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COMMISSION REGULATION (EU) 2016/631 OF 14 APRIL 2016 ESTABLISHING A NETWORK CODE ON REQUIREMENTS FOR GRID CONNECTION OF GENERATORS, TABLE OF PARAMETERS AND PROVISIONS.

No.	Reference to Regulation	Requirement
1.	Article 5 Paragraph 2 Table 1	Limit for maximum capacity threshold from which a power-generating module is: Type B ≥ 0,25 MW; Type C ≥ 5 MW; Type D ≥ 15 MW;
2.	Article 13 Paragraph 1(a) Point (ii) Table 2	Minimum time periods for which a power-generating module has to be capable of operating on different frequency ranges, deviating from a nominal value, without disconnecting from the network: 47,5 Hz-48,5 Hz more-than or equal to 30 minutes 48,5 Hz-49,0 Hz more-than or equal to 30 minutes 49,0 Hz-51,0 Hz Unlimited 51,0 Hz-51,5 Hz more-than or equal to 30 minutes
3.	Article 13 Paragraph 1(b)	A power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to 2,5 Hz/s calculated over a 500 ms time frame average.
4.	Article 13 Paragraph 2(b)	The automatic disconnection of power-generating modules is permitted at randomized frequencies, from 50,2 to 50,5 Hz if the maximum capacity of the unit is less than 10 kW. The frequency threshold is determined randomly by the DSO.
5.	Article 13 Paragraph 2 Figure 1	The active power frequency response capability of power-generating modules is displayed in Annex 1 Figure 1. The requirement has been defined following COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators Article 13 Paragraph 2.
6.	Article 13 Paragraph 2(c)	The frequency threshold shall be 50,2 Hz.
7.	Article 13 Paragraph 2(d)	The droop setting - 5%, with a possibility to change the setting from 2 % to 12 %.

No.	Reference to Regulation	Requirement
8.	Article 13 Paragraph 2(e)	The power-generating module shall be capable of activating a power frequency response with an initial delay no greater than: Hydropower plant - < 2 s; Thermal power plant - ≤ 1 s; Power park modules - ≤ 0,5 s
9.	Article 13 Paragraph 2(f)	Upon reaching the minimum regulating level the power-generating module shall be capable of operating continuously at that level.
10.	Article 13 Paragraph 3	The power-generating module shall be capable of maintaining constant output at its target active power output.
11.	Article 13 Paragraph 5 Figure 2	If the frequency falls below 49 Hz, the active power reduction rate of 2% of the maximum capacity at 50 Hz for each 1 Hz drop is admissible. The principle is displayed in Annex 2.
12.	Article 13 Paragraph 5	While defining the admissible active power reduction from the maximum capacity, the technical capabilities of power-generating modules and technical restrictions due to ambient conditions shall be considered and coordinated with the TSO.
13.	Article 13 Paragraph 6	If the power capacity of a type A power-generating module is larger than 10 kW, the necessity to be equipped with a logic interface (an input function to disconnect) is coordinated with the DSO.
14.	Article 13 Paragraph 7	- Voltage variation range at the connection point: 0,9 pu ≤ U ≤ 1,1 pu. - Frequency range: 49 Hz ≤ f ≤ 50,1 Hz. - If the conditions are complied for more than 60 seconds automatic connection is allowed. - The maximum admissible gradient of an increase in active power output is restricted to ≤ 10% P_{max}/ min, or to the technical capability of the power-generating module.
15.	Article 14 Paragraph 2(b)	The power-generating modules shall be equipped with an interface to control active power setpoint and shall be capable of exchanging information with the relevant system operator.
16.	Article 14 Paragraph 3(a) Point (iv)	The calculations of the maximum short-circuit current are performed considering the following conditions: The highest possible number of power-generating modules are operating; Assessing the possible expansion of the grid, the calculated results are increased by 30% (safety factor). The calculations of the minimum short-circuit current are performed considering the following conditions: The lowest possible number of power-generating modules are operating;

<table>
<tr><th>No.</th><th>Reference to Regulation</th><th>Requirement</th></tr>
<tr><td></td><td></td><td>Assessing the Lithuanian electric power system under maintenance state, where up to 2 disconnections occur (transmission line, power transformer, etc.).</td></tr>
<tr><td>17.</td><td>Article 14
Paragraph 3(a)
Figure 3,
Table 3.1
Table 3.2

Article 16
Paragraph 3(a)</td><td>Type B and Type C power generating modules' Fault-ride-through profile parameters:

<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (seconds)</th></tr>
<tr><td>U_{ret}</td><td>0,05</td><td>t_{clear}</td><td>0,25</td></tr>
<tr><td>U_{clear}</td><td>0,7</td><td>t_{rec1}</td><td>0,25</td></tr>
<tr><td>U_{rec1}</td><td>0,7</td><td>t_{rec2}</td><td>0,7</td></tr>
<tr><td>U_{rec2}</td><td>0,85</td><td>t_{rec3}</td><td>1,5</td></tr>
</table>

Type B and Type C power park modules' Fault-ride-through profile parameters:

<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (seconds)</th></tr>
<tr><td>U_{ret}</td><td>0,05</td><td>t_{clear}</td><td>0,25</td></tr>
<tr><td>U_{clear}</td><td>0,15</td><td>t_{rec1}</td><td>0,25</td></tr>
<tr><td>U_{rec1}</td><td>0,15</td><td>t_{rec2}</td><td>0,25</td></tr>
<tr><td>U_{rec2}</td><td>0,85</td><td>t_{rec3}</td><td>3,0</td></tr>
</table>

Type D synchronous power generating modules' Fault-ride-through profile parameters:

<table>
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<tr><td>U_{clear}</td><td>0,25</td><td>t_{rec1}</td><td>0,3</td></tr>
<tr><td>U_{rec1}</td><td>0,50</td><td>t_{rec2}</td><td>0,7</td></tr>
<tr><td>U_{rec2}</td><td>0,85</td><td>t_{rec3}</td><td>1,5</td></tr>
</table>

Type D power park modules' Fault-ride-through profile parameters:

<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (seconds)</th></tr>
<tr><td>U_{ret}</td><td>0,0</td><td>t_{clear}</td><td>0,25</td></tr>
<tr><td>U_{clear}</td><td>0,0</td><td>t_{rec1}</td><td>0,25</td></tr>
<tr><td>U_{rec1}</td><td>0,0</td><td>t_{rec2}</td><td>0,25</td></tr>
<tr><td>U_{rec2}</td><td>0,85</td><td>t_{rec3}</td><td>2,0</td></tr>
</table>

Fault-ride-through profiles have been displayed in Annex 3.</td></tr>
<tr><td>18.</td><td>Article 14
Paragraph 3(b)

Article 16
Paragraph 3(c)</td><td>The requirements are the identical to symmetrical faults case.</td></tr>
</table>

No.	Reference to Regulation	Requirement
19.	Article 14 Paragraph 4	Type B power-generating modules shall fulfill the following requirements before reconnecting to the network: - Voltage variation range at the connection point 0,9 pu ≤ U ≤ 1,1 pu. - Frequency range: 49 Hz ≤ f ≤ 50,1 Hz. - If the conditions are met, the reconnection is allowed with a 60 s delay. - The maximum admissible gradient of an increase in active power output is restricted to ≤ 10% P_{max}/min.
20.	Article 14 Paragraph 5(a)	Control commands and signals have been listed in Annex 9.
21.	Article 14 Paragraph 5(b)	Undervoltage (stage 1) U_n - 0,9 pu, operation is delayed by 180 s. Undervoltage (stage 2) U_n - 0,85 pu, operation is delayed by ≤ 3 s. Overvoltage (stage 1) U_n - 1,20 pu, operation is delayed by ≤ 5 s. Overvoltage (stage 2) U_n - 1,25 pu, operation is delayed by 100 ms. Over frequency ≥ 51,5 Hz, operation delayed by 200 ms. Under frequency ≤ 47, Hz, operation delayed by 200 ms. Rate of change of frequency ±2,5% Hz/s, operation delayed by 80 ms.
22.	Article 14 Paragraph 5(d)	The general tele-signal list is displayed in Annex 9.
23.	Article 15 Paragraph 2(a)	The tolerance of active power setpoint is either ±5% from the setpoint value or ±3% from the nominal value. A larger value is chosen as the tolerance. The integrated 10 min average shall not exceed 1%$P_{N.}$ Overregulation shall not exceed 10%$P_{N.}$ a) The ramp rate of the active power shall not be lower than: b) 50 % P_N/min (P_N - nominal power) for Hydropower plant; c) 20 % P_N/min for only electricity producing gas turbines, 8 % P_N/min – Combined cycle turbines; d) 5 % P_N/min for other, under normal operating conditions, fossil fuel or biogas as the energy source, power plants; e) 5 % P_N/min for other types of power plants;
24.	Article 15 Paragraph 2(c)	Frequency threshold – 49,8 Hz Droop setting – 5% (Droop setting shall be adjustable in the range from 2 to 12%) The delay cannot exceed the following values: Hydropower plants: <2 s. Thermal power plants: ≤1 s. Power park modules: ≤0,5 s.

