a list of information and documents to be provided as well as the requirements to be fulfilled by the *power-generating facility* owner within the framework of the compliance process. The list shall cover at least the following information, documents and requirements:

(a) all of the documentation and certificates to be provided by the *power-generating facility* owner;

(b) details of the technical data on the *power-generating module* of relevance to the grid connection;

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

(d) timeline for the provision of system data required to perform the studies;

(e) studies by the *power-generating facility* owner to demonstrate the expected steady-state and dynamic performance in accordance with the requirements set out in this Code;

(f) conditions and procedures, including the scope, for registering equipment certificates; and

(g) conditions and procedures for the use of relevant equipment certificates issued by an authorised certifier by the *power-generating facility* owner.

(9) The relevant system operator shall make public the allocation of responsibilities between the *power-generating facility* owner and the system operator for compliance testing, simulation and monitoring.

(10) The relevant system operator may totally or partially delegate the performance of its compliance monitoring to third parties.

(11) If compliance tests or simulations cannot be carried out as agreed between the relevant system operator and the *power-generating facility* owner due to reasons attributable to

the relevant system operator, then the relevant system operator shall not unreasonably withhold the operational notification.

(12) Testing of the performance of individual *power-generating modules* within a *power-generating facility* shall aim to demonstrate that the requirements of this Code have been complied with.

(13) Notwithstanding the minimum requirements for compliance testing set out in this Code, the relevant system operator is entitled to:

(a) allow the *power-generating facility* owner to carry out an alternative set of tests, provided that those tests are efficient and suffice to demonstrate that a *power-generating module* complies with the requirements of this Code;

(b) require the *power-generating facility* owner to carry out additional or alternative sets of tests in those cases where the information supplied to the relevant system operator in relation to compliance testing under the provisions of this Code, is not sufficient to demonstrate compliance with the requirements of this Code; and

(c) require the *power-generating facility* owner to carry out appropriate tests in order to demonstrate a power- generating module's performance when operating on alternative fuels or fuel mixes. The relevant system operator and the *power-generating facility* owner shall agree on which types of fuel are to be tested.

(14) The *power-generating facility* owner is responsible for carrying out the tests in accordance with the conditions laid down in the Code. The relevant system operator shall cooperate and not unduly delay the performance of the tests.

(15) The relevant system operator may participate in the compliance testing either on site or remotely from the system operator's control centre. For that purpose, the *power-generating facility* owner shall provide the monitoring equipment necessary to record all relevant test signals and measurements and ensure that the necessary representatives of the *power-generating facility* owner are available on site for the entire testing period. Signals specified by the relevant system operator shall be provided if, for selected tests, the system operator wishes to use its own equipment to record performance. The relevant system operator has sole discretion to decide about its participation.

2.8.4 Compliance tests for synchronous generators

(1) *Power-generating facility* owners shall undertake the following response compliance tests in relation to type B, C & D synchronous *power-generating modules*.

(a) the *power-generating module*'s technical capability to continuously modulate active power to contribute to frequency control in case of any large increase of frequency in the system shall be demonstrated. The steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including frequency step change response shall be verified;

(b) the test shall be carried out by simulating frequency steps and ramps big enough to trigger a change in active power of at least 10% of maximum capacity, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously at both the speed governor and load controller of the control systems, taking into account the scheme of those control systems;

(c) the test shall be deemed successful if the following conditions are fulfilled:

(i) the test results, for both dynamic and static parameters, meet the requirements set out in section 2.2.1 of this Code; and

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

(2) Type C & D synchronous *power-generating facility* owners shall undertake the following response compliance tests.

(a) it shall be demonstrated that the *power-generating module* is technically capable of continuously modulating active power at operating points below maximum capacity to contribute to frequency control in case of a large frequency drop in the system;

(b) the test shall be carried out by simulating appropriate active power load points, with low frequency steps and ramps big enough to trigger an active power change of at least 10% of maximum capacity, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously into both the speed governor and the load controller references;

(c) the test shall be deemed successful if the following conditions are fulfilled:

(i) the test results, for both dynamic and static parameters, comply with section 2.2.1 of this Code; and

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

(3) Type C & D synchronous *power-generating facility* owners shall undertake a frequency restoration control test and the following requirements shall apply:

(a) the *power-generating module*'s technical capability to participate in frequency restoration control shall be demonstrated and the cooperation of frequency control and frequency restoration control shall be checked;

(b) the test shall be deemed successful if the results, for both dynamic and static parameters, comply with the requirements in section 2.2.2 of this Code.

(4) Type C & D synchronous *power-generating facility* owners with black start capability shall perform black start test and the following requirements shall apply:

(a) for *power-generating modules* with black start capability, this technical capability to start from shut down without any external electrical energy supply shall be demonstrated;

(b) the test shall be deemed successful if the start-up time is kept within the time frame set out in section 2.6 of this Code.

(5) Type C & D synchronous *power-generating facility* owners shall undertake tripping to houseload test and the following requirements shall apply:

(a) the *power-generating modules*' technical capability to trip to and stably operate on houseload shall be demonstrated;

(b) the test shall be carried out at the maximum capacity and nominal reactive power of the *power-generating module* before load shedding;

(c) the relevant system operator shall have the right to set additional conditions;

(d) the test shall be deemed successful if tripping to house load is successful, stable houseload operation has been demonstrated in the time period set out in in this Code and re-synchronisation to the network has been performed successfully.

(6) Type C & D synchronous *power-generating facility* owners shall undertake a reactive power capability test and the following requirements shall apply:

(a) the *power-generating module*'s technical capability to provide leading and lagging reactive power capability in accordance with section 2.3 of this Code shall be demonstrated;

(b) the test shall be deemed successful if the following conditions are fulfilled:

(c) the *power-generating module* operates at maximum reactive power for at least one hour, both leading and lagging, at:

(i) minimum stable operating level,

(ii) maximum capacity, and

(iii) an active power operating point between those maximum and minimum levels;

(d) the *power-generating module*'s capability to change to any reactive power target value within the agreed or decided reactive power range shall be demonstrated.

2.8.5 Compliance simulations for synchronous *power-generating modules*

(1) Type B, C & D synchronous *power-generating facility* owners shall undertake high frequency response simulations and the following high frequency response simulation requirements shall apply:

(a) the *power-generating module*'s capability to modulate active power at high frequency in accordance with this Code shall be demonstrated by simulation;

(b) the simulation shall be carried out by means of high frequency steps and ramps reaching minimum regulating level, taking into account the droop settings and the deadband; and

(c) the simulation shall be deemed successful in the event that the simulation model of the *power-generating module* is validated against the compliance test for high frequency response described in section 2.2 of this Code.

(2) Type C & D synchronous *power-generating facility* owners shall undertake low frequency response simulations and the following low frequency response simulation requirements shall apply:

(a) the *power-generating module*'s capability to modulate active power at low frequencies in accordance with this Code shall be demonstrated;

(b) the simulation shall be carried out by simulating low frequency steps and ramps reaching maximum capacity, taking into account the droop settings and the deadband; and

(c) the simulation shall be deemed successful in the event that the simulation model of the *power-generating module* is validated against the compliance test for low frequency response described in section 2.2 of this Code.

(3) Type C & D synchronous *power-generating facility* owners providing primary and/or secondary frequency reserve shall undertake primary frequency response simulations and the following primary and/or secondary frequency reserve response simulation requirements shall apply:

(a) the *power-generating module*'s capability to modulate active power over the full frequency range as referred to in this Code shall be demonstrated;

(b) the simulation shall be carried out by simulating frequency steps and ramps big enough to trigger the whole active power frequency response range, taking into account the droop settings and the deadband; and

(c) the simulation shall be deemed successful in the event that the simulation model of the *power-generating module* is validated against the compliance test for primary and/or secondary frequency reserve response described in section 2.2 of this Code

(4) Type C & D synchronous *power-generating facility* owners providing island operation shall undertake the island operation simulation and the following requirements shall apply:

(a) the *power-generating module*'s performance during island operation in accordance with the conditions set out in this Code shall be demonstrated;

(b) the simulation shall be deemed successful in the event that the *power-generating module* reduces or increases the active power output from its previous operating point to any new operating point, within the P-Q-capability diagram and within the limits set out in section 2.6 of this Code, without disconnection of the power park module from the island due to over- or underfrequency.

(5) Type C & D synchronous *power-generating facility* owners shall undertake the reactive power capability simulation and demonstrate the following requirements:

(a) the *power-generating module*'s capability to provide leading and lagging reactive power in accordance with the conditions set out in section 2.3 of this Code.

(6) Type B, C & D synchronous *power-generating facility* owners shall undertake the simulation of fault-ride-through and the *power-generating module*'s capability to ride through faults in accordance with section 2.4 of this Code shall be demonstrated.

(7) Type B, C & D synchronous *power-generating facility* owners shall undertake the post fault active power recovery simulation and the *power-generating module*'s capability to provide post fault active power recovery referred to in section 2.4 of this Code shall be demonstrated.

(8) Type B, C & D synchronous *power-generating facility* owners shall undertake the power oscillations damping control simulation and the following requirements shall be demonstrated:

(a) that the *power-generating module*'s performance in terms of its control system ('PSS function') is capable of damping active power oscillations in accordance with the conditions set out in this Code;

(b) the tuning must result in improved damping of corresponding active power response of the AVR in combination with the PSS function, compared to the active power response of the AVR alone;

(c) the simulation shall be deemed successful if the following conditions are cumulatively fulfilled:

(i) the PSS function damps the existing active power oscillations of the *power-generating module* within a frequency range specified by the relevant *TSO*. That frequency range shall include the local mode frequencies of the *power-generating module* and the expected network oscillations; and

(ii) a sudden load reduction of the *power-generating module* from 1 pu to 0.6 pu of the maximum capacity does not lead to undamped oscillations in active or reactive power of the *power-generating module*.

2.8.6 Derogations

(1) Regulatory authorities (or another applicable authority in a GMS Member State) may, at the request of a *power-generating facility* owner or prospective owner, relevant system operator or relevant *TSO*, grant *power-generating facility* owners or prospective owners, relevant system operators or relevant *TSOs*, derogations from one or more provisions of this Code for new and existing power-generating modules in accordance with this Code.

(2) Each regulatory authority shall specify, after consulting relevant system operators and *power-generating facility* owners and other stakeholders whom it deems to be affected by this Code, the criteria for granting derogations pursuant to this Code. It shall publish those criteria on its website and notify them to the RPCC within nine months of the entry into force of this Code. The RPCC may require a regulatory authority to amend the criteria if it considers that they are not in line with this Code. This possibility to review and amend the criteria for granting derogations shall not affect the derogations already granted which shall continue to apply until the scheduled expiry date as detailed in the decision granting the exemption.

(3) If the regulatory authority deems that it is necessary due to a change in circumstances relating to the evolution of system requirements, it may review and amend at most once every year the criteria for granting derogations. Any changes to the criteria shall not apply to derogations for which a request has already been made.

(4) The regulatory authority may decide that *power-generating modules* for which a request for a derogation has been filed pursuant to this Code do not need to comply with the requirements of this Code from which a derogation has been sought from the day of filing the request until the regulatory authority's decision is issued.

(5) *Power-generating facility* owners, or prospective owners, may request a derogation to one or several requirements of this Code for *power-generating modules* within their facilities.

(6) A request for a derogation shall be filed with the relevant system operator and include:

(a) an identification of the *power-generating facility* owner, or prospective owner, and a contact person for any communications;

(b) a description of the *power-generating module* or modules for which a derogation is requested;

(c) a reference to the provisions of this Code from which a derogation is requested and a detailed description of the requested derogation;

(d) detailed reasoning, with relevant supporting documents and cost-benefit analysis pursuant to the requirements this Code; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade.

(7) Within two weeks of receipt of a request for a derogation, the relevant system operator shall confirm to the *power-generating facility* owner, or prospective owner, whether the request is complete. If the relevant system operator considers that the request is incomplete, the *power-generating facility* owner, or prospective owner, shall submit the additional required information within one month from the receipt of the request for additional information. If the *power-generating facility* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed to be withdrawn.

(8) The relevant system operator shall, in coordination with the relevant *TSO* and any affected adjacent DSO or DSOs, assess the request for a derogation and the provided cost-benefit analysis, taking into account the criteria determined by the regulatory authority or appointed authority.

(9) If a request for a derogation concerns a type C or D *power-generating module* connected to a distribution system, including a closed distribution system, the relevant system operator's assessment must be accompanied by an assessment of the request for a derogation by the relevant *TSO*. The relevant *TSO* shall provide its assessment within two months of being requested to do so by the relevant system operator.

(10) Within six months of receipt of a request for a derogation, the relevant system operator shall forward the request to the regulatory authority and submit the assessment(s). That period may be extended by one month where the relevant system operator seeks further information from the power-generating facility owner, or prospective owner and by two months where the relevant system operator requests the relevant *TSO* to submit an assessment of the request for a derogation.

(11) The regulatory authority shall adopt a decision concerning any request for a derogation within six months from the day after it receives the request. That time limit may be extended by three months before its expiry where the regulatory authority requires further information from the *power-generating facility* owner, or prospective owner, or from any other interested parties. The additional period shall begin when the complete information has been received.

(12) The *power-generating facility* owner, or prospective owner, shall submit any additional information requested by the regulatory authority within two months of such a request. If the *power-generating facility* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed to be withdrawn unless, before its expiry:

(a) the *power-generating facility* owner, or prospective owner, informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(13) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants a derogation, it shall specify its duration.

(14) The regulatory authority shall notify its decision to the relevant *power-generating facility* owner, or prospective owner, the relevant system operator and the relevant *TSO*.

(15) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(16) For Type A *power-generating modules*, a request for a derogation under this Code may be made by a third party on behalf of the *power-generating facility* owner, or prospective owner. Such a request may be for a single power-generating module or multiple, identical *power-generating modules*. In the case of the latter, and provided the cumulative maximum capacity is specified, the third party may substitute the details required with their details.

(17) Relevant system operators or relevant *TSOs* may request derogations for classes of *power-generating modules* connected or to be connected to their network.

(18) Relevant system operators or relevant *TSOs* shall submit their requests for derogations to the regulatory authority. Each request for a derogation shall include:

(a) identification of the relevant system operator or relevant *TSO*, and a contact person for any communications;

(b) a description of the *power-generating modules* for which a derogation is requested and the total installed capacity and number of *power-generating modules*;

(c) the requirement or requirements of this Code for which a derogation is requested, with a detailed description of the requested derogation;

(d) detailed reasoning, with all relevant supporting documents; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade;

(19) Where the request for a derogation is submitted by a relevant DSO, the regulatory authority shall, within two weeks from the day after receipt of that request, ask the relevant *TSO* to assess the request for a derogation in the light of the criteria determined by the regulatory authority.

(20) Within two weeks from the day after the receipt of such a request for assessment, the relevant *TSO* shall confirm to the relevant DSO whether the request for a derogation is complete. If the relevant *TSO* considers that it is incomplete, the relevant DSO shall submit the required additional information within one month from the receipt of the request for additional information.

(21) Within six months of receipt of a request for a derogation, the relevant *TSO* shall submit to the regulatory authority its assessment, including any relevant documentation. The six-month time limit may be extended by one month where the relevant *TSO* seeks further information from the relevant DSO.

(22) The regulatory authority shall adopt a decision concerning a request for a derogation within six months from the day after it receives the request. Where the request for a

derogation is submitted by the relevant DSO, the six- month time limit runs from the day following receipt of the relevant *TSO's* assessment.

(23) The six-month time limit referred to above may, before its expiry, be extended by an additional three months where the regulatory authority requests further information from the relevant system operator requesting the derogation or from any other interested parties. That additional period shall run from the day following the date of receipt of the complete information.

(24) The relevant system operator shall provide any additional information requested by the regulatory authority within two months from the date of the request. If the relevant system operator does not provide the requested additional information within that time limit, the request for a derogation shall be deemed withdrawn unless, before expiry of the time limit:

(25) the relevant system operator informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(26) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants derogation, it shall specify its duration.

(27) The regulatory authority shall notify its decision to the relevant system operator requesting the derogation, the relevant *TSO*.

(28) Regulatory authorities may lay down further requirements concerning the preparation of requests for derogation by relevant system operators. In doing so, regulatory authorities shall take into account the delineation between the transmission system and the distribution system at the national level and shall consult with system operators, power-generating facility owners and stakeholders, including manufacturers.

(29) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(30) Regulatory authorities shall maintain a register of all derogations they have granted or refused and shall provide the RPCC with an updated and consolidated register at least once every six months.

(31) The register shall contain, in particular:

(a) the requirement or requirements for which the derogation is granted or refused;

(b) the content of the derogation;

(c) the reasons for granting or refusing the derogation;

(d) the consequences resulting from granting the derogation.

(32) The RPCC shall monitor the procedure of granting derogations with the cooperation of the regulatory authorities or relevant authorities of the GMS Member State. Those authorities or relevant authorities of the Member State shall provide the RPCC with all the information necessary for that purpose.

(33) The RPCC may issue a reasoned recommendation to a regulatory authority t or relevant authority of the GMS Member State to revoke derogation due to a lack of justification.

3. High Voltage Direct Current Connections (HVDC)

3.1 Size of HVDC system and DC-connected power park modules

(1) The *HVDC system* and *DC-connected power park modules* shall comply with the requirements on the basis of the voltage level of its connection point and its maximum capacity according to the categories set out in below.

