Order 185 of 28.08.2019

Approving the Technical Norm regarding the technical connection requirements to public electrical grids for high voltage direct current systems and for power parks consisting of power generating modules which are connected to public electrical grids throughhigh voltage direct current systems

Taking into account the provisions of article 36 para (7) let. c), i) and n) of the Electricity and natural gas law 123/2012, with later amendments and additions, of article 5 para (1) and (4) from Commission Regulation (EU) 2016/1447 of 26 August 2016 instituting a network code with respect to the requirements for network connection of high voltage direct current systems and for power generating modules of the power park connected to direct current,

In accordance with the provisions of article 5 para (1) let. c) and d) and of article 9 para (1) let. h) from Governmental emergency ordinance 33/2007 on the organisation and operation of the National Regulatory Authority in the Energy domain, approved with amendments and additions by Law 160/2012, with later amendments and additions,

The president of the National Regulatory Authority in the Energy domain issues the following order:

Article 1- The Technical Norm is approved regarding the technical connection requirements to public electrical grids for high voltage direct current systems and for power parks consisting of power generating modules which are connected to public electrical grids through high voltage direct current systems, provided in the annex which is integrant part of this order.

Article 2- Economic operators of the electricity sector carry out the provisions of this order and the organisational entities of the National Regulatory Authority in the Energy domain supervise their compliance.

Article 3- This order is published in Romania’s Official Gazette, Part I, and comes in force on 8 September 2019.

Chairman of the National Regulatory Authority in the Energy domain,

Dumitru Chirita

Annex

Technical Norm regarding the technical connection requirements to electricity networks of public interest for high voltage direct current systems and for power parks consisting of power generating modules which are connected to public electrical grids of throughhigh voltage direct current systems

CHAPTER I

General provisions

Section 1- Purpose and scope

Art. 1. This technical norm establishes the technical requirements for the connection of high voltage direct current systems and power parks consisting of power generating modules which are connected to public electrical grids throughhigh voltage direct current systems.

Art. 2. (1) The connection requirements established in this technical norm apply to:

a) New high voltage direct current systems which inter-connect synchronous areas or control areas including back-to-back diagrams;

b) New high voltage direct current systems which connect power parks consisting of power generating modules to the electricity transmission or distribution networks;

c) New high voltage direct current systems which are integrated within a control area and connected to the electricity transmission network;

d) New high voltage direct current systems which are integrated within a control area and connected to the electricity distribution network, when the transmission and system operator proves there is cross-border impact, taking into account the long-term network development in this evaluation;

e) Power parks consisting of new power generating modules, which are connected to public electrical grids through high voltage direct current systems.

(2) The transmission and system operator or the distribution operators, as appropriate, refuse to allow the connection of the high voltage direct current systems and the power parks consisting of power generating modules which are connected to public electricial grids through high voltage direct current systems, which do not comply with the technical requirements provided in this technical norm, except when they are under derogation granted by NRA.

(3) This technical norm does not apply to high voltage direct current systems whose connection point is below 110 kV, except when the transmission and system operator proves there is cross-border impact, taking into account the long-term network development.

Section 2- Definitions and abbreviations

Art. 3. (1) The terms used in this technical norm have the meaning provided in the following norms:

a) Commission Regulation (EU) 2016/1447 of 26 August 2016 instituting a network code with respect to the requirements for network connection of high voltage direct current systems and for power generating modules of the power park connected to direct current;

b) Electricity and natural gas law 123/2012, with later amendments and additions;

c) Technical code of the electricity transmission network approved by Order 20/2004 of the president of the National Regulatory Authority in the Energy domain, with later amendments;

d) Regulation regarding users' connection to electricity networks of public interest, approved by Order 59/2013 of the president of the National Regulatory Authority in the Energy domain, with later amendments and additions;

e) Technical Norm regarding the technical connection requirements to electricity networks of public interest for generating modules, power parks consisting of power generating modules and power parks consisting of offshore power park modules (situated at sea), approved by Order 208/2018 of the president of the National Regulatory Authority in the Energy domain.

(2) Other terms than those provided in para (1) are defined as follows:

Owner	Natural or legal person holding or operating an HVDC system or DCCPPM, *as the case may be*
Maximum capacity (Pmax)	Active maximum power of DCCPPM which he can continuously generate without taking into consideration any load (consumption) provided in the TCA/CnC or agreed between RSO and the DCCPPM owner
Flexible alternating current transmission system (FACTS)	A system centred on power electronics and other static equipment providing control of one or several parameters of the alternating voltage transmission system
Contractual supply voltage	It usually is the nominal voltage U_n of the network; in case of

	medium and high voltage, following agreement between the DSO and the user, the contractual supply voltage can be different from the nominal one

(3) In this technical norm the following abbreviations are used:

NRA	National Regulatory Authority in the Energy domain
TCA	Technical connection approval
CnC	Connection certificate
DMS-SCADA	SCADA system of the distribution operator (Distribution Management System - Supervisory Control and Data Acquisition)
EMS-SCADA	SCADA system of the transmission operator (Energy Management System - Supervisory Control and Data Acquisition)
ENTSO-E	European Network of Transmission and System Operators for Electricity
FACTS	Flexible Alternating Current Transmission System
LVRT	Low voltage ride through
DCCPPM	DC-connected power park module - Power generating module/modules or a power park consisting of power generating modules inter-connected by alternating current and which are connected to an electricity transmission or distribution network through high voltage direct current system
d.c.	Direct current
a.c.	Alternating current
DSO	Distribution system operator; it can be a concessionaire distribution operator or another operator holding an electricity distribution network
RSO	Relevant system operator; relevant system operator can be the transmission and system operator or the distribution system operator
TSO	Transmission and system operator
PIF	Commissioning
AFR	Automatic fast reclosure

PTG sau ETN	Electricity transmission network sau Power transmission grid
PDG sau EDN	Electricity distribution network sau Power distribution grid
FSM	Frequency sensitive mode
LFSM-O	Limited frequency sensitive mode — overfrequency
LFSM-U	Limited frequency sensitive mode — underfrequency
ROCOF	Rate of change of frequency
HVDC system	High voltage direct current system
SCADA	Monitoring, control and data acquisition IT system associated to a technological process or an installation
STATCOM	Static synchronous compensator
SVC	Static var compensator
NPS	National Power System
r.u.	Relative unit
Pmax	Maximum capacity
Un	Nominal voltage of the network
Technical norm approved by Order 208/2018 of NRA	Technical Norm regarding the technical connection requirements to electricity networks of public interest for generating modules, power parks consisting of power generating modules and power parks consisting of offshore power park modules (situated at sea), approved by Order 208/2018 of the president of the National Regulatory Authority in the Energy domain
Regulation	Commission Regulation (EU) 2016/1447 of 26 August 2016 instituting a network code with respect to the requirements for network connection of high voltage direct current systems and for power generating modules of the power park connected to direct current

CHAPTER II

GENERAL REQUIREMENTS FOR CONNECTION OF HVDC SYSTEMS

Section 1- Requirements for active power control and frequency containment

Art. 4. (1) An HVDC system must have the capability to stay connected to the network and to operate within the frequency ranges and time periods provided in table 1 for the short-circuit power interval defined according to the provisions of article 38 para (4)**:**

Table 1: *Minimum periods when an HVDC system has to be capable to stay connected to the network and to operate at different frequencies, deviating from a nominal value*

Frequency range	**Time periods for operation**
47.0 Hz – 47.5 Hz	60 seconds
47.5 Hz – 49.0 Hz	Minimum 90 minutes
49.0Hz – 51.0 Hz	Unlimited
51.0 – 51.5 Hz	Minimum 90 minutes
51.5 Hz – 52.0 Hz	Minimum 15 minutes

(2) TSO and the HVDC system owner can agree upon more extended frequency ranges or on longer minimum operating time periods, if this is necessary to maintain or to restore the operational safety. These agreed values are registered in the solution study. If in economic and technical terms it is more feasible to use larger frequency ranges or longer minimum operating time periods, the HVDC system owner does not unreasonably refuse his agreement in this respect.

(3) Without prejudice to the provisions of para (1), an HVDC system must have the capability of automatic disconnection at frequency values specified by the TSO according to table 1 or agreed according to the provisions of para (2).

(4) No active power reduction is admitted at underfrequency below 49 Hz.

Art. 5. As regards the **withstanding capability to the rate of change of frequency,** an HVDC system must have the capability to stay connected to the network and operateat frequency variation rates of 2 Hz/s for a time period of 500 ms, of 1.5 Hz/s for a time period of 1000 ms and of 1.25 Hz/s for a time period of 2000 ms, depending on the system's short-circuit power in the connection point.

Art. 6. (1) As regards the **capability to control the transmitted active power,** an HVDC system must allow adjustment of the transmitted active power up to its maximum active power transmission capacity in every direction, according to the requirements received from the TSO. Thus the TSO:

a) Specifies in the TCA the maximum and minimum values of the variation step of the active power transmitted on the HVDC line, depending on the specific conditions of the connection point, following restrictions occurring in the dynamic regime study performed in order to issue the TCA. Usually the maximum value of the power variation step is 100% and the minimum value of the power variation step is 1% of the HVDC transmission capacity;

b) Specifies in the TCA the minimum HVDC active power transmission capacity in every direction, below which there is no demand for active power transmission capacity, according to the results of the elaborated study and

c) Specifies in the TCA the maximum delay period time, which cannot be above 5 minutes within which the HVDC system can adjust the transmitted active power according to the requirements received from the TSO.

(2) The manner in which an HVDC must be capable to modify the contribution of transmitted active power in case of disturbances in the a.c. networks where it is connected, comes from the lowest technical value indicated by the equipment manufacturer. If the initial delay is higher than 10 ms from receipt of the setpoint signal from the TSO, the HVDC system owner justifies this delay to the TSO.

(3) The HVDC system must have the capability to quickly reverse the delivery sense of active power. The active power reversal from the maximum transmission capacity limits in one direction to the maximum active power transmission capacity in the reverse direction, must be possible within 2 seconds at the most. In case of exceeding this interval the HVDC system owner justifies to the TSO the deviations from requirements in technical terms, namely the operational restrictions.

(4) In case of HVDC systems connecting different control areas or synchronous areas, they must be equipped with control functions enabling the TSO to modify the transmitted active power in view of cross-border balancing.

Art. 7. An HVDC system must allow **adjusting the ramping value of active power variation** within its technical capability limits, in accordance with the provisions transmitted by the TSO. In case the active power is modified in accordance with article 6 para (2) and (3), the ramp period is not adjusted.

Art. 8. When issuing the TCA the TSO specifies, in cooperation with TSOs of neighbouring countries, whether the **control functions** of the HVDC system must be capable to apply remedial measures, including stopping the ramp and blocking the FSM, LFSM-Oand LFSM-U as well as frequency control, as these resulted from the dynamic studies used for TCA issuance. Tripping and blocking criteria must comply with the requirements imposed under NPS emergency and restoration conditions.

Art. 9. (1) An HVDC system must have the capability to provide artificial inertia as response to frequency variations. This is activated at frequency values below 49 Hz, namely above 51 Hz, through fast adjustment of the active power introduced or extracted from the a.c. network, within a time period lower than or equal to 500 ms, in order to limit the rate of change of frequency . The requirement is based on studies made by TSO or ENTSO-E, which establish the minimum inertia of one's own system.

(2) The principle of the control system provided in para (1) and the associated performance parameters are agreed between the TSO and the HVDC system owner.

Art. 10. (1) As regards the **requirements applicable to the frequency deviation response**, when it operates in the frequency sensitive mode (FSM) the HVDC system must have thecapability to respond to frequency deviations from each connected a.c. network by adjusting the active power transmission, according to figure 1 and in compliance with the parameters specified by each TSO, within the limits indicated in table 2.

(2) Adjusting the frequency sensitive mode (FSM) is limited by the minimum HVDC active power transmission capacity and by the maximum HVDC active power transmission capacity (in each direction).