No.	Reference to Regulation	Requirement
		The requirements are displayed in Annex 4.
25.	Article 15 Paragraph 2(d) Table 4	Active power range related to maximum capacity: 10%; Frequency response insensitivity: 10 mHz or 0,02%; Frequency response dead-band: 0-500 mHz; Droop: 2-12 %; Parameters should be adjustable from the transmission system operator's (hereinafter - TSO) control system. The requirements are displayed in Annex 5.
26.	Article 15 Paragraph 2(d) Point (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 Annex 6 within 30 s.
27.	Article 15 Paragraph 2(d) Point (iv)	The delay cannot exceed: Hydropower plants: <2 s. Thermal power plants: <1 s. Power park modules: ≤0,5 s.
28.	Article 15 Paragraph 2(d) Point (v)	The power-generating module shall be capable of providing full active power frequency response for 30 minutes (full regulation range and full capacity).
29.	Article 15 Paragraph 2(d) Table 5	Active power range related to maximum capacity (frequency response range) – 10%. The delay cannot exceed: Hydropower plants: <2 s. Thermal power plants: <1 s. Power park modules: ≤0,5 s. Maximum admissible full activation time - 30 seconds.
30.	Article 15 Paragraph 2(e)	The power-generating module shall be capable to accept commands from the secondary system regulator, instructing the power-generating module to change the active power output.
31.	Article 15 Paragraph 2(g)	Real time information for Frequency sensitivity mode control is provided in Annex 9.
32.	Article 15 Paragraph 3	Power-generating modules shall be capable to automatically disconnect from the network when the voltage at the connection point is lower than 80% or higher than 120% of nominal value for a duration longer than 60 s. (Not applicable for Type D power generation modules).
33.	Article 15 Paragraph 5(b) Point (i)	The methodology of operation in the island mode and detection of the island mode have been defined separately. The requirements for the power-generating modules shall be coordinated with the power-generating facility owner. There shall be a fast re-synchronization option.
34.	Article 15 Paragraph 5(c) Point (iii)	Power-generating modules shall be capable of operating continuously in the island mode, irrespective of any auxiliary connections to the external network for at least 6 hours.

No.	Reference to Regulation	Requirement
35.	Article 15 Paragraph 6(a)	A power-generating module shall be capable of disconnecting automatically from the network to help preserve system stability or to prevent damage to the power-generating module in case of loss of angular stability or loss of control. Synchronous power-generating modules shall have asynchronous operation (pole slip) protection, where impedance shall be considered as the protection criterion. It is permitted to use a similar type of protection to detect loss of angular stability.
36.	Article 15 Paragraph 6(b)	Power-generating modules shall be equipped with a facility to provide fault recording. The measuring devices shall have a requirement for accuracy based on the measured parameter: Voltage – 0,5% accuracy; Active power – 0,5% accuracy; Reactive power – 0,5% accuracy; Frequency – 0,01% accuracy; A necessary condition while selecting the current transformer is to ensure that at maximum load on the secondary windings they are loaded between 40% and 120% of the rated value, at minimum load – at least 1% (or 5% if the CT accuracy class is 0.5) of the rated measurement device current.
37.	Article 15 Paragraph 6(b) Point (i)	"Electric energy generation and consumption regulation" (Elektros energijos tiekimo ir naudojimo taisyklės), issued on 11th of February, 2010 order Nr. 1-38 "Authorization of Electric energy generation and consumption regulation" (Dėl Elektros energijos tiekimo ir naudojimo taisyklių patvirtinimo) has declared that the electrical energy quality parameters are defined following LST EN 50160 standard. Electrical energy quality parameters for 330 kV voltage level are defined in "The permissible frequency and voltage quality parameters description" (Perdavimo tinkle leistinų dažnio ir įtampos kokybinių parametrų aprašas) issued by Litgrid AB.
38.	Article 15 Paragraph 6(e)	Unless the relevant system operator and power-generating facility owner agree otherwise (in coordination with the TSO), the variation of minimum and maximum ramp rate of active power output for a power-generating module, considering the specific characteristics of prime mover technology, are defined in Annex 10.
39.	Article 16 Paragraph 2(a)	Type D power-generating modules shall fulfill the following requirements relating to voltage stability: Connected to the 110 kV network: 0,85-0,9 pu 30 min

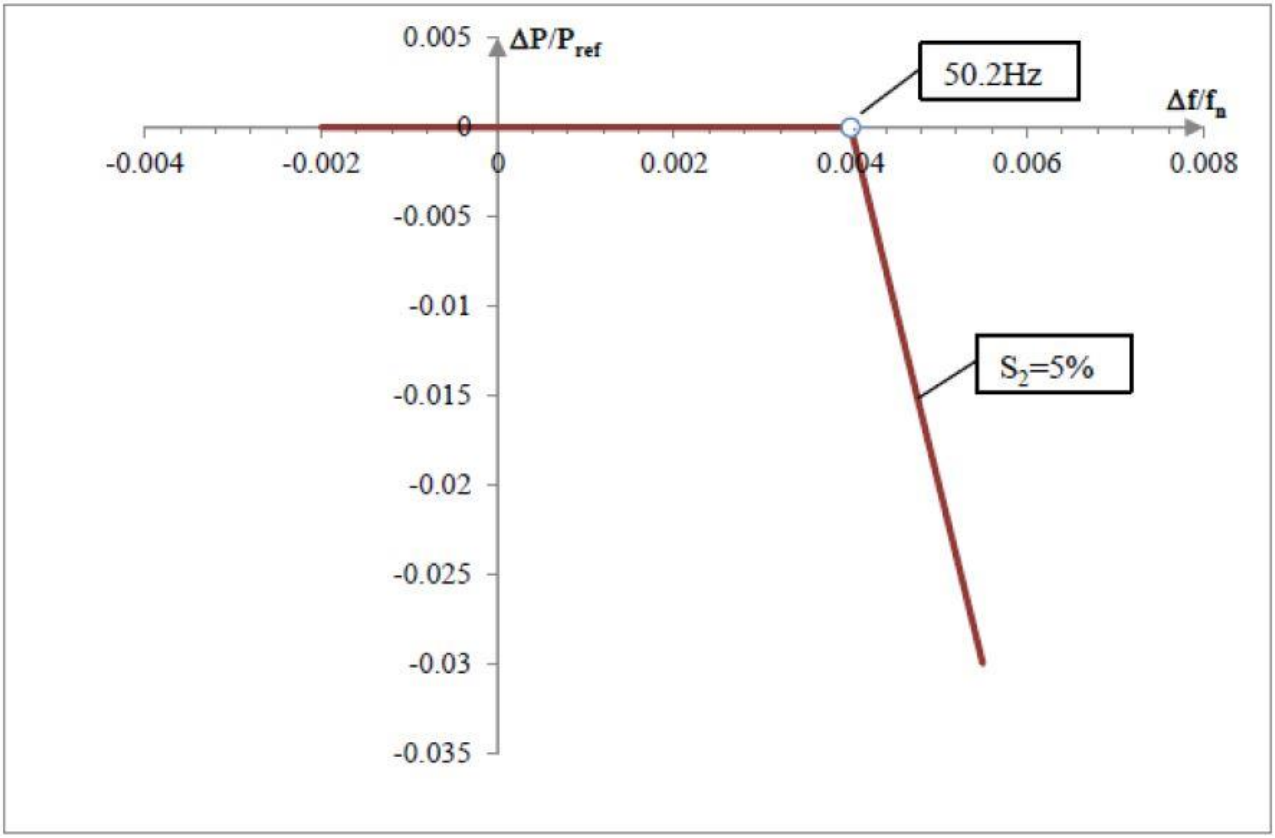
No.	Reference to Regulation	Requirement
		0,9-1,118 pu Unlimited 1,118-1,15 pu 20 min Connected to the 330- 400 kV network: 0,88-0,9 pu | 20 min 0,9-1,097 pu | Unlimited 1,097-1,15 pu | 20 min
40.	Article 16 Paragraph 4(d)	Settings of devices used for synchronization shall be: (i) Voltage difference between 0 and +5 % (ii) Frequency difference less-than or equal to 0,067 Hz (iii) Phase angle difference between 0 and +10°, where "+" is indicating that the voltage phase angle of the generator is leading.
41.	Article 17 Paragraph 2	Unless specified otherwise, synchronous power-generating module operating at rated power P_{max} shall be capable of generating the reactive power to the network a quantity corresponding to the power factor cosφ = 0,9 and consuming the reactive power from the network a quantity corresponding to the power factor cosφ = 0,9.
42.	Article 17 Paragraph 3	Concerning the reliability, Type B synchronous power-generating modules shall be capable of providing post-fault active power recovery. 90 % of active power shall be recovered within 5 s once the fault is cleared.
43.	Article 18 Paragraph 2(a)	The relevant system operator may specify supplementary reactive power to be provided at the connection point. The reactive power generated by the power-generating modules at the connection point shall be compensated to 0 MVAr.
44.	Article 18 Paragraph 2(b) Article 21 Paragraph 3(b)	U-Q/P_{max} and P-Q/P_{max} profiles of a synchronous power are displayed in Annex 7.
45.	Article 19 Paragraph 2	Concerning the system stability, Type D synchronous power-generating modules shall be equipped with a PSS (*Power system stabilizer*) function to attenuate power oscillations if the synchronous power-generating module capacity is above 15 MW. The parameters of the function are defined by the TSO based on the synchronous power-generating module connection point. The operator shall be capable of activating the function remotely.
46.	Article 19 Paragraph 3	The relevant TSO and the power-generating facility owner shall agree on the technical capabilities of the power-generating module to aid angular stability under fault conditions.

