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# Frequency ranges

ENTSO-E guidance document for national  
implementation for network codes on grid connection

31 January 2018

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**DESCRIPTION****Code(s) &  
Article(s)**

- Network code on requirements for grid connection of generators (NC RfG) – EU regulation 2016/631 of 14 April 2016: Article 13 and Article 16(2)(a).
- Network code on demand connection (NC DCC) - 2016/1388 of 17 August 2016: Article 12.
- Network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules HVDC (NC HVDC) – EU regulation 2016/1447 of 26 August 2016: Article 11 and Article 39(2)(a).

This document addresses the frequency ranges required for AC transmission and distribution lines, including HVDC systems on AC lines, as well as power generation and demand facilities.

The general principles for frequency ranges and time duration requirements are as follows:

- Frequency ranges for transmission and distribution network lines, including HVDC systems on AC lines, to stay connected to the system must be wider than for power generating and demand facilities.
- Frequency ranges for power generating facilities to stay connected to the system must be wider than for demand facilities.
- Frequency ranges for demand facilities to stay connected to the system must be narrower than for power generating facilities.

NC RfG requirements in article 13(1)(a) specify the following:

With regard to frequency ranges:

- (i) a power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 2;
- (ii) the relevant system operator, in coordination with the relevant TSO, and 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 module, if it is required to preserve or to restore system security;
- (iii) the power-generating facility owner shall not unreasonably withhold consent to apply wider frequency ranges or longer minimum times for operation, taking account of their economic and technical feasibility.

**Introduction**

NC RfG requirements in article 16(2)(a)(ii) specify the following:

Type D power-generating modules shall fulfil the following requirements relating to voltage stability:

With regard to voltage ranges:

- (ii) 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;

NC DCC requirements in article 12 specify the following:

1. Transmission-connected demand facilities, transmission-connected distribution facilities and distribution systems shall be capable of remaining connected to the network and operating at the frequency ranges and time periods specified in Annex I.
2. The transmission-connected demand facility owner or the DSO may agree with the relevant TSO on wider frequency ranges or longer minimum times for operation. If wider

frequency ranges or longer minimum times for operation are technically feasible, the consent of the transmission-connected demand facility owner or DSO shall not be unreasonably withheld.

NC HVDC requirements in article 11 specify the following:

1. An HVDC system shall be capable of staying connected to the network and remaining operable within the frequency ranges and time periods specified in Table 1, Annex I for the short circuit power range as specified in Article 32(2).
2. The relevant TSO and HVDC system owner may agree on wider frequency ranges or longer minimum times for operation if needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the HVDC system owner shall not unreasonably withhold consent.
3. Without prejudice to paragraph 1, an HVDC system shall be capable of automatic disconnection at frequencies specified by the relevant TSO.
4. The relevant TSO may specify a maximum admissible active power output reduction from its operating point if the system frequency falls below 49 Hz.

NC HVDC requirements in article 39(2) specify the following:

- a. With regard to frequency ranges and response: a DC-connected power park module shall be capable of staying connected to the remote-end HVDC converter station network and operating within the frequency ranges and time periods specified in Annex VI for the 50 Hz nominal system. Where a nominal frequency other than 50 Hz, or a frequency variable by design is used, subject to agreement with the relevant TSO, the applicable frequency ranges and time periods shall be specified by the relevant TSO taking into account specificities of the system and the requirements set out in Annex VI; 8.9.2016 L 241/20 Official Journal of the European Union EN;
- b. wider frequency ranges or longer minimum times for operation can be agreed between the relevant TSO and the DC-connected power park module owner to ensure the best use of the technical capabilities of a DC-connected power park module if needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the DC-connected power park module owner shall not unreasonably withhold consent;
- c. while respecting the provisions of point (a) of paragraph 2, a DC-connected power park module shall be capable of automatic disconnection at specified frequencies, if specified by the relevant TSO. Terms and settings for automatic disconnection shall be agreed between the relevant TSO and the DC-connected power park module owner.

In relation to the increased withstand capability stated in NC RfG article 13(1)(a)(ii):

Preserving or restoring system security, as mentioned in article 13(1)(a)(ii), should cover black-start restoration schemes as well as operation of local transmission system areas (such as countries or national regions) which have a higher risk of being operated in a system split mode a wider withstand capabilities could enhance the system stability. Therefore, an agreement with a power generating facility owner must focus on wider withstand capabilities than those specified in article 13(1)(a)(ii).

In relation to the combined effect of frequency and voltage ranges stated in NC RfG article 16(2)(a)(ii) :

Unless the non-mandatory requirement in article 16(2)(a)(ii) is implemented at a national level, the combined effect of frequency and voltage ranges (for type D PGM) must be understood as the minimum time of operation provided by the implementation of article 13(1)(a)(i) and article 16(2)(a)(i).