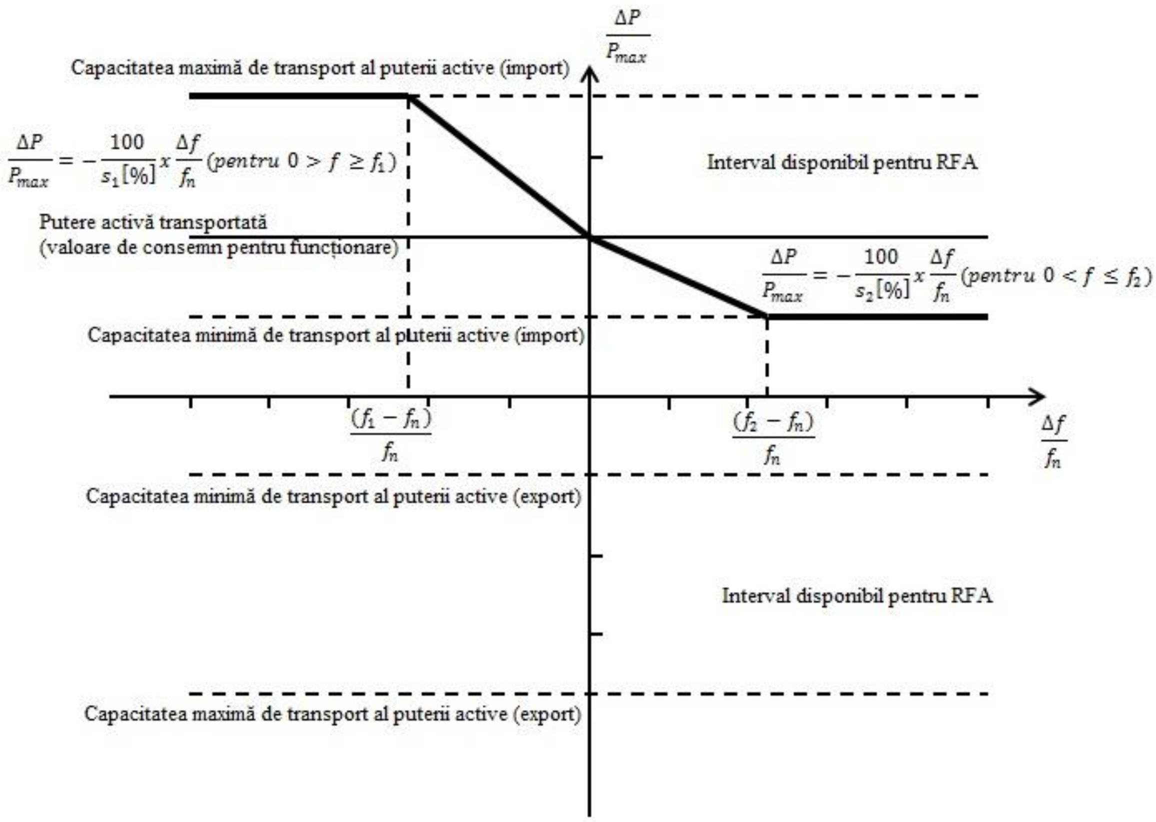

Fig. 1: *Response capability to frequency deviations of an HVDC system in FSM mode, illustrating the dead band and zero insensitivity band cases with positive value requested for active power (import mode). ΔP is the active power variation in the HVDC system, fn is the target*

frequency in the a.c. network in case FSM is provided, and Δf is the frequency deviation in the a.c. network where FSM is supplied.

Table 2: *Parameters for the frequency sensitive mode in FSM*

Parameters	**Intervals**
Dead band for frequency response	0 mHz
Statism s_1 (upward control)	3-12 %
Statism s_2 (downward control)	3-12 %
Insensitivity margin for frequency response	10 mHz

(3) Following a disposition transmitted by the TSO the HVDC system must have the capability to adjust statism for upward and downward control within 3-12%, dead band for frequency response and the operational interval of such variation within the limits of the active power range available for FSM, provided in figure 1 and, more general, within the 0-500 mHz limits, the value usually utilised being 0 mHz.

(4) Following the change of frequency step the HVDC system must allow the adjustment of the active power to the frequency sensitive mode defined in figure 1, so that the response can be:

a) So fast as the technical capability allows, but no more than 500 ms and
b) On the full line or above it, in accordance with figure 2, pursuant to the parameters specified by each TSO, within the limits provided in table 3 below**:**
   (i) The HVDC system must be capable to adjust the active power output ΔP up to the limit of the active power interval requested by the TSO in accordance with t_1 and t_2 as per the limits of table 3, where t_1 is the initial delay, usually of 500 ms, and t_2 is the time for full activation, usually 30 s;
   (ii) If the initial activation interval is greater than 500 ms, the HVDC system owner must justify it to the TSO.

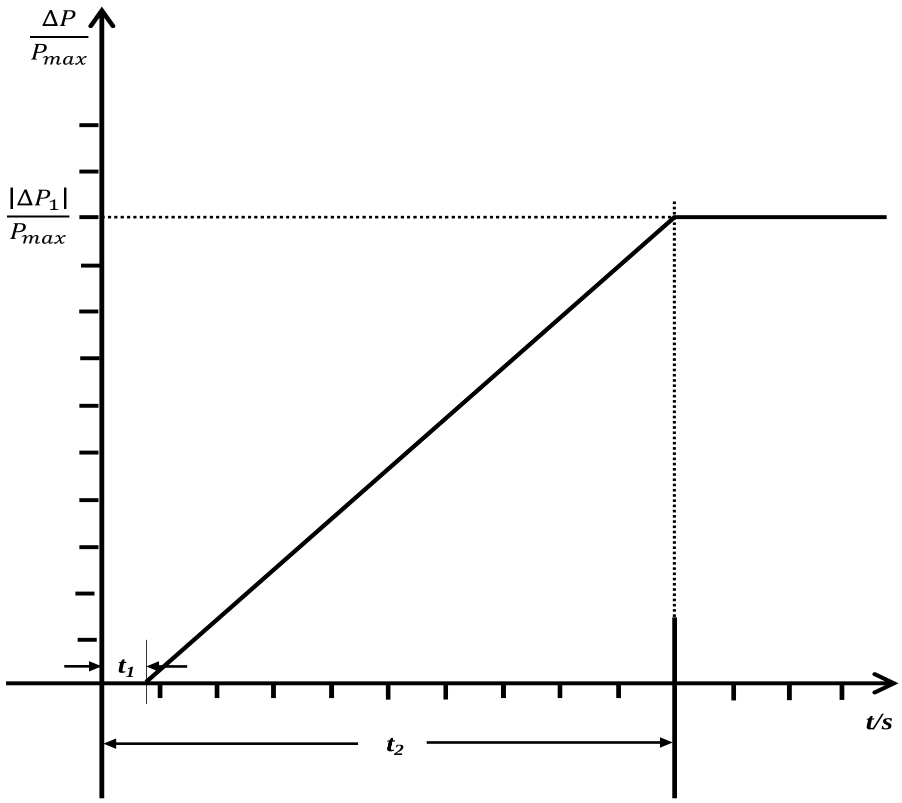

Fig. 2: *Response capability to frequency deviations of an HVDC system; ΔP is the active power variation triggered by the change of the frequency step*

Table 3: *Parameters for full activation of active power as response to the frequency step variation*

Parameters	Time
Initial maximum admissible delay t_1	500 ms
Maximum admissible time for full activation t_2, except when the TSO admits longer activation time periods	30 seconds

(5) In case of HVDC systems connecting different control or synchronous areas, in the FSM operational mode the HVDC system must be able to adjust the full response to frequency/active power any moment and for uninterrupted time period**;**

(6) Active power control must not have any negative impact over the frequency sensitive mode (FSM) during frequency deviations.

Art. 11. As regards the **limited frequency sensitive mode – over-frequency (**LFSM-O**),** in addition to the requirements of article 4 the following applies**:**

a) The HVDC system must have the capability to adjust the **frequency sensitive mode** to the a.c. network or networks, during import and export, in accordance with figure 3 to a threshold frequency f_1 of 50.2 Hz and with statism s_3 adjustable to above 0.1%, usually 5%;
b) The HVDC system must have the capability to adjust downward the active power to its minimum capacity of active power transmission;
c) The HVDC system must have the capability to adjust its **frequency sensitive mode** as quickly as possible, in technical terms, with initial interval of 0.5 sec usually and a time period as necessary for full activation, usually 30 sec**;**
d) The HVDC system must be able to guarantee stable operation during LFSM-O. When the LFSM-Omode is active, the hierarchy of control functions is organised in accordance with the provisions of article 41**.**

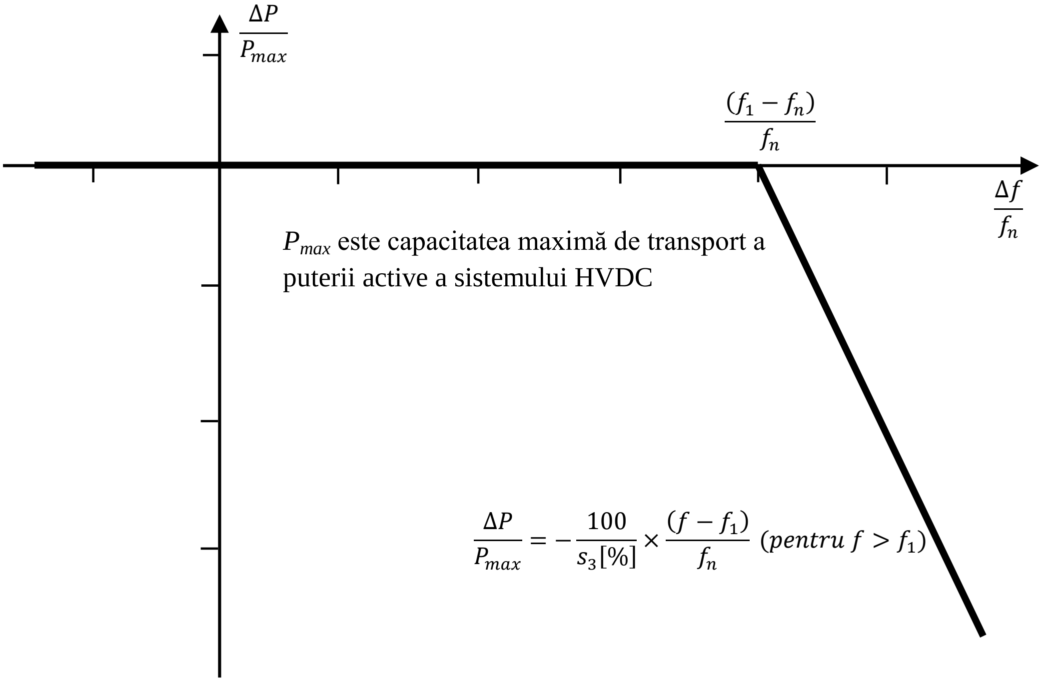

Fig. 3: *Response capability to frequency deviations of an HVDC system in LFSM-O. ΔP is the active power variation upon output from the HVDC system and, depending on operational conditions, either a decrease of import power or an increase of export power; fn is the nominal frequency of the a.c. network or networks which the HVDC system is connected to, and Δf is frequency variation in the network or networks which the HVDC system is connected to. In case of frequency increase where f is higher than f_1, the HVDC system reduces the active power depending on the set statism value.*

Art. 12. As regards the **limited frequency sensitive mode – under-frequency (**LFSM-U**),** in addition to the requirements of article 4, the following applies:

a) The HVDC system must have the capability to adjust its **frequency sensitive mode** in the a.c. network or networks during import and export, in accordance with figure 4 to a threshold frequency f_2 of 49.8 Hz, with statism s_4 adjustable to a value above 0.1 %, usually 5%**;**

b) In the LFSM-Umode the HVDC system must have the capability to adjust upward active power, up to its maximum active power transmission capacity**;**

c) The **frequency sensitive mode** must be activated as fast as possible, in technical terms, with initial interval of 0.5 sec usually and a time period as necessary for full activation, usually 30 sec;

d) The HVDC system must guarantee stable operation during LFSM-U. When the LFSM-Umode is active, the hierarchy of control functions is organised in accordance with the provisions of article 41.

