

INITIAL RfG FREQUENCY PARAMETER SELECTION

BASED ON DRAFT RfG VALUES

Issue	Article	Level of Difficulty (1-5)	Requirement	Range		Suggested GB Value		Comments
	Type A							
1.	13.1(a)		Frequency Ranges	47 – 47.5Hz 47.5 – 48.5Hz 48.5 – 49.0Hz 49.0 – 51.0Hz 51.0 – 51.5Hz 51.5 – 52Hz	20 seconds 90 minutes TSO defined (not less than 90mins) Unlimited 90 minutes 15 minutes	47 – 47.5Hz 47.5 – 49.0Hz 49.0 – 51Hz 51.0 – 51.5Hz 51.5 – 52Hz	20 seconds 90 minutes Continuous 90 minutes 15 minutes	Already consistent – no change required (CC.6.1.3) Slight discrepancy with the distribution code but this should be covered by RfG changes.
	13.1(b)		Rate of change of frequency	Specified by TSO				Not currently included in this workgroup. Under GC0079 at present.
2.	13.2		LFSM-O	Frequency threshold Droop	50.2 – 50.5Hz 2 – 12%	Frequency threshold Droop	50.4Hz 10%	Already consistent with BC.3.7.2 except Activation Time Activation time more or less fixed in RfG.
3.	13.3		Maintenance of Constant Active Power regardless of changes in System Frequency	49.5 – 50.5 Hz? – By interpretation		49.5 – 50.4Hz		Already consistent with CC.6.3.3
4.	13.4 & 13.5		Power Output with Falling Frequency	Below 49Hz falling by a reduction rate of 2% of the Maximum Capacity at 50Hz per 1Hz Frequency drop Below 49.5Hz by a reduction rate of 10% of the maximum Capacity at 50Hz per 1Hz Frequency drop		Power Output should not drop by more than prorata with frequency (ie maximum permitted requirement is 100% power at 49.5Hz falling linearly to 95% at 47.0Hz)		Already consistent with CC.6.3.3
	Type C							
5.	15.2(c)		LFSM-U	Frequency Threshold Droop Activation Time	49.8–49.5Hz 2 – 12% 2 s	Frequency Threshold Droop Activation Time	49.6Hz? 10%? 2 s	This is a new requirement to the GB Grid Code. Initial values based on LFSM Mode of Operation in opposite direction.
6.	10.2(c)		FSM	Active Power range Frequency Insensitivity Frequency Insensitivity Deadband Droop Maximum admissible delay t_1 for Generation with Inertia Maximum admissible	1.5 – 10% 10 – 30mHz 0.02–0.06% 0-500mHz 2 – 12% 2 s TSO defined	Active Power range $i\Delta P_{1}/P_{max}$ Frequency Insensitivity Δf_{i1} Frequency Insensitivity $\Delta f_{i1} / f_n$ Deadband Droop Maximum admissible delay t_1 for Generation with Inertia Maximum admissible delay t_1	10% ±15mHz ±0.03% ±15mHz 3 – 5% 2 s TBC?	Frequency Response Insensitivity is not currently used in GB. There is an issue as to how Primary and Secondary Response is defined. There only appears to be one option of low frequency response in RfG. Active Power Range, deadband and droop consistent with GB parameters. Discussion required on delay times and frequency

Issue	Article	Level of Difficulty (1-5)	Requirement	Range	Suggested GB Value	Comments
				delay t ₁ for Generation without Inertia Activation time t2 30 s	for Generation without Inertia Activation time t2 10s	insensitivity.
7.	10.2(f)		ASBMON	Status Signal (on/off) Scheduled Active Power output Actual value of Active Power output Actual parameter settings for Active Power Frequency Response Droop and deadband	Status Signal (on/off) Scheduled Active Power output Actual value of Active Power output Actual parameter settings for Active Power Frequency Response Droop and deadband	Changes required to NGTS3.24.95_RES. The current ASBMON specification does not include scheduled Active Power Output, Actual parameter settings for Active Power, droop and deadband.

