Order no. 72 of 02.08.2017

approving the technical norm on the technical requirements to connect synchronous power-generating modules to public electrical grids

In view of the provisions of Article 36 (7) (n) of the Electricity and Natural Gas Act no. 123/2012, as subsequently amended and supplemented, of Article 7 (4) of Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators, of Article 6 (11) of the Regulation (EC) No. 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No. 1228/2003,

pursuant to the provisions of Article 5 (1) (c) and (d) and of Article 9 (1) (h) of the Emergency Government Ordinance no. 33/2007 on the organization and functioning of the National Energy Regulatory Authority, approved as subsequently amended and supplemented by Law no. 160/2012,

the President of the National Energy Regulatory Authority hereby issues the present order:

Article 1. Approval is granted for the Technical norm on the technical requirements to connect synchronous power-generating modules to public electrical grids, provided in the Annex to this order.

Article 2. The economic operators in the electricity sector fulfill the provisions of this order, and the organizational entities within the National Energy Regulatory Authority supervise the compliance therewith.

Article 3. This order shall be published in the Romanian Official Journal, Part I, and enters into force on 27 April 2019.

Article 4. On the date of entry into force of this order, the following shall be abrogated:

a) Article 40, provisions of chapter 5.4.1. "Dispatchable generating units connected to public electrical grids", provisions of chapter 5.4.2. "Requirements for the telecommunication equipment", except Article 176 and the provisions of chapter 5.4.4. "Telecom, data

acquisition and tele-metering systems", except Article 187 of the Technical Transmission Grid Code, Part I – General basic rules, approved by Order no. 20/2004 of the President of the National Energy Regulatory Authority, published in the Official Journal of Romania, Part I, no. 828 of 8 September 2004, as subsequently amended and supplemented;

b) the provisions of chapters 4.4.1. "Dispatchable generating units", 4.4.2. "Facilities of other PDG users" and 4.4.3. "Telecom and data acquisition systems", except points 4.4.3.1. and 4.4.3.2. from the Technical Code of Electrical Distribution, approved by Order no. 128/2008 of the President of the National Energy Regulatory Authority, published in the Official Journal of Romania, Part I, no. 43 of 26 January 2009.

President,

Niculae Havrileț

Annex

Technical norm on the technical requirements to connect synchronous power-generating modules to public electrical grids

CHAPTER I

Purpose

Article 1. This technical norm sets out the minimum technical requirements for connecting synchronous power-generating modules to public electrical grids.

CHAPTER II

Scope of application

Article 2. (1) The technical requirements regarding connection provided in this technical norm shall apply to:

(a) new synchronous power-generating modules, according to the category to which they belong;

(b) new synchronous power-generating modules from pump-storage hydroelectric plants, combined heat and power facilities and industrial sites.

(2) The transmission system operator (hereinafter referred to as "TSO") or distribution system operators (hereinafter referred to as "DSOs"), as the case may be, shall refuse to allow the connection of synchronous power-generating modules which do not comply with the technical requirements set forth in this technical norm and which have not been granted a derogation.

(3) This technical norm shall not apply to:

(a) synchronous power-generating modules connected to the power transmission grid and/or to the power distribution grid and which belong, in full or in part, to islands of whose systems do not operate synchronously with the Continental Europe synchronous area;

(b) synchronous power-generating modules installed for a determined time period, usually less than 2 years, and which operates in parallel with the system for less than five minutes in a given calendar month, with the system being operated in normal state.

Parallel operation with the system during maintenance or commissioning tests of that synchronous power-generating module shall not count towards for the five-minute limit;

(c) synchronous power-generating modules which do not have a permanent connection point and are used by grid operators (TSO or DSO, as the case may be) temporarily/occasionally, when the installed capacity of the power system is partly or completely unavailable;

(d) storage devices except to synchronous power-generating modules from pump-storage hydroelectric plants;

(e) synchronous power-generating modules which use emerging technology, provided in Article 66 of Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for network connection of generators (hereinafter referred to as the "Regulation"), except Article 30 of the Regulation.