No.	Reference to Regulation	Requirement
47.	Article 20 Paragraph 2	Type B power park modules shall have the capability to provide the reactive power, based on the control algorithms, defined by the DSO. The control algorithms are defined as the following: a) Q_{fix} – keep constant reactive power within P/Q profile limits, b) Q(U) – maintain a constant voltage level within P/Q profile limits, c) Q(P) – maintain a specific reactive power level within P/Q profile limits, d) $\cos\varphi_{fix}$ – keep constant power factor within P/Q profile limits, e) $\cos\varphi(U)$ – maintain a constant power factor based on the voltage level within P/Q profile limits, f) $\cos\varphi(P)$ – maintain a constant power factor based on the active power P within P/Q profile limits. There shall be a possibility to apply this control remotely.
48.	Article 20 Paragraph 3	The post-fault active power recovery which the Type B power park module shall be capable of providing: a) The post-fault active power recovery begins, when the voltage at the connection point recovers to 90% of the rated voltage, b) More-than or equal to 70 % with an ±5% accuracy of the pre-fault active power has to be recovered within 10 s once the fault is cleared.
49.	Article 21 Paragraph 2	Power park modules shall be capable of providing synthetic inertia during very fast frequency deviations.
50.	Article 21 Paragraph 3(c)	The capability to ensure the reactive power P-Q/P_{max} operating at a power level lower than the maximum capability is displayed in Annex 8. At zero active power output, the power park module shall have the capability to inject from -0,4 to 0,4 P_{max} reactive power.
51.	Article 21 Paragraph 3(d) Point (iv)	The reactive power output shall be 0 MVar when the grid voltage value at the connection point equals the voltage setpoint. Reactive power exchange with the network has to cover voltage range from 0,9 to 1,1 pu in steps equal to 0,01 pu. Following a step change in voltage, the power park module shall be capable of achieving 90 % of the change in reactive power output within 3 s. The specified value must settle within 60 seconds, with a steady-state reactive tolerance no greater than 5 % of the maximum reactive power.
52.	Article 21 Paragraph 3(d) Point (vi)	The target power factor is 0,9. The tolerance of the target power factor is ±5% expressed through reactive power. The

No.	Reference to Regulation	Requirement
		target power factor following an active power step change has to be reached within 60 s.
53.	Article 21 Paragraph 3(e)	With regard to prioritizing active or reactive power contribution, reactive power contribution has priority during faults for which fault-ride-through capability is required.
54.	Article 22	Power system stabilizer (PSS)/Power oscillations damping equipment shall be installed in Type D power park modules and Type D synchronous power generating modules.

Note: The parameters of the generators and settings provided in the Table may be adjusted, if the characteristics of the Lithuanian electric power system will change.

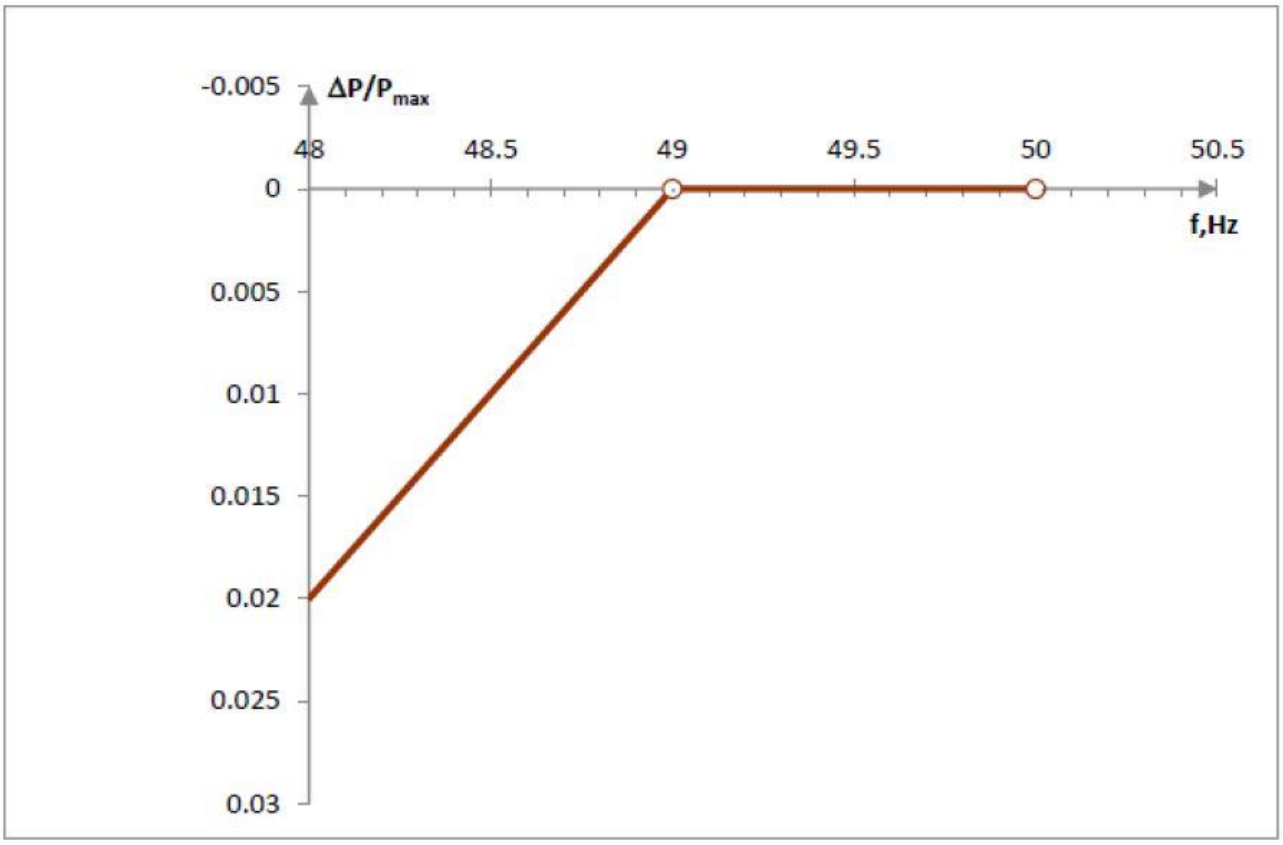
Annex 1. Active power frequency response capability of power-generating modules



Synchronous power generating modules: Pref – maximum capability;

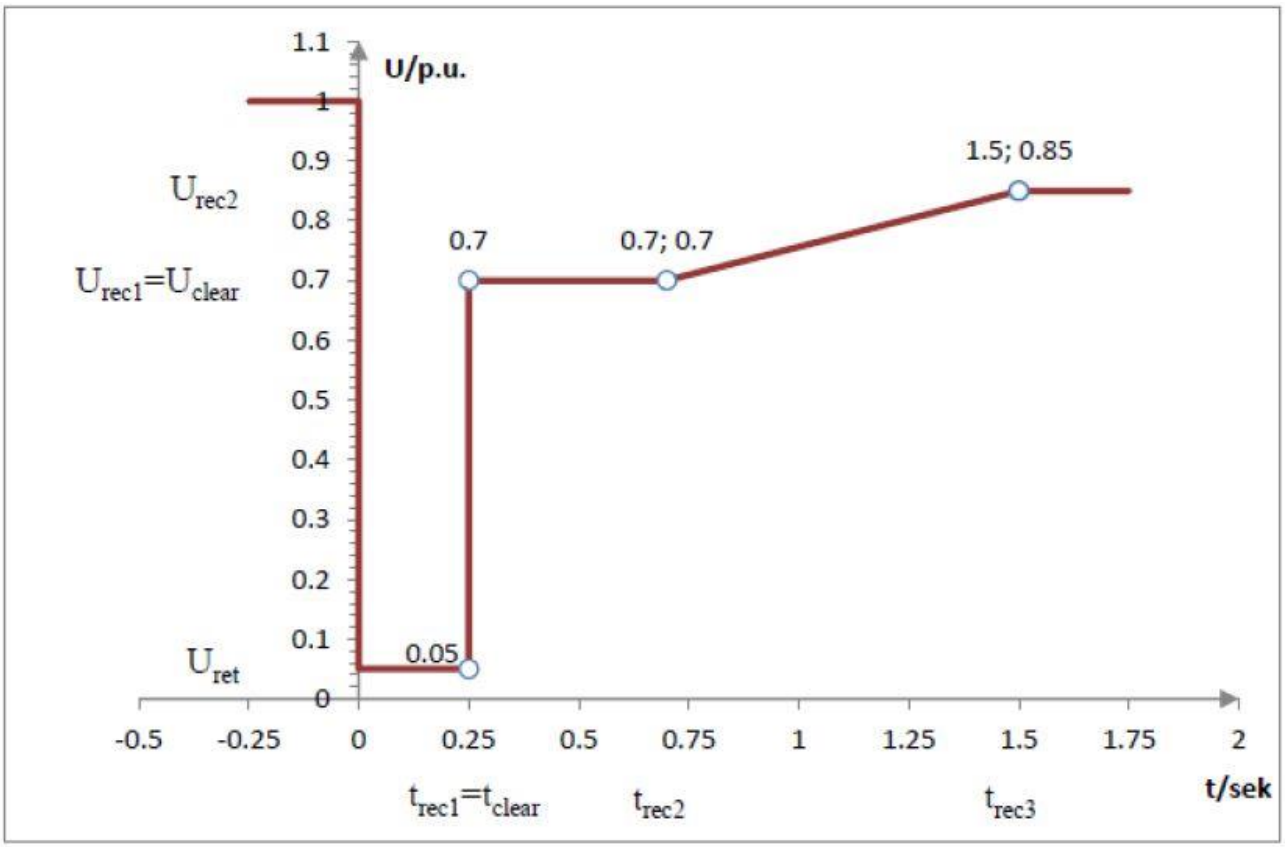
Power park modules: Pref – installed operating power.