1.Frequency Ranges:

Grid Code – CC.6.1.3

The **System Frequency** could rise to 52Hz or fall to 47Hz in exceptional circumstances. Design of **User's Plant and Apparatus** and **OTSDUW Plant and Apparatus** must enable operation of that **Plant and Apparatus** within that range in accordance with the following:

<u>Frequency Range</u>	<u>Requirement</u>
51.5Hz - 52Hz	Operation for a period of at least 15 minutes is required each time the Frequency is above 51.5Hz.
51Hz - 51.5Hz	Operation for a period of at least 90 minutes is required each time the Frequency is above 51Hz.
49.0Hz - 51Hz	Continuous operation is required
47.5Hz - 49.0Hz	Operation for a period of at least 90 minutes is required each time the Frequency is below 49.0Hz.
47Hz - 47.5Hz	Operation for a period of at least 20 seconds is required each time the Frequency is below 47.5Hz.

For the avoidance of doubt, disconnection, by frequency or speed based relays is not permitted within the frequency range 47.5Hz to 51.5Hz, unless agreed with **NGET** in accordance with CC.6.3.12.

Requirement for Generator – Article 13.1(a)

Type A power generating modules shall fulfil the following requirements relating to frequency stability:

- (a) 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 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 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.

Synchronous area	Frequency range	Time period for operation
Great Britain	47.0 Hz – 47.5 Hz	20 seconds
	47.5 Hz – 48.5 Hz	90 minutes
	48.5 Hz – 49.0 Hz	To be specified by each TSO, but not less than 90 minutes
	49.0 Hz – 51.0 Hz	Unlimited
	51.0 Hz – 51.5 Hz	90 minutes
	51.5 Hz – 52.0 Hz	15 minutes

Table 2: Minimum time periods for which a power generating module has to be capable of operating on different frequencies, deviating from a nominal value, without disconnecting from the network.

2.LFSM-O

Grid Code – BC.3.7.2

Plant in Limited Frequency Sensitive Mode

- (a) Each Synchronised Genset (or DC Converter at a DC Converter Station) operating in a Limited Frequency Sensitive Mode which is producing Active Power is also required to reduce Active Power output in response to System Frequency when this rises above 50.4Hz. In the case of DC Converters at DC Converter Stations, the provisions of BC.3.7.7 are also applicable. For the avoidance of doubt, the provision of this reduction in Active Power output is not an Ancillary Service. Such provision is known as “Limited High Frequency Response”.
 - (b) (i) The rate of change of Active Power output must be at a minimum rate of 2 per cent of output per 0.1Hz deviation of System Frequency above 50.4Hz.
 - (ii) The reduction in Active Power output must be continuously and linearly proportional as far as is practicable, to the excess of Frequency above 50.4Hz and must be provided increasingly with time over the period specified in (iii) below.
 - (iii) As much as possible of the proportional reduction in Active Power output must result from the frequency control device (or speed governor) action and must be achieved within 10 seconds of the time of the Frequency increase above 50.4Hz.
 - (iv) The residue of the proportional reduction in Active Power output which results from automatic action of the Genset (or Dc Converter at a DC Converter Station) output control devices other than the frequency control devices (or speed governors) must be achieved within 3 minutes from the time of the Frequency increase above 50.4Hz.
 - (v) Any further residue of the proportional reduction which results from non-automatic action initiated by the Generator or DC Converter Station owner shall be initiated within 2 minutes, and achieved within 5 minutes, of the time of the Frequency increase above 50.4Hz.
- (c) Each Genset (or DC Converter at a DC Converter Station) which is providing Limited High Frequency Response in accordance with this BC3.7.2 must continue to provide it until the Frequency has returned to or below 50.4Hz or until otherwise instructed by NGET.

Requirement for Generator - Article 13.2:

With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas:

- (b) the power generating module shall be capable of activating the provision of active power frequency response according to figure 1 at a frequency threshold and droop settings specified by the relevant TSO;
- (c) instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the cooperation of power generating module owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;
- (d) the frequency threshold shall be between 50.2 Hz and 50.5 Hz inclusive;
- (e) the droop settings shall be between 2 % and 12 %;
- (f) the power generating module shall be capable of activating a power frequency response with an initial delay that is as short as possible. If that delay is greater than two seconds, the power generating facility owner shall justify the delay, providing technical evidence to the relevant TSO;
- (g) the relevant TSO may require that upon reaching minimum regulating level, the power generating module be capable of either:
 - (i) continuing operation at this level; or
 - (ii) further decreasing active power output;
- (h) the power generating module shall be capable of operating stably during LFSM-O operation. When LFSM-O is active, the LFSM-O setpoint will prevail over any other active power setpoints.