Article 3. (1) The requirements of this technical norm shall not apply to existing synchronous power-generating modules, except if:

(a) a type C or D synchronous power-generating module undergoes modernization/ refurbishment which determines an update to the TCA/CnC according to the following procedure:

i) the synchronous power-generating module owner who intends to perform modernization/ refurbishment works shall give prior notice both to the relevant system operator and the TSO, as the case may be, of the project regarding the modernization/ refurbishment of the synchronous power-generating module;

ii) if the relevant system operator (RSO) considers that the modernization/ refurbishment of the synchronous power-generating module requires an update to the TCA/CnC, the RSO notifies the synchronous power-generating module owner and NRA regarding the requirements that must be complied in accordance with the classification in the significant categories for type C and type D modules and according to the provisions of this technical norm, as well as regarding the necessity to update the TCA/CnC;

iii) NRA shall decide upon the obligation of the synchronous power-generating module to comply, in part or in full, with the requirements provided in this technical norm.

iv) modernization/refurbishment works provided in letter (a) are the following:

– replacement of the synchronous alternator or modification of the voltage regulator type (including excitation systems), speed controller, PSS and

modification of the synchronous and transient reactance respectively, modification of the P-Q-profile introducing new compensation equipments, the modification of the reactive/active power control systems, provided such modifications allow compliance with the provisions of this technical norm;

– modification of the generation capacity of the synchronous power-generating module which leads to an increase in approved power evacuated in the system by at least 10% for type C synchronous power-generating modules and by at least 5% for type D synchronous power-generating modules respectively;

– increasing the category of the synchronous power-generating module to a higher category.

v) repair works for equipment mentioned in paragraph (iv) shall not be considered as modernization/refitting works.

(b) NRA shall decide to make a synchronous power-generating module subject to one or more requirements of this technical norm based on a proposal submitted by the TSO, according to the provisions of paragraphs (3) – (8).

(2) A synchronous power-generating module shall be considered as existing for the purposes of this technical norm, when:

(a) it is connected to the network on the date of entry into force of this technical norm; or

(b) the synchronous power-generating module owner concluded a firm contract for purchasing the main generating plant, within maximum two years from the date of entry into force of the Regulation, namely by 17.05.2018. The power-generating facility owner has the obligation to notify the relevant system operator (TSO or DSO, as the case may be) regarding the conclusion of the contract no later than 30 months from the date of entry into force of the Regulation.

(3) The TSO may propose to NRA, following a public consultation with the stakeholders (DSO, synchronous power-generating module owners etc.), to extend the application of the provisions set forth in this technical norm to existing synchronous power-generating modules. The purpose of this extension is to address significant factual changes in the power system, including the integration of renewable energy sources, smart grids, distributed generation or demand response.

(4) In order to extend the application of the provisions set forth in this technical norm to existing synchronous power-generating modules, the TSO shall perform a detailed and

transparent quantitative cost-benefit analysis according to the provisions of Article 38 and Article 39 of the *Regulation*, which shall include:

(a) the assessment of costs associated with the compliance of existing synchronous power-generating modules with the provisions of this technical norm;

(b) the socioeconomic benefit resulting from applying the requirements set out in this technical norm; and

(c) the possibility to apply alternative measures in order to reach the performances required by this technical norm.

(5) Before performing the quantitative cost-benefit analysis as described in paragraph (4), the TSO shall:

(a) carry out a preliminary qualitative comparison of costs and benefits;

(b) obtain NRA approval for carrying out the cost-benefit analysis.

(6) Within six months from receiving the report and the TSO proposal drafted in accordance with the provisions of Article 38 (4) of the Regulation, NRA shall decide upon the extension of the applicability of this technical norm to existing synchronous power-generating modules. NRA's decision upon the extension of the applicability of this technical norm to existing synchronous power-generating modules shall be published on NRA's website.

(7) The TSO shall take into consideration the results of the cost-benefit analysis and of the public consultation with power-generating facilities owners in order to assess the application of the requirements set forth in this technical norm to existing synchronous power-generating modules.

(8) The TSO may assess, every three years, the application of some or all requirements set forth by this technical norm to existing synchronous power-generating modules, according to the criteria and procedures provided in paragraphs (4) – (7).

CHAPTER III

DEFINITIONS AND ABBREVIATIONS

Article 4. (1) For the purposes of this technical norm, the terms used bear the following meaning:

pumped storage	means a hydro unit in which water can be raised upstream by means of pumps and stored to be used for the generation of electrical energy;
technical connection approval	means a written approval valid for a certain location only, to be issued by the grid operator upon request from a user about the possibilities and technical-economic conditions for network connection of demand facilities and/or generation facilities, while meeting the user's requirements as specified in the request;
frequency response deadband	means an interval used intentionally to make the frequency control unresponsive;
maximum capacity (P_{max})	means the maximum continuous active power which a generating unit can produce, less any load (demand) foreseen in the TCA/CnC or agreed upon between the relevant system operator and the power-generating facility owner;
black start capability	means the capability of recovery of a synchronous power-generating module from a total shutdown through a dedicated auxiliary power source without any electrical energy supply external to the synchronous power-generating module;
fault-ride-through capability (FRT or LVRT)	means the capability of electrical devices to be able to remain connected to the network and operate through periods of low voltage at the connection/interface point, as the case may be, caused by secured faults;
equipment certificate	means a document issued by an authorized certifier for equipment used by a generating unit, demand unit, DSO, demand facility or high-voltage direct current system (HVDC system). The equipment certificate defines the scope of its validity at national or other level at which a specific value is selected from the range allowed at European level. For the purposes of replacing specific parts of the compliance process, the equipment certificate may include mathematical models that have been verified against actual test results;