Annex 2. *Maximum power capability reduction with falling frequency*

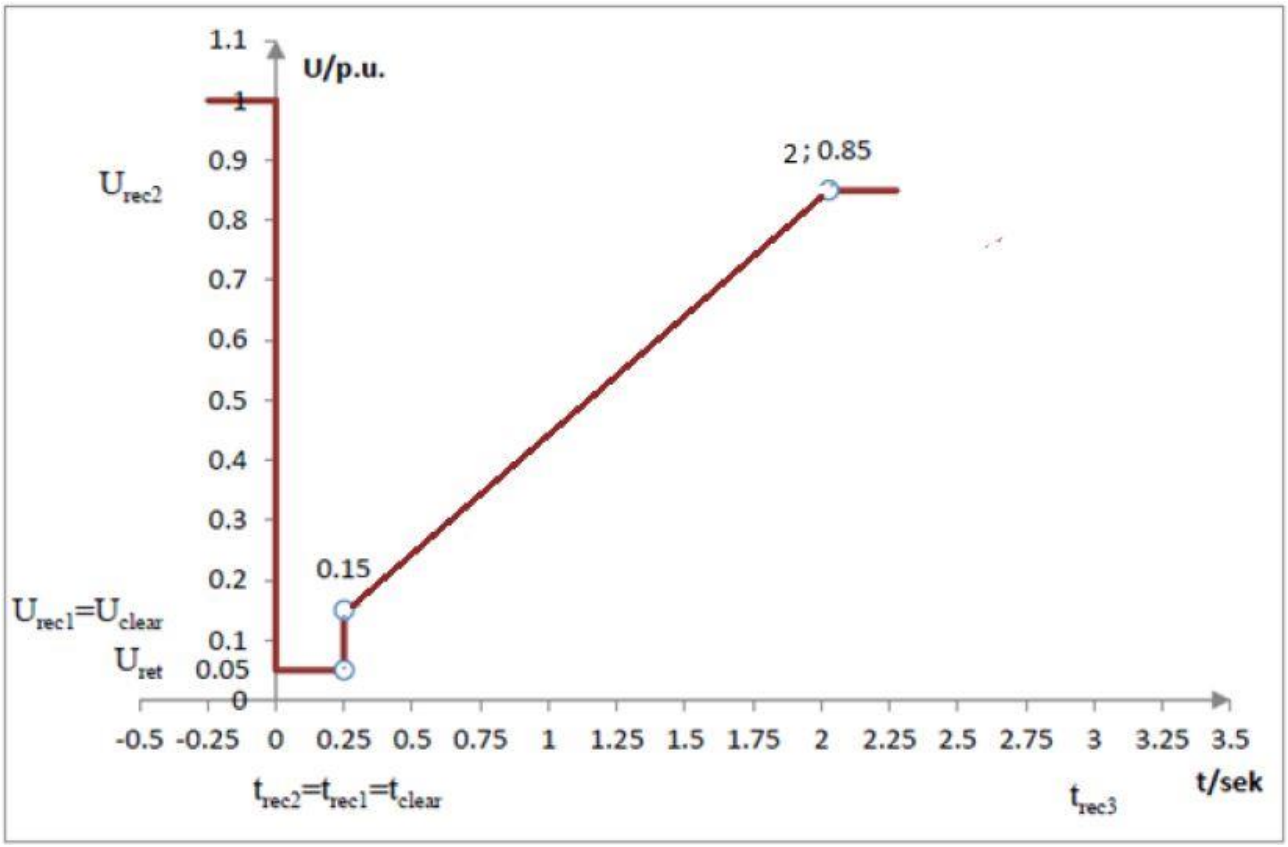


Annex 3. Fault-ride-through profile of a power-generating module

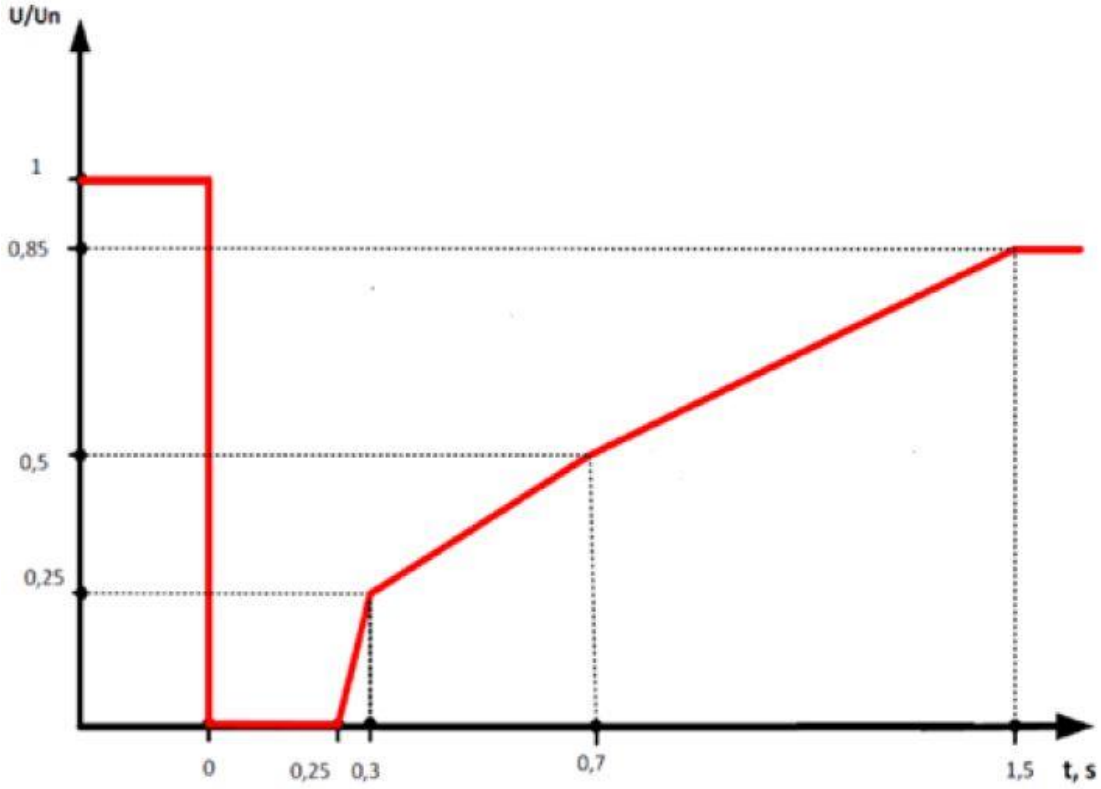
a) Fault-ride-through profile of a synchronous power-generating module



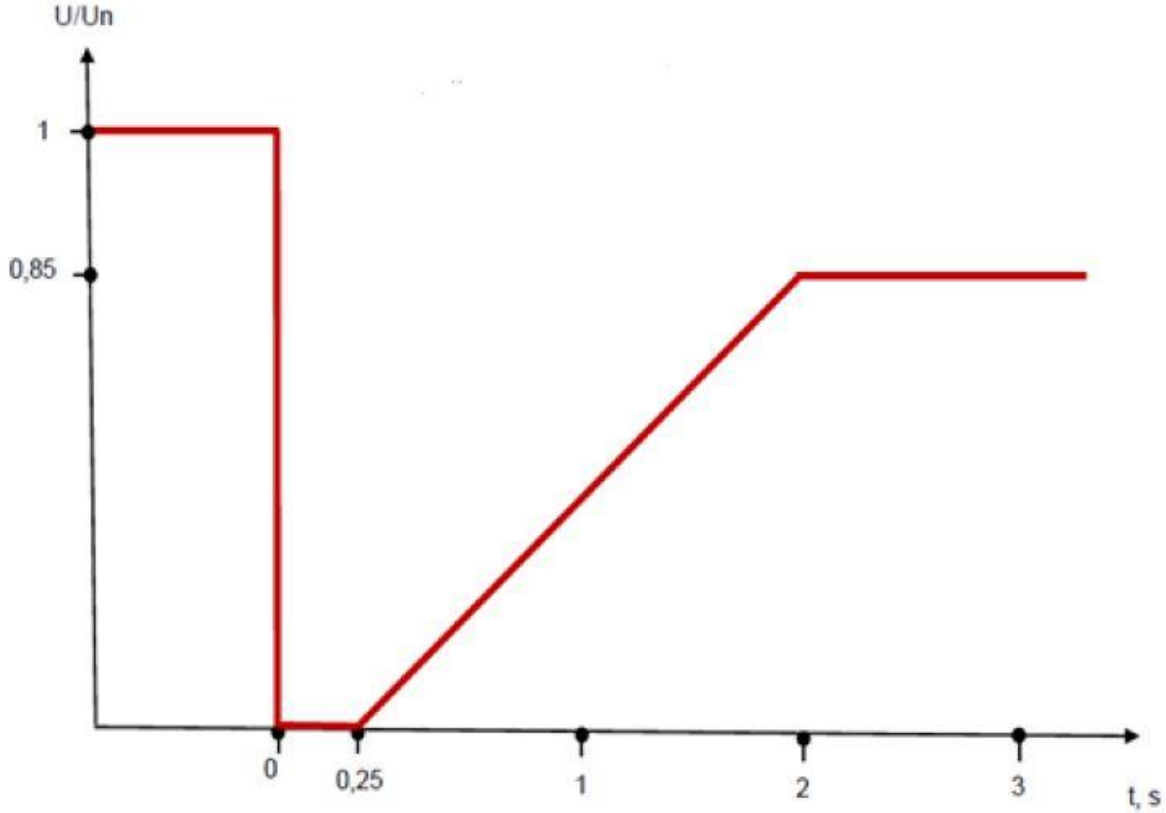
b) Fault-ride-through profile of a power park modules