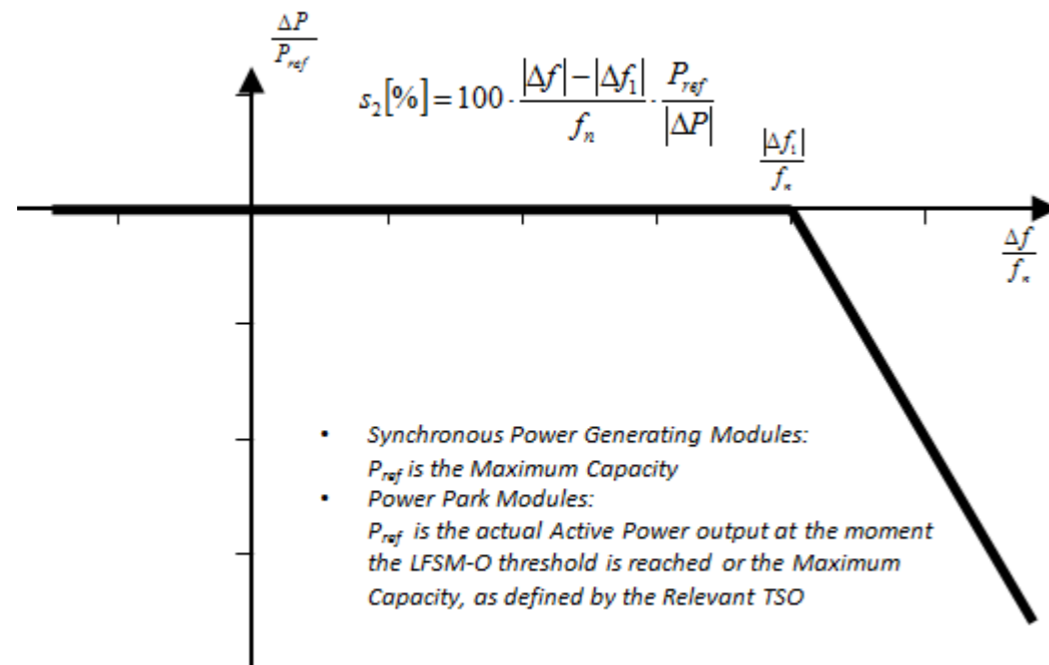


Figure 1: active power frequency response capability of power generating modules in LFSM-O. P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power generating modules and power park modules. ΔP is the change in active power output from the power generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At overfrequencies where Δf is above Δf_1 , the power generating module has to provide a negative active power output change according to the droop S_2 .

3. Maintenance of Constant Active Power Regardless of Changes in System Frequency:

Grid Code – CC.6.3.3

Each **Generating Unit, DC Converter** (including an **OTSDUW DC Converter**), **Power Park Module** and/or **CCGT Module** must be capable of:

- (a) continuously maintaining constant **Active Power** output for **System Frequency** changes within the range 50.5 to 49.5 Hz; and

(b) (subject to the provisions of CC.6.1.3) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 2 for **System Frequency** changes within the range 49.5 to 47 Hz, such that if the **System Frequency** drops to 47 Hz the **Active Power** output does not decrease by more than 5%. In the case of a **CCGT Module**, the above requirement shall be retained down to the **Low Frequency Relay** trip setting of 48.8 Hz, which reflects the first stage of the Automatic Low **Frequency Demand Disconnection** scheme notified to **Network Operators** under OC6.6.2. For **System Frequency** below that setting, the existing requirement shall be retained for a minimum period of 5 minutes while **System Frequency** remains below that setting, and special measure(s) that may be required to meet this requirement shall be kept in service during this period. After that 5 minutes period, if **System Frequency** remains below that setting, the special measure(s) must be discontinued if there is a materially increased risk of the **Gas Turbine** tripping. The need for special measure(s) is linked to the inherent **Gas Turbine Active Power** output reduction caused by reduced shaft speed due to falling **System Frequency**.

Figure 2

(c) For the avoidance of doubt in the case of a **Generating Unit** or **Power Park Module** (or **OTSDUW DC Converters** at the **Interface Point**) using an **Intermittent Power Source** where the mechanical power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of **System Frequency** under (a) above and should not drop with **System Frequency** by greater than the amount specified in (b) above.

(d) A **DC Converter Station** must be capable of maintaining its **Active Power** input (i.e. when operating in a mode analogous to **Demand**) from the **National Electricity Transmission System** (or **User System** in the case of an **Embedded DC Converter Station**) at a level not greater than the figure determined by the linear relationship shown in Figure 3 for **System Frequency** changes within the range 49.5 to 47 Hz, such that if the **System Frequency** drops to 47.8 Hz the **Active Power** input decreases by more than 60%.