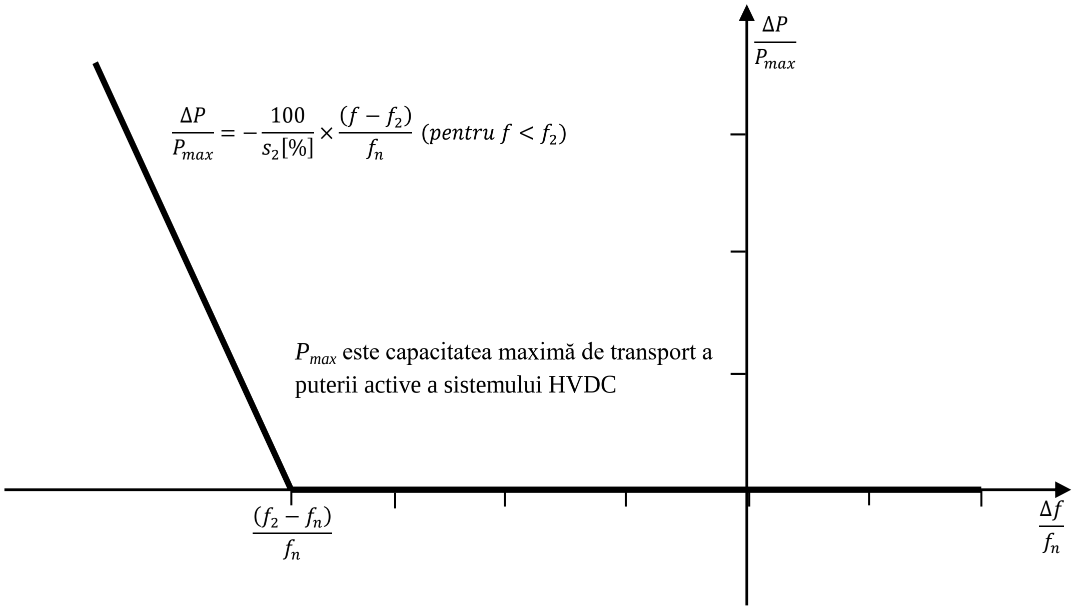

Fig. 4: *Response capability in active power to frequency deviations of an HVDC system in LFSM-U. ΔP is the active power variation of the HVDC system, depending on operational condition, on the increase of import power or increase of export power; fn is the nominal frequency of the a.c. network or networks which the HVDC system is connected to, and Δf is the frequency variation in the a.c. network or networks which the HVDC system is connected to. In case of frequency drops where f is lower than* f_2*, the HVDC increases active power depending on statism* s_4

Art. 13. (1) An HVDC systemmust be provided with a decentralised automatic frequency control mode in order to modify the active power of the HVDC conversion substation depending on the frequency in the connection point of the HVDC system, in order to maintain the systems frequency stability.

(2) The operational principle is the one specified in figure 1, and the associated performance parameters and activation criteria for frequency control are mentioned in tables 2 and 3**.**

Art. 14. (1) An HVDC system must be configured so as to limit the loss of active power injected into a synchronous area to the value specified by the TSO for its frequency-power control area, based on the impact of the HVDC system over the electric power system.

(2) The value provided in para (1) is established for each project depending on the maximum power exchanged through the HVDC system and the characteristics of the a.c. network it is connected to. This values are established in the solution study and are specified in the TCA.

(3) In case of an HVDC system connects two or more control areas, the respective TSOs are mutually consulting in order to establish a coordinated value of the maximum loss from the active energy injection, as specified in para (1), taking into account the common influence over different areas. This value is specified in the TCA.

Section 2 Requirements for reactive power control and voltage containment

Art. 15. (1) Without prejudice to the provisions of articles 26-31, an HVDC conversion substation must have the capability to stay connected to the network, operating at maximum value of the current within the HVDC system, within the network voltage limits in the connection point, expressed by voltage in the connection point in relative units, where 1 r.u. refers to the contractual voltage and during the time periods provided in tables 4 and 5. Establishing the contractual voltage at 1 r.u. is commonly performed by adjacent relevant system operators.

Table 4: *Minimum time periods when an HVDC system must be capable to operate without disconnecting, when the network voltage values in the connection point deviate from 1 r.u. Usually the maximum value of unlimited operation for 110 kV nominal voltage is 123 kV, while for 220 kV nominal voltage is 245 kV, as absolute values. In case of network areas where other voltage values are agreed upon, different from the nominal voltage, the table values are applied under operational agreements between users and the RSO. This table is applied to nominal voltage values ranging 110 kV and 220 kV.*

Voltage range	Time period operation
0.85 r.u. – 1.118 r.u.	Unlimited
1.118 r.u. – 1.15 r.u.	20 minutes

Table 5: *Minimum time periods when an HVDC system must be capable to operate without disconnecting, when the network voltage values in the connection point deviate from 1 r.u. Usually the maximum unlimited operation value for 400 kV nominal voltage is 420 kV, as absolute value. In case of network areas where other voltage values are agreed upon, different from the nominal voltage, the table values are applied under operational agreements between users and the RSO. This table is applied to nominal voltage of 400 kV.*

Voltage range	Operational period
0.85 r.u. – 1.05 r.u.	Unlimited
1.05 r.u. – 1.0875 r.u.	≥60 minutes
1.0875 r.u. – 1.10 r.u.	60 minutes

(2) The HVDC system owner and the RSO, in coordination with the TSO, can agree on more extended voltage ranges or over longer minimum operational periods than those specified in para (1), in order to provide optimum utilisation of the technical capability of the HVDC system, if this is necessary to maintain or to restore operational safety. If such more extended voltage ranges or longer minimum operational periods are feasible in economic and technical terms, the HVDC system owner cannot unjustifiably refuse his agreement for such proposals. These agreed values are specified in the TCA.

(3) Without prejudice to the provisions of para (2), RSO, in coordination with the TSO, is entitled to specify the voltage values in the connection point where an HVDC conversion substation must be capable of automatic disconnection. The requirements and parameters for automatic disconnection are agreed between the RSO in coordination with the TSO and the HVDC system owner and are usually given by reaching the limits of frequency and voltage values in the connection point, specified in tables 1, 4 and 5.

(4) For the connection points at a.c. nominal voltage of 1 r.u. which are not included in the limits provided in para (1), RSO in coordination with the TSO specifies the requirements applicable in the connection points**.**

Art. 16. (1) As regards the **short-circuit contribution during faults,** an HVDC system must have the capability to provide the transient regime component of the fault current in the connection point in case of symmetrical (three-phase) faultfaults under the following circumstances:

a) The HVDC system must be able to activate the provision of the transient regime component of the fault current by:

(i) Ensuring the supply of the transient regime component of the fault current in the connection point, corresponding to the voltage variation with a proportionality factor (k) ranging (2÷10), usually the set value is 2 according to the $\Delta I = k * \Delta U$ formula; or

(ii) Measuring the voltage variations at the terminals of the HVDC system and providing the transient regime component of the fault current to their terminals (reactive current component);

b) RSO in coordination with the TSO provides:

(i) The mode and moment in time when a voltage deviation is determined, as well as the deviation period. The voltage deviation is determined when the voltage measured in the connection point is under 0.85 r.u. The deviation period is considered until the voltage value is restored to above 0.85 r.u.;

(ii) The characteristics of the transient regime component of the fault current, including the time period to measure the voltage deviation and the transient regime component of the fault current which the current and voltage can be measured for differently compared to the method established in let. a) are: the increase time of the fault current, lower or equal to 30 ms and the removal time of the fault current, lower or equal to 60 ms**;**

(iii) Synchronisation and accuracy of the transient regime component of the fault current, which can include several stages during and after fault removal. Thereby, a reactive current depending on the amplitude of the voltage dip with proportionality factor between 2÷10, must beinjected into the terminals of the HVDC system immediately after the fault, when voltage drop is noticed according to item (ii), usually within 50 ms. The reactive current injected must be maintained during the entire voltage dip period, according to the voltage profile defined by the voltage ride through in figure 6 and to be immediately cancelled when the fault was removed.

(2) RSO in coordination with the TSO is entitled to establish requirements for the asymmetrical component of the fault current, with respect to the provision of the transient regime component of the fault current in case of one-phase or three-phase asymmetrical faults**.** Usually the requirements regarding the asymmetrical component of the fault current are similar to the requirements regarding the symmetrical component of the fault current provided in para (1). These requirements are notified to the owner.

Art. 17. (1) RSO in coordination with the TSO must establish requirements regarding the capability to inject reactive power in the connection points, in case of voltage variations. The proposal with such requirements includes a U-Q/P_{max} diagram, within which limits the HVDC conversion substation must inject reactive power to its maximum active power transmission capacity.

(2) The additional reactive power must compensate the reactive power of the high voltage line or cable between the terminals of the HVDC conversion substation and the connection point. The additional reactive power must be provided by a dedicated equipment delivered by the HVDC system owner. This additional reactive power is established by a reactive power compensation study in the connection point, exchange of null reactive power at zero active power, with maximum tolerance of 0.5 MVAr.

(3) Diagram U-Q/P_{max} provided in para (1) must comply with the following principles**:**

a) Diagram U-Q/P_{max} does not exceed the outline of diagram U-Q/$P_{max,}$ represented by the interior outline in figure 5 and it is not necessary to be rectangular**;**

b) The size of the U-Q/P_{max} diagram outline (interval Q/Pmax and voltage range) falls within the maximum values established in table 6**;**

c) The positioning of U-Q/P_{max} diagram falls within the exterior fixed contour from figure 5**.**

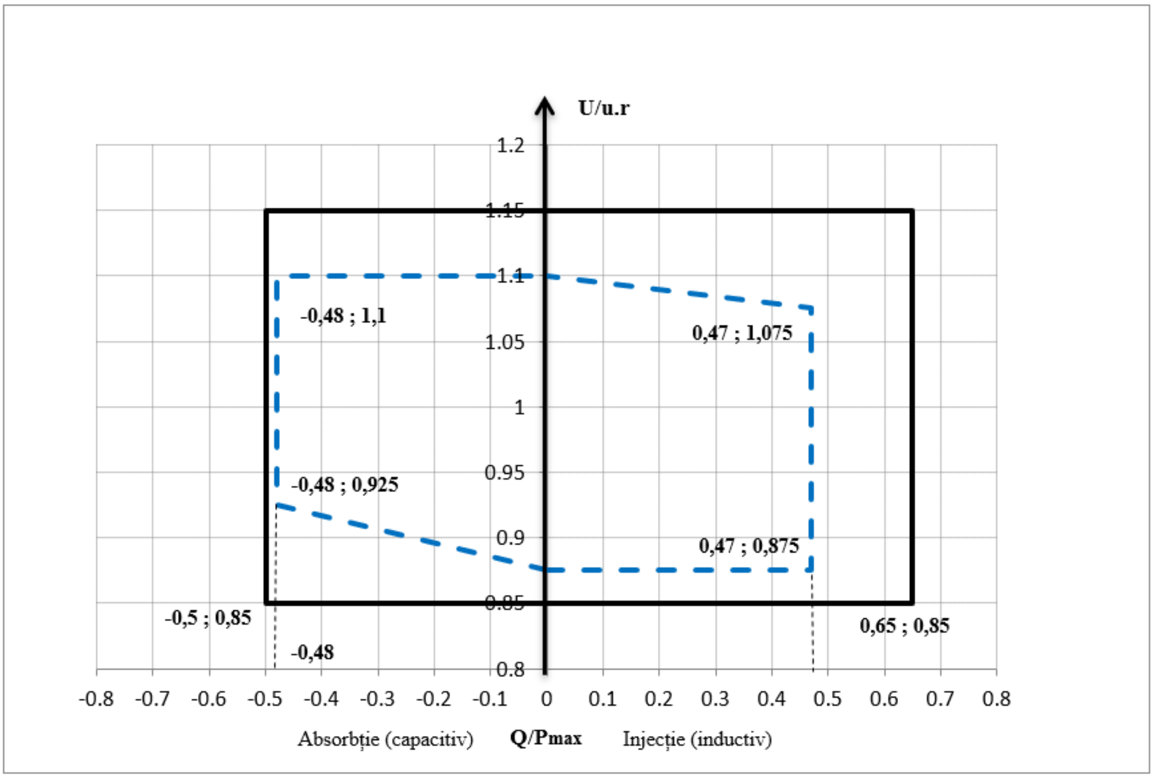

Fig. 5: *represents the typical limits of the U-Q/P_{max} diagram as dependency between voltage value in the connection point, expressed in relative units and Q/P_{max} representing the ratio between reactive power and the maximum HVDC active power transmission capacity The position, dimension and shape of the roll are informative and inside it other forms can be used than*

rectangular. For other profile forms than rectangular, the voltage range represents the highest and the lowest voltage values of the respective shape. Such a profile would not determine the availability of the entire reactive power range in the voltage range under stationary regime.

Table 6: *Parameters for inner winding in figure 5*

Maximum interval of Q/P_{max}	**Maximum interval of stationary voltage in r.u.**
0.95	0.225

(4) The HVDC system owner must provide a contour of the U-Q/Pmax diagram which can take any shape within which limits the HVDC system is capable to inject / absorb reactive power upon voltage variations and maximum capacity operation, but without causing in the connection point voltage variations above 2% from the voltage value before the modification. The contour must be analysed and approved by the TSO in consultation with the RSO.

(5) When it operates at an active power below the maximum HVDC active transmission capacity ($P<P_{max}$), the HVDC conversion substation must have thecapability to operate in any possible operational point, specified by the RSO in cooperation with the TSO and in accordance with the reactive power capability established through the $U\text{-}Q/P_{max}$ profile indicated in para (1) – (3).