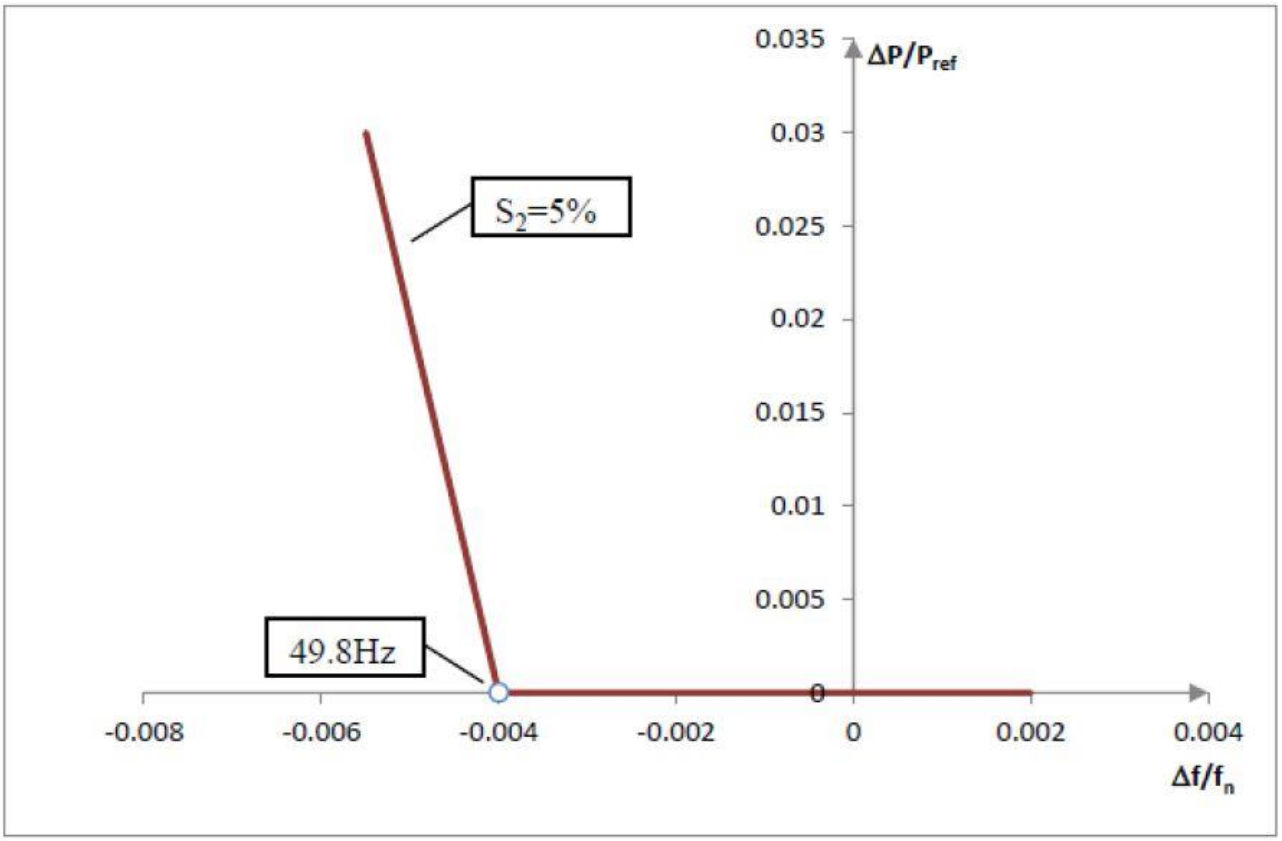
c) Fault-ride-through profile of a Type D synchronous power-generating module



d) Fault-ride-through profile of a Type D power park modules



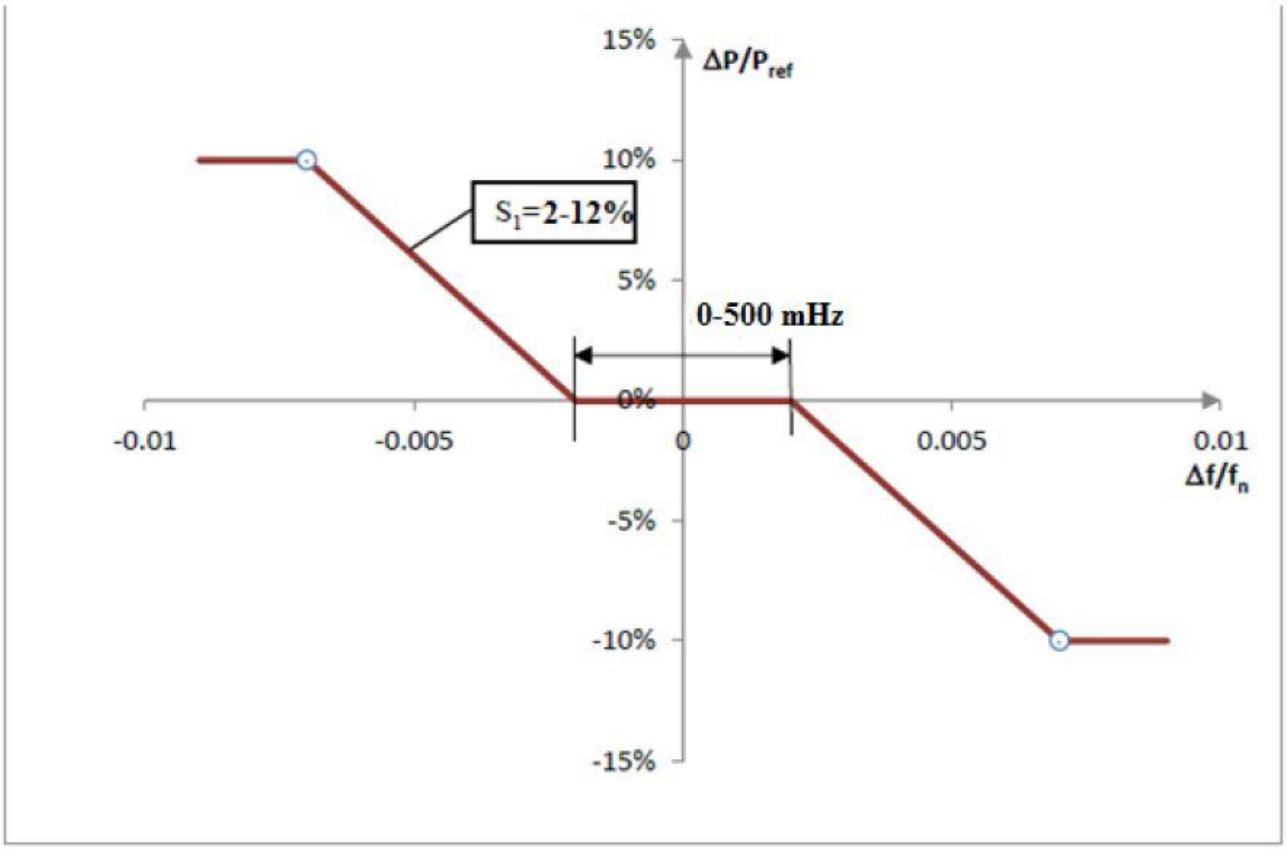
Annex 4. Active power frequency response capability of power-generating modules



Synchronous power generating modules: Pref – maximum capability;