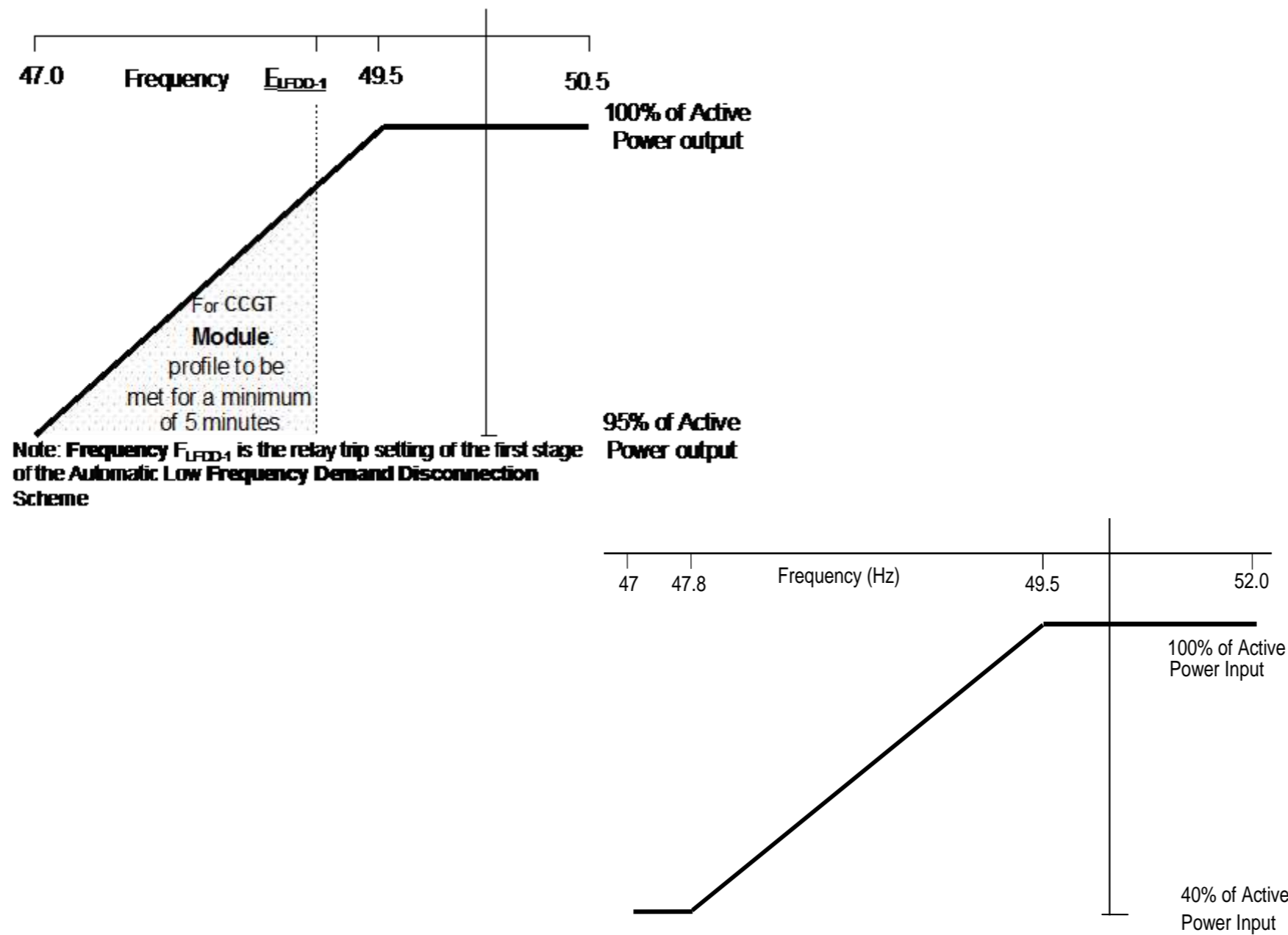


Figure 3

- (e) At a **Large Power Station**, in the case of an **Offshore Generating Unit, Offshore Power Park Module, Offshore DC Converter** and **OTSDUW DC Converter**, the **Generator** shall comply with the requirements of CC.6.3.3. **Generators** should be aware that Section K of the **STC** places requirements on **Offshore Transmission Licensees** which utilise a **Transmission DC Converter** as part of their **Offshore Transmission System** to make appropriate provisions to enable **Generators** to fulfil their obligations.
- (f) In the case of an **OTSDUW DC Converter** the **OTSDUW Plant and Apparatus** shall provide a continuous signal indicating the real time frequency measured at the **Interface Point** to the **Offshore Grid Entry Point**.