connection certificate (CnC)	means the unique document issued by the grid operator for a demand facility and/or a generation facility, certifying the fulfillment of network connection requirements, namely the construction of the connection facility as well as the electrical facilities of the user, establishing the technical conditions for using the network after the receving of the final operational notification (FON);
fast fault current	means a current injected by a synchronous power-generating module or HVDC system during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault, supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance;
secured fault	means a fault which is successfully cleared according to the TSO's planning criteria;
P-Q-capability diagram	means a diagram describing the reactive power capability of a synchronous power-generating module in the context of varying active power at the connection/interface point, as the case may be;
P_{max}/U-Q-profile	means a profile representing the reactive power capability of a synchronous power-generating module in the context of varying voltage at the connection/interface point, as the case may be;
instruction	means any command, within its authority, given by a TSO or DSO to a power-generating facility owner, DSO, as the case may be, or HVDC system owner in order to perform an action;
main generating plant	means one or more of the items of equipment required to convert the primary source of energy into electricity;
frequency	means the frequency of the power system expressed in Hertz that can be measured in all parts of the synchronous area, considered as a quasi-constant value for the system in the time frame of seconds, with only minor differences between different measurement locations. Its nominal value is 50Hz;

PSS-type power stabilization functionality or "PSS"	means an additional functionality of the AVR of a synchronous power-generating module whose purpose is to damp cross-zonal power oscillations;
synchronous compensation operation	means the operation of an alternator without prime mover to regulate voltage dynamically by production or absorption of reactive power;
houseload operation	means the operation which ensures that power-generating facilities are able to continue to supply their in-house loads in case of network failures resulting in synchronous power-generating modules being disconnected from the network;
power-generating facility owner	means a natural or legal entity owning a power-generating facility;
synchronous power-generating module	means an indivisible set of installations which can generate electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in synchronism;
inertia	means the capability of a rotating body, such as the rotor of an alternator, to maintain its state of uniform rotational motion and angular momentum unless an external torque is applied;
synthetic inertia	means the facility provided by the power park module or HVDC system to replace the effect of inertia of synchronous power-generating modules to a prescribed level of performance;
frequency response insensitivity	means the inherent particularity of a control system specified as the minimum magnitude of change in the frequency or input signal that results in a change of output power or output signal;
power-generating facility	means a facility that converts primary energy into electrical energy and which consists of one or more generating units connected to a network at one or more connection points;
overexcitation limiter	means a control device within the automatic voltage regulator which prevents the rotor of an alternator from overloading by limiting the excitation current;

relevant network operator	means the TSO or DSO to whose system a power-generating module, demand facility, distribution system or HVDC system is or will be connected;
slope	means the ratio of the change in voltage, based on reference 1 r.u. voltage, to a change in reactive power in- feed from zero to maximum reactive power, based on maximum reactive power;
connection point	means a physical point in the network to which a user is connected, representing the interface to which the synchronous power-generating module, the demand facility, the power distribution grid or the HVDC system connects to a power transmission grid, to an offshore network, to a power distribution grid, including a closed power distribution grid or HVDC system;
interface point	means a point in which the user's facilities are interfaced in terms of ownership from the grid operator's facilities;
active power	means the real component of the apparent power at fundamental frequency, expressed in watts (W) or multiples thereof such as kilowatts ("kW") or megawatts ("MW");
apparent power	means the product of voltage and current at fundamental frequency, and the square root of three in the case of three-phase systems, usually expressed in kilovolt-amperes ("kVA") or megavolt-amperes ("MVA");
installed capacity	means the nominal (apparent) active power of a power-generating module, indicated in the technical documentation of the constructing manufacturer and registered on the nameplate or indicated by the manufacturer;
reactive power	means the imaginary component of the apparent power at fundamental frequency, usually expressed in kilovar ("kVAr") or megavar ("MVAr");
minimum stable operating level	means the minimum active power, as specified in the TCA/CnC or as agreed between the relevant system operator and the power-generating facility owner, at which the synchronous power-generating module can be operated stably