(2) *An HVDC system* or *DC-connected power park module* within the following categories shall be considered as significant:

Connection point below 110 kV and maximum capacity:

(a) greater than 0.8 kW and less than the maximum capacity threshold for a type B *HVDC system* or *DC-connected power park* in Table 3-1 (type A);

(b) at or above the maximum capacity threshold for a type B *HVDC system* or *DC-connected power park* and less than the maximum capacity threshold for type C in Table 3-1 (type B);

(c) at or above the maximum capacity threshold for a type C *HVDC system* or *DC-connected power park* and less than the maximum capacity threshold for type D in Table 3-1 (type C); or

(d) at or above the maximum capacity threshold for a type D *HVDC system* or *DC-connected power park* in Table 3-1 (type D).

A *HVDC system* or *DC-connected power park module* with a connection point at 110 kV or above is also categorised as type D.

Table 3-1 Limits for thresholds for type B, C and D *HVDC system* and *DC-connected power park module*

Synchronous areas	Limit for maximum capacity threshold from which a *HVDC system or DC-connected power park module* is of type B	Limit for maximum capacity threshold from which a *HVDC system or DC-connected power park module* is of type C	Limit for maximum capacity threshold from which a *HVDC system or DC-connected power park module* is of type D
Interconnected GMS	1 MW	40 MW	75 MW

3.2 Frequency tolerance, active power and frequency control requirements

3.2.1 Frequency tolerance

(1) All *HVDC system* and *DC-connected power park modules* shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 3-2.

(2) The relevant *TSO* and the *HVDC system* or *DC-connected power park module* owner may agree on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations to ensure the best use of

the technical capabilities of a *HVDC system* or *DC-connected power park module*, if it is required to preserve or to restore system security.

(3) Tripping times for when frequency goes outside of the normal operating range of 49.0 to 51.0 Hz shall be agreed with the relevant *TSO*. The *TSO* shall co-ordinate such settings to minimise the risk of cascade tripping and network collapse.

Table 3-2 Minimum time periods for which a *HVDC system* and *DC-connected power park module* must be capable of operating at different frequencies without disconnecting from the network, for specified ranges representing deviations from the nominal value.

Synchronous area	Frequency range	Minimum time period for operation of each *HVDC system* or *DC-connected power park module* each time the system frequency is in the specified frequency ranges
Interconnected GMS	47.0 Hz-47.5 Hz	To be specified by each *TSO*, but not less than 15 seconds
	47.5 Hz-49.0 Hz	To be specified by each *TSO*, but not less than 30 minutes
	49.0 Hz-51.0 Hz	Unlimited
	51.0 Hz-51.5 Hz	30 minutes
	51.5 Hz-52.0 Hz	15 minutes

3.2.2 Active power and frequency control requirements

(1) Type B, C and D *HVDC systems* and *DC-connected power park modules* shall be capable of continuous operation, at up to 100% active power output, within a frequency range of 49.0 to 51.0 Hz and voltage range of 0.05 pu either side of nominal voltage.

(2) Type B, C and D *HVDC systems* and *DC-connected power park modules* shall be capable of continuous operation at any point between the limits of 0.85 power factor leading and 0.95 power factor lagging, when supplying 100% active power output.

(3) The active power output from type B, C and D *HVDC systems* and *DC-connected power park modules* shall not decrease by more than a proportionate decrease in frequency when the frequency varies within the range of 47.5 to 49.0 Hz.

(4) Type B, C and D *HVDC systems* and *DC-connected power park modules* shall remain connected to the *network* for a rate of change of frequency of up to and including 1.0 Hz per second measured over a rolling window of 500 ms, provided that the network frequency remains within the operating range specified in Table 3-2.

(5) *HVDC systems* and *DC-connected power park modules* shall be designed to be capable to provide power-frequency response in order to stabilise the grid *frequency*. The metering accuracy for the grid frequency shall be at least ± 10 mHz.

(6) *HVDC system* and *DC-connected power park modules* shall be capable of frequency response to meet the requirements shown in Figure 3-1.

(a) The default settings for f_{min}, f_{max}, f_4 and f_5 shall be as shown in Table 3-3 for *DC-connected power park modules* Table 3-4 for *HVDC systems*, unless otherwise agreed upon between RPCC, the relevant *TSO* and *HVDC system* and *DC-connected power park modules*.

(b) The droop settings shall be between 2% and 12%.

(c) The purpose of frequency points f_1 to f_4 is to form a dead band and a control band for *HVDC system* and *DC-connected power park modules* contracted for primary frequency response. The purpose of frequency points f_4 to f_5 is to supply mandatory critical power/frequency response.

(d) Type A, B, C & D *DC-connected power park modules* and Type A *HVDC systems* are not required to provide any positive response to a low frequency, $P_{Delta} = 0$, unless otherwise agreed by the relevant *TSO* and the *DC-connected power park module.*

(e) Type B, C & D *HVDC systems* shall be designed with the capability to provide a P_{Delta} of not less than 5% of $P_{available}$. P_{Delta} is the setpoint to which the *available active power* has been reduced in order to provide frequency stabilisation (primary frequency response) in the case of falling grid frequency.

(f) Type B, C & D *HVDC systems* connecting two synchronous areas shall be capable of automatic remedial actions including, but not limited to, stopping the ramping and blocking power frequency response. The triggering and blocking criteria shall be determined by *RPCC* and the relevant *TSO's*.

(g) Type B, C & D *HVDC systems* or *DC-connected power park module* settings for $P_{Delta,}$ f_1, f_2 and f_3 shall be as agreed between RPCC, the relevant *TSO* and *HVDC systems* or *DC-connected power park modules* owners.

Figure 3-1 Frequency response requirements for *HVDC system* and *DC-connected power park modules*

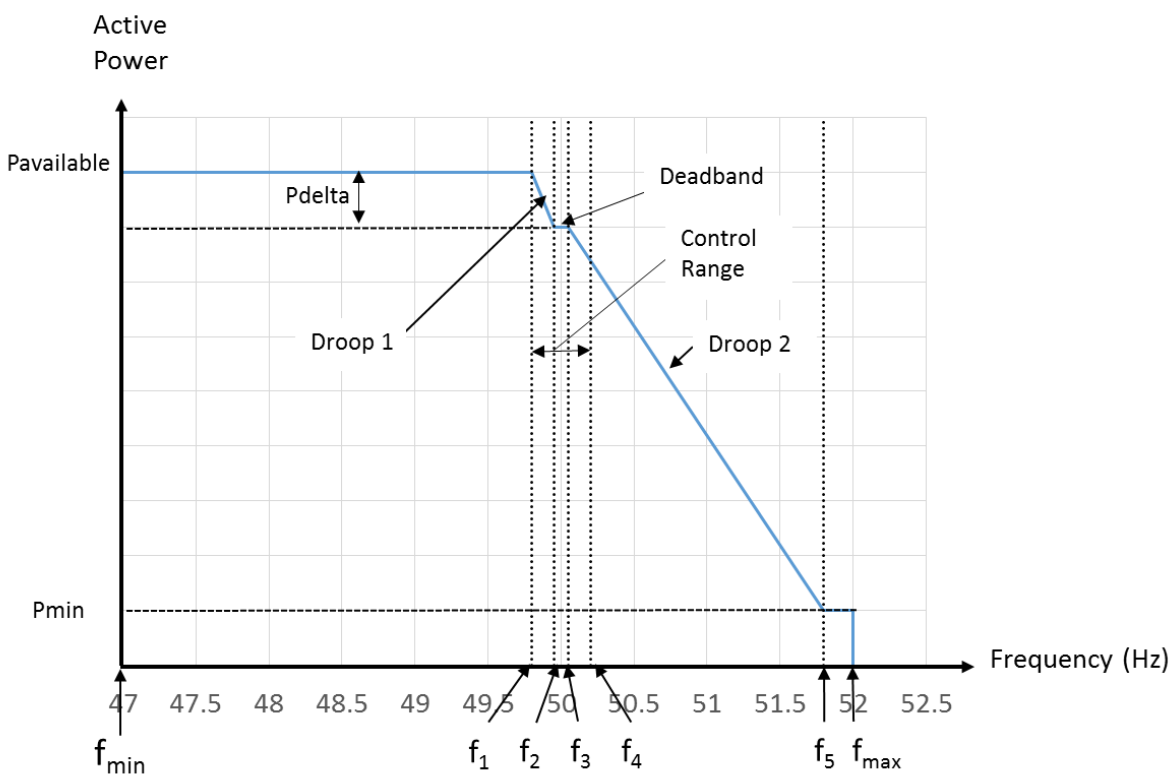


Table 3-3 Frequency response default settings for Type A, B, C & D *DC-connected power park modules*

***HVDC system* or *DC-connected power park module* Type**	**Type A**	**Type B**	**Type C & D**	Unit
f_{min}	47.0	47.0	47.0	Hz
f_{max}	52.0	52.0	52.0	Hz
f_1	47.0	47.0	47.0	Hz
f_2	47.0	47.0	47.0	Hz
f_3	50.5	As agreed with *TSO*	50.2	Hz
f_4	50.5	50.5	50.5	Hz
f_5	52.0	52.0	52.0	Hz
P_{Delta}	0	As agreed with *TSO*	As agreed with *TSO*	%

Table 3-4 Frequency response default settings for Type A, B, C & D *HVDC systems*

***HVDC system* or *DC-connected power park module* Type**	**Type A**	**Type B**	**Type C & D**	**Unit**
f_{min}	47.0	47.0	47.00	Hz
f_{max}	52.0	52.0	52.00	Hz
f_1	47.0	As agreed with *TSO*	49.80	Hz
f_2	47.0	As agreed with *TSO*	49.98	Hz
f_3	50.5	As agreed with *TSO*	50.02	Hz
f_4	50.5	50.5	50.50	Hz
f_5	52.0	52.0	52.00	Hz
P_{Delta}	0	As agreed with *TSO*	As agreed with *TSO*	%

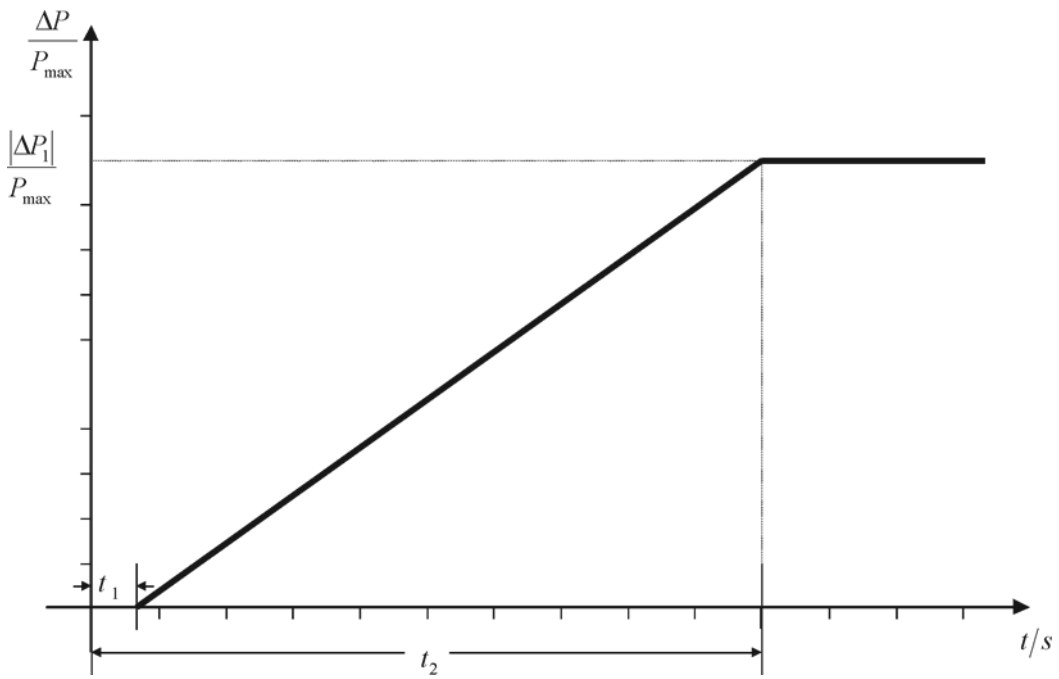
(7) For Type B, C & D *HVDC systems* and *DC-connected power park modules* the delay time for the start of the activation of P_{Delta}, in response to a step in the frequency, shall be designed to be less than 2 seconds or as agreed between RPCC, the relevant *TSO* and *HVDC systems* and *DC-connected power park modules* owners. The delay time is shown as time t_1 in Figure 3-2. If the delay to activation of the active power frequency response is greater than 2 seconds then the *HVDC systems* and *DC-connected power park modules* owners shall provide technical evidence demonstrating why a longer time is needed.

(8) For Type B, C & D *HVDC systems* and *DC-connected power park modules* the full response time for provision of P_{Delta}, in response to a step in the frequency, shall be

designed to be less than 30 seconds or as agreed between RPCC, the relevant *TSO* and *HVDC systems* or *DC-connected power park modules* owners. The full activation time is shown as time t_2 in Figure 3-2.

(9) For Type B, C & D *HVDC systems* and *DC-connected power park modules* the sustained time for provision of P_{Delta} active power frequency response shall be designed to be at least 15 minutes or as agreed between RPCC, the relevant *TSO* and *HVDC systems* or *DC-connected power park modules* owners.

Figure 3-2 Active power frequency response capability to a step in frequency



(10) Type C and D *HVDC systems* or *DC-connected power park modules* shall also be equipped with appropriate plant controllers enabling automatic signals to be sent by relevant *TSO's*' SCADA systems to the plant controllers to automatically adjust the generation output over the full range available.

(11) Type C and D *HVDC systems* or *DC-connected power park modules* shall be equipped with PMU (Phasor Measurement Unit) where type C and D generators connected to system above 230kV.

3.3 Synthetic Inertia

(1) Type C & D *HVDC systems* and *DC-connected power park modules* shall be capable of providing synthetic inertia in response to frequency changes, activated in low and/or high frequency regimes by rapidly adjusting the active power injected to or withdrawn from the AC network in order to limit the rate of change of frequency. The requirement shall at least take account of the results of the studies undertaken by *RPCC* or *TSOs* to identify if there is a need to set out minimum inertia.

(2) The principle of this control system and the associated performance parameters shall be agreed between *RPCC* (or the relevant *TSO*) and the *HVDC system* or *DC-connected power park module* owner.

3.4 Voltage tolerance, voltage control and reactive power provision

(1) *HVDC systems* and *DC-connected power park modules* shall be capable of staying connected to the remote-end HVDC converter station network and operating within the voltage ranges (per unit) for the time periods specified in Table 3-5 and Table 3-6:

(a) wider voltage ranges or longer minimum times for operation can be agreed between the relevant system operator, the relevant *TSO* and the *HVDC systems* or *DC-connected power park modules owners* to ensure the best use of the technical capabilities of the *HVDC systems* or *DC-connected power park modules* if needed to preserve or to restore system security. If wider voltage ranges or longer minimum times for operation are economically and technically feasible, the *HVDC systems* or *DC-connected power park modules* owners shall not unreasonably withhold consent;

(b) The relevant *TSO* may specify shorter periods of time during which *HVDC systems* or *DC-connected power park modules* shall be capable of remaining connected to the network in the event of simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency;

Table 3-5 Minimum voltage range capabilities for *HVDC systems* and *DC-connected power park modules* connected above 230 kV

Synchronous area	Voltage range	Minimum time period for operation
Interconnected GMS	0.85 pu - 0.90 pu	60 minutes for *DC-connected power park module* Unlimited for *HVDC system*
	0.900 pu - 1.118 pu	Unlimited
	1.118 pu - 1.150 pu	To be specified by each *TSO*, but not less than 20 minutes

Table 3-6 Minimum voltage range capabilities for *HVDC systems* and *DC-connected power park modules* connected below or equal to 230 kV

Synchronous area	Voltage range	Minimum time period for operation
Interconnected GMS	0.85 pu - 0.90 pu	60 minutes for *DC-connected power park module* Unlimited for *HVDC system*
	0.900 pu - 1.118 pu	Unlimited
	1.118 pu - 1.150 pu	To be specified by each *TSO*, but not less than 20 minutes

(2) The parameters and settings of the components of the voltage control system shall be agreed between the *HVDC systems* and *DC-connected power park modules* owners and the relevant system operator, in coordination with the relevant *TSO*;

(3) The relevant *TSO* shall specify whether active power contribution or reactive power contribution of the *HVDC system* and *DC-connected power park module* has priority during faults for which fault-ride-through capability is required. If priority is given to active

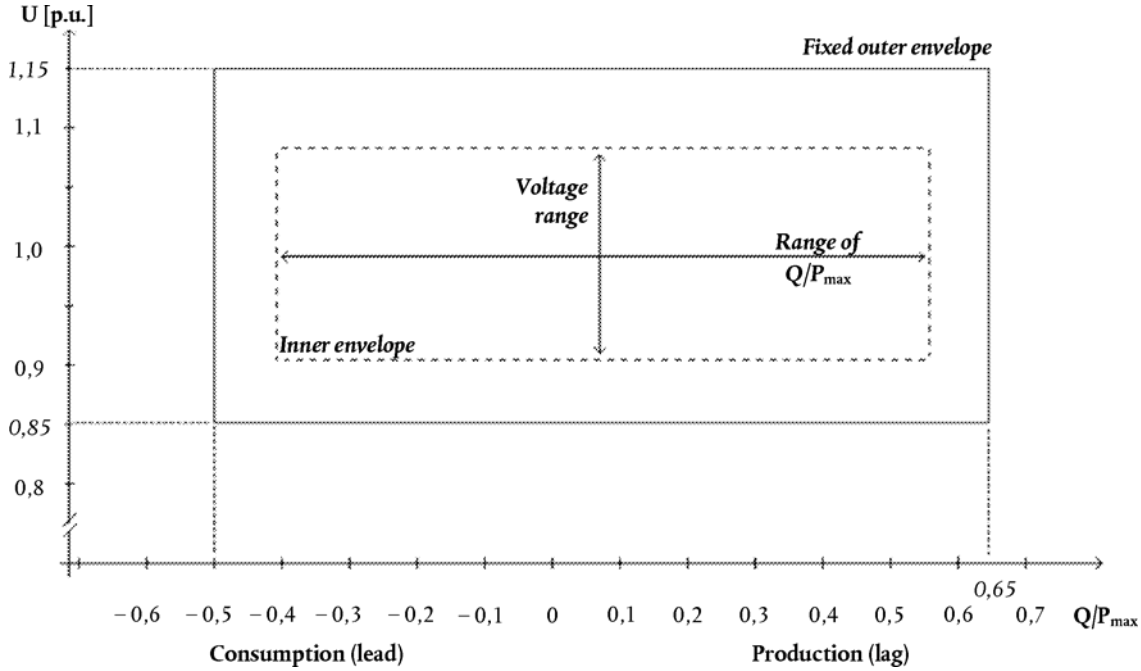
power contribution, its provision shall be established within a time from the fault inception as specified by the relevant system operator, in coordination with the relevant *TSO*.