Requirement for Generators – Article 13.3

The power generating module shall be capable of maintaining constant output at its target active power value regardless of changes in frequency, except where output follows the changes specified in the context of paragraphs 2 and 4 of this Article or points (c) and (d) of Article 15(2) as applicable.

4. Power Output with Falling Frequency:

Grid Code – CC.6.3.3

See above

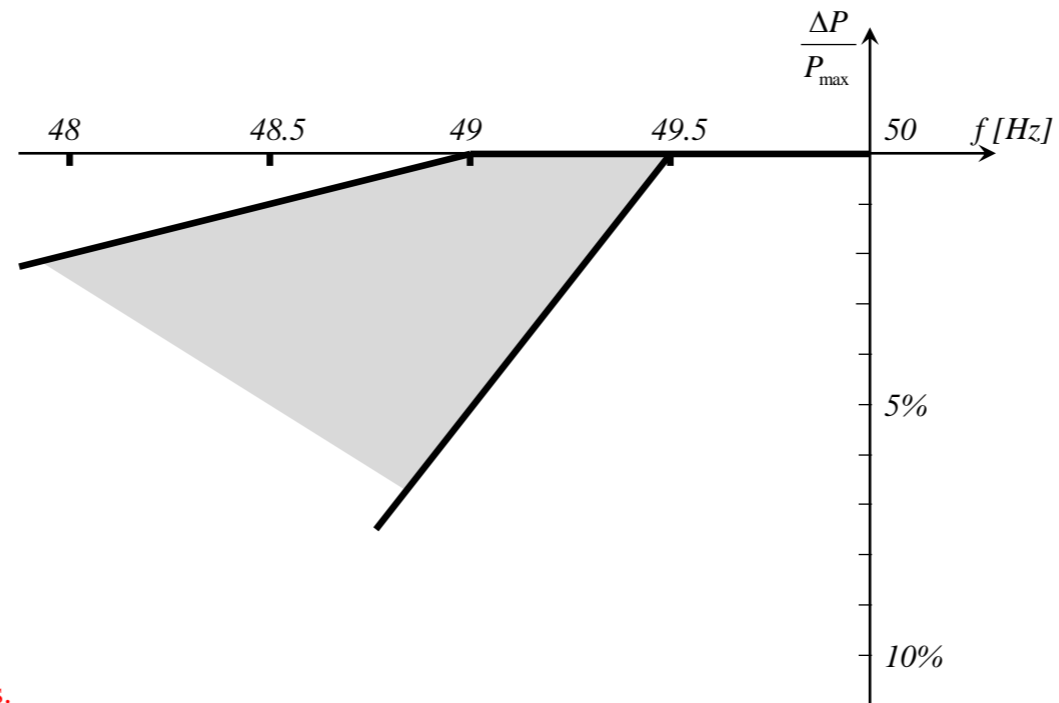
Requirement for Generators – Articles 13.4 &13.5

The relevant TSO shall specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 2:

- (a) below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50 Hz per 1 Hz frequency drop;
- (b) below 49.5 Hz falling by a reduction rate of 10% of the maximum capacity at 50 Hz per 1 Hz frequency drop.

The admissible active power reduction from maximum output shall:

- (c) clearly specify the ambient conditions applicable;



(d) take account of the technical capabilities of power generating modules.

Figure 2: Maximum power capability reduction with falling frequency. The diagram represents the boundaries in which the capability can be specified by the relevant TSO.