	<p><b>Key definitions:</b></p> <p>None</p>
<p><b>NC frame</b></p>	<p>Non-exhaustive topics are those for which European-level CNCs do not contain all information or parameters necessary to apply the requirements immediately. These requirements are typically described in the CNCs as “TSO / relevant system operator shall define” or “defined by / determined by / in coordination with the TSO / relevant TSO”.</p> <p>Even though values must be set at a national level, frequency-related issues normally require a system-wide response, meaning that collaboration between TSOs at the synchronous area level is necessary.</p> <p>See also the general IGD on parameters related to frequency stability.</p>
<p><b>Further info</b></p>	<p>The latest NCs and further information are available here:</p> <ul style="list-style-type: none"> <li>[1] Network Code on requirements for grid connection of generators (NC RfG) - EU regulation 2016/631</li> <li>[2] Network Code on Demand Connection (NC DCC) – EU regulation 2016/1388</li> <li>[3] Network Code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules(NC HVDC) – Eu regulation 2016/1447</li> <li>[4] ENTSO-E Network Code for HVDC Connections and DC-connected Power Park Modules; Explanatory Note, 30 April 2014</li> <li>[5] System Operational Guideline (SO GL) - EU regulation 2017/1485</li> </ul>
<p><b>INTERDEPENDENCIES</b></p>	
<p><b>Between the CNCs</b></p>	<ul style="list-style-type: none"> <li>• NC DCC article 19(1)(c)(i)</li> <li>• NC DCC article 28(2)(a)</li> <li>• NC HVDC article 39(2)(a)</li> </ul>
<p><b>With other NCs</b></p>	<p>Interrelations with SO GL - Minimum specifications for Frequency Containment Reserves, according to SO GL, article 154(6)</p>
<p><b>System characteristics</b></p>	<p>Not applicable</p>
<p><b>Technology characteristics</b></p>	<p>Not applicable</p>
<p><b>COLLABORATION</b></p>	
<p><b>TSO – TSO</b></p>	<p>The Synchronous Area Operational Agreement (SAOA) must clearly state where times exceeding the minimum time requirements according to NC RfG, NC DCC and the HVDC are required.</p>
<p><b>TSO – DSO</b></p>	<p>All network components installed in the transmission and distribution grid system must be able to operate within the frequency and time duration requirements specified.</p>

**RSO – Grid User**

The RSO and grid users must ensure that power generating facilities, demand facilities and HVDC systems are able to operate within the frequency and time duration requirements specified.

According to NC RfG requirement Article 13(1), requirements to power generating units are illustrated in the following table.

Ranges	Synchronous area				
	GB	IE / NI	Baltic	Nordic	CE
47,0 Hz-47,5 Hz	20 seconds				
47,5 Hz-48,5 Hz	90 minutes	90 minutes	To be specified by each TSO, but not less than 30 minutes	30 minutes	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 90 minutes	To be specified by each TSO, but not less than 90 minutes	To be specified by each TSO, but not less than the period for 47,5 Hz-48,5 Hz	To be specified by each TSO, but not less than 30 minutes	To be specified by each TSO, but not less than the period for 47,5 Hz-48,5 Hz
49,0 Hz-51,0 Hz	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
51,0 Hz-51,5 Hz	90 minutes	90 minutes	To be specified by each TSO, but not less than 30 minutes	30 minutes	30 minutes
51,5 Hz-52,0 Hz	15 minutes				

**Methodology**

Recommendations for frequency ranges and time duration for each synchronous area for power generating facilities are specified in the following tables.

Frequency range and time duration requirements for demand facilities and HVDC systems must follow the general principles stated in the introduction section.

Region CE:

Ranges	Synchronous area	
	CE	Proposal of WG CNC
47,0 Hz-47,5 Hz		
47,5 Hz-48,5 Hz	To be specified by each TSO, but not less than 30 minutes	30 minutes, but longer minimum time periods may be required for countries, which are exposed to a higher risk of islanding (e.g. peninsular area) to allow for an extended period of time for system restoration
48,5 Hz-49,0 Hz	To be specified by each TSO, but not less than the period for 47,5 Hz-48,5 Hz	30 minutes, but longer minimum time periods may be required for countries, which are exposed to a higher risk of islanding (e.g. peninsular area) to allow for an extended period of time for system restoration
49,0 Hz-51,0 Hz	Unlimited	Unlimited
51,0 Hz-51,5 Hz	30 minutes	30 minutes
51,5 Hz-52,0 Hz		

Region Nordic:

Ranges	Synchronous area	
	Nordic	Proposal of WG CNC
47,0 Hz-47,5 Hz	-----	-----
47,5 Hz-48,5 Hz	30 minutes	30 minutes
48,5 Hz-49,0 Hz	To be specified by each TSO, but not less than 30 minutes	30 minutes
49,0 Hz-51,0 Hz	Unlimited	Unlimited
51,0 Hz-51,5 Hz	30 minutes	30 minutes
51,5 Hz-52,0 Hz	-----	-----

Region Baltic:

Ranges	Synchronous area	
	Baltic	Proposal of WG CNC
47,0 Hz-47,5 Hz	-----	-----
47,5 Hz-48,5 Hz	To be specified by each TSO, but not less than 30 minutes	30 minutes
48,5 Hz-49,0 Hz	To be specified by each TSO, but not less than the period for 47,5 Hz-48,5 Hz	To be specified by each TSO, but not less than 30 minutes
49,0 Hz-51,0 Hz	Unlimited	Unlimited
51,0 Hz-51,5 Hz	To be specified by each TSO, but not less than 30 minutes	30 minutes
51,5 Hz-52,0 Hz	-----	-----

Region IE/NI:

Ranges	Synchronous area	
	IE /NI	Proposal of WG CNC
47,0 Hz-47,5 Hz	-----	-----
47,5 Hz-48,5 Hz	90 minutes	90 minutes
48,5 Hz-49,0 Hz	To be specified by each TSO, but not less than 90 minutes	90 minutes
49,0 Hz-51,0 Hz	Unlimited	Unlimited
51,0 Hz-51,5 Hz	90 minutes	90 minutes
51,5 Hz-52,0 Hz	-----	-----

Region GB:

Ranges	Synchronous area	
	GB	Proposal of WG CNC
47,0 Hz-47,5 Hz	20 seconds	20 seconds
47,5 Hz-48,5 Hz	90 minutes	90 minutes
48,5 Hz-49,0 Hz	To be specified by each TSO, but not less than 90 minutes	90 minutes
49,0 Hz-51,0 Hz	Unlimited	Unlimited
51,0 Hz-51,5 Hz	90 minutes	90 minutes
51,5 Hz-52,0 Hz	15 minutes	15 minutes