Art. 18. (1) The HVDC system owner ensures that the reactive power of the HVDC conversion substation exchanged with the network in the connection point is limited to the values specified by the RSO in cooperation with the TSO depending on the location requirements, usually at 0 MVAr for null active power exchange with the system.

(2) The reactive power variation caused by the operation of the HVDC conversion substation under reactive power control, provided in article 19 para (1), does not lead to a voltage leap greater than 2% of the voltage value before such modification. RSO in cooperation with the TSO establishes this maximum tolerable value of the voltage variation, usually 2% for 400 kV and 3% for 110 kV and 220 kV.

Art. 19. (1) As regards the **control modes of reactive power,** an HVDC conversion substation must have the capability to operate in one or several of the reactive power control modes, provided below, as specifies the RSO in cooperation with the TSO:

a) The usually used voltage control mode;
b) Reactive power control mode;

c) Power factor control mode;

(2) An HVDC conversion substation must be capable to operate under additional control modes specified by the RSO in cooperation with the TSO.

Art. 20. Each HVDC conversion substation must be capable to contribute to voltage control in the connection point by using its capacities, at the same time respecting the provisions of articles 17 and 18, in accordance with the following control characteristics:

a) A reference voltage in the connection point is the nominal voltage or the voltage value agreed between the RSO and the TSO, namely the contractual supply voltage. The voltage value requested for voltage control is continuously transmitted as value expressed in absolute values (kV) and variable into steps for defined time periods (usually longer than 30 minutes);

b) Voltage control is performed with or without dead band selectable in a range from 0 up to ± 5% of Un, namely 0.05 r.u. if Un is 1 r.u., by steps of maximum 0.5%. The dead band must be adjustable into steps, as specified by the RSO in cooperation with the TSO. The dead band value is expressed as percentage of the requested voltage, corresponding to an absolute voltage value of ± 0.25 kV for 110 kV & 220 kV and ± 0.5 kV for 400 kV;

c) After a step type voltage change, the HVDC conversion substation must:

   (i) Reach 90% of the step value in moment t_1, established by the RSO in coordination with the TSO, within (1÷5) seconds interval, usually 1 second and

   (ii) Be limited to the value specified by the variation ramp active within the time interval t_2, established by the RSO in coordination with the TSO in the (1÷60) seconds interval, usually 10 seconds, with tolerance under stationary regime of usually 5% Qmax, which however does not produce voltage variation greater than the dead band defined in let. b);

d) The voltage control mode includes the capability to modify the resulting reactive power based on the result from a reference voltage value modified and another additional component of the requested reactive power. For gradual variation of the requested voltage the reactive power variation should be 90% Qmax in 1 minute.

Art. 21. As regards the **reactive power control mode**, the RSO indicates a reactive power variation in MVAr/minute (usually 20 MVAr/minute) or in % from the maximum value of reactive power per minute (usually 90% Qmax per minute), as well as the associated accuracy in the connection point (usually ±5% Qmax), using the capacities of the HVDC system and at the same time respecting the provisions of articles 17 and 18.

Art. 22. As regards the **power factor control mode**, the HVDC conversion substation must have the capability to adjust the power factor in the connection point to a defined target value, respecting the provisions of articles 17 and 18. The prescribed reference values must be available into steps which must not exceed a maximum permitted value established by the RSO, usually 0.05.

Art. 23. RSO in cooperation with the TSO and the HVDC system owner specifies which of the three options of reactive power control mode with associated reference values must be applied, and all the necessary equipments to permit remote selection of control modes and of reference values. Such values are transmitted in the technical project stage**.**

Art. 24. As regards setting the hierarchy of **active or reactive power contribution** and taking into account the capabilities of the HVDC system mentioned in accordance with this technical norm, the TSO establishes, depending on location and the conclusions of static and dynamic regime studies whether the priority goes to the active power contribution or the reactive power contribution during the high or low voltage operation or during faults which require the low voltage ride through. In case that the priority goes to active power contribution, its provision is established at the latest 150 ms from the beginning of the fault.

Art. 25. (1) As regards **power quality** the HVDC system owner must make sure that his own network connection system does not determine fast voltage variations above ± 5% of the nominal voltage in the network it is connected to.
(2) The HVDC system must provide power quality in the connection point according to applicable standards (European ones and the performance standard for electricity transmission or system services, namely the standard for electricity distribution services, as appropriate). The compliance with standard values is monitored through quality measurements from quality analysers installed in the connection point.

Section 3- Requirements for the low voltage ride through capability

Art. 26. While respecting the provisions of article 15, the TSO specifies a voltage-time dependency diagram as provided in figure 6 and taking into account the voltage development in time specified for the power park generating modules according to the provisions of Regulation (EU) 631/2016. This diagram is applied in connection points during faults, when the HVDC conversion substation must be able to remain connected to the network and in stable operating state after the system has been restored post-fault. The voltage time development diagram represents the lower permitted limit of the actual voltage variation at terminals at the network voltage level in the connection point, upon occurrence of a symmetrical fault, as time function before fault, during fault and after fault. Any fault ride through exceeding t_{rec2} is established by the TSO in accordance with the provisions of article 15.

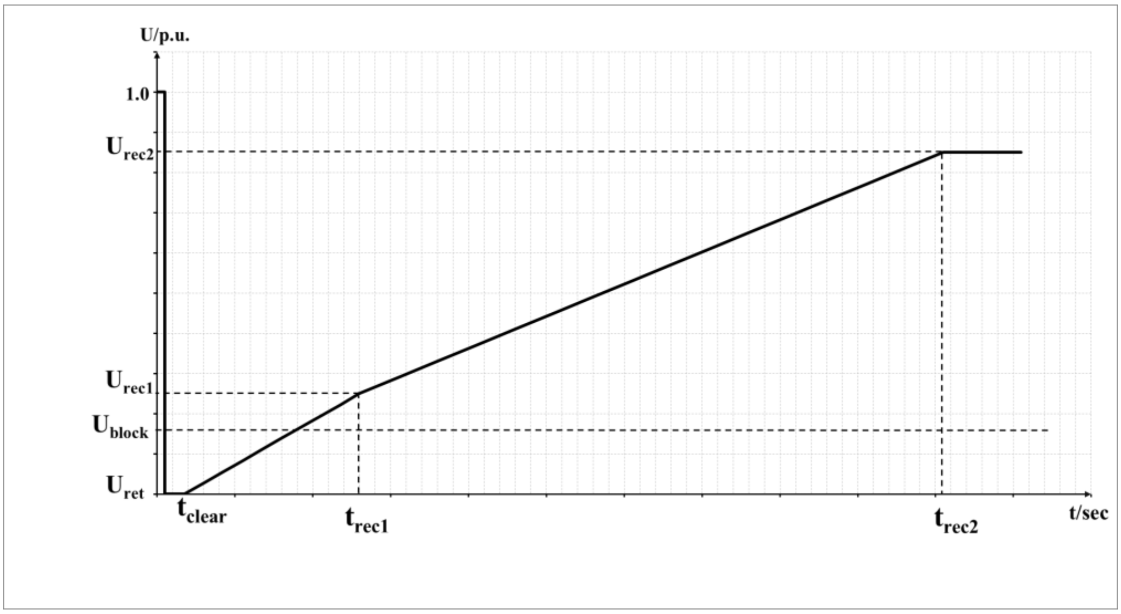

Fig. 6: *Capability diagram regarding voltage ride through of the HVDC conversion substation. The diagram represents the lower limit of the voltage time development graph in the connection point, expressed in relative units before, during and after fault removal.* U_{ret} *voltage is the residual voltage in the connection point during a fault,* t_{clear} *is the time when the fault was removed,* U_{rec1} *and* t_{rec1} *represent certain points of the lower residual voltage limits after fault removal.* U_{block} *is the blocking voltage in the connection point. The temporary values here mentioned are measured against the fault time* t_{fault}*. The fault ride through parameters are provided in table 7.*

Table 7: *Parameters referring to voltageride through capability*

Voltage parameters [r.u.]		Time parameters [seconds]	
U_{ret}	0.00	T_{clear}	0.25
U_{rec1}	0.25	t_{rec1}	2.5
U_{rec2}	0.85	t_{rec2}	10.0

Art. 27. (1) At the request of the HVDC system owner, the RSO provides the operational conditions before and after fault, which are taken into consideration for low voltage ride through capability as result of calculations in the connection point, as provided in article 38, with respect to:

a) The minimum short-circuit power before the fault in the connection point, expressed in MVA;
b) The active and reactive power of the HVDC conversion substation before the fault, expressed as percentage, usually 90% of the maximum HVDC transmission capacity, as well as the voltage in the connection point and
c) The minimum short-circuit power after fault in the connection point, expressed in MVA**.**

(2) As alternative the RSO provides the generic values for the conditions provided in para (1), derived from typical cases.

Art. 28. The HVDC conversion substation must stay connected to the network and continue to stably operate in case that the actual voltage variation at terminals on voltage level in the connection point during a symmetrical fault, taking into account the conditions provided in article 38, is higher than the lower voltage development limit described in the fault ride through diagram provided in article 26, except for the protection tripping's against internal electrical faults which require disconnecting the HVDC conversion substation from the network. The diagrams and settings of protection systems against internal electrical faults must not endanger the performance of the low voltage ride through capacity requested by the TSO.

Art. 29. The TSO can establish voltage limits depending on location and the conclusions of the static and dynamic regime studies (U_{block}), in the network connection points, under certain network conditions, when blocking the HVDC system is permitted. Blocking means remaining connected to the network without active and reactive power contribution for a time interval which must be as little as possible in technical terms and which is commonly established by the TSO and the HVDC system owner.

Art. 30. In accordance with the provisions of article 40, the low voltage protection is established by the HVDC system owner at the highest possible technical capability of the HVDC conversion substation so as it can provide the HVDC system operation in the domain indicated in figure 6. The RSO in cooperation with the TSO can also establish lower values which he will stipulate in the TCA or in the CnC.

Art. 31. The low voltage ride through capabilities requested in case of asymmetrical faults must comply with the provisions of article 16.

Art. 32. As far as the **active power restoration after fault** is concerned, in the TCA the TSO specifies the level and time graph of active power restoration which the HVDC system is capable to provide and it, and represents active power restoration in a time interval of (1÷10) seconds at (80÷90)% value of the power before fault, usually at minimum 10% of the maximum active power / minute.

Art. 33. As regards **rapid recovery after fault in d.c.** the HVDC systems, including the d.c. overhead lines must permit rapid recovery after transient faults occurred in the HVDC system, usually 90% of the pre-fault value within 150 milliseconds. The details of such capacity are subject to coordination and agreement on the protection systems and settings established according to the provisions of article 40.

Section 4- Requirements for command and control

Art. 34. As regards **energising and synchronising the HVDC conversion substations,** except for contrary requirements from the RSO, during energising or synchronisation of an HVDC conversion substation to the a.c. network or during connecting an HVDC conversion substation energised to an HVDC system, the HVDC conversion substation must have the capability to limit any changes in the voltage level into a permanent regime established by the RSO in coordination with the TSO. The specified level must not exceed 5% of the pre-synchronisation voltage. Usually the maximum amplitude is 5% of the pre-synchronisation voltage, maximum 30 s time period and maximum one period as measurement interval for transient voltage values.

Art. 35. (1) As regards the **interaction between HVDC systems and other power plants or equipments** when several HVDC conversion substations or other installations and equipments are found in their immediate electrical proximity, the TSO requests an additional specific study which should demonstrate that no negative interaction can occur. The study will take into consideration the long term development plan for the entire forecasted lifecycle of the HVDC system. Will be executed at least the studies on local and inter-area oscillations, sub-synchronous resonance, sub-synchronous torque interaction (ITSS), sub-synchronous control instability, harmonic resonance, harmonic interaction, and super-synchronous instability.. In case of negative interactions are detected, the studies must identify the potential mitigation measures to be implemented in view of providing compliance with the requirements of this technical norm.

(2) The studies provided in para (1) are elaborated by the HVDC system owner, with participation of all the other parties identified by the TSO as being relevant for each connection point. All parties are informed about the studies results.

(3) All the parties identified as relevant by the TSO for each connection point, TSO included, contribute to the studies and provide all the relevant data and models necessary in order to reach the

purpose of such studies. The TSO collects such information and, if need be, transmits it to the party responsible for the studies, in accordance with the obligations of confidentiality provided in article 10 of the Regulation. The TSO specifies the interactions which must be analysed and the **sub-synchronous torque interaction** studies, provides the list of technical data necessary to be transmitted by the equipment manufacturer, the system conditions and the lists of technical data requiring to be added in view of the elaboration of the studies. Technical data lists are provided in Annexes 1 and 2, which are integrant parts of this technical norm.