5. LFSM-U

Grid Code – not defined

Requirement for Generators – Article 15.2(c)

In addition to paragraph 2 of Article 13, the following requirements shall apply to type C power generating modules with regard to limited frequency sensitive mode – underfrequency (LFSM-U):

- (i) the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified by the relevant TSO in coordination with the TSOs of the same synchronous area as follows:
 - the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive;
 - the droop settings specified by the TSO shall be in the range 2 – 12 %.
 This is represented graphically in Figure 4;
- (ii) the actual delivery of active power frequency response in LFSM-U mode shall take into account:
 - ambient conditions when the response is to be triggered;
 - the operating conditions of the power generating module, in particular limitations on operation near maximum capacity at low frequencies and the respective impact of ambient conditions according to paragraphs 4 and 5 of Article 13; and
 - the availability of the primary energy sources.
- (iii) the activation of active power frequency response by the power generating module shall not be unduly delayed. In the event of any delay greater than two seconds, the power generating facility owner shall justify it to the relevant TSO;
- (iv) in LFSM-U mode the power generating module shall be capable of providing a power increase up to its maximum capacity;
- (v) stable operation of the power generating module during LFSM-U operation shall be ensured;

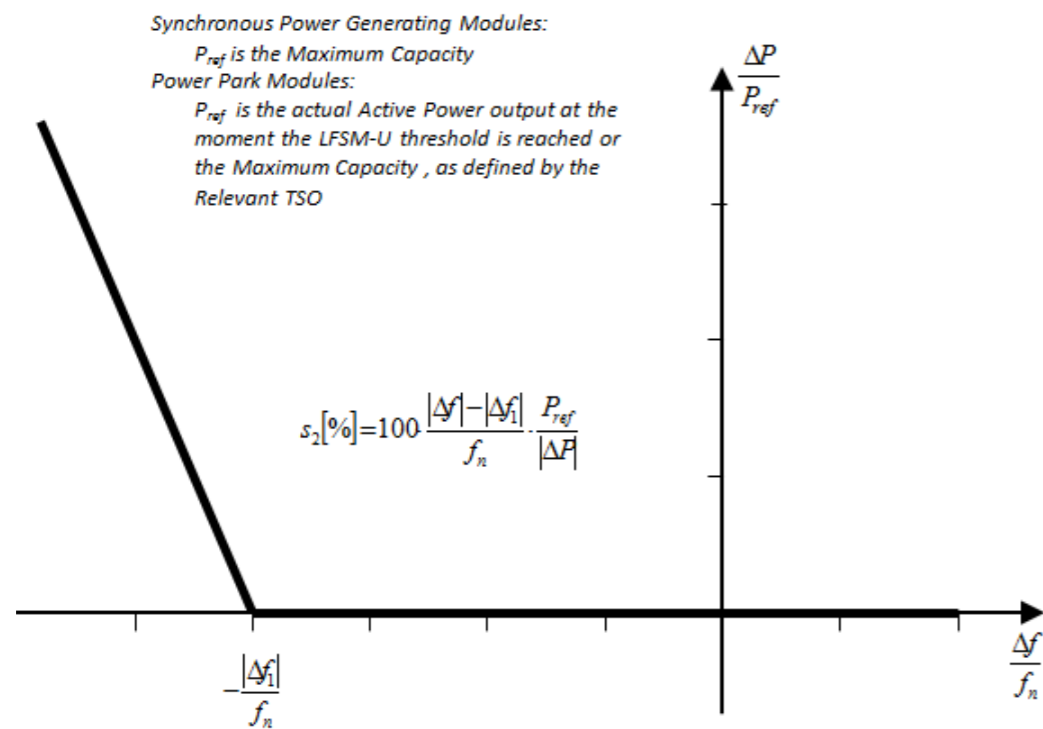


Figure 4: active power frequency response capability of power generating modules in LFSM-U. P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power generating modules and power park modules. ΔP is the change in active power output from the power generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At underfrequencies where Δf is below Δf_1 the power generating module has to provide a positive active power output change according to the droop S_2 .

6. FSM:

Grid Code - not defined

Requirement for Generators – Articles 15.2(d)

in addition to point (c) of paragraph (2), the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating:

- (i) the power generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4. In specifying those parameters, the relevant TSO shall take account of the following facts:
- in case of overfrequency, the active power frequency response is limited by the minimum regulating level;
 - in case of underfrequency, the active power frequency response is limited by maximum capacity;
 - the actual delivery of active power frequency response depends on the operating and ambient conditions of the power generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources;

Parameters		Ranges
Active power range related to maximum capacity $\frac{ \Delta P_1 }{P_{\max}}$		1.5 – 10%
Frequency response insensitivity	$ \Delta f_i $	10 – 30 mHz
	$\frac{ \Delta f_i }{f_n}$	0.02 – 0.06%
Frequency response deadband		0 – 500 mHz
Droop s_1		2 – 12%

Table 4: Parameters for active power frequency response in FSM (explanation for Figure 5)