(4) *HVDC systems* and *DC-connected power park modules* shall fulfil the following requirements relating to voltage stability:

(a) The reactive power capabilities of *HVDC systems* and *DC-connected power park modules* at maximum HVDC active power transmission capacity shall meet the requirements specified by the relevant *TSO*, in the context of varying voltage. The relevant system operator shall specify a U-Q/P_{max}-profile that may take any shape with ranges in accordance with Table 3-7, within which the *HVDC systems* and *DC-connected power park modules* shall be capable of providing reactive power at its maximum HVDC active power transmission capacity and at every possible operating point below maximum HVDC active power transmission capacity. The relevant *TSO* shall consider the long term development of the network when determining these ranges, as well as the potential costs for *HVDC systems* and *DC-connected power park modules* of delivering the capability of providing reactive power production at high voltages and reactive power consumption at low voltages.

(b) The relevant *TSO* may specify supplementary reactive power to be provided if the connection point of *HVDC systems* or *DC-connected power park modules* is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power exchange of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the *HVDC systems* or *DC-connected power park modules,* or its alternator terminals if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.

Figure 3-3 U-Q/P_{max}-profile of *HVDC system* and *DC-connected power park module*



The diagram represents the boundaries of the U-Q/P_{max}-profile with the voltage at the connection point, expressed in pu, against the ratio of the reactive power (Q) to the

maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.

Table 3-7 Parameters for the inner envelope in

Synchronous area	Maximum range of Q/P_{max}	Maximum range of steady-state voltage level in PU
Interconnected GMS	0.95	0.225

(5) During the synchronisation of *HVDC systems* or *DC-connected power park modules* to the AC collection network, they shall have the capability to limit any voltage changes to a steady-state level specified by the relevant *TSO*. The level specified shall not exceed 5% of the pre-synchronisation voltage. The relevant system operator, in coordination with the relevant *TSO*, shall specify the maximum magnitude, duration and measurement window of the voltage transients.

(6) *HVDC systems* and *DC-connected power park modules* owners shall ensure that voltage unbalance is less than 1%.

3.5 Fault ride through capability

(1) Fault-ride-through capability of Type B, C & D *HVDC systems* and *DC-connected power park modules* is required as follows:

(a) each *TSO* shall specify a voltage-against-time-profile in line with Figure 3-4 at the connection point for fault conditions, which describes the conditions under which the *HVDC systems* or *DC-connected power park modules* are capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults on the transmission system;

(b) the voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault;

(c) the lower limit referred to in point (b) above shall be specified by the relevant *TSO* using the parameters set out in Figure 3-4, and within the ranges set out in Table 3-9;

(d) each *TSO* shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of:
   (i) the calculation of the pre-fault minimum short circuit capacity at the connection point,
   (ii) the pre-fault active and reactive power operating point of the *HVDC systems* or *DC-connected power park modules* at the connection point and voltage at the connection point, and
   (iii) calculation of the post-fault minimum short circuit capacity at the connection point;

(e) The short circuit current levels shall not exceed the limits specified in Table 3-8:

Table 3-8 Short Circuit Current Level

Requirements	GMS
Short Circuit Current Levels: ▪ **500 kV**	50 kA
▪ **220-230 kV**	40 kA
▪ **115-132 kV**	31.5 kA

(f) at the request of *HVDC systems* or *DC-connected power park modules* owners, the relevant system operator shall provide the pre-fault and post-fault conditions to be considered for fault-ride-through capability as an outcome of the calculations at the connection point as specified in point (d) above regarding:

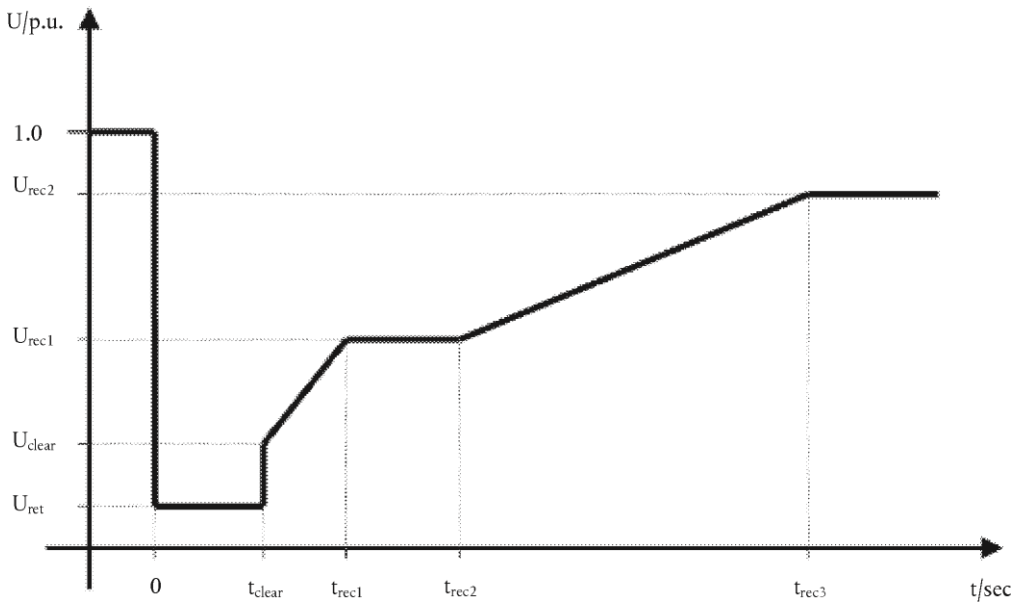
(i) pre-fault minimum short circuit capacity at each connection point expressed in MVA,

(ii) pre-fault operating point of the *HVDC systems* or *DC-connected power park modules* expressed in active and reactive power output, and voltage at the connection point, and

(iii) post-fault minimum short-circuit capacity at each connection point expressed in MVA.

Alternatively, the relevant system operator may provide generic values derived from typical cases;

Figure 3-4 Fault-ride-through profile of a *HVDC system* and *DC-connected power park module*



The diagram represents the lower limit of the voltage-against-time profile for the voltage at the connection point, expressed in pu, during and after a fault. U_{ret} is the retained voltage at the connection point during a fault; t_{clear} is the instant when the fault has been cleared; and U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} specify certain points of lower limits of voltage recovery after fault clearance.

Table 3-9 Parameters for fault-ride-through capability of Type B, C & D *HVDC system* and *DC-connected power park module*

Voltage parameters (pu)		Time parameters (seconds)	
Type B & C HVDC system and DC-connected power park module			
U_{ret}:	0.05 – 0.20	t_{clear}:	0.15 (or 0.25 if system protection and secure operation so require)
U_{clear}:	0.70 – 0.90	t_{rec1}:	t_{clear}
U_{rec1}:	U_{clear}	t_{rec2}:	t_{rec1}-0.70
U_{rec2}:	0.85 – 0.90 and ≥ U_{clear}	t_{rec3}:	t_{rec2}-1.50
Type D *HVDC system* and *DC-connected power park module*			
U_{ret}:	0	t_{clear}:	0.15 (or 0.25 if system protection and secure operation so require)
U_{clear}:	0.25	t_{rec1}:	t_{clear}-0.45
U_{rec1}:	0.50 – 0.70	t_{rec2}:	t_{rec1}-0.70
U_{rec2}:	0.85 – 0.90	t_{rec3}:	t_{rec2}-1.50

(g) the *HVDC system* and *DC-connected power park module* shall be capable of remaining connected to the network and continuing to operate stably when the actual course of the phase-to-phase network voltages at the connection point during a symmetrical fault, given the pre-fault and post-fault conditions in points (d) and (e) above, remains above the lower limit specified in point (b) above, unless the protection scheme for internal electrical faults requires the disconnection of the *HVDC system* or *DC-connected power park module* from the network. The protection schemes and settings for internal electrical faults must not jeopardise fault-ride- through performance;

(h) without prejudice to point (f) above, undervoltage protection (either fault-ride-through capability or minimum voltage specified at the connection point voltage) shall be set by the *HVDC system* or *DC-connected power park module* owner according to the widest possible technical capability of the *HVDC System* or *DC-connected power park module*, unless the relevant system operator requires narrower settings. The settings shall be justified by the *HVDC system* or *DC-connected power park module* owner in accordance with this principle;

(2) Fault-ride-through capabilities in case of asymmetrical faults shall be specified by each *TSO*.

3.6 Power oscillation damping requirements

(1) The *HVDC systems* and *DC-connected power park modules* shall be capable of contributing to the damping of power oscillations in connected AC networks. The control systems of the *HVDC systems* and *DC-connected power park modules* shall not reduce the damping of power oscillations.

(2) The relevant *TSO* shall specify a frequency range of oscillations that the control scheme shall positively damp and the network conditions when this occurs, at least accounting for any dynamic stability assessment studies undertaken by *TSOs* to identify the stability limits and potential stability problems in their transmission systems.

(3) The selection of the control parameter settings shall be agreed between the relevant *TSO* and the *HVDC systems* and *DC-connected power park modules* owners.

3.7 Subsynchronous torsional interaction (SSTI) damping requirements

(1) The *HVDC systems* and *DC-connected power park modules* shall be capable of contributing to electrical damping of torsional frequencies.

(2) The relevant *TSO* shall specify the necessary extent of SSTI studies and provide input parameters, to the extent available, related to the equipment and relevant system conditions in its network. The SSTI studies shall be provided by the *HVDC systems* and *DC-connected power park modules* owners. The studies shall identify the conditions, if any, where SSTI exists and propose any necessary mitigation procedure. GMS member states may provide that the responsibility for undertaking the studies in accordance with this section lies with the *TSO*. All parties shall be informed of the results of the studies.

(3) All parties identified by the relevant *TSO* as relevant to each connection point, including the relevant *TSO*, shall contribute to the studies and shall provide all relevant data and models as reasonably required to meet the purposes of the studies. The relevant *TSO* shall collect this input and, where applicable, pass it on to the party responsible for the studies.

(4) The relevant *TSO* shall assess the result of the SSTI studies. If necessary for the assessment, the relevant *TSO* may request that *HVDC systems* and *DC-connected power park modules* owners perform further SSTI studies in line with this same scope and extent.

(5) The relevant *TSO* may review or replicate the study. The *HVDC systems* and *DC-connected power park modules* owners shall provide the relevant *TSO* all relevant data and models that allow such study to be performed.

(6) Any necessary mitigating actions identified by the studies carried out in accordance with the paragraphs above, and reviewed by the relevant *TSOs*, shall be undertaken by the *HVDC systems* and *DC-connected power park modules* owners as part of the connection of new HVDC converter stations.

3.8 Short circuit contribution during faults

(1) The relevant system operator shall specify and make publicly available the method and the pre-fault and post-fault conditions for the calculation of at least the minimum and maximum short circuit power at the connection points.

(2) The *HVDC systems* and *DC-connected power park modules* shall be capable of operating within the range of short circuit power in Table 3-8 and network characteristics specified by the relevant system operator.

3.9 Power quality

(1) Each relevant system operator shall provide the *HVDC systems* and *DC-connected power park modules* owners with network equivalents describing the behaviour of the network at the connection point, enabling the *HVDC systems* and *DC-connected power park modules* owners to design their system with regard to at least, but not limited to, harmonics and dynamic stability over the lifetime of the *HVDC systems* and *DC-connected power park modules*.

(2) The total harmonic distortion for voltage and current levels shall not exceed the values specified in Table 3-10

Table 3-10 Harmonic distortion level for voltage and current

Requirements	GMS
Harmonic Voltage Distortion:	
- 500 kV	1.0 - 1.5%
- 220 - 230 kV	1.5 - 2.5%
- 115 - 132 kV	2.0 - 3.0%
Harmonic Current Distortion:	
- 500 kV	1.0 - 1.5%
- 220 - 230 kV	1.5 - 2.5%
- 115 - 132 kV	2.0 - 3.0%

(3) Type D *HVDC systems* and *DC-connected power park modules* shall meet the Total Harmonic Distortion (THD) requirements specified in IEC 61000-4.

(4) Type D *HVDC systems* and *DC-connected power park modules* shall continuously measure the harmonic distortion as required in IEC 61000-4.

3.10 Protection requirements

(1) Type A *HVDC systems* and *DC-connected power park modules* shall have loss of mains protection as specified by the relevant *TSO*.

(2) Type B, C & D *HVDC systems* and *DC-connected power park modules* shall fulfil the following additional requirements for control schemes and settings:

(a) the schemes and settings of the different control devices of the *HVDC systems* or *DC-connected power park modules* that are necessary for transmission system stability and for taking emergency action shall be coordinated and agreed between the relevant *TSO*, the relevant system operator and the *HVDC systems* or *DC-connected power park modules* owners;

(b) any changes to the schemes and settings, of the different control devices of the *HVDC systems* or *DC-connected power park modules* shall be coordinated and agreed between the relevant *TSO*, the relevant system operator and the *HVDC systems* or *DC-connected power park modules* owners;

(3) Type C & D *HVDC systems* and *DC-connected power park modules* shall fulfil the following additional requirements for control schemes and settings:

(a) the relevant system operator shall specify the schemes and settings necessary to protect the network, taking into account the characteristics of the *HVDC systems* or *DC-connected power park modules*. The protection schemes needed for the *HVDC systems* or *DC-connected power park modules* and the network, as well as the settings relevant to the *HVDC systems* or *DC-connected power park modules,* shall be coordinated and agreed between the relevant system operator and the *HVDC systems* or *DC-connected power park modules* owners. The protection schemes and settings for internal electrical faults must not jeopardise the performance of *HVDC systems* or *DC-connected power park modules*, in line with the requirements set out in this Code;

(b) electrical protection of the *HVDC systems* or *DC-connected power park modules* shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the *HVDC systems* or *DC-connected power park modules*;

(c) protection schemes may cover the following aspects:
- external and internal short circuit,
- asymmetric load (negative phase sequence),
- fibre optic current differential protection,
- over-/underexcitation,
- over-/undervoltage at the connection point,
- inter-area oscillations,
- inrush current,
- HVDC and transformer protection,
- back-up against protection and switchgear malfunction,
- overfluxing (U/f),
- rate of change of frequency, and
- neutral voltage displacement.

(d) changes to the protection schemes needed for the *HVDC systems* or *DC-connected power park modules* and the network, and to the settings relevant to the *HVDC systems* or *DC-connected power park modules,* shall be agreed between the system operator and the *HVDC systems* or *DC-connected power park modules* owners, and agreement shall be reached before any changes are made.

(4) the *HVDC system* and *DC-connected power park module* owner shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest):

(i) network and *HVDC system* or *DC-connected power park module* protection;

(ii) synthetic inertia, if applicable;

(iii) frequency control (active power adjustment);

(iv) power restriction; and

(v) power gradient constraint;

3.11 System Restoration, Islanding and Black start capability

(1) Type C & D *HVDC systems* and *DC-connected power park modules* shall fulfil the following requirements relating to system restoration, black start and quick re-synchronisation capability.

(2) *HVDC systems* and *DC-connected power park modules* contracted for black start shall have the following black start capabilities:

(a) black start capability is not mandatory without prejudice to the GMS Member State's rights to introduce obligatory rules in order to ensure system security;

(b) *HVDC systems* and *DC-connected power park modules* owners shall, at the request of the relevant *TSO*, provide a quotation for providing black start capability. The relevant *TSO* may make such a request if it considers system security to be at risk due to a lack of black start capability in its control area;

(c) *HVDC systems* and *DC-connected power park modules* with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a time frame specified by the relevant system operator in coordination with the relevant *TSO*;

(d) *HVDC systems* and *DC-connected power park modules* with black start capability shall be able to synchronise within the frequency limits laid down in section 3.2 and, where applicable, voltage limits specified by the relevant system operator or in section 3.3;

(e) *HVDC systems* and *DC-connected power park modules* with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand;

(f) *HVDC systems* and *DC-connected power park modules* with black start capability shall:
- be capable of regulating load connections in block load,
- be capable of controlling frequency using speed or droop control modes,
- control frequency in case of overfrequency and underfrequency within the whole active power output range between minimum regulating level and maximum capacity as well as at houseload level,
- be capable of parallel operation of a few *power-generating modules* within one island, and
- control voltage automatically during the system restoration phase;

(3) *HVDC systems* and *DC-connected power park modules* contracted for islanding shall have the following capability to take part in island operation:

(a) *HVDC systems* and *DC-connected power park modules* shall be capable of taking part in island operation if required by the relevant system operator in coordination with the relevant *TSO* and:
- the frequency limits for island operation shall be those established in accordance with section 3.2,
- the voltage limits for island operation shall be those established in accordance with section 3.3;

(b) *HVDC systems* and *DC-connected power park modules* shall be able to control island frequency during island operation.