(4) The TSO evaluates the study results based on the application domain and their dimension, in accordance with the provisions of para (1). If it is necessary for evaluation the TSO can ask the HVDC system owner to carry out additional studies in accordance with the application domain and with the specified extent according to the provisions of para (1). The purpose of such studies is to demonstrate the operation of the HVDC substation under critical conditions and the necessary measures for damping the oscillations.

(5) The TSO can fully or partially review the studies if he considers it necessary. The HVDC system owner transmits to the TSO all the data and relevant models which enable performing the study.

(6) The necessary damping measures identified in the elaborated studies in accordance with para (2) – (5) and evaluated by the TSOmust be taken by the HVDC system owner as part of the connection process of new HVDC conversion substations.

(7) The TSO can specify temporary performance values associated to certain events related to an individual HVDC system or to several HVDC systems which are usually influenced. This requirement can be provided in order to protect the integrity of both the TSO's equipment and those of network users'. Such temporary values are specified depending on the area development, especially the subsequent connection of power parks consisting of power generating modules.

Art. 36. As regards the **capability of damping power oscillations,** the HVDC system must be able to contribute to mitigating power oscillations in the connected a.c. networks. The control system of the HVDC system does not reduce the amortisement of power oscillations characteristic for the mitigation of sub-synchronous torque interaction. The TSO establishes in the TCA a frequency range for oscillations where the control system will contribute to damping and to the network conditions usually to the occurrence of such event. These are included in the studies assessing the dynamic stability performed by the TSO in order to identify the stability limits and the potential steady-state problems within transmission systems. Control parameter settings are selected by mutual agreement between the TSO and the HVDC system owner, following basic simulations using static regime studies and network events, by means of modal analysis, impedance and frequency analysis methods or advanced simulations using electromagnetic transients and simulations in the time range. Additional control functions for oscillation damping can appear necessary after such studies and analyses.

Art. 37. (1) As regards the **capability to damp the sub-synchronous torque interaction (ITSS)**, the HVDC equipments must be capable to contribute to the electrical damping of torque frequency oscillations.

(2) The TSO specifies the necessary scope of ITSS studies and provides the input parameters to the extent possible with respect to the pieces of equipment and the system conditions, namely within his network. The ITSS studies are provided by the HVDC system owner. The studies identify the possible conditions when ITSS occur and propose the necessary damping procedures. The interaction factor is used in order to identify and simulate interactions against generating units.

(3) All the parties that the TSO identified as relevant for each connection point, TSO included, contribute to studies and provide all the relevant data and models as reasonably necessary to reach the purpose of such studies. The TSO collects this information and transmits it to the party responsible for studies, in accordance with the confidentiality obligations provided in article 10 of the Regulation.

(4) The TSO assesses the result of ITSS studies. If necessary for evaluation the TSO can ask the HVDC system owner to further make ITSS studies in accordance with the same application domain and observing the same scope.

(5) The TSO can review or reproduce the study. The HVDC system owner delivers to the TSO all the relevant data and models that enable making the study**.**

(6) The necessary damping measures identified in the studies performed in accordance with para (2) or (4) and evaluated by the TSO must be taken by the HVDC system owner as part in the connection of new HVDC conversion substations.

Art. 38. (1) As far as the **network characteristics** are concerned the RSO specifies and places at the general public's disposal the method and pre- and post-fault conditions with respect to:

a) The calculation of the minimum and maximum short-circuit power before fault in the connection point;
b) The active and reactive power of the HVDC system considered before fault in the connection point and the voltage in the connection point and
c) The calculation of the minimum and maximum short-circuit power after fault in the connection point.

(2) Upon request from an HVDC system owner the RSO provides the conditions before and after fault, usually the relevant values resulting from typical situations, which are taken into consideration for the low voltage ride through capability as result of calculations in the connection point according to the provisions of para (1) with respect to:

a) The minimum and maximum short-circuit power before fault in each connection point expressed in MVA;
b) The operational conditions of the HVDC system before fault, expressed by active power, reactive power and the voltage in the connection point and
c) The minimum and maximum short-circuit power after fault in the connection point expressed in MVA.

(3) The HVDC system must be able to operate in the variation range of the short-circuit power defined by the TSO and upon the network characteristics specified by the RSO.

(4) Each RSO involved provides to the HVDC system owner network equivalents which describe the network behaviour in the connection point, enabling the HVDC system owners to design their system at least with respect to, but not exclusively, the harmonics and the dynamic stability during the entire lifecycle of the HVDC system**.**

Art. 39. (1) As regards the **operational stability of the HVDC system,** HVDC system must be able to find points of stable operation, with minimum variation in the active power flow and of the voltage level during and after any modification, planned or unplanned, for the HVDC system or for the a.c. network which it is connected to. The HVDC system must maintain stable operation in any point of the P-Q capability diagram in case of power oscillations between it and the connection point**.**

(2) The HVDC system owner makes certain that the tripping or the disconnection of an HVDC conversion substation, as part of an HVDC system with multiple terminals or integrated, does not lead to transient voltages in the connection point which usually exceed l% of the pre-fault voltage and in exceptional cases 5% of the pre-fault voltage.

(3) The system is designed in such manner as to withstand transient faults on high voltage a.c. lines from an adjacent network or near the HVDC system and not to determine disconnection from the network of the HVDC system equipments because of AFR of a.c. network lines. The HVDC system must stay connected to the network in case of one-phase or three-phase AFR operation on the lines from the looped network it is connected to. The specific technical details are subject to coordination and to the requirements for protection systems and settings agreed with the RSO.

(4) The HVDC system owner provides the RSO informations about the HVDC system resilience to disturbances in the c.a. system in accordance with the operational requirements of NPS.

Section 5- Requirements for adequate devices and settings

Art. 40. (1) As regards the **diagrams and controls of electrical protections** the RSO specifies in coordination with the TSO the protection diagrams and associated settings, taking into account the characteristics of the HVDC system. The relevant protection diagrams for the HVDC system and network, as well as the relevant settings for the HVDC system must be coordinated and agreed upon between the RSO, TSO and the HVDC system owner. The protection diagrams and their settings for internal electrical faults must not endanger the performance of the HVDC system. Protection and automation systems comply at least with the requirements provided in article 139 let. f) of the Technical Norm approved by NRA Order 208/2018.

(2) The electrical protections of the HVDC system prevail against the dispatcher dispositions, taking into account the system's operational safety, the personnel's and public's health and security as well as damping any failure occurred in the HVDC system.

(3) The changes made in the protection diagrams or their settings which are relevant for the HVDC system and network are agreed upon between the RSO, TSO and the HVDC system owner, before being implemented by the owner**.**

Art. 41. (1) As regards the **hierarchical classification of protection and control systems,** a protection-control diagram indicated by the HVDC system owner and consisting of various command modes, including controls of specific parameters must be coordinated and agreed upon between the TSO, RSO and the HVDC system owner**.**

(2) As regards the hierarchical classification of protection and control systems the HVDC system owner organises his protection and control devices in accordance with the following hierarchy, in the decreasing order of significance, except when the TSO in coordination with the RSO specifies otherwise:

a) Protection of the electrical network and of the HVDC system;
b) Support active power control in emergency cases;
c) Artificial inertia, if appropriate;
d) Automatic corrective actions, as provided in article 8**;**

e) Limited FSM, LFSM-Oand LFSM-U**;**
f) FSM and frequency control and
g) Limitations regarding the power variation ramp**.**

Art. 42. (1) As regards the **modifications of diagrams and settings for protection and control systems**, the parameters of different command modes and the settings of HVDC system protections must be able to be modified in the HVDC conversion substation if the RSO or the TSO requests it, in accordance with para (3) and only with the HVDC system owner's agreement.
(2) The modification of diagrams or of parameter settings in various command and protection modes of the HVDC system, including the procedure, must be coordinated and agreed upon between the TSO and the HVDC system owner.
(3) The control mode selection and setting the requested values for the HVDC system must be possible from a remote location, as provided by the RSO in cooperation with the TSO, by integrating the HVDC system in the RSO's SCADA and EMS SCADA systems.

Section 6 Requirements to restore the electrical power system

Art. 43. (1) As far as black start capability is concerned the HVDC system must have the technical capability to use the entire transmission capacity with a view to provide black start capability**.**
(2) In case one of the conversion substations is energised an HVDC system with black start capability must be able to energise the bus-bar of the a.c. transformer station which another conversion substation is connected to, within maximum 300 seconds after the closure of the HVDC system. The HVDC system must have the synchronisation capability in the frequency range established in article 4 and within the voltage limits from article 15. According to each case, the TSO can provide higher voltage and frequency ranges whenever necessary to restore operational safety, which ranges are specified in the solution study.
(3) The RSO and the HVDC system owner agree and establish, before commissioning, the parameters of synchronisation devices with a view to enable the synchronisation of the HVDC system as follows:

a) Voltage range ±5% Un (at terminals) for 400 kV, namely ± 10% Un for voltage levels below 400 kV;
b) Frequency range, (47.5 - 51) Hz;
c) Phase difference range below 10º;
d) Phase succession;
e) Voltage difference below 5% Un namely 10% Un and frequency difference below 50 mHz.

f) Verification time of metered values - 60 seconds**.**

(4) The OTS and the HVDC system owner agree on the capability and availability of black start capability and on the operational procedure.

CHAPTER III

REQUIREMENTS FOR THE DCCPPM AND FOR THE END HVDC CONVERSION SUBSTATIONS

Section 1- Requirements for the DCCPPM modules

Art. 44. (1) As regards the **requirements for frequency sensitive mode** the DCCPPM must be capable to receive a signal fast transmitted from a connection point of the synchronous area providing the frequency sensitive mode, signal which it must be able to process within 0.1 second from issuance and to be able to provide activation of frequency sensitive mode. Frequency must be metered in the connection point in the synchronous area wherefrom the frequency response is provided.

(2) The DCCPPM connected through HVDC systems which connectswith more than one control area must be capable to provide coordinated frequency control as provided by the TSO in the solution study.

Art. 45. (1) As regards **frequency domains and frequency sensitive mode** the DCCPPM must have the capability to stay connected to the network of the d.c. – a.c. end conversion substation and to operate within the frequency ranges and during the time periods provided in table 8.

Table 8: *Minimum periods for the 50 Hz nominal system where a power generating module connected in d.c. must be capable to stay connected to the network and to operate at different frequency values, which are deviated from the nominal one, without getting disconnected from the network*

Frequency range	Time periods for operation
47.0 Hz – 47.5 Hz	20 seconds
47.5 Hz – 49.0 Hz	Minimum 90 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 – 51.5 Hz	Minimum 90 minutes
51.5 Hz – 52.0 Hz	15 minutes

(2) The OTS and the DCCPPM owner establish by mutual agreement larger frequency ranges or longer minimum operating time periods in order to provide best operation of technical capacities of the DCCPPM, if this is necessary to maintain or to restore the operational safety. If in economic and

technical terms it is more feasible to use larger frequency ranges or longer minimum operating time periods, the DCCPPM owner will not refuse in unreasonable manner his agreement in this respect.

(3) In compliance with the provisions of para (1) the DCCPPM must have the capability of automatic disconnection at certain frequency values in the connection point, usually values below 47 Hz with 20 seconds' verification time, namely at 52.1 Hz every 1 second. The conditions and parameters for automatic disconnection are agreed upon between the TSO and the DCCPPM owner in the solution study stage.

Art. 46. The DCCPPM must stay connected to the network of the d.c. – a.c. end conversion substation and to operate at frequency variation rates in the a.c. system up to ± 2 Hz/s for 500 ms time period, measured at any moment as average of the frequency variation rate in the previous second, in the DCCPPM connection point from the d.c. – a.c. end conversion substation for the 50 Hz nominal system.

Art. 47. (1) The DCCPPM must have the capability to provide limited frequency sensitive mode, namely at over-**frequency** above the 50 Hz **(LFSM-O)** nominal value, respecting the provisions of article 157 from the Technical Norm approved by NRA Order 208/2018**.**

(2) The DCCPPM must be able to maintain constant the active power value mobilized regardless of frequency variations, within the limit of power provided by the primary source, except when the power generating modules composing the power park respond to over-frequency or to acceptable active power reductions at under-frequency as accepted by the RSO in accordance with the provisions of articles 157 and 159 from the Technical Norm approved by NRA Order 208/2018.

Art. 48. (1) As regards the requirements about a DCCPPM's capability to control power, the active power control system of the DCCPPM must permit modifying the reference active power in accordance with the guidelines provided by the RSO or the TSO to the DCCPPM owner.