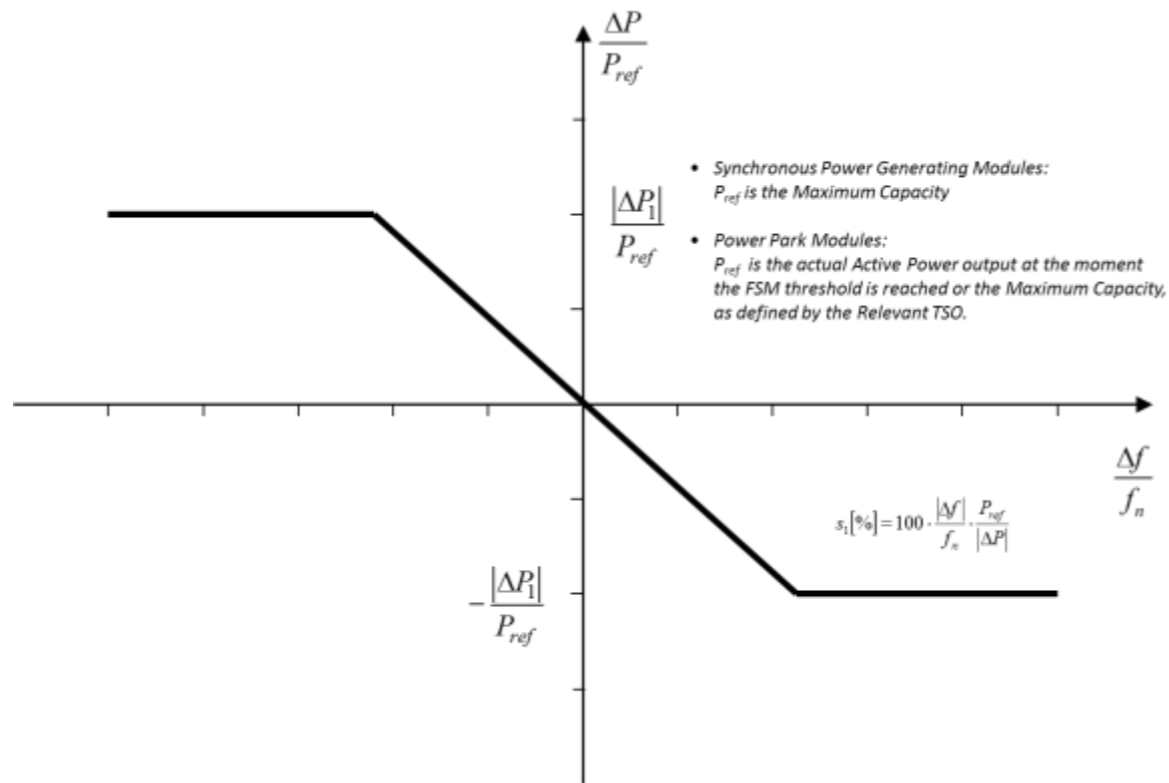


Figure 5: Active power frequency response capability of power generating modules in FSM illustrating the case of zero deadband and insensitivity. P_{ref} is the reference active power to which ΔP is related. ΔP is the change in active power output from the power generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network.

- (ii) the frequency response deadband of frequency deviation and droop must be able to be reselected repeatedly;
- (iii) in the event of a frequency step change, the power generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power generating module) within the ranges given in Table 5. The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account;

(iv) The initial activation of active power frequency response required shall not be unduly delayed.

If the delay in initial activation of active power frequency response is greater than two seconds, the power generating facility owner shall provide technical evidence demonstrating why a longer time is needed.

For power generating modules without inertia, the relevant TSO may specify a shorter time than two seconds. If the power generating facility owner cannot meet this requirement they shall provide technical evidence demonstrating why a longer time is needed for the initial activation of active power frequency response;