	for an unlimited time;
minimum regulating level	means the minimum active power, as specified in the TCA/CnC or as agreed between the relevant system operator and the power-generating facility owner, down to which the synchronous power-generating module can control active power;
island operation	means the independent operation of a whole network or part of a network that is isolated after being disconnected from the interconnected system, where at least one synchronous power-generating module or one HVDC system supplies power to this network and controls the frequency and voltage;
frequency control	means the capability of a synchronous power-generating module or HVDC system to adjust its active power output in response to a measured deviation of system frequency from a setpoint, in order to maintain stable system frequency;
limited frequency sensitive mode – overfrequency (LFSM-O)	means a synchronous power-generating module or HVDC system operating mode which will result in active power output reduction in response to a change in system frequency above a certain value;
limited frequency sensitive mode – underfrequency (LFSM-U)	means a synchronous power-generating module or HVDC system operating mode which will result in active power output increase in response to a change in system frequency below a certain value;
frequency sensitive mode (FSM)	means the operating mode of a synchronous power-generating module or HVDC system in which the active power output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency;
automatic voltage regulator (AVR)	means the continuously acting automatic equipment controlling the terminal voltage of one or more synchronous power-generating modules by comparing the actual terminal voltage with a reference value and controlling the output of an excitation control system;

network	means the ensemble of lines, including their support and protection elements, substations and other interconnected electricity equipment by means of which electricity is transmitted from a power generating capacity to a user; the network can be a transmission grid or a distribution grid;
high-voltage direct current system (HVDC system)	means a power system which transmits energy in the form of direct current and at a nominal voltage that is higher than or equal to 110 kV, between two or more alternating current buses and which comprises at least two alternating current/direct current converter stations and the overhead power lines or direct current cables between such stations;
steady-state stability (stability at minor disturbances)	means the ability of a network or an ensemble of generating units (power system) to revert and maintain stable operation following a minor disturbance (equivalent to the ability of a power system to reach steady-state identical to the initial state or very close to it, following any minor disturbance);
dynamic (transient) stability	means the ability of a network or an ensemble of generating units (power system) to revert to a synchronous operational state following one or several major disturbances;
droop (s_2)	means the ratio of a steady-state change of frequency to the resulting steady-state change in active power output, expressed in percentage terms. For synchronous power-generating modules, the change in frequency is expressed as a ratio to nominal frequency and the change in active power expressed as a ratio to maximum power $$s_2\ [\%] = 100\times (\Delta f/\ f_n)\times (P_{max}/\Delta P\ )$$
stator	means the portion of a rotating machine which includes the stationary magnetic parts with their associated windings;
voltage	means the difference in electrical potential between two points of an electric circuit.
power-generating unit	means either a synchronous generating unit or a power park module;
setpoint	means the target value for any parameter typically used in

	control schemes;
synchronous area	means an area covered by synchronously interconnected TSOs, such as the synchronous areas of Continental Europe ("CE"), Great Britain ("GB"), Ireland-Northern Ireland ("IRE") and Nordic ("NE") and the power systems of Lithuania, Latvia and Estonia, together referred to as "Baltic" which are part of a wider synchronous area.

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

NRA	National Energy Regulatory Authority
TCA	Technical connection approval
PTG code	Technical Transmission Grid Code
CnC	Connection certificate
DMS-SCADA	SCADA system of the distribution operator (Distribution Management System – Supervisory Control and Data Acquisition)
EMS-SCADA	SCADA of the transmission operator (Energy Management System – Supervisory Control and Data Acquisition)
ENTSO-E	European Network of Transmission System Operators for Electricity
LVRT	Low voltage ride-through
DSO	Distribution operator; can be the concessionaire distribution operator or another operator owning a power distribution grid
GO	Grid operator; the grid operator may be the transmission system operator or a distribution operator
TSO	Transmission and system operator
Ci	Installed capacity
PIF	Commissioning
PSS	Cross-zonal power oscillations stabilizer
AR	Automatic reset

AVR	Automatic voltage regulator
ASC	Automatic speed controller
PTG	Power transmission grid
FSM	Frequency sensitive mode
LFSM-O	Limited frequency sensitive mode – overfrequency
LFSM-U	Limited frequency sensitive mode – underfrequency
HVDC	High-voltage direct current system
SCADA	Supervisory, Control And Data Acquisition System of a technological process or facility
NPS	National Power System
r.u.	relative unit
Un	nominal voltage of the network (reference voltage)

CHAPTER IV

REQUIREMENTS FOR SYNCHRONOUS POWER-GENERATING MODULES FROM PUMPED STORAGE PLANTS, COMBINED HEAT AND POWER FACILITIES AND INDUSTRIAL SITES

Article 5. (1) Pump-storage synchronous power-generating modules shall fulfil all the relevant requirements set forth in this technical norm, in both generating and pumping operation mode.