(2) The time to reach the active power reference or the rate of change of the active power when the reference is modified must fall within (10÷30) % P_{max}/min depending on the technology used, dead time must be 1 second and reference achievement tolerance must be 1% P_{max}.

(3) Manual control must be allowed in case the remote automatic control devices are not operational.

Art. 49. The DCCPPM must have the capability to provide limited frequency sensitive mode at at under-frequency (LFSM-U), respecting the provisions of article 163 from the Technical Norm approved by NRA Order 208/2018.

Art. 50. The DCCPPM must have the capability to provide frequency sensitive mode in accordance with the provisions of article 164 let. a) – f) from the Technical Norm approved by NRA Order 208/2018.

Art. 51. As regards the requirements concerning the frequency restoration capability, the DCCPPM must provide specific functions to deliver such services, established by procedures elaborated by the TSO. These request at least the LFSM-O, LFSM-U, and FSM control, active power control with 1% control accuracy and rate of change of active power at least of 10%P_{max}/min, connection to the central frequency-power regulator.

Art. 52. (1) As far as **voltage ranges** are concerned the DCCPPM must have the capability to stay connected to the network of the d.c. – a.c. end conversion substation and to operate within the voltage ranges (r.u.) and during the time periods provided in table 9 and 10. The applicable voltage ranges and the periods are selected using the 1 r.u. reference voltage.

Voltage range	Time period for operation
0.85 r.u. – 0.90 r.u.	60 minutes
0.90 r.u. – 1.118 r.u.	Unlimited
1.118 r.u. – 1.15 r.u.	20 minutes

Table 9: *Minimum time periods when a DCCPPM must be capable to operate without disconnecting whenever the network voltage deviates from 1 r.u. in the connection point. Usually the maximum unlimited operation for 110 kV nominal voltage is 123 kV, namely for 220 kV nominal voltage is 245 kV, as absolute values. In case of network areas where other voltage values than the nominal one are agreed the table values are applied according to operational agreements between the users and the RSO. This table is applied to nominal voltage values between 110 kV and 220 kV.*

Voltage range	Time period for operation
0.85 r.u. – 0.90 r.u.	60 minutes
0.90 r.u. – 1.05 r.u.	Unlimited
1.05 r.u. – 1.15 r.u.	20 minutes

Table 10: *Minimum time periods when a DCCPPM must be capable to operate without disconnecting when network voltage deviates from 1 r.u. in the connection point. Usually the maximum unlimited operation value for 400 kV nominal voltage is 420 kV, as absolute value. In case of network areas where other voltage values than the nominal one are agreed the table values are applied according to operational agreements between the users and the RSO. This table is applied to 400 kV nominal voltage.*

(2) The RSO, TSO and the DCCPPM owner can establish by mutual agreement larger voltage ranges or longer minimum operational periods in order to provide optimum utilisation of the DCCPPM's technical capacities, if this is necessary to maintain or to restore operational safety. If such more extended voltage ranges or longer minimum operational periods are feasible in economic and technical terms the DCCPPM owner will not refuse his agreement in unreasonable manner.

(3) In case of DCCPPM with an interface point to the network of the conversion substation within the HVDC part, the RSO in cooperation with the TSO can specify, during the technical project stage depending on the specific location, voltage values for the HVDC interface point at which a DCCPPM must be capable of automatic disconnection. The conditions and parameters of such automatic disconnection are agreed upon between the RSO, TSO and the DCCPPM owner.

Art. 53. As regards the **possibilities of** DCCPPM **to inject reactive power :**

a) In case there are several DCCPPM connected to a single connection point of an a.c. network, the DCCPPM owners conclude agreements with the HVDC system owners regarding the compliance with the following requirements:

(i) It must have the capability to achieve, using installations or equipments and/or additional software, the capabilities to deliver the reactive power prescribed by the RSO in cooperation with the TSO, according to the requirements regarding voltage restoration, expressed either on the connection date or later and it must:

— Have reactive power capabilities for some or for all the equipments in accordance with the requirements regarding voltage stability, expressed either on the connection date or later and the equipments already installed as part of the DCCPPM connection to the a.c. network upon initial connection and commissioning; or

— Demonstrate and later reach to an agreement with the RSO and the TSO regarding the manner in which the reactive power capability can be delivered when the DCCPPM is connected to more connection points from the a.c. network or the network of the d.c. – a.c. end conversion substation connects either a DCCPPM or an HVDC system with another owner. Such agreement includes a contract whereby the DCCPPM owner commits to finance and install the reactive power capabilities provided in this article for his DCCPPM at a date specified by the RSO in cooperation with the TSO. The RSO in cooperation with the TSO informs the DCCPPM owner about the completion date of any committed project which will require the DCCPPM owner to install the full reactive power capacity;

(ii) The RSO in cooperation with the TSO must take into account the refurbishment calendar of the reactive power capacity in the DCCPPM when establishing the time for such refurbishment of the reactive power capacity. The project calendar must be provided by the DCCPPM owner upon connection to the a.c. network**;**

b) The DCCPPM must comply with the following requirements regarding **voltage stability**, either on connection date or later in accordance with the agreement specified in let. a)**:**

(i) With respect to the reactive power capability at maximum HVDC active power transmission capacity, the DCCPPM must fulfil the reactive power capability requirements established by the RSO in coordination with the TSO in the context of variable voltage. The RSO establishes a U-Q/P_{max} (figure 7) profile that can have any shape within the limits established in table 11, where the DCCPPM must have the capability to inject/absorb reactive power upon voltage variations and during HVDC system's operation at maximum HVDC reactive power transmission capacity. The RSO in cooperation with the TSO takes into consideration the long term network development when he establishes such values as well as the possible costs for power park modules providing the capability to generate reactive power at high voltage and consume reactive power at low voltage.

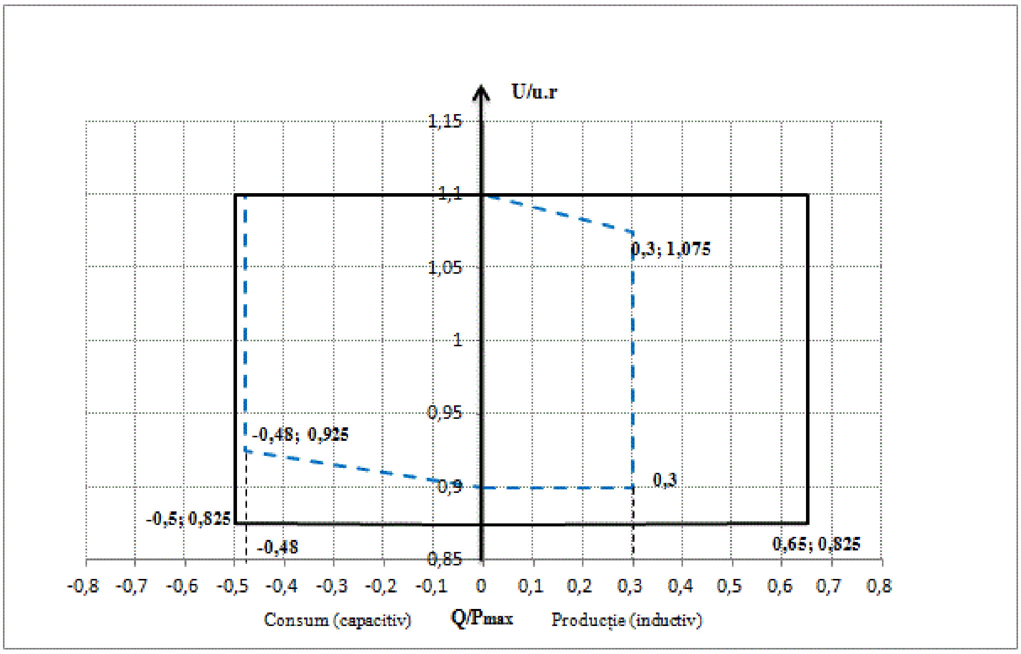

Figure 7 represents the typical limits of the U-Q/P_{max} diagram as dependency between the connection point voltage expressed in relative units and the ratio between reactive power (Q) and maximum capacity (P_{max}). The position, dimension and shape of the roll are informative, as the TSO can request, depending on system conditions in the connection point other shapes as well of the U-Q/P_{max} diagram within the Q/P_{max} maximum interval of 0.75.

Maximum Q/P_{max} interval	Maximum voltage range under stationary regime, expressed in relative units, r.u.
0.75	0.200

Table 11- *Parameters of the interior roll of figure 7*

In case the development plan of the electricity transmission network so provides the DCCPPM will connect in a.c. to the synchronous area:

- The DCCPPM must have the capabilities provided in article 172 let. a) from the Technical Norm approved by NRA Order 208/2018 regarding the supply of the transient regime component of the fault current in the connection point or to the terminals of the d.c. - a.c. conversion substation in case of symmetrical (three-phase) faults.
- The DCCPPM must have the capabilities provided in article 172 let. b) from the Technical Norm approved by NRA Order 208/2018, regarding the supply of the transient regime component of the fault current in the connection point or to the terminals of the d.c. - a.c. conversion substation in case of asymmetrical one-phase or two-phase faults.
- The DCCPPM must have the capability to supply additional reactive power, established by the RSO, in the connection point unless it is found at the a.c. terminals of the conversion substation. The additional reactive power must compensate the reactive power of the high voltage line or cable between the conversion substation and the connection point. Such additional reactive power is established by means of a compensation study of the reactive power in the connection point and it must provide null reactive power exchange for zero active power in the connection point, with tolerance of maximum 0.5 MVAr if voltage is ≥ 110 kV in the connection point.
- The DCCPPM must have the capability to produce reactive power at maximum capacity in the connection point, respecting the requirements provided in article 172 let. d) from the Technical Norm approved by NRA Order 208/2018;
- With respect to the capability to produce reactive power under maximum capacity below Pmax), the DCCPPM owner must comply with the requirements provided in article 172 let. e) from the Technical Norm approved by NRA Order 208/2018;

- As far as the command modes for reactive power are concerned the DCCPPM owner complies with the requirements provided in article 172 let. f) from the Technical Norm approved by NRA Order 208/2018;
- In terms of hierarchical classification for the active or reactive power contribution, the DCCPPM owner complies with the requirements provided in article 172 let. g) from the Technical Norm approved by NRA Order 208/2018;
- As regards damping the power oscillations, if this is specified by the TSO when issuing the TCA, the DCCPPM owner complies with the requirements provided in article 172 let. h) from the Technical Norm approved by NRA Order 208/2018;

(ii) With respect to the reactive power delivery capability the RSO can establish additional reactive power which must be delivered if the connection point of a DCCPPM is neither at the high voltage terminals of the step-up transformer nor at the generator's terminals, if there is no step-up transformer. Such additional reactive power must compensate the reactive power exchange of the high voltage line or cable between the high voltage terminals of the DCCPPM's step-up transformer or the alternator's terminals, if there is no step-up transformer and the connection point, and it must be delivered by the owner responsible for the respective line or cable.

c) As far as the priority classification is concerned for the active power contribution of a DCCPPM, the RSO in cooperation with the TSO specifies which of them has priority during faults for which it is needed the low voltage ride through. In case priority is granted to the active power contribution, its delivery is established within a time interval from the beginning of the fault, as specified by the RSO in cooperation with the TSO.

Art. 54. The DCCPPM and the end HVDC systems must comply with the general **control and regulation** requirements:

a) During synchronisation of a DCCPPM to the a.c. collecting network, the DCCPPM must have the capability to limit voltage variations to the permanent regime level provided by the RSO in cooperation with the TSO. The specified level must not exceed 5% of the pre-synchronisation voltage. The RSO in cooperation with the TSO must specify the maximum amplitude, time period and transient voltage measurement window**.**

b) The DCCPPM owner provides the output signal,s as specified by the RSO in cooperation with the TSO.

Art. 55. As far as **network characteristics** are concerned, the following conditions applies for DCCPPM**:**

a) The RSO specifies and places at the owner's disposal the pre- and post-fault method and conditions to calculate the minimum and maximum short-circuit power in the connection point with the HVDC system;
b) The DCCPPM must have the capability of stable operation during the minimum-maximum short-circuit power interval and within the limits of characteristics from the connection point with the HVDC system specified by the RSO in cooperation with the TSO;
c) Every RSO and HVDC system owner supply to the DCCPPM owner network equivalents representing the system, enabling DCCPPM owners to design their own system as far as harmonics are concerned.