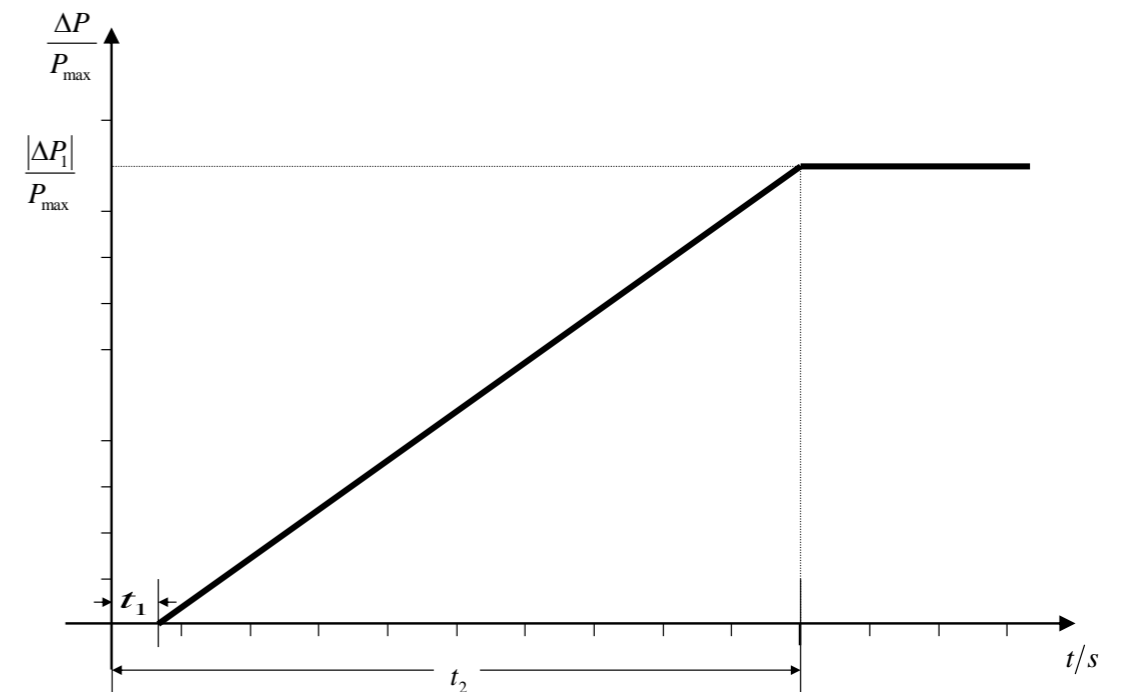


Figure 6: Active power frequency response capability. P_{max} is the maximum capacity to which ΔP relates. ΔP is the change in active power output from the power generating module. The power generating module has to provide active power output ΔP up to the point ΔP_1 in accordance with the times t_1 and t_2 with the values of ΔP_1 , t_1 and t_2 being specified by the relevant TSO according to Table 5. t_1 is the initial delay. t_2 is the time for full activation.

- (v) the power generating module shall be capable of providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO. In specifying the period, the TSO shall have regard to active power headroom and primary energy source of the power generating module;
- (vi) within the time limits laid down in point (v) of paragraph (2) (d), active power control must not have any adverse impact on the active power frequency response of power generating modules;
- (vii) the parameters specified by the relevant TSO in accordance with paragraphs 1, 2, 3 and 5 shall be notified to the relevant regulatory authority. The modalities of that notification shall be specified in accordance with the applicable national regulatory framework;

Parameters	Ranges or values
Active power range related to maximum capacity (frequency response range) $\frac{ \Delta P_1 }{P_{\max}}$	1.5 – 10%
For power generating modules with inertia, the maximum admissible initial delay t_1 unless justified otherwise in line with Article 15 (2) (d) (iv)	2 seconds
For power generating modules without inertia, the maximum admissible initial delay t_1 unless justified otherwise in line with Article 15 (2) (d) (iv)	as specified by the relevant TSO.
Maximum admissible choice of full activation time t_2 , unless longer activation times are allowed by the relevant TSO for reasons of system stability	30 seconds

Table 5: Parameters for full activation of active power frequency response resulting from frequency step change (explanation for Figure 6).

7. ASBMON:

Grid Code – TS3.24.95_RES

<http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Electrical-Standards-Documents/>

Requirement for Generators – Articles 15.2(g)

with regard to real-time monitoring of FSM:

(i) to monitor the operation of active power frequency response, the communication interface shall be equipped to transfer in real time and in a secured manner from the power generating facility to the network control centre of the relevant system operator or the relevant TSO, at the request of the relevant system operator or the relevant TSO, at least the following signals:

- status signal of FSM (on/off);
- scheduled active power output;
- actual value of the active power output;
- actual parameter settings for active power frequency response;
- droop and deadband;

(ii) the relevant system operator and the relevant TSO shall specify additional signals to be provided by the power generating facility by monitoring and recording devices in order to verify the performance of the active power frequency response provision of participating power generating modules.