(c) In the event of a power surplus, *HVDC systems* and *DC-connected power park modules* shall be capable of reducing the active power output from a previous operating point to any new operating point within the P-Q-capability diagram. In that regard, the *HVDC systems* and *DC-connected power park modules* shall be capable of reducing active power output as much as inherently technically feasible, but to at least 55% of its maximum capacity;

(d) the method for detecting a change from interconnected system operation to island operation shall be agreed between the *HVDC systems* or *DC-connected power park modules* owners and the relevant system operator in coordination with the relevant *TSO*. The agreed method of detection must not rely solely on the system operator's switchgear position signals;

(4) *HVDC systems* and *DC-connected power park modules* shall have the following quick re-synchronisation capabilities:

(a) in case of disconnection of the *HVDC systems* and *DC-connected power park modules* from the network, the *HVDC systems* and *DC-connected power park modules* shall be capable of quick re-synchronisation in line with the protection strategy agreed between the relevant system operator in coordination with the relevant *TSO* and the *HVDC systems* and *DC-connected power park modules* owners;

3.12 Information requirements

Need to check overlaps with requirements in telecommunications and information exchange codes

(1) Type C & D *HVDC systems* and *DC-connected power park modules* shall provide at least the data requirements to RPCC as specified in Table 3-11.

Table 3-11 RPCC Minimum Requirements for Telemetering for Type C & D *HVDC system* or *DC-connected power park modules*

Type of Connection	Telemetering Required	Telemetered Status Indicators
Generation connected directly to Interconnected Transmission System	MW, MVArs, kV, MWh, MVArh	Generator main circuit breakers
Generation not directly connected to Interconnected Transmission System	MW	None

(2) The above data requirements can be provided to RPCC via the relevant *TSO* and the relevant *TSO* shall specify the information exchange standards. The relevant *TSO* shall make the precise list of data required available publicly.

(3) Type C & D *HVDC systems* and *DC-connected power park modules* shall provide day ahead forecast output energy for each hour of the following day to a RMS (root mean square) accuracy of 15% and hourly availability to the relevant *TSO* by 10:00 on the previous day.

(4) Type C & D *HVDC systems* and *DC-connected power park modules* shall provide actual hourly availability and output energy to the grid that occurred and the average primary resource for that hour (i.e. Wind speed for wind generators and solar radiation for solar generation).

3.12.1 Operation of HVDC systems and DC-connected power park modules

(1) Type B, C & D *HVDC systems* and *DC-connected power park modules* shall be equipped with automatic controllers capable of receiving instructions from the relevant system operator and from the relevant *TSO*. These automatic controllers shall be capable of operating the *HVDC converter units* of the *HVDC systems* or *DC-connected power park modules* in a coordinated way. The relevant system operator shall specify the automatic controller hierarchy per *HVDC converter unit*.

(2) The automatic controllers of the *HVDC systems* or *DC-connected power park modules* referred to in point (1) above shall be capable of sending the following signal types to the relevant system operator:

(a) operational signals, providing at least the following:

(i) start-up signals;

(ii) AC and DC voltage measurements;

(iii) AC and DC current measurements;

(iv) Active and reactive power measurements on the AC side;

(v) DC power measurements;

(vi) HVDC converter unit level operation in a multi-pole type HVDC converter;

(vii) Elements and topology status; and

(viii) Frequency control active power ranges.

(b) alarm signals, providing at least the following:

(i) emergency blocking;

(ii) ramp blocking;

(iii) fast active power reversal.

(iv) the maximum capacity of the installation in kW;

(c) operational signals, providing at least the following:

(i) start-up command;

(ii) active power setpoints;

(iii) frequency sensitive mode settings;

(iv) reactive power, voltage or similar setpoints;

(v) reactive power control modes;

(vi) power oscillation damping control; and

(vii) synthetic inertia.

(d) alarm signals, receiving at least the following:

(i) emergency blocking command;

(ii) ramp blocking command;

(iii) active power flow direction; and

(iv) fast active power reversal command.

(e) The relevant system operator will specify the quality of the supplied signal.

3.12.2 Fault recording and monitoring

(1) Type C & D *HVDC systems* and *DC-connected power park modules* shall be equipped with a facility to provide fault recording and dynamic system behaviour monitoring of the following parameters for each of HVDC converter station:

(a) AC and DC voltage;

(b) AC and DC current;

(c) active power;

(d) reactive power; and

(e) frequency.

(2) The relevant system operator may specify quality of supply parameters to be complied with by the *HVDC systems* and *DC-connected power park modules*, provided that reasonable prior notice is given.

(3) The particulars of the fault recording equipment, including analogue and digital channels, and the settings, including triggering criteria and sampling rates, shall be agreed between the *HVDC systems* and *DC-connected power park modules* owners, and the relevant *TSO*.

(4) All dynamic system behaviour monitoring equipment shall include an oscillation trigger, specified by the relevant *TSO*, with the purpose of detecting poorly damped power oscillations.

(5) The facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the *HVDC systems* or *DC-connected power park modules* owners and the relevant system operator to access the information electronically. The communications protocols for recorded data shall be agreed between the *HVDC systems* and *DC-connected power park modules* owners and the relevant *TSO*.

3.13 Connection, compliance and testing requirements

3.13.1 Operational notification procedure for connection

(1) The *HVDC systems* and *DC-connected power park modules* owners shall demonstrate to the relevant system operator that it has complied with the requirements set out in this code by successfully completing the operational notification procedure for connection of each *HVDC system* or *DC-connected power park module,* described below.

(2) The relevant system operator shall clarify and make publicly available the details of the operational notification procedure which shall have at least the following information:

(a) the location at which the connection is made;

(b) the date of the connection;

(c) the maximum capacity of the installation in kW;

(d) the type of primary energy source of the *DC-connected power park module*;

(e) reference to equipment certificates issued by an authorised certifier used for equipment that is in the site installation;

(f) as regards equipment used for which an equipment certificate has not been received, information shall be provided as directed by the relevant system operator; and

(g) the contact details of the *HVDC systems* and *DC-connected power park modules* owners and installer, and their signatures.

(3) The *HVDC systems* and *DC-connected power park modules* owners shall ensure that the relevant system operator is notified about the permanent decommissioning of a *HVDC system* or *DC-connected power park module* in accordance with relevant legislation.

(4) The relevant system operator shall have the right to request that Type B, C & D *HVDC systems* and *DC-connected power park modules* owners include the following in the operational notification:

(a) evidence of an agreement on the protection and control settings relevant to the connection point between the relevant system operator and the *HVDC systems* or *DC-connected power park modules owners*;

(b) itemised statement of compliance;

(c) detailed technical data for the *HVDC systems* and *DC-connected power park modules* with relevance to the grid connection as specified by the relevant system operator;

(d) equipment certificates issued by an authorised certifier in respect of *HVDC systems* and *DC-connected power park modules*, where these are relied upon as part of the evidence of compliance;

(e) simulation models as required by the relevant *TSO*;

(f) compliance test reports demonstrating steady-state and dynamic performance as required by this Code, including use of actual measured values during testing, to the level of detail required by the relevant system operator; and

(g) studies demonstrating steady-state and dynamic performance as required by this Code, to the level of detail required by the relevant system operator.

(5) The operational notification procedure for connection of each new type C & D *HVDC system* and *DC-connected power park module* shall comprise an energisation operational notification ('EON'), an interim operational notification ('ION'), and a final operational notification ('FON').

(a) An EON shall entitle the *HVDC system* and *DC-connected power park modules* owners to energise its internal network and auxiliaries for the *HVDC systems* or *DC-connected power park modules* by using the grid connection that is specified for the connection point.

(b) An EON shall be issued by the relevant system operator, subject to completion of preparations including agreement on the protection and control settings relevant to the connection point between the relevant system operator and the *HVDC systems* or *DC-connected power park module*s owner.

(c) An ION shall entitle the *HVDC Systems* or *DC-connected power park modules* owners to operate the *power-generating module* and generate power by using the grid connection for a limited period of time.

(d) An ION shall be issued by the relevant system operator, subject to completion of the data and study review process as required by this Code.

(e) The maximum period during which *HVDC systems* or *DC-connected power park modules* owners may maintain ION status shall be 24 months. The relevant system operator is entitled to specify a shorter ION validity period. An extension of the ION shall be granted only if the *HVDC system* or *DC-connected power park module* owner has made substantial progress towards full compliance. Outstanding issues shall be clearly identified at the time of requesting extension.

(f) A FON shall entitle *HVDC systems* and *DC-connected power park modules* owners to operate *HVDC systems* or *DC-connected power park modules* by using the grid connection.

(g) A FON shall be issued by the relevant system operator, upon prior removal of all incompatibilities identified for the purpose of ION status and subject to completion of the data and study review process as required above.

(h) The relevant system operator, on acceptance of a complete and adequate notification, shall issue a final operational notification to the *HVDC system* and *DC-connected power park module* owner.

(i) If incompatibility is identified in connection with the issuing of the FON, a derogation may be granted upon a request made to the relevant system operator, in accordance with the derogation procedure in this Code. A FON shall be issued by the relevant system operator if the *HVDC system* or *DC-connected power park module* complies with the provisions of the derogation.

3.13.2 Limited operational notification procedure for connection

(1) The *HVDC systems* and *DC-connected power park modules* owners to whom a FON has been granted shall inform the relevant system operator immediately in the following circumstances:

(a) *HVDC system* or *DC-connected power park module* 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 *HVDC systems* and *DC-connected power park modules* owners shall apply to the relevant system operator for a limited operational notification (LON) if the *HVDC systems* or *DC-connected power park modules* owners reasonably expect the circumstances detailed in paragraph (1) above to persist for more than three months.

(3) A LON shall be issued by the relevant system operator with clear identification of:

(a) the unresolved issues justifying the granting of the 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 the possibility for extension if evidence to the satisfaction of the relevant system operator demonstrates that substantial progress has been made towards achieving full compliance.

(4) The FON shall be suspended during the period of validity of the LON with regard to the subjects for which the LON has been issued.

(5) A further prolongation of the period of validity of the LON may be granted upon request for a derogation made to the relevant system operator before the expiry of that period.

(6) The relevant system operator may refuse the operation of the *HVDC systems* or *DC-connected power park modules* if the LON terminates and the circumstance which caused it to be issued remains. In such a case the FON shall automatically be invalid.

(7) If the relevant system operator does not grant an extension of the period of validity of the LON, or if it refuses to allow the operation of the *HVDC systems* or *DC-connected power park modules* once the LON is no longer valid, the *HVDC systems* or *DC-connected power park modules* owners may refer the issue to the regulatory authority within six months of the notification of the decision of the relevant system operator.

3.13.3 Compliance testing process

(1) The *HVDC systems* and *DC-connected power park modules* owners shall ensure that each *HVDC system* or *DC-connected power park module* complies with the requirements applicable under this Code throughout the lifetime of the facility.

(2) The *HVDC systems* and *DC-connected power park modules* owners shall notify to the relevant system operator any planned modification of the technical capabilities of a *HVDC system* or *DC-connected power park module* which may affect its compliance with the requirements applicable under this Code, before initiating that modification.

(3) The *HVDC systems* and *DC-connected power park modules* owners shall notify the relevant system operator of any operational incidents or failures of a *HVDC system* or *DC-connected power park module* that affect its compliance with the requirements of this Code, without undue delay, after the occurrence of those incidents.

(4) The *HVDC systems* and *DC-connected power park modules* owners shall notify the relevant system operator of the planned test schedules and procedures to be followed for verifying the compliance of a *HVDC system* or *DC-connected power park module* with the requirements of this Code, in due time and prior to their launch. The relevant system operator shall approve in advance the planned test schedules and procedures. Such approval by the relevant system operator shall be provided in a timely manner and shall not be unreasonably withheld.

(5) The relevant system operator may participate in such tests and record the performance of the *HVDC systems* or *DC-connected power park modules*.

(6) The relevant system operator shall assess the compliance of *HVDC systems* or *DC-connected power park modules* with the requirements applicable under this Code, throughout the lifetime of the *HVDC Systems* or *DC-connected power park modules*. The *HVDC systems* or *DC-connected power park modules* owners shall be informed of the outcome of this assessment.

(7) The relevant system operator shall have the right to request that the *HVDC systems* or *DC-connected power park modules* owners carry out compliance tests and simulations according to a repeat plan or general scheme or after any failure, modification or replacement of any equipment that may have an impact on the compliance of the *HVDC systems* or *DC-connected power park modules* with the requirements of this Code. The *HVDC systems* or *DC-connected power park modules* owners shall be informed of the outcome of those compliance tests and simulations.

(8) The relevant system operator shall make publicly available a list of information and documents to be provided as well as the requirements to be fulfilled by the *HVDC systems* and *DC-connected power park modules* owners within the framework of the compliance process. The list shall cover at least the following information, documents and requirements:

(a) all of the documentation and certificates to be provided by the *HVDC systems* and *DC-connected power park modules* owners;

(b) details of the technical data on the *HVDC systems, HVDC converters* and *DC-connected power park modules* of relevance to the grid connection;

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

(d) timeline for the provision of system data required to perform the studies;

(e) studies of the *HVDC systems* and *DC-connected power park modules* to demonstrate the expected steady-state and dynamic performance in accordance with the requirements set out in this code;

(f) conditions and procedures, including the scope, for registering equipment certificates; and

(g) conditions and procedures for the use of relevant equipment certificates, issued by an authorised certifier, by the *HVDC systems* and *DC-connected power park modules* owner.

(9) The relevant system operator shall make public the allocation of responsibilities between the *HVDC systems* and *DC-connected power park modules* owners and the system operators for compliance testing, simulation and monitoring.

(10) The relevant system operator may totally or partially delegate the performance of its compliance monitoring to third parties.

(11) If compliance tests or simulations cannot be carried out as agreed between relevant system operators and the *HVDC systems* and *DC-connected power park modules* owners due to reasons attributable to the relevant system operators, then the relevant system operators shall not unreasonably withhold the operational notification.

(12) Testing of the performance of individual *HVDC converters* and *DC-connected power park modules* within *HVDC systems* and *DC-connected power park modules* shall aim to demonstrate that the requirements of this Code have been complied with.

(13) Notwithstanding the minimum requirements for compliance testing set out in this Code, the relevant system operator is entitled to:

(a) allow *HVDC systems* and *DC-connected power park modules* owners to carry out an alternative set of tests, provided that those tests are efficient and suffice to demonstrate that a *power-generating module* complies with the requirements of this Code; and

(b) require *HVDC systems* and *DC-connected power park modules* owners to carry out additional or alternative sets of tests in those cases where the information supplied to the relevant system operator in relation to compliance testing under the provisions of this Code is not sufficient to demonstrate compliance with the requirements of this Code.

(14) The *HVDC systems* and *DC-connected power park modules* owners are responsible for carrying out the tests in accordance with the conditions laid down in this Code. The relevant system operator shall cooperate and not unduly delay the performance of the tests.

(15) The relevant system operator may participate in the compliance testing either on site or remotely from the system operator's control centre. For that purpose, the *HVDC systems* and *DC-connected power park modules* owners shall provide the monitoring equipment necessary to record all relevant test signals and measurements as well as to ensure that the necessary representatives of the *HVDC systems* and *DC-connected power park modules* owners are available on site for the entire testing period. Signals specified by the relevant system operator shall be provided if, for selected tests, the system operator wishes to use its own equipment to record performance. The relevant system operator has sole discretion to decide about its participation.

3.13.4 Compliance testing for HVDC systems

(1) Equipment certificates may be used instead of part of the tests below, on the condition that they are provided to the relevant system operator.

(2) *HVDC systems* owners shall undertake the following reactive power capability test:

(a) the *HVDC converter* units or the *HVDC converter* stations shall demonstrate the technical capability to provide leading and lagging reactive power according to this *Code*;

(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:

(i) Operation at minimum HVDC active power transmission capacity;

(ii) Operation at maximum HVDC active power transmission capacity;

(c) Operation at active power setpoints between those minimum and maximum HVDC active power transmission capacities.

(d) The test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC converter units or the HVDC converter stations have been operating for no less than 1 hour at maximum reactive power, both leading and lagging, for each parameter as referred to in point (b);

(ii) the HVDC converter units or the HVDC converter stations demonstrate the capability to change to any reactive power setpoint within the applicable reactive power range within the specified performance targets of the relevant reactive power control scheme; and

(iii) no action of any protection occurs within the operation limits specified by the reactive power capability diagram.

(3) HVDC systems owners shall undertake the following voltage control mode test:

(a) the HVDC converter units or the HVDC converter stations shall demonstrate the capability to operate in voltage control mode in the conditions set forth in this Code;

(b) the voltage control mode test shall apply concerning the verification of the following parameters:

(i) the implemented slope and deadband of the static characteristic;

(ii) the accuracy of the regulation;

(iii) the insensitivity of the regulation;

(iv) the time of reactive power activation.

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the range of regulation and adjustable droop and deadband is compliant with agreed or decided characteristic parameters, according to this Code;

(ii) the insensitivity of voltage control is not higher than 0.01 pu;

(iii) following a step change in voltage, 90% of the change in reactive power output has been achieved within the times and tolerances defined in this Code.

(4) *HVDC systems* owners shall undertake the following reactive power control mode test:

(a) the HVDC converter units or the HVDC converter stations shall demonstrate the capability to operate in reactive power control mode, according to the conditions referred to in this Code;

(b) the reactive power control mode test shall be complementary to the reactive power capability test;

(c) the reactive power control mode test shall be applied to verify the following parameters:

(i) the reactive power setpoint range and step;

(ii) the accuracy of the regulation; and

(iii) the time of reactive power activation.