(2) Synchronous compensation operation of pump-storage synchronous power-generating modules shall not be limited in time by the technical design of the synchronous power-generating module.

(3) Pump-storage synchronous power-generating modules with variator speed fulfill the requirements applicable to synchronous power-generating modules.

(4) In addition to the provisions set forth in paragraph (3), for pump-storage synchronous power-generating modules with variator speed classified in the B, C or D categories, the relevant system operator, in coordination with the TSO, shall have the right to specify that a module be capable of providing fast fault current at

the connection point in case of symmetrical (three-phase) faults, under the following conditions:

(a) the synchronous power-generating module shall be capable of supplying fast fault current either by:

i) ensuring the supply of the fast fault current at the connection point, or

ii) measuring voltage variations at the terminals of synchronous power-generating modules and providing fast fault current at the terminals of these modules.

(b) the relevant system operator, in coordination with the TSO, shall specify:

i) how and when a voltage deviation is to be determined, as well as the duration of the voltage deviation;

ii) the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current;

iii) the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance.

Article 6. For synchronous power-generating modules embedded in the networks of industrial sites, their owners, the grid operators of the industrial sites and the relevant system operator to whose network the industrial site's network is connected, shall have the right to agree upon the conditions of disconnection from the relevant system operator's network of these synchronous power-generating modules and upon the critical load necessary for the generation processes within the industrial site. The exercise of this right shall be coordinated with the TSO.

Article 7. With the exception of requirements regarding the frequency response of synchronous power-generating modules at overfrequency and the reduction of maximum active power at underfrequency within the admissible limits, the requirements regarding the capability to maintain constant or variable active power output shall not apply to synchronous power-generating modules or users of cogeneration power-generating modules embedded in the networks of industrial sites, provided all following criteria are fulfilled:

(a) the primary purpose of those facilities is to produce heat for production processes of the industrial site concerned;

(b) heat and power-generating is inextricably interlinked, that is to say any change of heat generation results inadvertently in a change of active power-generating and vice versa;

(c) synchronous power-generating modules are of type A, B or C.

Article 8. The classification of cogeneration power-generating modules shall be based on their electrical maximum capacity.

CHAPTER V

GENERAL CONDITIONS FOR TYPE A SYNCHRONOUS POWER-GENERATING MODULES

Article 9. Type A synchronous power-generating modules shall fulfil the following requirements in relation to frequency stability:

(a) the synchronous power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in table 1A;

(b) the synchronous power-generating module shall be capable of remaining connected to the network and operate at frequency variation rates of 1 Hz/sec.

Table 1A. Minimum duration for which a synchronous power-generating module has to be capable to remain connected to the network and to operate at different frequencies, deviating from the nominal value

Frequency range	**Time period for operation**
47.5 Hz – 49.0 Hz	30 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	30 minutes

Article 10. Type A synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency increases above the nominal value of 50 Hz (LFSM-O), thus:

(a) at overfrequencies, the synchronous power-generating module shall decrease the active power output according to the frequency variation, in accordance with figure 1A and with the following parameters:

i) the frequency threshold from which the synchronous power-generating module ensures overfrequency response is 50.2 Hz;

ii) the droop settings shall be between 2% and 12% and shall be disposed by the relevant system operator via dispach instructions.

iii) the synchronous power-generating module shall be capable of decreasing the active power related to the frequency variation with an initial delay that is lower than two seconds. If that delay is greater than two seconds, the synchronous power-generating module owner shall justify the delay, providing technical evidence to the TSO.

(b) when reaching the power related to the minimum control level, the synchronous power-generating module shall be capable of:

i) continuing its operation at this level; or

ii) continuing to reduce the active power output according to the dispach instructions and in accordance with its own technical particularity submitted together with the technical data and which does not deviate from the functional particularities of synchronous power-generating modules of the same type.

(c) the synchronous power-generating module shall be stable during operation in the LFSM-O mode during frequency increases over 50.2 Hz. So long LFSM-O is active, the LFSM-O setpoint shall prevail over any other active power setpoints.