Art. 56. (1) Requirements regarding electrical protection diagrams and associated settings necessary for DCCPPM are in accordance with the provisions of article 171 let. f) from the Technical Norm approved by NRA Order 208/2018, where the network means the synchronous area network. Protection diagrams must be designed taking into account the system performance, network characteristics and the technical characteristics of the power generating modules technology in the power park and they must be established by mutual agreement with the RSO in cooperation with the TSO.

(2) The hierarchical classification of protection and control devices of the DCCPPM are organised in accordance with the provisions of article 171 let. g) from the Technical Norm approved by NRA Order 208/2018, in case the network refers to the synchronous area network and it is thus agreed with the RSO in cooperation with the TSO.

Art. 57. As far as the **power quality** is concerned the DCCPPM owners must make sure their network links do not determine disturbances or fluctuations of the network supply voltage in the connection point above the level specified by the RSO in cooperation with the TSO according to the applicable Performance standards for electricity transmission and system services and for electricity distribution services. The network users' contribution to related studies cannot be refused in unjustified manner. The necessary process for the studies execution and the provision of relevant data by all the involved network users, as well as the damping measures found and implemented must respect the procedure from article 35.

Art. 58. The DCCPPM owners transmit to the RSO the technical data provided in Annex 2, which is integrant part of this technical norm and complies with the general system operation requirements provided in article 171 from the Technical Norm approved by NRA Order 208/2018.

Section 2 Requirements for end HVDC conversion substations

Art. 59. The end HVDC conversion substations must comply with the requirements provided in articles 4÷51, on condition of requirements provided in articles 60÷63.

Art. 60. As far as the **frequency response** is concerned, the owner of the end HVDC conversion substation and the DCCPPM owner agree with respect to the technical methods for the transmition of the signal in accordance with the provisions of article 44. In case the TSO requests it the HVDC system must provide the network frequency as signal in the connection point. For an HVDC system connecting a power generating module of the power park adjusting the active power response depending on frequency is limited by the capability of DCCPPM modules.

Art. 61. (1) In terms of **voltage ranges**:

a) An end HVDC conversion substation must have the capability to stay connected to the network of the end HVDC conversion substation and to operate within the voltage ranges (r.u.) and time periods specified in tables 12 and 13. The applicable voltage ranges and time periods specified are selected using the 1 r.u. reference voltage**;**

b) Larger voltage ranges or longer minimum operational periods are agreed upon between the RSO in cooperation with the TSO and with the DCCPPM owner, in accordance with the provisions of article 52 and 53**;**

c) In case of interface with a.c. voltage values which are not included in the application domain of tables 12 and 13, the RSO in cooperation with the TSO must specify the requirements applicable to the connection point**;**

Voltage range	Time period for operation
0.85 r.u. – 0.90 r.u.	60 minutes
0.90 r.u. – 1.118 r.u.	Unlimited
1.118 r.u. – 1.15 r.u.	20 minutes

Table 12: *Minimum time periods during which an end HVDC conversion substation must be capable to operate without disconnecting, when the network voltage in the connection point deviates from 1 r.u. Usually the maximum value of unlimited operation for 110 kV nominal voltage is 123 kV and for 220 kV nominal voltage is 245 kV, as absolute values. In case of network areas where other voltage values than the nominal one are agreed the table values are applied according to operational agreements between the users and the RSO. This table is applied to nominal voltage values between 110 kV and 220 kV.*

Voltage range	Time period for operation
0.85 r.u. – 0.90 r.u.	60 minutes
0.90 r.u. – 1.05 r.u.	Unlimited
1.05 r.u. – 1.15 r.u.	20 minutes

Table 13: *Minimum time periods during which an end HVDC conversion substation must be capable to operate without disconnecting when the network voltage deviates from 1 r.u. in the connection point. Usually the maximum value of unlimited operation for 400 kV nominal voltage is 420 kV, as absolute value. In case of network areas where other voltage values than the nominal one are agreed the table values are applied according to operational agreements between the users and the RSO. This table is applied to 400 kV nominal voltage.*

(2) An end HVDC conversion substation must comply with the following requirements regarding voltage stability in the connection points as regards the reactive power delivery capability**:**

a) The RSO in cooperation with the TSO must establish requirements regarding the capability to inject reactive power for various voltage levels. When establishing such requirements the RSO in cooperation with the TSO determines a U-Q/P_{max} profile of any shape, within which limits the end HVDC conversion substation should inject reactive power at maximum HVDC active power transmission capacity;

b) The U-Q/P_{max} profile is established by the RSO in cooperation with the TSO. The U-Q/Pmax profile (figure 8) can take any form within the limits established in table 14. Usually the U-Q/P_{max} profile is the one shown with dotted line in figure 8.

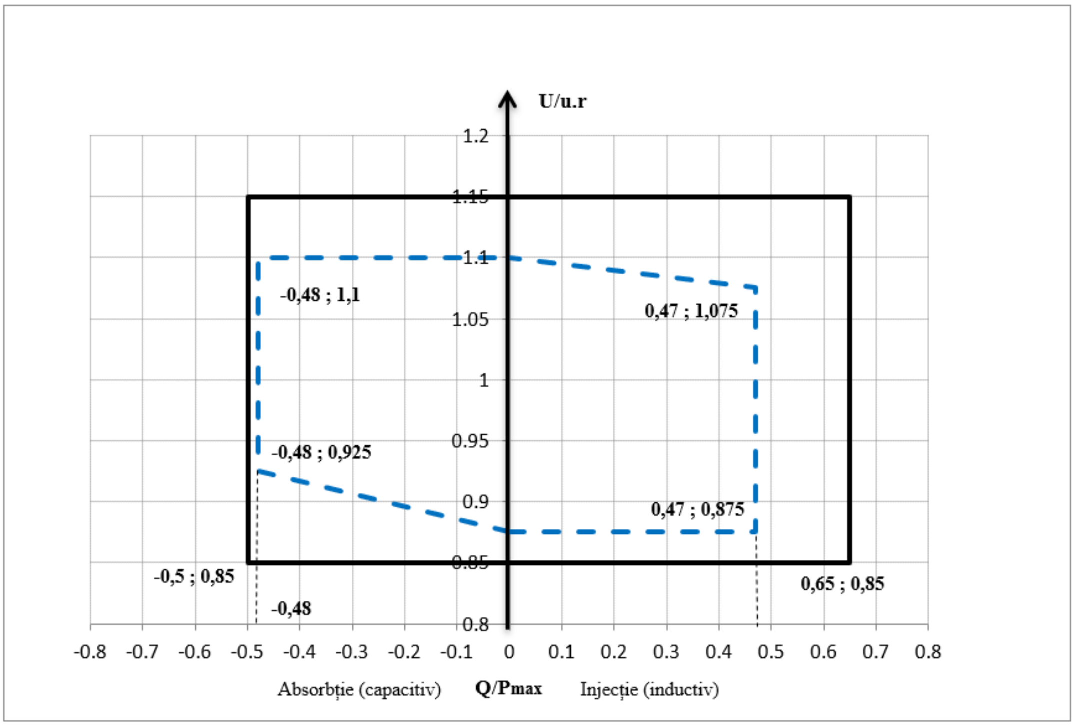

Fig. 8 *represents the typical limits of the U-Q/P_{max} diagram as dependency between the connection point voltage expressed in relative units and the ratio between reactive power (Q) and maximum capacity (P_{max}). The position, dimension and shape of the roll are informative, as the TSO can request depending on system conditions in the connection point other forms as well of the U-Q/P_{max} diagram in the 0.95 Q/P_{max} maximum intervals.*

Maximum Q/P_{max} interval	Maximum voltage range under stationary regime, expressed in relative units
0.95	0.225

Table 14: *Parameters for the interior roll of figure 8*

Art. 62. As far as the **network characteristics** are concerned the HVDC conversion substation owner must provide pertinent data to any DCCPPM owner, in accordance with article 55.

Art. 63. In terms of **power quality** the owners of end HVDC conversion substations must make certain their network connections do not determine distortions or fluctuations of the network supply voltage in the connection point above the level specified by the RSO in cooperation with the TSO according to the provisions of applicable performance standards for electricity transmission and system services and for electricity distribution services. The network users' contribution as necessary for related studies, including without limitation the existing DCCPPM and HVDC systems cannot be refused in unjustified manner. The necessary process for the execution of studies and provision of relevant data by all the involved network users as well as the damping measures found and implemented must respect the procedure from article 35.

CHAPTER IV

EXCHANGE OF INFORMATION AND COORDINATION

Section 1- Operation of HVDC systems

Art. 64. As far as operation instruments are concerned, each HVDC conversion unit of an HVDC system must be equipped with an automatic regulator, capable to receive comands from the RSO and the TSO. Such automatic regulator must be able to operate in coordinated manner the HDVC conversion units of the HVDC system. The RSO specifies the automatic control hierarchy for each HVDC conversion unit according to the provisions of article 139 let. g) from the Technical Norm approved by NRA Order 208/2018.

Art. 65. The automatic regulator of the HVDC system mentioned in article 64 must be capable to transmit to the RSO the following types of signals:

a) At least the following operational signals:

(i) Start-up signals;

(ii) The measured value of thea.c. and d.c voltage . at both ends;

(iii) The measured value of the a.c. and d.c. current;

(iv) The measured value of the active and reactive power in the a.c. part;

(v) The measured values offrequency and voltage in the a.c. part;

(vi) The measured value of d.c. power;

(vii) Operation at HVDC conversion unit level in an HVDC converter with multiple poles;

(viii) Topology elements and status and also

(ix) The active power domain in FSM, LFSM-Oand LFSM-Umode.

(b) At least the following alarm and status signals:

(i) Blocking emergency;

(ii) Blocking ramps;

(iii) Fast reversal of the active power sense;

(iv) Primary equipments status;

Art. 66. The automatic regulator mentioned in article 64 must be able to receive the following signals from the RSO**:**

a) At least the following operational signals:

(i) Start-up command;

(ii) the prescribed values for active power;

(iii) Settings of the frequency sentitive mode;

(iv) The prescribed values for reactive power, voltage or power factor;

(v) Selection of voltage or reactive power control modes namely with or without response to the frequency sensitive mode - FSM ;

(vi) Control of power oscillation damping and

(vii) Artificial inertia;

b) At least the following alarm and status signals:

(i) Blocking emergency command;

(ii) Blocking ramps command;

(iii) Primary equipments status command; direction of the active power flow; and

(iv) Fast reversal command of the active power sense.

Art. 67. With respect to each signal, the RSO can establish the quality of the provided signal. The RSO establishes and communicates to the owner, during the technical project stage, the measurement accuracy requirements and the data transmission protocol**.**

Art. 68. (1) The HVDC system owner must provide continuity in the transmission of statusn and operational values provided in articles 65 and 66 by the RSO.

(2) The RET-connected HVDC system is integrated only within the EMS-SCADA system and it provides at least the exchange of signals from articles 65 and 66. EMS-SCADA integration is provided through two independent communication paths, of which at least the main one will be provided by optical fibre support. The owner is responsible to provide maintenance of the two communication paths.

(3) The HVDC system connected to the RED is integrated both in the EMS-SCADA and in the DMS-SCADA. EMS-SCADA integration is provided at least for the following exchange of signals: active power, reactive power, voltage and frequency in the connection point, requested active and reactive power values, status signals and controls for the circuit breaker position. EMS-SCADA integration is provided through two independent communication paths, of which at least the main one will be provided by optical fibre support. DMS-SCADA integration is provided for at least the following exchange of signals: active power, reactive power, voltage and frequency in the connection point, status signals and controls for the circuit breaker position and for disconnectors positions.

Art. 69. The HVDC system owner has the obligation to provide compatibility of data exchange equipments at the interface with the RSO's EMS-SCADA system, namely DMS-SCADA, for the characteristics he has requested.

Art. 70. The HVDC system owner must provide electricity supply and payment for the electricity of the monitoring, control and data transmission installations provided in articles 65 and 66 so as they can be available at least three hours after losing the supply source.

Art. 71. Integration in EMS-SCADA, DMS-SCADA, and in the monitoring power quality system is provided by care of the HVDC system owner.

Art. 72. The HVDC system owner has the obligation to allow RSO's and TSO's access to the outputs of its own measuring systems for voltage, current, frequency, active and reactive power and to the information on primary equipments indicating the status of installations and of alarm signals, with a view to transfer such information to the interface with the control and data acquisition system DMS-SCADA, namely EMS-SCADA and with the tele metering system.