(d) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the reactive power setpoint range and step is meets the requirements of this Code;

(ii) the accuracy of the regulation is compliant with the conditions as referred to this Code.

(5) *HVDC systems* owners shall undertake the following power factor control mode test:

(a) the HVDC converter units or the HVDC converter stations shall demonstrate the capability to operate in power factor control mode according to the conditions referred to in this Code;

(b) the power factor control mode test shall be applied to verify the following parameters:

(i) the power factor setpoint range;

(ii) the accuracy of the regulation;

(iii) the response of reactive power due to step change of active power.

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the power factor setpoint range and step meets the requirements of this *Code*;

(ii) the time of reactive power activation as a result of step active power change does not exceed the requirements specified in accordance with this *Code*;

(iii) the accuracy of the regulation is compliant with the value, as referred to in this *Code*.

(6) *HVDC systems* owners shall undertake the following frequency response test:

(a) the *HVDC systems* shall demonstrate the technical capability to continuously modulate active power over the full operating range between maximum HVDC active power transmission capacity and minimum HVDC active power transmission capacity to contribute to frequency control, and shall verify the steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including robustness during 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 at least 10% of the full active power frequency response range in each direction, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

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

(i) activation time and full response time of full active power frequency response range as result of a step frequency change has been no longer than required by this *Code*;

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

(iii) the initial delay time complies with the requirements of this *Code*;

(iv) the droop settings are available within the range provided for in this *Code* and deadband (thresholds) are not more than the value in this *Code*;

(v) insensitivity of active power frequency response at any relevant operating point does not exceed the requirements set forth in this *Code*.

(7) *HVDC systems* owners shall undertake the following high frequency response test:

(a) the *HVDC systems* shall demonstrate the technical capability to continuously modulate active power to contribute to frequency control in case of a large increase in system frequency and shall verify the steady-state parameters of regulations, such as droop and deadband, 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 the full operating range for active power, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

(c) the test shall be deemed to be passed, provided that the following conditions are both fulfilled:

(i) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in this *Code*;

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

(8) *HVDC systems* owners shall undertake the following low frequency response test:

(a) the *HVDC systems* shall demonstrate the technical capability to continuously modulate active power at operating points below maximum HVDC active power transmission capacity to contribute to frequency control in the case of a large drop of system frequency;

(b) the test shall be carried out by simulating at appropriate active power load points with low frequency steps and ramps big enough to activate at least 10% of the full operating range for active power, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

(c) the test shall be deemed to be passed, provided that the following conditions are both fulfilled:

(i) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in in this Code;

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

(9) *HVDC systems* owners shall undertake the following active power controllability test:

(a) the *HVDC systems* shall demonstrate the technical capability to continuously modulate active power over the full operating range according to this Code;

(b) the test shall be carried out by the relevant *TSO* sending manual and automatic instructions*TSO*;

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the *HVDC system* has demonstrated stable operation;

(ii) the time of adjustment of the active power is shorter than the delay specified pursuant to this Code;

(iii) the dynamic response of the *HVDC systems* when receiving instructions for the purposes of exchange or sharing of reserves or participating in imbalance netting processes, if capable of fulfilling the requirements for these products, as specified by the relevant *TSO*, has been demonstrated.

(10) *HVDC systems* owners shall undertake the following ramping rate modification test:

(a) the *HVDC systems* shall demonstrate the technical capability to adjust the ramping rate according to this Code;

(b) the test shall be carried out by the relevant *TSO* sending instructions for ramping modifications;

(c) the tests shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) ramping rate is adjustable;

(ii) the *HVDC systems* have demonstrated stable operation during ramping periods.

(11) *HVDC systems* owners shall undertake the following black start test, if applicable:

(a) the *HVDC systems* shall demonstrate the technical capability to energise the busbar of the remote AC substation to which it is connected, within a time frame specified by the relevant *TSO*, according to this Code;

(b) the test shall be carried out while the *HVDC system* starts from shut down;

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the *HVDC system* has demonstrated being able to energise the busbar of the remote AC-substation to which it is connected;

(ii) the *HVDC system* operates from a stable operating point at an agreed capacity, according to the requirements of this Code.

3.13.5 Compliance simulations for HVDC systems

(1) Equipment certificates may be used instead of part of the simulations below, on the condition that they are provided to the relevant system operator.

(2) *HVDC systems* owners shall undertake the following fast fault current injection simulation:

(a) the HVDC converter units or HVDC converter stations owners shall simulate fast fault current injection in the conditions set forth in this Code;

(b) the simulation is deemed to be passed, provided that compliance with the requirements specified in accordance with this Code is demonstrated.

(3) *HVDC systems* owners shall undertake the following fault-ride-through capability simulation:

(a) the *HVDC systems* owners shall simulate the capability for fault-ride-through in the conditions set forth in this Code; and

(b) the simulation is deemed to be passed, provided that compliance with the requirements specified in accordance with this Code is demonstrated.

(4) *HVDC systems* owners shall undertake the following post fault active power recovery simulation:

(a) the *HVDC systems* owners shall simulate the capability for post fault active power recovery in the conditions set forth in this Code;

(b) the simulation is deemed to be passed, provided that compliance with the requirements specified in accordance with this Code is demonstrated.

(5) *HVDC systems* owners shall undertake the following reactive power capability simulation:

(a) the HVDC converter units or the HVDC converter stations owners shall simulate the capability for leading and lagging reactive power capability in the conditions referred to in this Code;

(b) the simulation shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the simulation model of the HVDC converter unit or the HVDC converter station is validated against the compliance tests for reactive power capability as referred to in this Code;

(ii) compliance with the requirements as referred to in this Code is demonstrated.

(6) *HVDC systems* owners shall undertake the following power oscillations damping control simulation:

(a) the *HVDC systems* owner shall demonstrate the performance of its control system (POD function) to damp power oscillations in the conditions set forth in this Code;

(b) the tuning shall result in improved damping of corresponding active power response of the *HVDC system* in combination with the POD function compared to the active power response of the *HVDC system* without POD;

(c) the simulation shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the POD function damps the existing power oscillations of the *HVDC system* within a frequency range specified by the relevant *TSO*. This frequency range shall include the local mode frequency of the *HVDC system* and the expected network oscillations; and

(ii) a change of active power transfer of the *HVDC system,* as specified by the relevant *TSO*, does not lead to undamped oscillations in active or reactive power of the *HVDC system*.

(7) *HVDC systems* owners shall undertake the following simulation of active power modification in case of disturbance:

(a) the *HVDC systems* owners shall simulate the capability to quickly modify active power according to this Code;

(b) the simulation shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the *HVDC system* has demonstrated stable operation when following the pre-specified sequence of active power variation;

(ii) the initial delay of the adjustment of the active power is shorter than the value specified in this Code, or reasonably justified if greater.

(8) *HVDC systems* owners shall undertake the following fast active power reversal simulation, as applicable:

(a) the *HVDC systems* owners shall simulate the capability to quickly reverse active power according to this Code.

(b) The simulation shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the *HVDC system* has demonstrated stable operation;

(ii) the time of adjustment of the active power is shorter than the value specified in this Code or reasonably justified if greater.

3.13.6 Compliance testing for DC-connected power park modules

(1) Equipment certificates may be used instead of part of the tests below, on the condition that they are provided to the relevant system operator.

(2) *DC-connected power park modules* owners shall undertake the following reactive power capability tests:

(a) the *DC-connected power park modules* shall demonstrate the technical capability to provide leading and lagging reactive power capability according to this Code;

(b) the reactive power capability test shall be carried out at maximum reactive power, both leading and lagging, and provide verification of the following parameters:

(i) operation in excess of 60% of maximum capacity for 30 minutes;

(ii) operation within the range of 30-50% of maximum capacity for 30 minutes; and

(iii) operation within the range of 10-20% of maximum capacity for 60 minutes.

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the *DC-connected power park module* has been operating for no less than the requested duration at maximum reactive power, both leading and lagging, for each parameter as referred to in paragraphs above;

(ii) the *DC-connected power park module* has demonstrated its capability to change to any reactive power setpoint within the agreed or decided reactive power range within the specified performance targets of the relevant reactive power control scheme; and

(iii) no action of any protection occurs within the operation limits specified by reactive power capability diagram.

(3) *DC-connected power park modules* owners shall undertake the following voltage control mode test:

(a) the *DC-connected power park modules* shall demonstrate the capability to operate in voltage control mode in the conditions set forth in this Code;

(b) the voltage control mode test shall provide verification of the following parameters:

(i) the implemented slope and deadband of the static characteristic;

(ii) the accuracy of the regulation;

(iii) the insensitivity of the regulation;

(iv) the activation and full response time of reactive power activation.

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the range of regulation and droop and deadband is compliant with agreed or decided characteristic parameters, according to this Code;

(ii) the insensitivity of voltage control is not higher than 0.01 pu, according to this Code;

(iii) following a step change in voltage, 90% of the change in reactive power output is achieved within the times and tolerances required by this Code.

(4) *DC-connected power park modules* owners shall undertake the following reactive power control mode test:

(a) the *DC-connected power park modules* shall demonstrate the capability to operate in reactive power control mode, according to the conditions referred to in this Code;

(b) the reactive power control mode test shall be complementary to the reactive power capability test;

(c) the reactive power control mode test shall be applied to provide verification of the following parameters:

(i) the reactive power setpoint range and step;

(ii) the accuracy of the regulation;

(iii) the time of reactive power activation.

(d) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the reactive power setpoint range and step is ensured according to this Code;

(ii) the accuracy of the regulation is compliant with the conditions as referred to in this Code.

(5) *DC-connected power park modules* owners shall undertake the following power factor control mode test:

(a) the *DC-connected power park modules* shall demonstrate the capability to operate in power factor control mode according to the conditions referred to in this Code;

(b) the power factor control mode test shall apply concerning the verification of the following parameters:

(i) the power factor setpoint range;

(ii) the accuracy of the regulation;

(iii) the response of reactive power due to step change of active power.

(c) the test shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the power factor setpoint range and step meet the requirements of this Code;

(ii) the time of reactive power activation as result of step active power change does not exceed the requirement according to this Code;

(iii) the accuracy of the regulation is compliant with the value, as referred to in this Code.

(6) With regard to the tests identified in the paragraphs above, the relevant *TSO* may select only two of the three control options for testing.

(7) *DC-connected power park modules* owners shall undertake the following response compliance tests in relation to type B, C & D *DC-connected power park modules*:

(a) the technical capability of the *DC-connected power park modules* to continuously modulate active power to contribute to frequency control in the case of a large increase in system frequency shall be demonstrated. The steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including frequency step change response, shall be verified;

(b) the test shall be carried out by simulating frequency steps and ramps big enough to trigger at least 10% of the maximum capacity change in active power, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously at both the speed governor and load controller of the control systems, taking into account the scheme of those control systems;

(c) the test shall be deemed to be successful if the following conditions are fulfilled:

(i) the test results, for both dynamic and static parameters meet the requirements set out in this Code; and

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

(8) Type C & D *DC-connected power park modules* owners shall undertake the following response compliance tests.

(a) the technical capability of the *DC-connected power park modules* to continuously modulate active power at operating points below maximum capacity to contribute to frequency control in case of a large frequency drop in the system shall be demonstrated;

(b) the test shall be carried out by simulating appropriate active power load points, with low frequency steps and ramps big enough to trigger an active power change of at least 10% of maximum capacity, taking into account the droop settings and the deadband;

(c) the test shall be deemed to be successful if the following conditions are fulfilled:

(i) the test results, for both dynamic and static parameters, comply with this Code; and

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

(9) Type C & D *DC-connected power park modules* owners shall undertake frequency restoration control tests and the following requirements shall apply:

(a) the technical capability of the *DC-connected power park modules* to participate in frequency restoration control shall be demonstrated and the cooperation of frequency control and frequency restoration control shall be checked;

(b) the test shall be deemed to be successful if the results, for both dynamic and static parameters, comply with the requirements of this Code.

(10) Type C & D *DC-connected power park modules* owners with black start capability shall perform black start tests and the following requirements shall apply:

(a) for *DC-connected power park modules* with black start capability, the technical capability to start from shut down without any external electrical energy supply shall be demonstrated;

(b) the test shall be deemed to be successful if the start-up time is kept within the time frame set out in this Code.

(11) Type C & D *DC-connected power park modules* owners shall undertake tests of the fast signal response. The test shall be deemed to be passed if the response of the *DC-connected power park modules* is demonstrated to be within the time specified in this *Code*.

(12) The relevant system operator, in coordination with the relevant *TSO*, shall agree with the *DC- connected power park modules* owners the compliance tests required for *DC-connected power park modules* where the AC collection network is not at nominal 50 Hz frequency*TSO*.

3.13.7 Compliance simulations for DC-connected power park modules

(1) *DC-connected power park* modules are subject to the compliance simulations detailed in this Code. Equipment certificates may be used instead of part of the simulations described below, on the condition that they are provided to the relevant system operator.

(2) Type B, C & D *DC-connected power park module* owners shall undertake a fast fault current injection simulation:

(a) the *DC-connected power park modules* owners shall simulate the capability for fast fault current injection in the conditions set forth in this Code; and

(b) the simulation shall be deemed to be passed, provided that compliance with the requirement according to this Code is demonstrated.

(3) Type B, C & D *DC-connected power park modules* owners shall undertake a post fault active power recovery simulation:

(a) the *DC-connected power park modules* owners shall simulate the capability for post fault active power recovery in the conditions set forth in this Code; and

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to this Code is demonstrated.

(4) Type C & D *DC-connected power park modules* owners shall undertake a reactive power capability simulation of *DC-connected power park modules*:

(a) the *DC-connected power park modules* owners shall simulate the capability for leading and lagging reactive power in the conditions referred to in this Code; and

(b) the simulation shall be deemed to be passed, provided that the following conditions are cumulatively fulfilled:

(i) the simulation model of the *DC-connected power park module* is validated against the compliance tests for reactive power capability as referred to in this Code;

(ii) compliance with the requirements referred to in this Code is demonstrated.

(5) Type B, C & D *DC-connected power park modules* owners shall undertake a power oscillations damping control simulation:

(a) the *DC-connected power park modules* owners shall simulate the capability for power oscillations damping under the conditions as referred to in this Code; and

(b) the simulation shall be deemed to be passed, provided that the model demonstrates compliance with the conditions of this Code.

(6) Type B, C & D *DC-connected power park modules* owners shall undertake a fault-ride-through capability simulation:

(a) the *DC-connected power park modules* owners shall simulate the capability for fault-ride-through under the conditions as referred to in this Code;

(b) the simulation shall be deemed to be passed, provided that the model demonstrates compliance with the conditions of this Code.

3.13.8 Derogations

(1) Regulatory authorities (or another applicable authority in a GMS Member State) may, at the request of a *HVDC system* or *DC-connected power park module* owner or prospective owner, relevant system operator or relevant *TSO*, grant *HVDC system* or *DC-connected power park module* owners or prospective owners, relevant system operators or relevant *TSOs*, derogations from one or more provisions of this Code for new and existing *HVDC systems* or *DC-connected power park modules* in accordance with this Code.

(2) Each regulatory authority shall specify, after consulting relevant system operators and *HVDC systems* and *DC-connected power park modules* owners, and other stakeholders whom it deems to be affected by this Code, the criteria for granting derogations pursuant to this Code. It shall publish those criteria on its website and notify them to the RPCC within nine months of the entry into force of this Code. The RPCC may require a regulatory authority to amend the criteria if it considers that they are not in line with this Code. This possibility to review and amend the criteria for granting derogations shall not affect the derogations already granted which shall continue to apply until the scheduled expiry date as detailed in the decision granting the exemption.

(3) If the regulatory authority deems that it is necessary due to a change in circumstances relating to the evolution of system requirements, it may review and amend at most once every year the criteria for granting derogations. Any changes to the criteria shall not apply to derogations for which a request has already been made.

(4) The regulatory authority may decide that *HVDC system* or *DC-connected power park modules* for which a request for a derogation has been filed pursuant to this Code do not need to comply with the requirements of this Code from which a derogation has been sought from the day of filing the request until the regulatory authority's decision is issued.

(5) *HVDC systems* or *DC-connected power park modules* owners, or prospective owners, may request a derogation to one or several requirements of this Code for *power-generating modules* within their facilities.

(6) A request for a derogation shall be filed with the relevant system operator and include:

(a) an identification of the *HVDC system* or *DC-connected power park module* owner, or prospective owner, and a contact person for any communications;

(b) a description of the *HVDC system* or *DC-connected power park module* or modules for which a derogation is requested;

(c) a reference to the provisions of this Code from which a derogation is requested and a detailed description of the requested derogation;

(d) detailed reasoning, with relevant supporting documents and cost-benefit analysis pursuant to the requirements this Code; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade.

(7) Within two weeks of receipt of a request for a derogation, the relevant system operator shall confirm to the *HVDC system* or *DC-connected power park module* owner, or prospective owner, whether the request is complete. If the relevant system operator considers that the request is incomplete, the *HVDC System* or *DC-connected power park module* owner, or prospective owner, shall submit the additional required information within one month from the receipt of the request for additional information. If the *HVDC system* or *DC-connected power park module* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn.

(8) The relevant system operator shall, in coordination with the relevant *TSO* and any affected adjacent DSO or DSOs, assess the request for a derogation and the provided cost-benefit analysis, taking into account the criteria determined by the regulatory authority or appointed authority.

(9) If a request for a derogation concerns a type C or D *HVDC System* or *DC-connected power park module* connected to a distribution system, including a closed distribution system, the relevant system operator's assessment must be accompanied by an assessment of the request for a derogation by the relevant *TSO*. The relevant *TSO* shall provide its assessment within two months of being requested to do so by the relevant system operator.