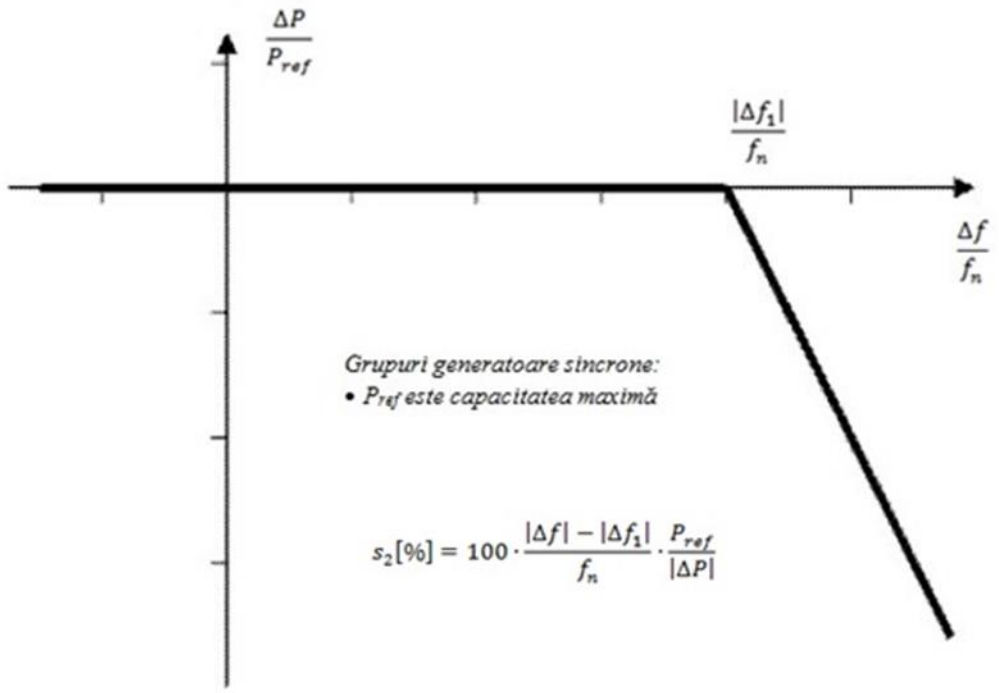


Figure 1A. Active power frequency response capability of type A synchronous power-generating modules in LFSM-O

where: ΔP is the variation of the active power output a synchronous power-generating module; P_{ref} is the active power reference based on which ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network. At overfrequencies where Δf is above +200 mHz compared to the nominal value (50 Hz), the synchronous power-generating module has to decrease the active power according to the droop s_2.

Article 11. The synchronous power-generating module shall be capable of maintaining constant the value of the active power mobilized regardless of the frequency variations, except where synchronous power-generating modules follow frequency increases or have acceptable active power decreases at frequency decreases according to the provisions of Article 10 and Article 12.

Article 12. The TSO sets the active power output reduction of the synchronous power-generating module compared to the maximum active power output following the frequency decrease, within the admissible limits specified in figure 2A, hence:

(a) at underfrequencies below 49 Hz, a maximum power output reduction is admitted at a percentage of 2% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power output reduction curve depending on the frequency, situated above the dotted line, is admitted;

(b) at underfrequencies below 49.5 Hz, a maximum active power reduction is admitted at a percentage of maximum 10% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power reduction curve depending on the frequency, situated above the continuous line is admitted.

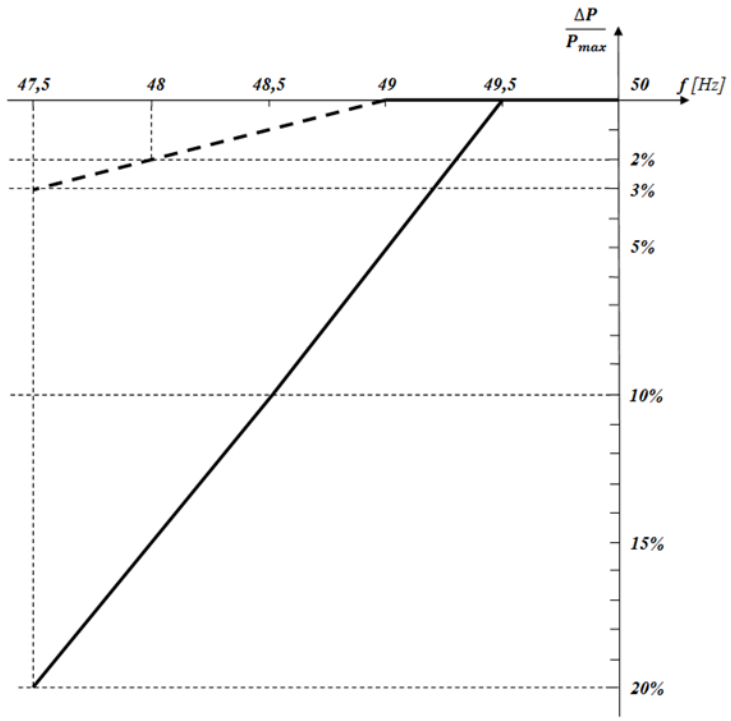


Figure 2A. Admissible limits for power reduction established by the TSO in case of underfrequency