Power park modules: Pref – installed operating power

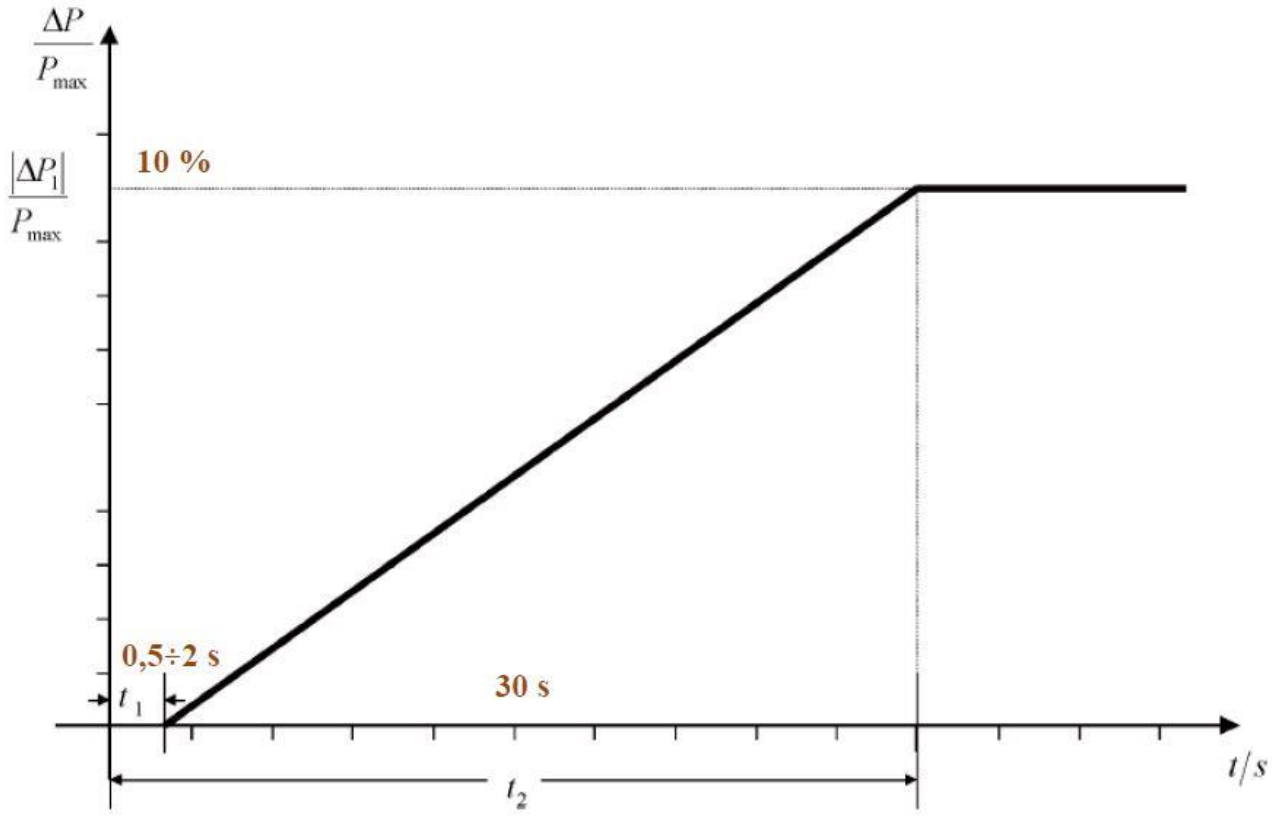
Annex 5. Active power frequency response parameters



Synchronous power generating modules: Pref – maximum capability;

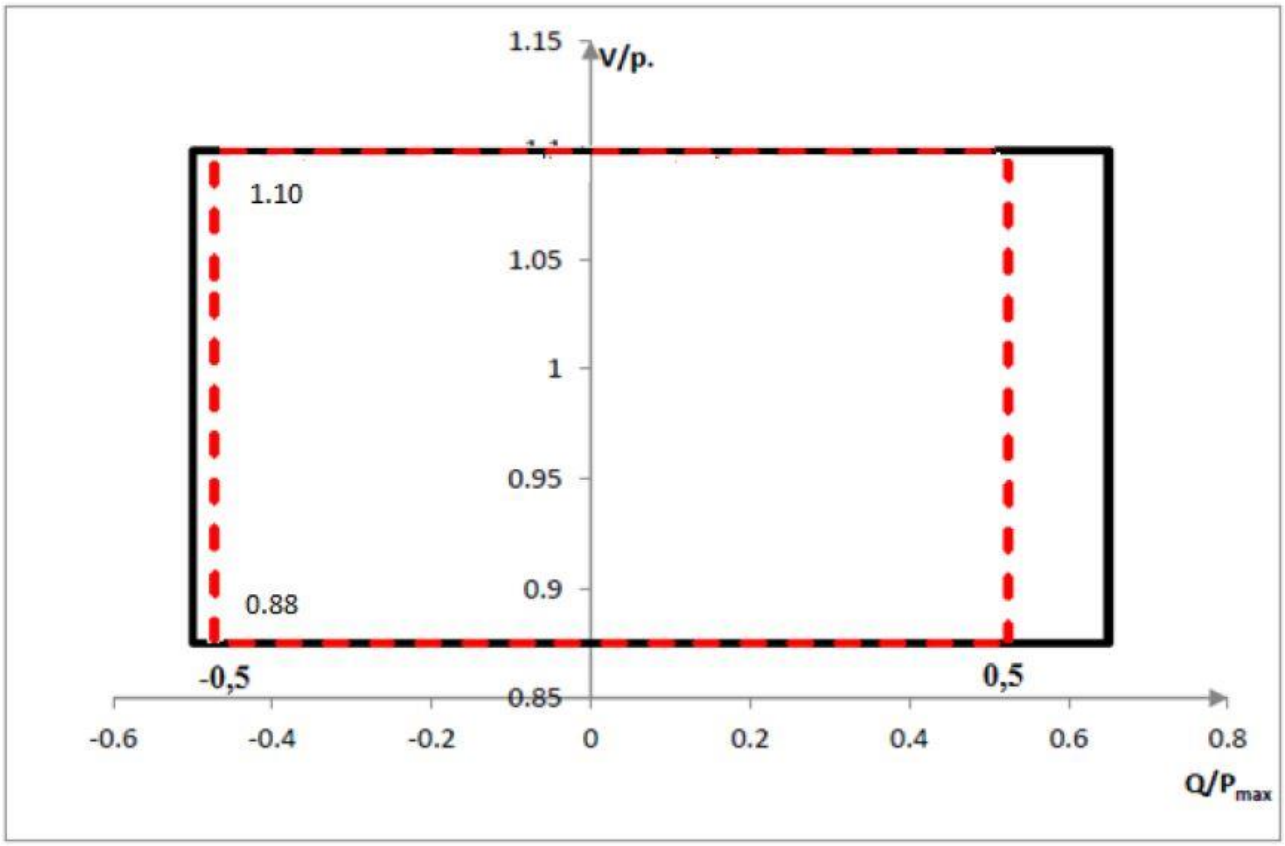
Power park modules: Pref – installed operating power.