(10) Within six months of receipt of a request for a derogation, the relevant system operator shall forward the request to the regulatory authority and submit the assessment(s). That period may be extended by one month where the relevant system operator seeks further information from the *HVDC System* or *DC-connected power park module* owner, or prospective owner and by two months where the relevant system operator requests the relevant *TSO* to submit an assessment of the request for a derogation.

(11) The regulatory authority shall adopt a decision concerning any request for a derogation within six months from the day after it receives the request. That time limit may be extended by three months before its expiry where the regulatory authority requires further information from the *HVDC System* or *DC-connected power park module* owner, or prospective owner, or from any other interested parties. The additional period shall begin when the complete information has been received.

(12) The *HVDC System* or *DC-connected power park module* owner, or prospective owner, shall submit any additional information requested by the regulatory authority within two months of such request. If the *HVDC System* or *DC-connected power park module* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn unless, before its expiry:

(13) the *HVDC System* or *DC-connected power park module* owner, or prospective owner, informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(14) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants a derogation, it shall specify its duration.

(15) The regulatory authority shall notify its decision to the relevant *HVDC System* or *DC-connected power park module* owner, or prospective owner, the relevant system operator and the relevant *TSO*.

(16) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(17) For Type A *HVDC System* or *DC-connected power park modules*, a request for a derogation under this Code may be made by a third party on behalf of the *HVDC System* or *DC-connected power park module* owner, or prospective owner. Such a request may be for a single *HVDC System* or *DC-connected power park module* or multiple, identical *HVDC System* or *DC-connected power park modules*. In the case of the latter, and provided the cumulative maximum capacity is specified, the third party may substitute the details required with their details.

(18) Relevant system operators or relevant *TSOs* may request derogations for classes of *HVDC System* or *DC-connected power park modules* connected or to be connected to their network.

(19) Relevant system operators or relevant *TSOs* shall submit their requests for derogations to the regulatory authority. Each request for a derogation shall include:

(a) identification of the relevant system operator or relevant *TSO*, and a contact person for any communications;

(b) a description of the *HVDC system* or *DC-connected power park modules* for which a derogation is requested and the total installed capacity and number of *HVDC System* or *DC-connected power park modules*;

(c) the requirement or requirements of this Code for which a derogation is requested, with a detailed description of the requested derogation;

(d) detailed reasoning, with all relevant supporting documents; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade;

(20) Where the request for a derogation is submitted by a relevant DSO, the regulatory authority shall, within two weeks from the day after receipt of that request, ask the relevant *TSO* to assess the request for a derogation in the light of the criteria determined by the regulatory authority.

(21) Within two weeks from the day after the receipt of such request for assessment, the relevant *TSO* shall confirm to the relevant DSO whether the request for a derogation is complete. If the relevant *TSO* considers that it is incomplete, the relevant DSO shall submit the required additional information within one month from the receipt of the request for additional information.

(22) Within six months of receipt of a request for a derogation, the relevant *TSO* shall submit to the regulatory authority its assessment, including any relevant documentation. The six-month time limit may be extended by one month where the relevant *TSO* seeks further information from the relevant DSO.

(23) The regulatory authority shall adopt a decision concerning a request for a derogation within six months from the day after it receives the request. Where the request for a derogation is submitted by the relevant DSO, the six- month time limit runs from the day following receipt of the relevant *TSO's* assessment.

(24) The six-month time limit referred to above may, before its expiry, be extended by an additional three months where the regulatory authority requests further information from the relevant system operator requesting the derogation or from any other interested parties. That additional period shall run from the day following the date of receipt of the complete information.

(25) The relevant system operator shall provide any additional information requested by the regulatory authority within two months from the date of the request. If the relevant system operator does not provide the requested additional information within that time limit, the request for a derogation shall be deemed withdrawn unless, before expiry of the time limit:

(26) the relevant system operator informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(27) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants derogation, it shall specify its duration.

(28) The regulatory authority shall notify its decision to the relevant system operator requesting the derogation, the relevant *TSO*.

(29) Regulatory authorities may lay down further requirements concerning the preparation of requests for derogation by relevant system operators. In doing so, regulatory authorities shall take into account the delineation between the transmission system and the distribution system at the national level and shall consult with system operators, *HVDC System* or *DC-connected power park module* owners and stakeholders, including manufacturers.

(30) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(31) Regulatory authorities shall maintain a register of all derogations they have granted or refused and shall provide the RPCC with an updated and consolidated register at least once every six months.

(32) The register shall contain, in particular:

(a) the requirement or requirements for which the derogation is granted or refused;

(b) the content of the derogation;

(c) the reasons for granting or refusing the derogation;

(d) the consequences resulting from granting the derogation.

(33) The RPCC shall monitor the procedure of granting derogations with the cooperation of the regulatory authorities or relevant authorities of the GMS Member State. Those authorities or relevant authorities of the Member State shall provide the RPCC with all the information necessary for that purpose.

(34) The RPCC may issue a reasoned recommendation to a regulatory authority t or relevant authority of the GMS Member State to revoke derogation due to a lack of justification.

4. Demand Connection

4.1 Frequency tolerance, active power and frequency control requirements

4.1.1 Frequency tolerance

(1) All *Demand facilities* shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 4-1.

(2) The relevant *TSO* and the *Demand facility* owner may agree on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations to ensure the best use of the technical capabilities of a *Demand facility*, if it is required to preserve or to restore system security.

(3) Tripping times for when frequency is outside the normal operating range of 49.0 to 51.0 Hz shall be agreed with the relevant *TSO*. The *TSO* shall co-ordinate such settings to minimize the risk of cascade tripping and network collapse

Table 4-1 Minimum time periods for which a *Demand facility* has to be capable of operating on different frequencies, deviating from a nominal value, without disconnecting from the network.

Synchronous area	Frequency range	Minimum time period for operation of each *Demand facility* each time the system frequency is in the range
Interconnected GMS	47.5 Hz-48.5 Hz	To be specified by each *TSO*, but not less than 30 minutes
	48.5 Hz-49.0 Hz	To be specified by each *TSO*, but not less than 30 minutes
	49.0 Hz-51.0 Hz	Unlimited
	51.0 Hz-51.5 Hz	30 minutes

4.1.2 Active power and frequency control requirements

(1) All *Demand facilities* shall fulfil the following requirements related to low frequency demand disconnection functional capabilities:

(a) each *Demand facility* owner shall provide capabilities that enable automatic 'low frequency' disconnection of a specified proportion of their demand. The relevant *TSO* may specify a disconnection trigger based on a combination of low frequency and rate-of-change-of-frequency measures;

(b) the low frequency demand disconnection functional capabilities shall allow for disconnecting demand in stages for a range of operational frequencies;

(c) the low frequency demand disconnection functional capabilities shall allow for operation using a nominal Alternating Current ('AC') input to be specified by the relevant system operator, and shall meet the following requirements:

(i) frequency range: at least between 47-50 Hz, adjustable in steps of 0.05 Hz;

(ii) operating time: no more than 150 ms after triggering the frequency setpoint;

(iii) voltage lock-out: blocking of the functional capability shall be possible when the voltage is within a range of 30 to 90% of reference 1 pu voltage;

(iv) determine the direction of active power flow at the point of disconnection;

(d) the AC voltage supply used in providing low frequency demand disconnection functional capabilities, shall be provided from the network at the frequency signal measuring point, so that the frequency of the low frequency demand disconnection functional capabilities supply voltage is the same as the one of the network.

(e) The low frequency demand disconnection shall be coordinated by the relevant TSO and unless otherwise agreed by RPCC the settings in Table 4-2 shall apply.

Table 4-2 Low frequency demand disconnection settings

Synchronous area	Frequency range	Demand to be disconnected	Delay
Interconnected GMS	49.0 Hz	~5 %	150 mS
	48.9 Hz	~5 %	150 mS
	48.8 Hz	~5 %	150 mS
	48.7 Hz	~5 %	150 mS
	48.6 Hz	~5 %	150 mS
	48.5 Hz	~5 %	150 mS
	48.4 Hz	~5 %	150 mS
	48.3 Hz	~5 %	150 mS
	48.2 Hz	~5 %	150 mS
	48.1 Hz	~5 %	150 mS

(2) All *Demand facilities* shall fulfil the following requirements related to disconnection or reconnection of the *Demand facility*:

(a) the relevant *TSO* shall specify the conditions under which a *Demand facility* is entitled to reconnect to the transmission system. Installation of automatic reconnection systems shall be subject to prior authorisation by the relevant *TSO*;

(b) the *Demand facility* shall be capable of synchronisation for frequencies within the ranges set out above. The relevant *TSO* and the *Demand facility* owner shall agree on the settings of synchronisation devices prior to connection of the *Demand facility*, including voltage, frequency, phase angle range and deviation of voltage and frequency;

(c) a *Demand facility* shall be capable of being remotely disconnected from the transmission system when required by the relevant *TSO*. If required, the automated disconnection equipment for reconfiguration of the system in preparation for block loading shall be specified by the relevant *TSO*. The relevant *TSO* shall specify the time required for remote disconnection.

(3) *Demand facilities* may offer demand response active power control or demand response transmission constraint management to relevant system operators and relevant *TSOs*.

(4) *Demand facilities* may offer demand response system frequency control to relevant system operators and relevant *TSOs*.

4.2 Voltage tolerance, voltage control and reactive power provision

(1) *Demand facilities* shall be capable of staying connected to the network and operating within the voltage ranges (per unit) for the time periods specified in Table 4-3 and Table 4-4;

(2) Wider voltage ranges or longer minimum times for operation can be agreed between the relevant system operator, the relevant *TSO* and the *Demand facility* if needed to preserve or to restore system security.

Table 4-3 Minimum voltage range capabilities for *Demand facility* connected above 230 kV

Synchronous area	Voltage range	Minimum time period for operation of the *Demand facilities*
Interconnected GMS	0.85 pu - 0.90 pu	Unlimited
	0.900 pu - 1.118 pu	Unlimited
	1.118 pu - 1.150 pu	To be specified by each *TSO*, but not less than 20 minutes

Table 4-4 Minimum voltage range capabilities for *Demand facility* connected below or equal to 230 kV

Synchronous area	Voltage range	Minimum time period for operation of the *Demand facilities*

Interconnected GMS	0.85 pu - 0.90 pu	60 minutes *Demand facility*
	0.900 pu - 1.118 pu	Unlimited
	1.118 pu - 1.150 pu	To be specified by each *TSO*, but not less than 20 minutes

(3) *Demand facilities* could have the following low voltage demand disconnection functional capabilities:

(a) the relevant *TSO* may specify, in coordination with *Demand facilities* owners, low voltage demand disconnection functional capabilities for the transmission-connected facilities;

(b) based on the *TSO's* assessment concerning system security, the implementation of on load tap changer blocking and low voltage demand disconnection shall be binding for the transmission-connected *Demand facilities*;

(c) if the relevant *TSO* decides to implement a low voltage demand disconnection functional capability, the equipment for both on load tap changer blocking and low voltage demand disconnection shall be installed in coordination with the relevant *TSO*;

(d) the method for low voltage demand disconnection shall be implemented by relay or control room initiation;

(e) the low voltage demand disconnection functional capabilities shall have the following features:

(i) the low voltage demand disconnection functional capability shall monitor the voltage by measuring all three phases;

(ii) blocking of the relays' operation shall be based on direction of either active power or reactive power flow.

(4) For *Demand facilities* with on load tap changers, the following requirements shall apply:

(a) if required by the relevant *TSO*, transformers at transmission-connected *Demand facilities* shall be capable of automatic or manual on load tap changer blocking;

(b) the relevant *TSO* shall specify the automatic on load tap changer blocking functional capability.

4.3 Short circuit requirements

(1) The relevant *TSO* shall specify the maximum short-circuit current at the connection point that *Demand facilities* shall be capable of withstanding. The calculation shall be based on the rated short-circuit withstand capability of its transmission network elements,

(2) The short circuit current levels shall not exceed the limits specified in Table 4-5

Table 4-5 Short Circuit Current Level

Requirements	GMS
Short Circuit Current Levels: ▪ **500 kV**	50 kA
▪ **220-230 kV**	40 kA
▪ **115-132 kV**	31.5 kA

(3) The relevant *TSO* shall deliver to *Demand facilities* owners an estimate of the minimum and maximum short-circuit currents to be expected at the connection point as an equivalent of the network.

(4) The *Demand facilities* owners, in conjunction with the relevant *TSO*, shall ensure that the maximum fault clearance times specified in Table 4-6 are not exceeded for three phase or single phase faults.

Table 4-6 Maximum Fault Clearance Time

Requirements	GMS
Max Fault Clearance times: ▪ **500 kV**	80 ms
▪ **220-230 kV**	100 (1) - 120 ms (2)
▪ **115-132 kV**	120 (1) - 150 ms (2)

Note:

(1) Targeted value

(2) Admissible transitory value

(5) After an unplanned event, the relevant *TSO* shall inform the affected *Demand facilities* owners as soon as possible, and no later than one week after the unplanned event, of the changes above a threshold for the maximum short-circuit current that the affected transmission-connected *Demand facilities,* , shall be able to withstand from the relevant *TSO's* network in accordance with the paragraphs above.

(6) The threshold referenced in the above paragraph for the maximum short-circuit current that can be withstood shall be specified by *Demand facilities* owners for their facilities.

(7) Before a planned event, the relevant *TSO* shall inform the affected transmission-connected *Demand facilities* owners as soon as possible, and no later than one week before the planned event, of the changes above a threshold for the maximum short-circuit current that the affected *Demand facilities* shall be able to withstand from the relevant *TSO's* network.

(8) The threshold referenced in the above paragraph for the maximum short-circuit current that can be withstood shall be specified by *Demand facilities* owners for their facilities *Demand facility*.

(9) The relevant *TSO* shall request information from *Demand facilities* owners concerning the contribution in terms of short-circuit current from the facilities. As a minimum, the equivalent modules of the network shall be delivered and demonstrated for zero, positive and negative sequences.

(10) After an unplanned event, the *Demand facilities* owners shall inform the relevant *TSO* as soon as possible, and no later than one week after the unplanned event, of the changes in short-circuit contribution above the threshold set by the relevant *TSO*.

(11) Before a planned event, *Demand facilities* owners shall inform the relevant *TSO* as soon as possible, and no later than one week before the planned event, of the changes in short-circuit contribution above the threshold set by the relevant *TSO*.

4.4 Reactive power requirements

(1) *Demand facilities* shall be capable of maintaining their steady-state operation at their connection point within a reactive power range specified by the relevant *TSO*, according to the following conditions:

(a) *Demand facilities* shall provide importing and exporting reactive power which shall not be wider than 48 percent of the larger of the maximum import capacity and maximum export capacity (0.9 power factor import or export of active power), except in situations where either technical or financial system benefits are demonstrated, for *Demand facilities*, by the *Demand facility* owner and accepted by the relevant *TSO*;

(b) the relevant *TSO* and *Demand facilities* owners shall agree on the scope of the analysis which shall address the possible solutions and determine the optimal solution for reactive power exchange between their systems, taking adequate consideration of the specific system characteristics, variable structure of power exchange, bidirectional flows and the reactive power capabilities in their distribution systems;

(c) the relevant *TSO* may establish the use of metrics other than power factor in order to set out equivalent reactive power capability ranges;

(d) the reactive power range requirement values shall be met at the connection point;

(e) where a connection point is shared between a power-generating module and a *Demand facility*, equivalent requirements shall be met at the point defined in relevant agreements or national law.

(2) The relevant *TSO* may require the transmission-connected distribution system to actively control the exchange of reactive power at the connection point for the benefit of the entire system. The relevant *TSO* and the *Demand facilities* owners shall agree on a method to carry out this control, to ensure a justified level of security of supply for both parties. The justification shall include a roadmap in which the steps and the timeline for fulfilling the requirement are specified.

4.5 Protection requirements

(1) The relevant *TSO* shall specify the devices and settings required to protect the transmission network in accordance with the characteristics of *Demand facilities*. The

relevant *TSO* and the *Demand facilities* owners shall agree on protection schemes and settings relevant to the *Demand facilities*.

(2) Electrical protection of *Demand facilities* shall take precedence over operational controls while respecting system security, health and safety of staff and the public.

(3) Protection scheme devices may cover the following elements:

(a) external and internal short circuit;

(b) over- and under-voltage at the connection point to the transmission system;

(c) over- and under-frequency;

(d) demand circuit protection;

(e) unit transformer protection;

(f) back-up against protection and switchgear malfunction.

(4) The relevant *TSO* and the *Demand facilities* owners shall agree on any changes to the protection schemes relevant to the *Demand facilities*, and on the arrangements for the protection schemes of the *Demand facilities*.

4.6 Control requirements

(1) The relevant *TSO* and the *Demand facilities* owners shall agree on the schemes and settings of the different control devices of *Demand facilities*.

(2) The agreement shall cover at least the following elements:

(a) isolated (network) operation;

(b) damping of oscillations;

(c) disturbances to the transmission network;

(d) automatic switching to emergency supply and restoration to normal topology;

(e) automatic circuit-breaker re-closure (on 1-phase faults).

(3) The relevant *TSO* and the *Demand facilities* owners shall agree on any changes to the schemes and settings of the different control devices of the *Demand facilities* relevant to system security.

(4) With regard to priority ranking of protection and control, the *Demand facilities* owners shall set the protection and control devices of *Demand facilities*, in compliance with the following priority ranking, organised in decreasing order of importance:

(a) transmission network protection;

(b) *Demand facility* protection;

(c) frequency control (active power adjustment);

(d) power restriction.

4.7 Information requirements

(1) *Demand facilities* shall be equipped according to the standards specified by the relevant *TSO* in order to exchange information between the relevant *TSO* and the *Demand facilities* with the specified time stamping. The relevant *TSO* shall make the specified standards publicly available.