Article 13. (1)The admissible active power reduction compared to the maximum active power output in case of frequency deviations below 49.5 Hz is established:

(a) under standard environmental conditions related to a temperature of 20 degrees Celsius;

(b) depending on the technical capability of synchronous power-generating modules.

(2) The synchronous power-generating module owner shall provide the relevant system operator and the TSO with the dependency diagram of the active power in terms of temperature factors and the technical data regarding the synchronous power-generating module's technical capability as set forth in Annex no. 1 to this technical norm.

(3) The data provided in paragraph (2) shall be submitted during the commissioning stage within the connection process.

Article 14. (1) The synchronous power-generating module shall be equipped with a logic interface in order to reduce the active power output to the point of shut-down in a time period of no more than five seconds after receiving the disconnect command.

(2) The technical requirements for the logic interface described in paragraph (1) and its connection to the SCADA system of the relevant system operator are mandatory for type A synchronous power-generating modules connected in MV.

(3) For type A synchronous power-generating modules connected in LV, the relevant system operator shall specify, in agreement with the synchronous power-generating module owner, the technical requirements and the mode of utilization of the logic interface.

Article 15. (1) The relevant system operator sets forth the requirements for the automatic connection of a synchronous power-generating module to the network, after these requirements have been agreed upon with the TSO.

(2) The requirements set forth in paragraph (1) include:

(a) the frequency range within which an automatic connection is admissible, namely 47.5-51 Hz, and a corresponding delay time, usually of 15 minutes;

(b) the slope admitted for the active power increase after connection, usually of (10-30)% of P_{max}/min (indicated by the synchronous power-generating module manufacturer).

Article 16. The type A synchronous power-generating module shall be capable of generating nominal active and reactive power at its terminals, simultaneously and on an ongoing indeterminate basis, in accordance with the equivalent P-Q-profile, in the 49.5-50.5 Hz frequency range and in the (0.85-1.1) U_n voltage range.

Article 17. (1) For type A synchronous power-generating modules connected in MV, with an installed capacity larger than a power threshold

specified by the relevant system operator, the latter shall have the right to request the integration into DMS-SCADA of several status values and the active power output value. The power threshold specified by the relevant system operator shall not be smaller than 100 kVA.

(2) The communication path shall be specified by the relevant system operator who sets these requirements in the TCA.

(3) The integration of the values specified in paragraph (1) into the DMS-SCADA system of the relevant system operator shall fall under the responsibility of the synchronous power-generating module owner.

(4) For type A synchronous power-generating modules connected in LV, the relevant system operator shall specify, in agreement with the synchronous power-generating module owner, the possibility to submit the active power output value via existing and available data transmission systems or via systems which are to be implemented, as well as the advisability of integration into the DMS-SCADA system.

Article 18. The type A synchronous power-generating module owner shall provide the equipment necessary for data exchange at the relevant system operator's DMS-SCADA system interface level, according to the particularities requested by it, for the strict compliance with the provisions of Article 17.

Article 19. The connection solution of type A synchronous power-generating modules with installed capacities lower than 1 MW shall not allow their island operation, including via endowment with protections which trip the synchronous power-generating modules at the occurrence of such an operation state.

CHAPTER VI

GENERAL CONDITIONS FOR TYPE B SYNCHRONOUS POWER-GENERATING MODULES

Article 20. Type B synchronous power-generating modules shall fulfil the following requirements in relation to frequency stability:

(a) the synchronous power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in table 1B;

(a) the synchronous power-generating module shall be capable of remaining connected to the network and operate at frequency variation rates of 1 Hz/sec.