Annex 6. Active power frequency response capability

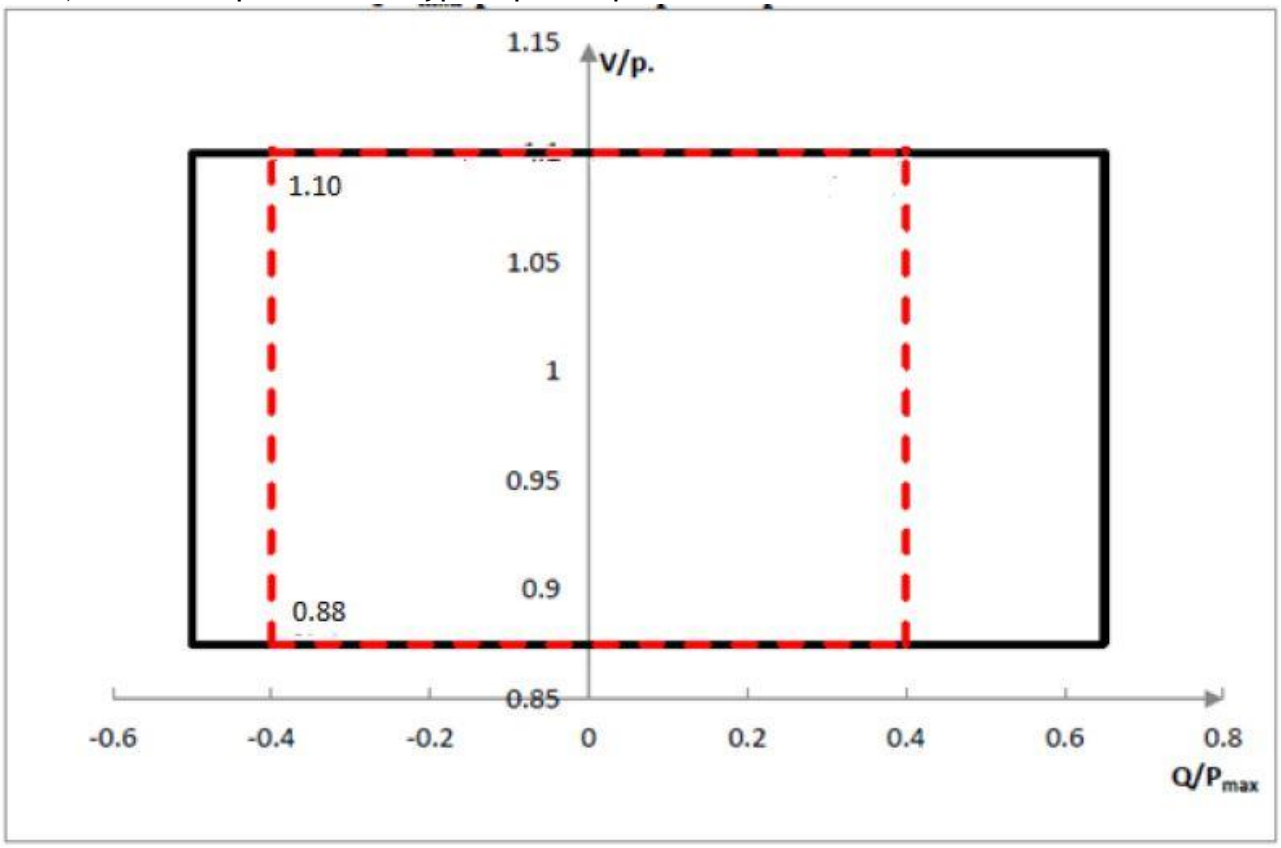


Annex 7. U-Q/Pmax-profile of a Type C power-generating module

a) U-Q/P_{max}-profile of a Type C synchronous power-generating module

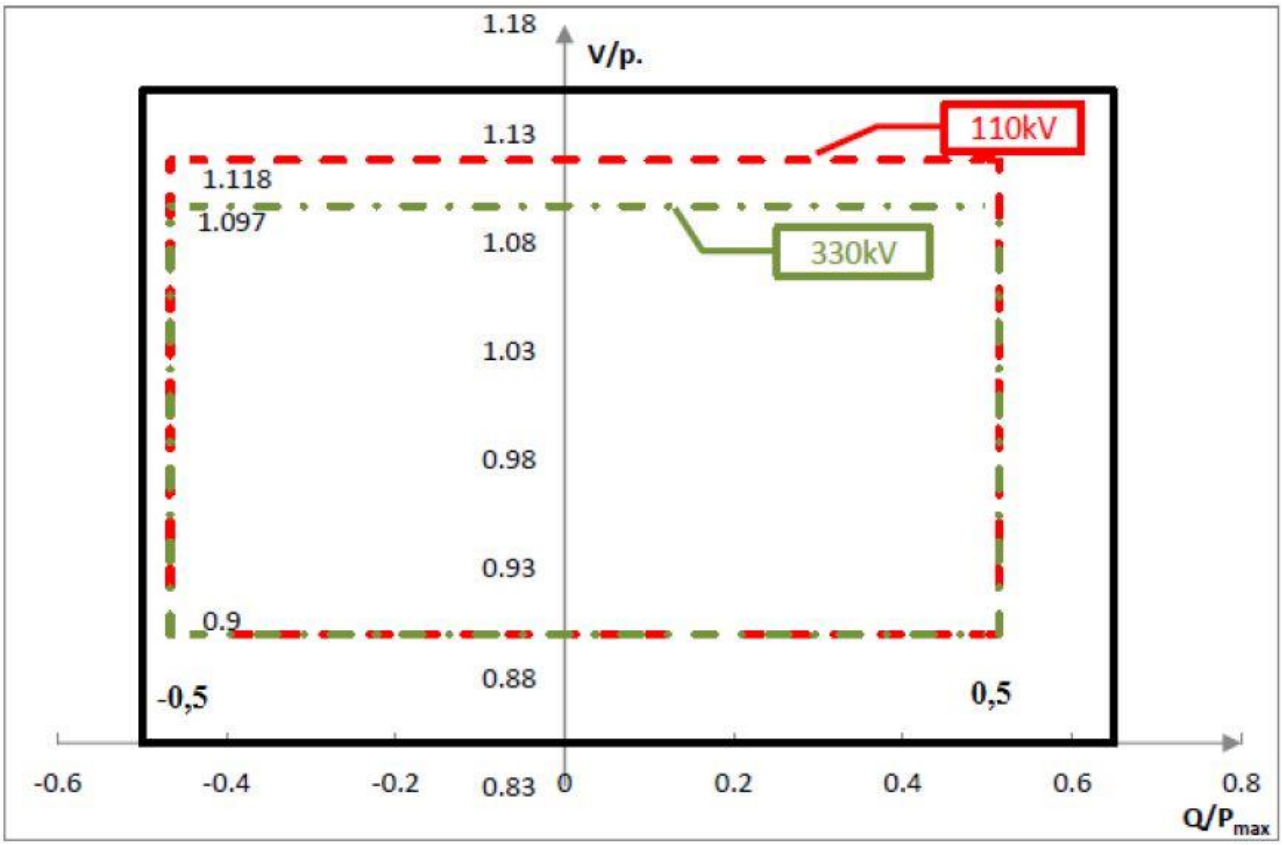


b) U-Q/P_{max}-profile of a Type C power park module

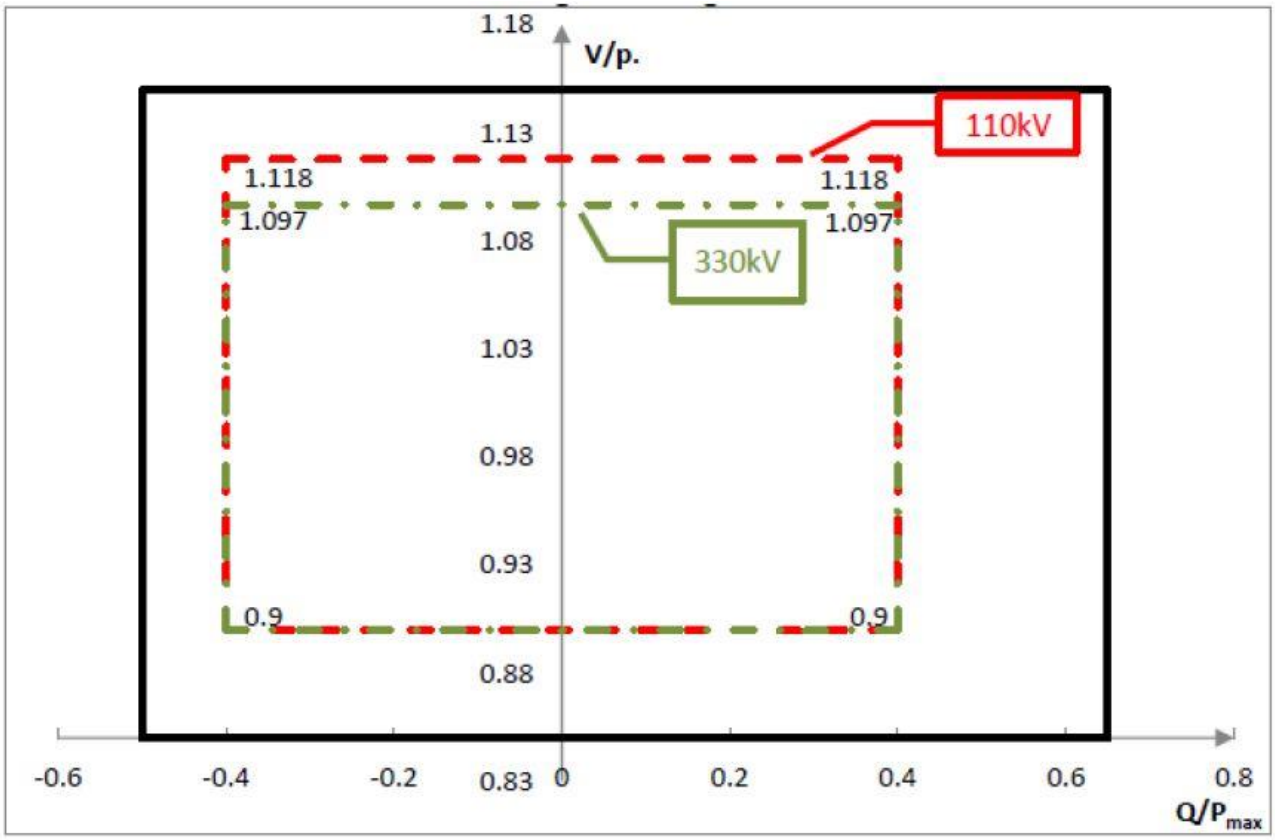


U-Q/Pmax-profile of a Type D power-generating module

a) U-Q/P_{max}-profile of a Type D synchronous power-generating module

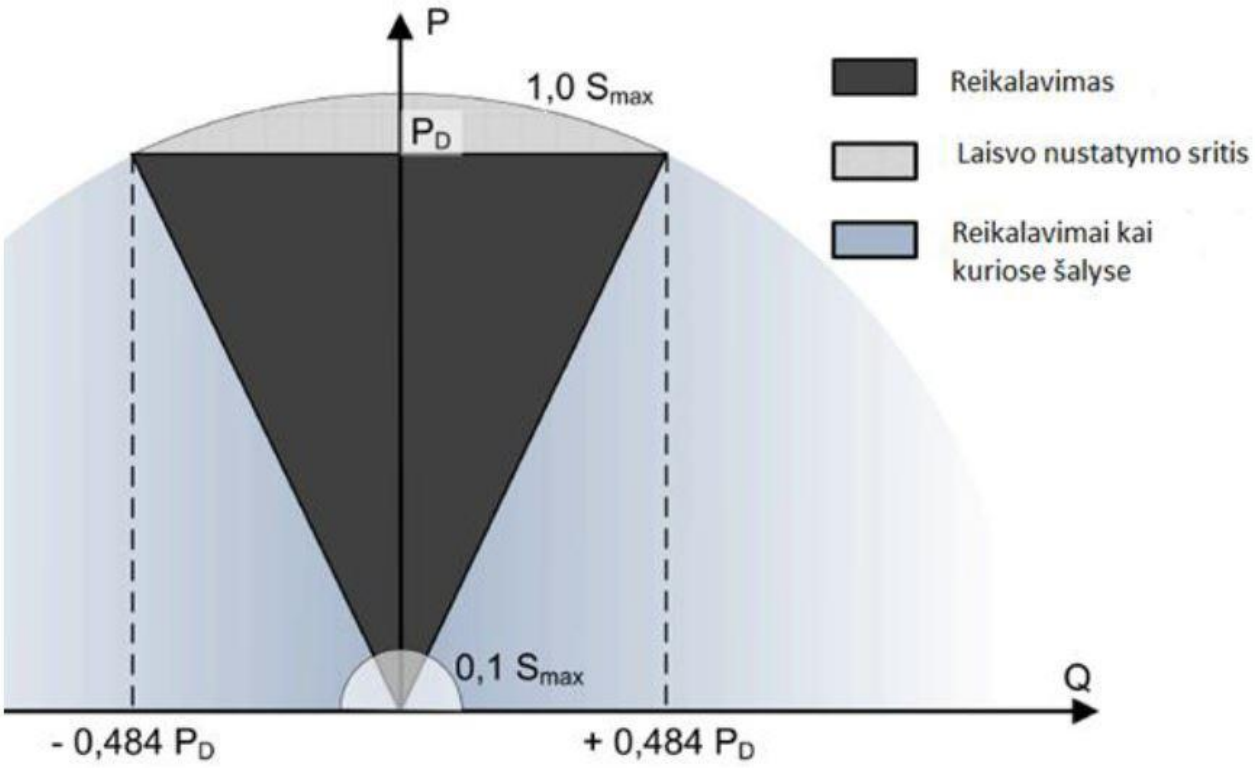


b) U-Q/P_{max}-profile of a Type C power park module

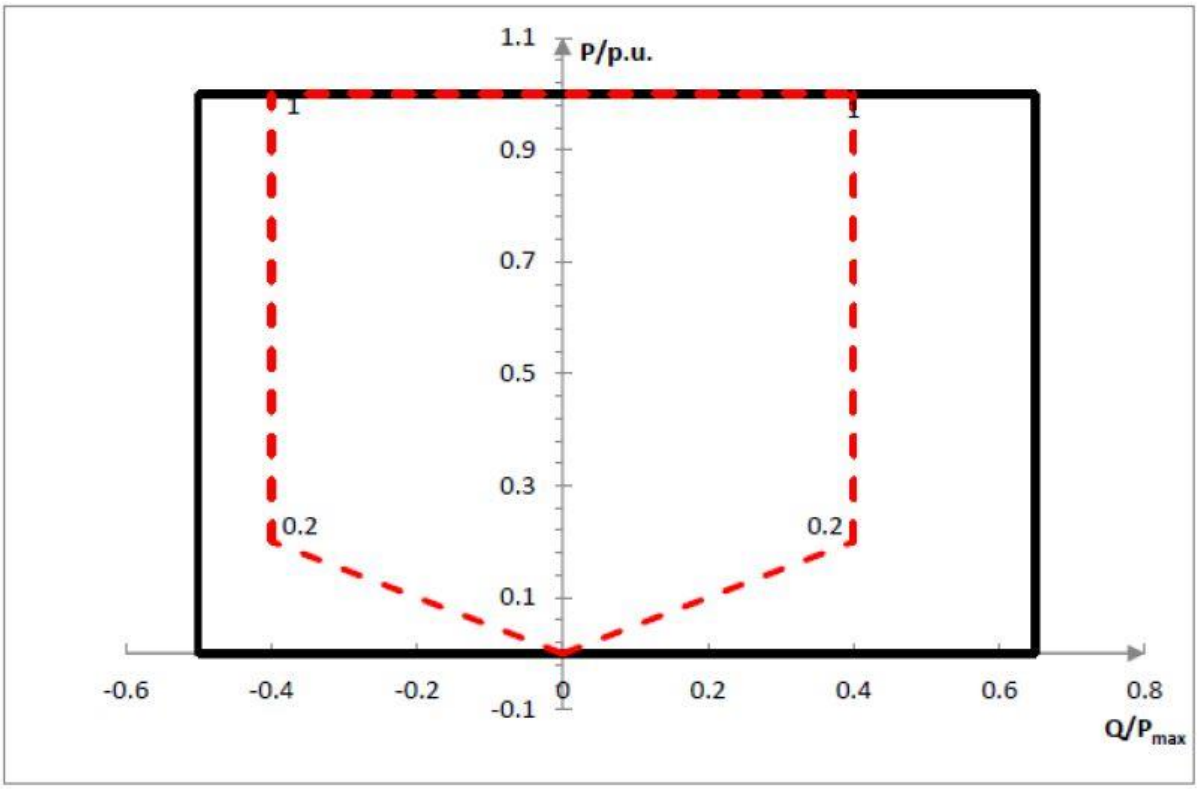


Annex 8 P-Q/P_{max}-profile of a power park module

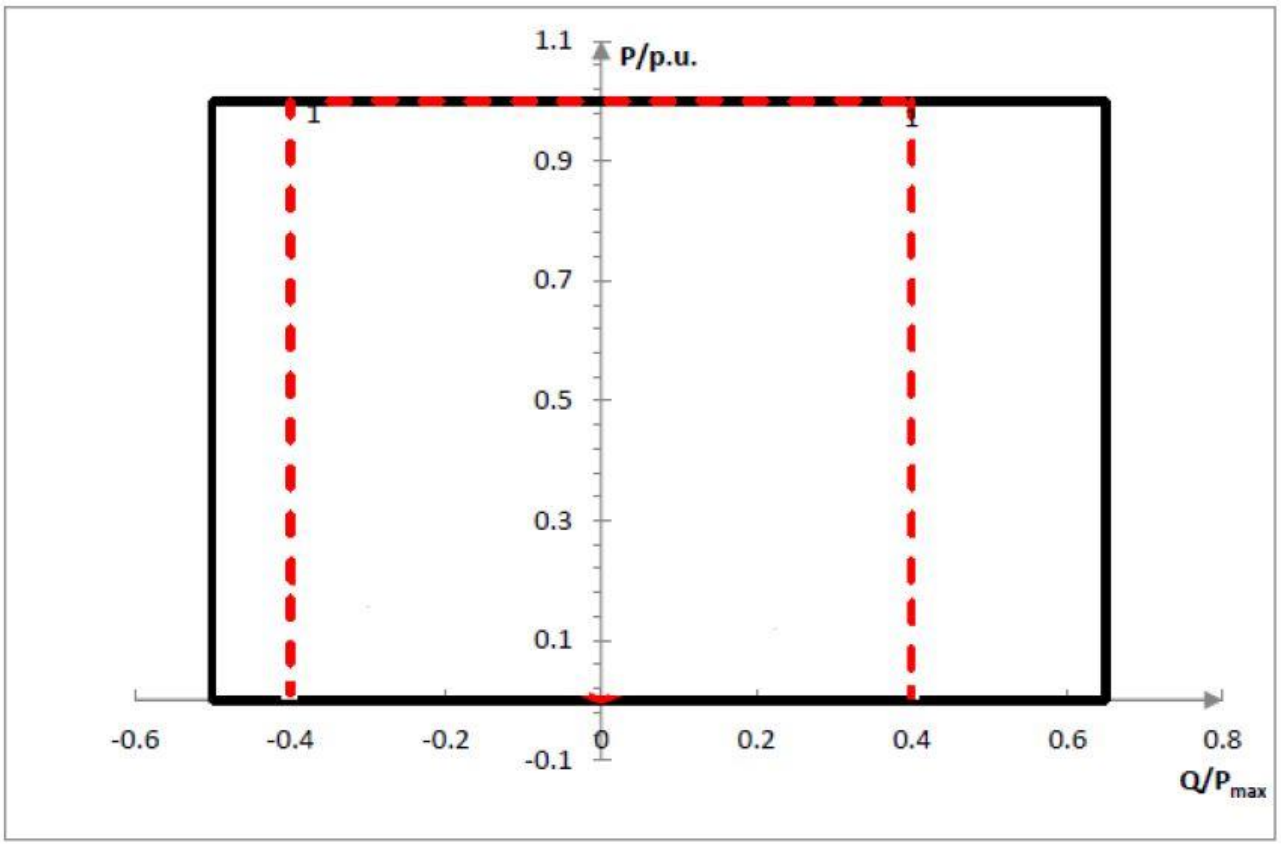
P-Q/P_{max}-profile of a Type B power park module



P-Q/P_{max}-profile of a Type C power park module



P-Q/P_{max}-profile of a Type D power park module



Annex 9 STANDARD TELEINFORMATION LIST

Table 1 Standard tele information list

Telesignals	Telemetry	Telecontrol
Protocols: IEC61850 Status 00 – Intermediate position 01 (0) – OFF position 10 (1) – ON position 11 – Faulty position	Protocols: IEC61850-5-104 Connection with DSO: IEC 60870-5-101	Protocols: IEC61850-5-104 Discrete: OFF command_01(0) - Turn OFF ON command_10(1) - Turn ON IEC 61850-5-104 Analog control
Module position- ON/OFF	Generation of Active power, MW	Active power setpoint