(2) The relevant *TSO* shall specify the information exchange standards. The relevant *TSO* shall make publicly available the precise list of data required.

4.8 Demand disconnection or demand connection

(1) All *Demand facilities* shall fulfil the following requirements related to low frequency demand disconnection functional capabilities:

(a) *Demand facilities* owners shall provide capabilities that enable automatic 'low frequency' disconnection of a specified proportion of their demand. The relevant *TSO* may specify a disconnection trigger based on a combination of low frequency and rate-of-change-of-frequency;

(b) the low frequency demand disconnection functional capabilities shall allow for disconnecting demand in stages for a range of operational frequencies;

(c) the low frequency demand disconnection functional capabilities shall allow for operation based on a nominal Alternating Current ('AC') input, to be specified by the relevant system operator, and shall meet the following requirements:

(i) frequency range: at least between 47-50 Hz, adjustable in steps of 0.05 Hz;

(ii) operating time: no more than 150 ms after triggering the frequency setpoint;

(iii) voltage lock-out: blocking of the functional capability shall be possible when the voltage is within a range of 30 to 90% of reference 1 pu voltage;

(iv) provide the direction of active power flow at the point of disconnection;

(d) the AC voltage supply used in providing low frequency demand disconnection functional capabilities, shall be provided from the network at the frequency signal measuring point, as used in providing functional capabilities in accordance with paragraph above, so that the frequency of the low frequency demand disconnection functional capabilities supply voltage is the same as the one of the network.

(2) The relevant *TSO* may specify low voltage demand disconnection functional capabilities, and the following requirements may apply:

(a) low voltage demand disconnection functional capabilities for the *Demand facilities*;

(b) based on the *TSO's* assessment concerning system security, the implementation of on load tap changer blocking and low voltage demand disconnection shall be binding for *Demand facilities*;

(c) the equipment for both on load tap changer blocking and low voltage demand disconnection shall be installed in coordination with the relevant *TSO*;

(d) the method for low voltage demand disconnection shall be implemented by relay or control room initiation;

(e) the low voltage demand disconnection functional capabilities shall have the following features:

(i) the low voltage demand disconnection functional capability shall monitor the voltage by measuring all three phases;

(ii) blocking of the relays' operation shall be based on direction of either active power or reactive power flow.

(3) If blocking of on load tap changers is required, the following requirements shall apply:

(a) the transformer at the transmission-connected distribution facility shall be capable of automatic or manual on load tap changer blocking;

(b) the relevant *TSO* shall specify the automatic on load tap changer blocking functional capability.

(4) *Demand facilities* shall fulfil the following requirements related to disconnection or reconnection of *Demand facilities*:

(a) with regard to the capability of reconnection after a disconnection, the relevant *TSO* shall specify the conditions under which *Demand facilities* are entitled to reconnect to the transmission system. Installation of automatic reconnection systems shall be subject to prior authorisation by the relevant *TSO*;

(b) *Demand facilities* shall be capable of synchronisation at frequencies within the ranges set out in this Code. The relevant *TSO* and the *Demand facilities* owners shall agree on the settings of synchronisation devices prior to connection of the *Demand facilities*, including voltage, frequency, phase angle range and deviation of voltage and frequency;

(c) *Demand facilities* shall be capable of being remotely disconnected from the transmission system when required by the relevant *TSO*. If required, the automated disconnection equipment for reconfiguration of the system in preparation for block loading shall be specified by the relevant *TSO*. The relevant *TSO* shall specify the time required for remote disconnection.

4.9 Power quality

(1) *Demand facilities* owners shall ensure that their connection to the network does not result in a determined level of distortion or fluctuation of the supply voltage on the network at the connection point.

(2) The harmonic distortion for voltage and current levels shall not exceed the values specified in Table 4-7:

Table 4-7 Harmonic distortion level for voltage and current

Requirements	GMS
Harmonic Voltage Distortion:	
- 500 kV	1.0 - 1.5%
- 220 - 230 kV	1.5 - 2.5%
- 115 - 132 kV	2.0 - 3.0%
Harmonic Current Distortion:	
- 500 kV	1.0 - 1.5%
- 220 - 230 kV	1.5 - 2.5%
- 115 - 132 kV	2.0 - 3.0%

(3) *Demand facilities* owners shall ensure that voltage unbalance is less than 1%.

(4) *TSOs* shall coordinate their power quality requirements with the requirements of adjacent *TSOs*.

4.10 Connection, compliance and testing requirements

4.10.1 Operational notification procedure for connection

(1) The *Demand facilities* owners shall demonstrate to the relevant system operator that they have complied with the requirements set out in this code by successfully completing the operational notification procedure for connection of each *Demand facilities,* described below.

(2) The operational notification procedure for the connection of each new *Demand facility*, shall comprise:

(a) an energisation operational notification (EON);

(b) an interim operational notification (ION);

(c) a final operational notification (FON).

(3) The relevant *TSO* shall specify and make publicly available further details concerning the operational notification procedure.

(4) An EON shall entitle the *Demand facility* owner to energise its internal network and auxiliaries by using the grid connection that is specified for the connection point.

(5) An EON shall be issued by the relevant *TSO*, subject to completion of preparations including agreement on the protection and control settings relevant to the connection point between the relevant *TSO* and the *Demand facility* owner.

(6) An ION shall entitle the *Demand facility* owner to operate the *Demand facility* by using the grid connection for a limited period of time.

(7) An ION shall be issued by the relevant *TSO*, subject to completion of the data and study review process as required by this Code.

(a) With regard to the data and study review, the relevant *TSO* shall have the right to request that the *Demand facility* owner provide the following:

(b) an itemised statement of compliance;

(c) detailed technical data of the *Demand facility* relevant to the grid connection as specified by the relevant *TSO*;

(d) equipment certificates issued by an authorised certifier in respect of *Demand facility*, where these are relied upon as part of the evidence of compliance;

(e) simulation models, as specified in this Code and required by the *TSO*;

(f) studies demonstrating expected steady-state and dynamic performance as required in this Code;

(g) details of intended practical method of completing compliance tests according to this Code.

(8) The maximum period during which the *Demand facility* may maintain ION status shall be 24 months. The relevant *TSO* is entitled to specify a shorter ION validity period. An extension of the ION shall be granted only if the *Demand facility* has made substantial progress towards full compliance. Outstanding issues shall be clearly identified at the time of requesting extension.

(9) An extension of the period during which the *Demand facility* may maintain ION status, beyond the period established may be granted if a request for a derogation is made to the relevant *TSO* before the expiry of that period in accordance with the derogation procedure laid down in this Code.

(10) A FON shall entitle the *Demand facility* owner to operate the *Demand facility* by using the grid connection.

(11) A FON shall be issued by the relevant *TSO*, upon prior removal of all incompatibilities identified for the purposes of the ION status and subject to the completion of the data and study review process as required by this Code.

(12) For the purposes of the data and study review, the *Demand facility* owner must submit the following to the relevant *TSO*:

(a) an itemised statement of compliance; and

(b) an update of the applicable technical data, simulation models and studies as referred in this Code, including the use of actual measured values during testing.

(13) If incompatibility is identified in connection with the issuing of the FON, a derogation may be granted upon a request made to the relevant *TSO* in accordance with the Code. A FON shall be issued by the relevant *TSO* if the *Demand facility* complies with the provisions of the derogation.

(14) Where a request for a derogation is rejected, the relevant *TSO* shall have the right to refuse to allow the operation of the *Demand facility* until the *Demand facility* owner and

the relevant *TSO* resolve the incompatibility and the relevant *TSO* considers that the *Demand facility* complies with the provisions of this Code.

(15) If the relevant *TSO* and the *Demand facility* owner do not resolve the incompatibility within a reasonable time frame, but in any case not later than six months after the notification of the rejection of the request for a derogation, each party may refer the issue to the regulatory authority for decision.

4.10.2 Limited operational notification

(1) *Demand facilities* owners to whom a FON has been granted, shall inform the relevant *TSO*, no later than 24 hours after the incident has occurred, of the following circumstances:

(a) the facility is temporarily subject to either significant modification or loss of capability affecting its performance; or

(b) equipment failure leading to non-compliance with some relevant requirements.

(2) A longer time period to inform the relevant *TSO* can be agreed with *Demand facilities* owners depending on the nature of the changes.

(3) The *Demand facilities* owners shall apply to the relevant *TSO* for a limited operational notification (LON), if the transmission-connected *Demand facility* owner or transmission-connected distribution system operator expects the circumstances to persist for more than three months.

(4) A LON shall be issued by the relevant *TSO* and shall contain the following information which shall be clearly identifiable:

(a) the unresolved issues justifying the granting of the 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 the possibility of an extension if evidence is submitted to the satisfaction of the relevant *TSO* demonstrating that substantial progress has been made towards achieving full compliance.

(5) The FON shall be suspended during the period of validity of the LON with regard to the items for which the LON has been issued.

(6) A further extension of the period of validity of the LON may be granted upon a request for a derogation made to the relevant *TSO* before the expiry of that period, in accordance with the derogation procedure described in this Code.

(7) The relevant *TSO* shall have the right to refuse to allow the operation of *Demand facilities* once the LON is no longer valid. In such cases, the FON shall automatically become invalid.

(8) If the relevant *TSO* does not grant an extension of the period of validity of the LON in accordance with this section or if it refuses to allow the operation of the transmission-connected *Demand facility*, the *Demand facility* owner may refer the issue to the regulatory authority for decision within six months after the notification of the decision of the relevant *TSO*.

4.10.3 Compliance testing process

(1) The *Demand facilities* owners shall ensure that *Demand facilities* comply with the requirements applicable under this Code throughout the lifetime of the facilities.

(2) The *Demand facilities* owners shall notify to the relevant system operator any planned modification of the *Demand facilities* which may affect its compliance with the requirements applicable under this Code, before initiating that modification.

(3) The *Demand facilities* owners shall notify the relevant system operator of any operational incidents *Demand facilities* that affect its compliance with the requirements of this Code, without undue delay, after the occurrence of those incidents.

(4) The *Demand facilities* owner shall notify the relevant system operator of the planned test schedules and procedures to be followed for verifying the compliance of *Demand facilities* with the requirements of this Code, in due time and prior to their launch. The relevant system operator shall approve in advance the planned test schedules and procedures. Such approval by the relevant system operator shall be provided in a timely manner and shall not be unreasonably withheld.

(5) The relevant system operator may participate in such tests and record the performance of the *Demand facilities*.

(6) The relevant system operator shall assess the compliance of *Demand facilities* with the requirements applicable under this Code, throughout the lifetime of the *Demand facilities*. The *Demand facilities* owners shall be informed of the outcome of this assessment.

(7) The relevant system operator shall have the right to request that the *Demand facilities* owners carry out compliance tests and simulations according to a repeat plan or general scheme or after any failure, modification or replacement of any equipment that may have an impact on the *Demand facilities* compliance with the requirements of this Code. *Demand facility*

(8) The relevant system operator shall make publicly available a list of information and documents to be provided as well as the requirements to be fulfilled by *Demand facilities* owners within the framework of the compliance process. The list shall cover at least the following information, documents and requirements:

(a) all the documentation and certificates to be provided by the *Demand facilities* owners;

(b) details of the technical data on the *Demand facilities* of relevance to the grid connection;

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

(d) timeline for the provision of system data required to perform the studies;

(e) studies by the *Demand facilities* owners to demonstrate the expected steady-state and dynamic performance in accordance with the requirements set out in this code;

(f) conditions and procedures, including the scope, for registering equipment certificates; and

(g) conditions and procedures for the use of relevant equipment certificates issued by an authorised certifier by the *Demand facilities* owners.

(9) The relevant system operator shall make public the allocation of responsibilities between the *Demand facilities* owners and the system operator for compliance testing, simulation and monitoring.

(10) The relevant system operator may totally or partially delegate the performance of its compliance monitoring to third parties.

(11) If compliance tests or simulations cannot be carried out as agreed between the relevant system operator and the *Demand facilities* owners due to reasons attributable to the relevant system operator, then the relevant system operator shall not unreasonably withhold the operational notification.

(12) Testing of the performance of *Demand facilities* shall aim at demonstrating that the requirements of this Code have been complied with.

(13) Notwithstanding the minimum requirements for compliance testing set out in this Code, the relevant system operator is entitled to:

(a) allow *Demand facilities* owners to carry out alternative sets of tests, provided that those tests are efficient and suffice to demonstrate that *Demand facilities* comply with the requirements of this Code

(b) require the *Demand facilities* owners to carry out additional or alternative sets of tests in those cases where the information supplied to the relevant system operator in relation to compliance testing under the provisions of this Code, is not sufficient to demonstrate compliance with the requirements of this Code; and

(14) The *Demand facilities* owners are responsible for carrying out the tests in accordance with the conditions laid down in the Code. The relevant system operator shall cooperate and not unduly delay the performance of the tests.

(15) The relevant system operator may participate in the compliance testing either on site or remotely from the system operator's control centre. For that purpose, the *Demand facilities* owners shall provide the monitoring equipment necessary to record all relevant test signals and measurements as well as to ensure that the necessary representatives of the *Demand facilities* owners are available on site for the entire testing period. Signals specified by the relevant system operator shall be provided if, for selected tests, the system operator wishes to use its own equipment to record performance. The relevant system operator has sole discretion to decide about its participation.

4.10.4 Compliance testing for disconnection and reconnection of *Demand facilities*

(1) The *Demand facilities* shall comply with the requirements for disconnection and reconnection and shall be subject to the following compliance tests.

(2) With regard to testing of the capability of reconnection after an incidental disconnection due to a network disturbance, reconnection shall be achieved through a reconnection procedure, preferably by automation, authorised by the relevant *TSO*.

(3) With regard to the synchronisation test, the technical synchronisation capabilities of *Demand facilities* shall be demonstrated. This test shall verify the settings of the

synchronisation devices. This test shall cover the following matters: voltage, frequency, phase angle range, deviation of voltage and frequency.

(4) With regard to the remote disconnection test, the capability of *Demand facility's* for remote disconnection at the connection point or points from the transmission system when required by the relevant *TSO* and within the time specified by the relevant *TSO* shall be demonstrated.

(5) With regard to the low frequency demand disconnection test, the technical capability of *Demand facility's for* low frequency demand disconnection of a percentage of demand to be specified by the relevant *TSO*, in coordination with adjacent *TSOs*, where equipped, shall be demonstrated.

(6) With regard to the low frequency demand disconnection relays test, the technical capability of *Demand facilities* to operate from a nominal AC supply input shall be demonstrated in accordance with this Code. This AC supply input shall be specified by the relevant *TSO*.

(7) With regard to the low voltage demand disconnection test, the technical capability of *Demand facilities* to operate in a single action with on load tap changer blocking in this code shall be demonstrated.

(8) An equipment certificate may be used instead of part of the tests required, on the condition that it is provided to the relevant *TSO*.

4.10.5 Compliance simulations for *Demand facilities*

(1) *Demand facilities* are subject to the compliance simulations detailed in this Code. Equipment certificates may be used instead of part of the simulations described below, on the condition that they are provided to the relevant system operator.

(2) With regard to the reactive power capability simulation of *Demand facilities* without onsite generation:

(a) the reactive power capability at the connection point of *Demand facilities* without onsite generation shall be demonstrated;

(b) load flow simulation models of the *Demand facilities* shall be used to calculate the reactive power exchange under different load conditions. Minimum and maximum load conditions resulting in the lowest and highest reactive power exchange at the connection point shall be part of the simulations;

(c) the simulation shall be deemed passed if the results demonstrate compliance with the requirements set out in this Code.

(3) With regard to the reactive power capability simulation of *Demand facilities* with onsite generation:

(a) load flow simulation models of the *Demand facilities* shall be used to calculate the reactive power exchange under different load conditions and under different generation conditions;

(b) a combination of minimum and maximum load and generation conditions resulting in the lowest and highest reactive power capability at the connection point shall be part of the simulations;

(c) the simulation shall be deemed passed if the results demonstrate compliance with the requirements set out in this Code.

4.10.6 Derogations

(1) Regulatory authorities (or another applicable authority in a GMS Member State) may, at the request of a *Demand facility* owner or prospective owner, relevant system operator or relevant *TSO*, grant *Demand facility* owners or prospective owners, relevant system operators or relevant *TSOs*, derogations from one or more provisions of this Code for new and existing *Demand facility* in accordance with this Code.

(2) Each regulatory authority shall specify, after consulting relevant system operators and *Demand facility* owners and other stakeholders whom it deems to be affected by this Code, the criteria for granting derogations pursuant to this Code. It shall publish those criteria on its website and notify them to the RPCC within nine months of the entry into force of this Code. The RPCC may require a regulatory authority to amend the criteria if it considers that they are not in line with this Code. This possibility to review and amend the criteria for granting derogations shall not affect the derogations already granted which shall continue to apply until the scheduled expiry date as detailed in the decision granting the exemption.

(3) If the regulatory authority deems that it is necessary due to a change in circumstances relating to the evolution of system requirements, it may review and amend at most once every year the criteria for granting derogations. Any changes to the criteria shall not apply to derogations for which a request has already been made.

(4) The regulatory authority may decide that *Demand facilities* for which a request for a derogation has been filed pursuant to this Code do not need to comply with the requirements of this Code from which a derogation has been sought from the day of filing the request until the regulatory authority's decision is issued.

(5) *Demand facility* owners, or prospective owners, may request a derogation to one or several requirements of this Code for their *Demand facilities*.