Section 2- Parameters and settings

Art. 73. The parameters and prescribed values for the main control functions of an HVDC system are established by mutual agreement between the HVDC system owner and the RSO in coordination with the TSO. The parameters and prescribed values are implemented into a control hierarchy which must enable their change if necessary. These main control functions are, without limitation**:**

a) Artificial inertia, if applicable in accordance with the provisions of articles 9 and 54**;**
b) The frequency sensitive mode (FSM, LFSM-Oand LFSM-U), mentioned in articles 10÷14**;**
c) Frequency-power control, if need be, mentioned in article 13**;**
d) The active / reactive power or voltage control mode if applicable, in accordance with the provisions of article 6, article 7, article 15 and article 17-23**;**
e) Capability to damp power oscillations, mentioned in article 36**;**
f) Capability to control the damping of sub-synchronous torque interactions, mentioned in article 37.

Section 3- Defects registration and monitoring

Art. 74. (1) An HVDC system must be equipped with a device to ensure the registering of faults and the monitoring of the system's dynamic behaviour, this ones usually being oscillo disturbance-graphs or equipments that can replace the functions provided by such graph. These devices must provide registration of the following parameters in each HVDC conversion substation**:**

a) a.c. voltage on each phase and d.c**;**
b) a.c. current on each phase and d.c.**;**
c) Active power on each phase**;**
d) Reactive power on each phase and
e) frequency**.**

(2) The RSO is entitled to establish the performance of parameters placed at disposal through the fore-mentioned devices, provided they have been previously agreed with the owner.

(3) The settings of the faults registration equipment, including the registration start-up criteria and the sampling rates are established by mutual agreement between the HVDC system owner and the RSO upon commissioning, and are recorded by written dispositios. They also include a start-up principle for detecting oscillations between the HVDC system and the connection point, set by the TSO**;**

(4) The RSO, TSO and HVDC system owner establish by mutual agreement the need to include a criterion detecting oscillations in order to monitor the system's dynamic behaviour established by the TSO, with a view to detect insufficiently damped oscillations, namely non-damped ones as well;
(5) The monitoring system for the system's dynamic behaviour must enable the owner's and RSO's access to information. The communication protocols for registered data are established by mutual agreement between the owner, RSO and TSO before selecting the monitoring equipment.

Art. 75. The RSO can specify the quality of supplied measuring parameters which must be observed by the HVDC system, provided a reasonable notice has been given.

Art. 76. (1) The informations regarding the fault registration equipment mentioned in article 74, including the analogue and digital channels, settings including the tripping criteria and sampling rates are established by mutual agreement between the HVDC system owner, RSO and TSO. The RSO establishes the requirements with respect to measuring accuracy and data transmission protocol and communicates them to the owner during the technical project stage.
(2) All the equipments monitoring the system's dynamic behaviour must include a start-up criterion based on oscillation, established by the TSO, in order to detect badly damped power variations.

Art. 77. The monitoring supply quality system and the system's dynamic behaviour must include provisions as regards the HVDC system owner's and RSO's electronic access to information. Communication protocols for registered data are established by mutual agreement between the HVDC system owner, RSO and TSO during the technical project stage and requirements refer to measuring accuracy and data transmission protocol**.**

Section 4- Simulation models

Art. 78. (1) Upon request of RSO or TSO the HVDC system owner or the DCCPPM must transmit the models for simulation of the HVDC system operation or of the DCCPPM's, as appropriate, which must adequately reflect their behaviour both under stationary and dynamic regime, including also transient electromagnetic phenomena.
(2) The format of model transmission and of the documentation regarding model structure and electrical diagram is established by the RSO in coordination with the TSO.

Art. 79. In view of the dynamic regime simulations the delivered models must comprise at least the following sub-models, without limitation, depending on the existence of mentioned components:

a) Models of HVDC conversion units;
b) Models of a.c. components;

c) Models of d.c. networks;
d) Voltage and power control;
e) Special control elements resulting as necessary, such as the power oscillation damping (POD) function, control on the damping of sub-synchronous torque interactions (ITSS);
f) Power control in case of multiple connections, if need be;
g) Protection models for the HVDC system, as agreed between the TSO and the HVDC system owner.

Art. 80. The HVDC system owner verifies the models against the results of compliance tests performed in accordance with the provisions of the notification procedure for connection to electricity networks of public interest of high voltage direct current systems or of power parks consisting of power generating modules, which are connected to electricity networks of public interest through high voltage direct current systems and verifying their conformity, approved by order of the president of the National Regulatory Authority in the Energy domain and a report of such verification is transmitted to the TSO. Models are then used in view of verifying their conformity with the requirements of this technical norm, inclusive, but without limitation, the conformity simulations, as well as studies of continuous evaluation under system planning and operation.

Art. 81. An HVDC system owner sends the registrations of the HVDC system to the RSO or the TSO in order to compare the response of models with such registrations.

Art. 82. An HVDC system owner issues an equivalent model of the control system in case there are adverse control interactions with HVDC conversion substations and other electrical connections nearby. The equivalent model must contain all necessary data for a realistic simulation of negative control interactions.

ANNEX 1 to the technical norm

Technical data with respect to HVDC systems / conversion substations

The technical data requested to be provided by the HVDC system owner refer to the provisions of this technical norm. In accordance with the provisions of the notification and conformity procedure additional data will be requested for each stage of the notification and conformity process.

The HVDC system owner must place at the RSO's disposal the protection types, the connection mode to voltage, current and tripping circuits, and the activation matrix of protection functions in the connection point, established by project.

Depending on the needs to provide operational safety within NPS the RSO and TSO can ask information from the HVDC system owner in addition to that provided in the following table.

D – Detailed data for planning

S – Planning data communicated in the connection request

R – Validated data completed upon installation commissioning

Description of data	Measuring unit	Data category
Absorbed power		
Frequency:		
Frequency range in which the HVDC system / conversion substation stays operational	Hz	D
Nominal frequency	Hz	D
Maximum frequency rate which the HVDC system / conversion substation stays operational for	Hz/s	
Operational time depending on the frequency range	min	D
Voltage in the connection point:		
Nominal / contractual voltage	kV	S, D
U-Q/Pmax diagram in the connection point		S, D
Minimum / maximum voltage which the HVDC system / conversion substation stays operational for	kV	D
Operational times depending on voltage ranges	kV	D
Voltage in the direct current circuit:		
Nominal voltage	kV	S, D
Minimum / maximum voltage which the HVDC system / conversion substation stays operational for	kV	D
Operational times depending on voltage ranges	kV	D
Control and data acquisition:		
Communication path (type, technical performance, etc.)	Text	D
Remote control and transmitted data	Text	D
Current measuring transformers	A/A	D
Voltage measuring transformers	kV/V	D
Characteristics of the measuring system	Text	R
Measuring transformers - details of testing certificates	Text	R

Network configuration:		
a.c. connection diagram	Single-line diagram	S, D, R
d.c. substation diagram	Diagram	S, D, R
Network impedance:		
Positive, negative and zero sequence impedance values	Ω	S, D, R
Short-circuit currents:		
Maximum short-circuit current calculated in the connection point	kA	S, D, R
Minimum short-circuit current calculated in the connection point	kA	S, D, R
Transformers in the connection point:		
Saturation curve	Diagram	R
Data on transformer units (number of taps, voltage ratio, tap change mode, etc.)	Diagram, text	S, D, R
AVR data / logical diagram for transformers with automatic on load tap changer		

Data regarding the direct current converter and circuit		
Type of converter	Technical description, diagrams	
d.c. line/link resistance with components: - 0% d.c. voltage withstanding resistance in the inverter - 50% d.c. constant voltage withstanding resistance in the centre of the d.c. line - 100% resistance to control the d.c. voltage of the rectifier	Ω	
d.c. line / link inductance	mH	
Number of converter bridges	Number and connection diagram	
Switch resistance - per bridge	Ω	
Switch reactance - per bridge	Ω	
Logical diagram of switching circuits - opening angle of thiristors		
Minimum switch angle (opening)	degrees	
Maximum switch angle (opening)	degrees	
Set value of the switch angle (opening)	degrees	
Integrated transformer		
Nominal tap ratio of the converter-transformer from dc to ac	r.u.	
Number of taps, maximum/minimum tap		
Tap blocking value (criterion and checking parameter for on tap blocking / fixing)		
Control mode / type: Blocked , power, current, voltage		
Δi (fraction whereby the d.c. power or current are reduced when the inverter controls the line current)	r.u.	
Rc, Xc switching reactance	Ω	
Total power losses equivalent in auxiliary transistors and circuits	Ω	

Voltage drops in thiristor bridges	V	
Resistance to earth (grounding in the thiristor control circuit)	Ω	
Data for area interaction studies		
Relevant data of the a.c. connecting network - Characteristic network impedance, - Technical data of the SVC, STATCOM compensation equipment, filters - Technical data of power plants including their electrical and mechanical model (for inertia) and control types – voltage / reactive power - Mathematical and electrical equivalent of other HVDC substations - Mathematical and electrical equivalent of FACTS equipment		
Surge transients after fault		
Calculation of the interaction factor of each generating unit $$UIF_i = \frac{MW_{HVDC}}{MVA_i}\left(1 - \frac{SC_i}{SC_{tot}}\right)^2$$ where: UIF_i - interaction factor of the unit MW_{HVDC} - nominal capacity of the HVDC system MVA_i- apparent unit power SC_i- short-circuit power of the HVDC unit in the connection point SC_{tot} - total short-circuit power in the connection point		

ANNEX 2 to the technical norm

Technical data with respect to the DCCPPM

The technical data requested to be provided by the DCCPPM owner refer to the provisions of this technical norm. In accordance with the provisions of the notification and conformity procedure additional data will be requested for each stage of the notification and conformity process.

The DCCPPM owner must place at the RSO's disposal the protection types, the connection mode to voltage, current and tripping circuits, and the activation matrix of project-established protection functions in the connection point.

Depending on the needs to provide operational safety within NPS the RSO and TSO can ask information from the DCCPPM owner in addition to that provided in the following table.

D – Detailed data for planning

S – Planning data communicated in the connection request

R – Validated data completed upon installation commissioning

Description of data	Measuring unit	Data category
Connection point	Text, diagram	S, D, R
Standard environmental conditions which the technical data were determined for	Text	R
Nominal voltage in the connection point	kV	S, D, R
Maximum short-circuit current in the connection point:		
- Symmetrical	kA	D,R
- Non-symmetrical	kA	D, R
Minimum short-circuit current in the connection point:		
- Symmetrical	kA	D, R
- Non-symmetrical	kA	D, R
Generating modules		
Apparent nominal power	MVA	S, D, R
Nominal power factor (cos φ_n)		S, D, R
Net capacity	MW	S, D, R
Nominal active power generated at terminals	MW	S, D, R
Maximum active power generated at terminals	MW	S, D, R
Nominal voltage at terminals	KV	S, D, R
Consumption of auxiliary / internal services upon maximum power generated at terminals	MW	S, D,R
Reactive power under inductive regime, maximum at terminals	MVAr	S, D, R
Reactive power under capacitive regime, maximum at terminals	MVAr	S, D, R
Low voltage ride through LVRT	Diagram	S, D,R
Short-circuit ratio		D,R
Data on synchronous generator module connected by power electronics / asynchronous,		

wind type		
Type of wind unit (horizontal / vertical axis)	Description	S,R
Rotor diameter	m	S,R
Height of rotor axis	m	S,R
Control system of blades (pitch/stall)	Text	S,R
Rate control system (fixed/two steps/variable)	Text	S,R
Type of generator	Description	S,R
Type certificates of inverters accompanied by results of tests made by acknowledged European laboratories for: frequency and voltage variations and ride through	Certificates	D
Type of frequency converter and nominal parameters (kW)		S,R
Variation rate of active power	MW/min	P, T
Reactive power	KVAr	S, T
Nominal current	A	S, R
Nominal voltage	V	S, R
Start-up wind speed	m/s	S, R
Nominal wind speed (corresponding to nominal capacity)	m/s	S, R
Disconnecting wind rate	m/s	S, R
Power variation generated with the wind rate	Table	S, R
P-Q diagram	Graphic data	S. R. P. T
Power quality parameters of the DCCPPM		
Flicker coefficient at uninterrupted operation		S, T
Flicker step factor for switch operations		S, T
Voltage variation factor		S, T
Maximum number of switch operations every 10 min		S, T
Maximum number of switch operations every 2 hours		S, T
At the bus-bar of DCCPPM modules		
Total current distortion factor THD_i		S, T
Harmonics (up to harmonic 50)		S, T
Negative sequence non-symmetry factor		S, T
Capability in terms of reactive power:		
Reactive power under inductive / capacitive regime at maximum generated power	MVAr generated	S, D, R
Reactive power under inductive / capacitive regime at minimum generated power	MVAr generated	S, D, R
Reactive power under inductive / capacitive regime at zero generated power	MVAr generated	S, D, R