"STOP" signal	Consumption of Active power, MW	Reactive power setpoint
Allow to start	Generation of Reactive power, kVAr	Voltage setpoint
Start signal	Consumption of Reactive power, MVAr	Ramp rate
Wind power plant is not is service due	Voltage at common point of coupling, kV	Active power limit setpoint
Wind power plant identification number	Current at common point of coupling, A	Frequency sensitivity mode
	Frequency at common point of coupling, Hz	Droop setting
	THD % (only for power mark modules)	Frequency threshold setting
	Voltage flicker severity (short term)	Frequency dead band setting
	60 s average of the wind speed	
	Maximum permitted Active power, MW	
	Ramp rate	
	Active power setpoint	
	Minimum reactive power, MVAr	
	Maximum reactive power, MVAr	
	Power factor setpoint	
	Voltage setpoint, kV	
	Frequency deadband	
	Droop	
	Frequency threshold	
	Active power output	

Annex 10 ACTIVE POWER RAMP UP AND RAMP DOWN LIMITS

Table 2 Active power ramp up and ramp down limits

Power generating module type	**Lowest ramp rate, % [P_{max}/min]**
Fossil fuel generators	5 % [P_{max}/min]
Gas generators only generating electrical energy	20% [P_{max}/min]
Combined cycle generators	8% [P_{max}/min]
Hydro generators	50 % [P_{max}/min]
PV modules	100 % [P_{max}/min]
Other generators	5 % [P_{max}/min]