(6) A request for a derogation shall be filed with the relevant system operator and include:

(a) an identification of the *Demand facility* owner, or prospective owner, and a contact person for any communications;

(b) a description of the *Demand facility* section for which a derogation is requested;

(c) a reference to the provisions of this Code from which a derogation is requested and a detailed description of the requested derogation;

(d) detailed reasoning, with relevant supporting documents and cost-benefit analysis pursuant to the requirements this Code; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade.

(7) Within two weeks of receipt of a request for a derogation, the relevant system operator shall confirm to the *Demand facility* owner, or prospective owner, whether the request is complete. If the relevant system operator considers that the request is incomplete, the *Demand facility* owner, or prospective owner, shall submit the additional required information within one month from the receipt of the request for additional information. If

the *Demand facility* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn.

(8) The relevant system operator shall, in coordination with the relevant *TSO* and any affected adjacent DSO or DSOs, assess the request for a derogation and the provided cost-benefit analysis, taking into account the criteria determined by the regulatory authority or appointed authority.

(9) Within six months of receipt of a request for a derogation, the relevant system operator shall forward the request to the regulatory authority and submit the assessment(s). That period may be extended by one month where the relevant system operator seeks further information from the *Demand facility* owner, or prospective owner and by two months where the relevant system operator requests the relevant *TSO* to submit an assessment of the request for a derogation.

(10) The regulatory authority shall adopt a decision concerning any request for a derogation within six months from the day after it receives the request. That time limit may be extended by three months before its expiry where the regulatory authority requires further information from the *Demand facility* owner, or prospective owner, or from any other interested parties. The additional period shall begin when the complete information has been received.

(11) The *Demand facility* owner, or prospective owner, shall submit any additional information requested by the regulatory authority within two months of such request. If the *Demand facility* owner, or prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn unless, before its expiry:

(12) the *Demand facility* owner, or prospective owner, informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(13) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants a derogation, it shall specify its duration.

(14) The regulatory authority shall notify its decision to the relevant *Demand facility* owner, or prospective owner, the relevant system operator and the relevant *TSO*.

(15) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(16) Relevant system operators or relevant *TSOs* may request derogations for classes of *Demand facilities* connected or to be connected to their network.

(17) Relevant system operators or relevant *TSOs* shall submit their requests for derogations to the regulatory authority. Each request for a derogation shall include:

(a) identification of the relevant system operator or relevant *TSO*, and a contact person for any communications;

(b) a description of the *Demand facilities* for which a derogation is requested;

(c) the requirement or requirements of this Code for which a derogation is requested, with a detailed description of the requested derogation;

(d) detailed reasoning, with all relevant supporting documents; and

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade;

(18) Where the request for a derogation is submitted by a relevant DSO, the regulatory authority shall, within two weeks from the day after receipt of that request, ask the relevant *TSO* to assess the request for a derogation in the light of the criteria determined by the regulatory authority.

(19) Within two weeks from the day after the receipt of such request for assessment, the relevant *TSO* shall confirm to the relevant DSO whether the request for a derogation is complete. If the relevant *TSO* considers that it is incomplete, the relevant DSO shall submit the required additional information within one month from the receipt of the request for additional information.

(20) Within six months of receipt of a request for a derogation, the relevant *TSO* shall submit to the regulatory authority its assessment, including any relevant documentation. The six-month time limit may be extended by one month where the relevant *TSO* seeks further information from the relevant DSO.

(21) The regulatory authority shall adopt a decision concerning a request for a derogation within six months from the day after it receives the request. Where the request for a derogation is submitted by the relevant DSO, the six- month time limit runs from the day following receipt of the relevant *TSO's* assessment.

(22) The six-month time limit referred to above may, before its expiry, be extended by an additional three months where the regulatory authority requests further information from the relevant system operator requesting the derogation or from any other interested parties. That additional period shall run from the day following the date of receipt of the complete information.

(23) The relevant system operator shall provide any additional information requested by the regulatory authority within two months from the date of the request. If the relevant system operator does not provide the requested additional information within that time limit, the request for a derogation shall be deemed withdrawn unless, before expiry of the time limit:

(24) The relevant system operator informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

(25) The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants derogation, it shall specify its duration.

(26) The regulatory authority shall notify its decision to the relevant system operator requesting the derogation, the relevant *TSO*.

(27) Regulatory authorities may lay down further requirements concerning the preparation of requests for derogation by relevant system operators. In doing so, regulatory authorities shall take into account the delineation between the transmission system and the distribution system at the national level and shall consult with system operators, *Demand facility* owners and stakeholders, including manufacturers.

(28) A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the RPCC.

(29) Regulatory authorities shall maintain a register of all derogations they have granted or refused and shall provide the RPCC with an updated and consolidated register at least once every six months.

(30) The register shall contain, in particular:

(a) the requirement or requirements for which the derogation is granted or refused;

(b) the content of the derogation;

(c) the reasons for granting or refusing the derogation;

(d) the consequences resulting from granting the derogation.

(31) The RPCC shall monitor the procedure of granting derogations with the cooperation of the regulatory authorities or relevant authorities of the GMS Member State. Those authorities or relevant authorities of the Member State shall provide the RPCC with all the information necessary for that purpose.

(32) The RPCC may issue a reasoned recommendation to a regulatory authority or relevant authority of the GMS Member State to revoke derogation due to a lack of justification.

ANNEX: Connection Code – History of Comments

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
1.	Thailand	Section 2.1 (2a)	Missing – in Table 2-1	Corrected in version 0.3	
2.	Thailand	Table 2-3 Type C &D	f2,f3 (may be f1 and f4) should be consistent with LFC	Confirmed values are consistent with LFC code	
3	Thailand	Section 2.5 (3c)	May add “Generator Shedding”	Added in version 0.3	
4	Thailand	Section 3.2.2 (5)	Change The metering accuracy for the grid frequency shall be at least ± 10 mHz to ± 20 mHz.	10 mHz is the international standard so no change recommended	
5	Thailand	Section 3.2.1 (3)	Delete high frequency tripping > 51.0 Hz	No change recommended. If frequency is greater than 51 Hz (the IEC standard) the HVDC system may trip to protect damage to the HVDC system. Trip setting has to be agreed with TSO.	
6	Thailand	Section 4.2.1 (1)	Table of Under Frequency Relay Setting should be added.	Table 4.2 added with proposed Under Frequency Relay Settings	
7	Thailand	General	Connection Code is a very detail document for Regional Interconnection	Understood but this is in line with international best practice. Specifically when IPP’s, ITC’s and independent Demands are part of the interconnected system and trading in GMS.	
8	China	Section 2 and 3	We suggest PMU (Phase Measure Unit) should be installed in power plant where type C and D generators connected to system above 230kV.	Agree – section 2.2.2 (11) and section 3.2.2 (11) added to version 0.3	

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
9	China	Section 2.2	We suggest the active power adjust capability should be defined for nuclear power plant. For example, in China, the nuclear generator should be able to decrease power to 80% of nominal capacity in 3 hours and decrease to 50% of nominal capacity in 6 hours.	Agree – section 2.2.2 (12) added to version 0.3.	
10	China	Section 3.4	For wind farm, reactive power compensation devices should be installed in wind farm when reactive capacity of wind generators does not match the demand of system voltage control, among which at least 50% of the capacity should be dynamic reactive compensation device.	Disagree – no change proposed - EU setting 0.95 total range 0.5 lagging and 0.45 leading..	
11	China	Section 3.12	Wind power forecasting system should be deployed for wind farm and reported to the relevant system operator which could forecast wind power for the coming 72 hours. The RMS (root mean square) of forecasting should be less than 15%.	Section 3.12.1 (3) & (4) added to version 0.3. Forecast for following day added for HVDC systems and DC connected systems.	
12	China	Section 3.10 (3)	A fiber optic current differential protection should be deployed for transmission line above 110kV for wind farm.	Agreed added to version 0.3 Section 3.10 (3). Note 110kV is automatically type C or D.	
13	China		What is the meaning of f6 in figure 2-1 and 3-1?	Deleted f6 and simplified Figure 2.1 / 3.1 and tables 2.3 / 3.3/ 3.4 have been changed. Text has been corrected. Corrections done to version 0.3.	
14	China		AGC (automatic generation control) function should be necessary for type C and D generator. Furthermore, the amount of AGC capacity should be defined, such as not less than 40%. .	Agree – text added to section 2.2.2 (10) added to version 0.3.	

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
15	China		The active power vibration zone of hydro generator should be defined, such as less than 45% of its nominal capacity in China.	Agree – paragraph added as section 2.2.2 (11) in version 0.3.	
16	China	Section 3.8 & 4.3	The short Circuit Current Level Table, 2-6,3-8 and 4-4, we suggest a higher standard as the following value should be considered, because the power grid will become more and more close connected.	Disagree – no changes proposed. These short Circuit Current Levels were agreed in the GMS performance standard. China can have tighter settings internally.	
17	China	Section 4.3	The Maximum Fault Clearance Time in table 4-5, we suggest the time for 500kV could be changed from 80 ms to 80 – 90 ms.	Disagree – no changes proposed. The 80 ms Maximum Fault Clearance Time was agreed in the GMS performance standard.	
18	Vietnam	Section 2	How about the requirements of relay protection, coordinated protection.	This is a TSO function is described in section 2.5 (3).	
19	Vietnam	Section 2.1	How about the requirements for RE (wind and solar); we do not think the technical requirements is similar to traditional generations.	Agree this is stipulated in section 3.1 DC (non-synchronously) connected power park modules.	
20	Vietnam	Table 2-1	Threshold in VN Grid Code is 30 MW; and the specific requirements are also depended on what is voltage level you connect. For example, above 220kV and under 220kV. Pls clarify the differences between 40MW and 75MW requirements?	40 MW is the GMS performance requirement whereas IEC 60000 is from 20 MVA. 75 MW is the European grid code requirement. The voltage requirement is already specified and above 110 kV is automatically type D and is the European requirement.	

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
21	Vietnam	Section 2	VN GC stipulated detailed requirement of AGC, PSS, PMU - Phasor Measurement Unit, IT communication at connection point, SCADA/EMS/DMS,…. For interconnection, it's better for large power plants.	The detailed requirements for AGC are the responsibility of the relevant TSO and depends on SCADA / EMS system in place. PSS settings have to be determined by relevant TSO in conjunction with RPCC. See security code. PMU's have been added see point 8 above. IT comms covered in information exchange code. SCADA/EMS/DMS functionality described in system operations codes.	

<table>
<tr><th>#</th><th>Country</th><th>Reference section in the document</th><th>Country Comment</th><th>Consultants Review and Recommendation</th><th>Country Acceptance</th></tr>
<tr><td>22</td><td>Vietnam</td><td></td><td>In Vietnam, Grid Code stipulate as follows:
<table>
<tr><th rowspan="2">Frequency band</th><th colspan="2">Minimum time</th></tr>
<tr><th>Hydro power plants</th><th>Thermo power plants</th></tr>
<tr><td>From 46 Hz to 47.5 Hz</td><td>20 seconds</td><td>Not required</td></tr>
<tr><td>From 47.5 Hz to 48.0 Hz</td><td>10 minutes</td><td>10 minutes</td></tr>
<tr><td>From 48 Hz to under 49 Hz</td><td>30 minutes</td><td>30 minutes</td></tr>
<tr><td>From 49 Hz to 51 Hz</td><td>Continuous generation</td><td>Continuous generation</td></tr>
<tr><td>From 51 Hz to 51.5 Hz</td><td>30 minutes</td><td>30 minutes</td></tr>
<tr><td>From 51.5 Hz to 52 Hz</td><td>03 minutes</td><td>01 minute</td></tr>
</table></td><td>Values in grid code are what was agreed in GMS performance standard. No changes proposed. Vietnam can have higher standard for isolated operations.</td><td></td></tr>
<tr><td>23</td><td>Vietnam</td><td></td><td>In order to support the frequency control, the large power plants (above 30MW in Vietnam) must equipped AGC. For interconnection, it should be done.</td><td>GMS performance standard agreed on 40 MW. IEC 60000 is 20 MVA and above.</td><td></td></tr>
<tr><td>24</td><td>Vietnam</td><td></td><td>VN Grid Code is 0.9 power factor lagging for Hydro and Thermal plants and 0.95 for Wind and solar plants.</td><td>Values in grid code are what was agreed in GMS performance standard. No changes proposed. Vietnam can have higher standard.</td><td></td></tr>
<tr><td>25</td><td>Vietnam</td><td></td><td>VN GC requires under range 46 Hz to 49 Hz and over 51 Hz.</td><td>See point 22 above.</td><td></td></tr>
<tr><td>26</td><td>Vietnam</td><td></td><td>Deadband in VN is -0.05Hz- + 0.05Hz.</td><td>+- 0.02 Hz agreed in GMS performance standard. I think that this could be wider but have stuck to what was agreed.</td><td></td></tr>
</table>

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
27	Vietnam		Primary FC is very importance for any interconnection system. It should be required for all kind of type.	The settings are in line with international standards – see changes below.	
28	Vietnam	Table 2.3, 3.3 & 3.4.	Could you pls explain the requirements of Type A in the table. As far as understand that type A will not be required to provide FC?	Most international standards requires mandatory primary frequency response for all units above 50.5 Hz.	
29	Vietnam	Table 2.6	VN GC requires 50 kA maximum fault level current for 220 -230 kV.	Disagree – no changes proposed. These short Circuit Current Levels were agreed in the GMS performance standard.	
30	Vietnam	Table 2.6	What's requirements for 110kV bus bar of 500 or 220kV Substation. VN GC allows 40kA.	The ratings are for all equipment specification – mainly for breakers.	
31	Vietnam	Section 3	What are differences between HVDC connection and AC?. Would you pls show us?	There are a few changes. Section 3.3 Synthetic inertia, section 3.5 short circuit fault contribution, Section 3.6 power oscillation damping, section 3.9 power quality and harmonic damping, some protection requirements in section 3.10 being the main – the main thing is that the same frequency and voltage criteria.	
32	Vietnam	Section 4	Should we have detailed regulations for customers connection?; we are not sure that how much influence the customer/demand to interconnection grid?. The consultant is requested to clarify and explain for us.	Large consumers that can impact interconnection must meet requirements plus customers that are members of GMS (trading).	
33	Vietnam	Section 4.3 (4)	VN GC requires maximum clearance time is 100 ms.	Disagree – no changes proposed. The 100 - 120ms Maximum Fault Clearance Time was agreed in the GMS performance standard. VN code can be the strictest value without violating grid code.	

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
34	Vietnam		Add more provisions on the connection of the AC power systems through the Back to back converter stations.	To be discussed - what additional requirements is Vietnam thinking of that are missing from the Connection Code?	
35	Vietnam	Section 2.3 (1)	In the Responsibility Area of those TSO that decide in accordance with Table 2.5 of the Connection Code [Section 2 – RfG] that Power Generating Modules connected to nominal voltages between 300 kV and 400 kV shall stay connected for an unlimited time in the voltage range from 0.90 to 1.05 pu. - Complement regulations for Power Generating Modules that connected to nominal voltages above 400kV. - Specify the voltage range 0.90 to 1.05 pu for the terminal side or HV side of Power Generating Modules.	Type D generators are those connected to 132 kV and above – section 2.3 (4). I'm not sure where the reference to 300 – 400 kV comes from. This is the same as in the European Code. Do you want to add an additional category for generators connected to 300 kV and above?	
36	Vietnam	Section 2.4.1 (d)	(i) different short circuit capacity, does each TSO need specify short circuit capacity for all connection point? (iii) Pre-fault and post fault short circuit capacity will have the same value. Please clarify why is it needed?	TSO shall specify the short circuit capacity, it does not have to be different for each connection point. The values can't exceed the values agreed in Table 2.6. The value could be stricter. Post fault will have a different value as the network configuration has changed. A line or transformer has tripped. The post fault calculation is required for auto-reclose devices.	
37	Vietnam	Section 2.5 (1)	- Regulations in paragraph (5) of Section 2.4 of this Network Code not related to the Power Flow Management. - Paragraph (8) of Section 2.4 of this Network Code not exist.	Please clarify comments as there is no cross referencing in my version of connection code section 2.5 (1).	

#	Country	Reference section in the document	Country Comment	Consultants Review and Recommendation	Country Acceptance
38	Vietnam	Section 2.5	Add: - For the case that the relay protection of power-generating facility owner need to connect with Grid relay protection, the relay protection of power-generating facility owner must satisfy the TSO requirement and have the acceptance of SO. - The reliability of relay protection must not less than 99% - Power plant must have FR with GPS - Power plant bigger than 300MW must have PMU with GPS. Line that connect the Power plant connecting to 220kV grid must have 2 separate communication channel for Relay protection.	Agree. Version 0.4 updated. Paragraph 2.5 (5) added for protection relay requirements. Paragraph 2.5 (6) added with fault recorder and PMU requirements.	
39	Vietnam	Section 2.8	It should have the regulation in detail regarding to dynamic performance test of excitation system, especially the test of PSS behavior (refer to WECC, NERC regulation). What is the role of SO in the tests? such as the requirement of excitation and governor controller?	Agree please provide the relevant test requirements. We can reference the tests in NERC or IEEE. To be discussed at next meeting. The SO can be a witness or participate in tests (section 2.8 (5)) SO is required sign off that the tests demonstrate grid code compliance. (section 2.8 (6)). SO can request additional tests (section 2.8 (7)).	
40	Vietnam	Section 3.2.2	The droop settings shall be between 2% and 12%. – this is too wide.	Disagree. This is the international standard – no change recommended.	
41	Vietnam	Section 3.9	Should add requirement for Total Harmonic Distortion.	Agree - Section 4.10 (3) added with reference to IEC 61000 - 4.	
42	Vietnam	Section 3.13.6	Should add article on monitoring harmonic after commissioning of DC-connected power park modules.	Agree - Section 4.10 (4) added with reference to IEC 61000 - 4.	