Table 1B. Minimum duration for which a type B synchronous power-generating module has to be capable to remain connected to the network and to operate at different frequencies, deviating from the nominal value

Frequency range	**Time period for operation**
47.5 Hz – 49.0 Hz	30 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	30 minutes

Article 21. Type B synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency increases above the nominal value of 50 Hz (LFSM-O), thus:

(a) at overfrequencies, the synchronous power-generating module shall decrease the active power output according to the frequency variation, in accordance with figure 1B and with the following parameters:

i) the frequency threshold from which the synchronous power-generating module ensures overfrequency response is 50.2 Hz;

ii) the droop settings shall be between 2% and 12% and shall be disposed by the relevant system operator via dispach instructions.

iii) the synchronous power-generating module shall be capable of decreasing the active power related to the frequency variation with an initial delay that is lower than two seconds. If that delay is greater than two seconds, the synchronous power-generating module owner shall justify the delay, providing technical evidence to the TSO.

(b) when reaching the power related to the minimum control level, the synchronous power-generating module shall be capable of:

i) continuing its operation at this level; or

ii) continuing to reduce the active power output according to the dispatch instructions and in accordance with the functional particularities of synchronous power-generating modules of the same type;

(c) the synchronous power-generating module shall be stable during operation in the LFSM-O mode during frequency increases above 50.2 Hz. So long LFSM-O is active, the LFSM-O setpoint shall prevail over any other active power setpoints.

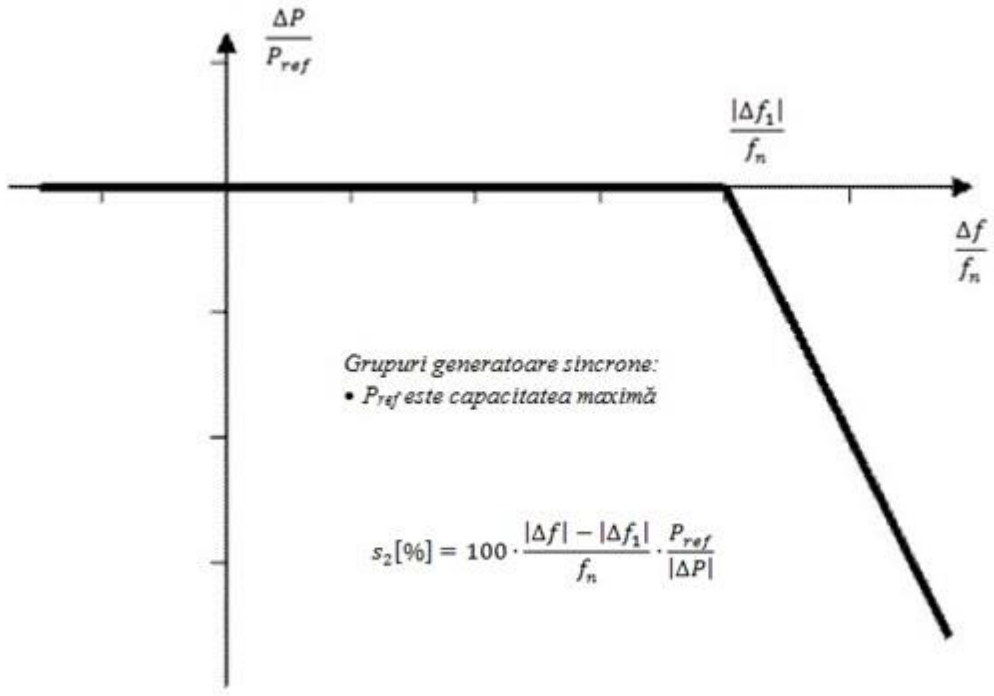


Figure 1B. Active power frequency response capability of type B synchronous power-generating modules in the LFSM-O mode

where: ΔP is the variation of the active power output from a synchronous power-generating module; P_{ref} is the active power reference based on which ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network. At overfrequencies where Δf is above +200 mHz compared to the nominal value (50 Hz), the synchronous power-generating module has to decrease the active power according to the droop s_2.

Article 22. The type B synchronous power-generating module shall be capable of maintaining constant the value of the active power mobilized regardless of the frequency variations, except where synchronous power-generating modules follow

frequency increases or have acceptable active power decreases at frequency decreases according to the provisions of Article 21 and Article 23.

Article 23. The TSO sets the reduction of the active power output of the type B synchronous power-generating module compared to the maximum active power output following the frequency decrease, within the admissible limits specified in figure 2B, hence:

(a) at underfrequencies below 49 Hz, a maximum active power reduction is admitted at a percentage of 2% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power output reduction curve depending on the frequency situated above the dotted line is admitted;

(b) at underfrequencies below 49.5 Hz, a maximum active power reduction is admitted at a percentage of 10% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power reduction curve depending on the frequency situated above the continuous line is admitted.

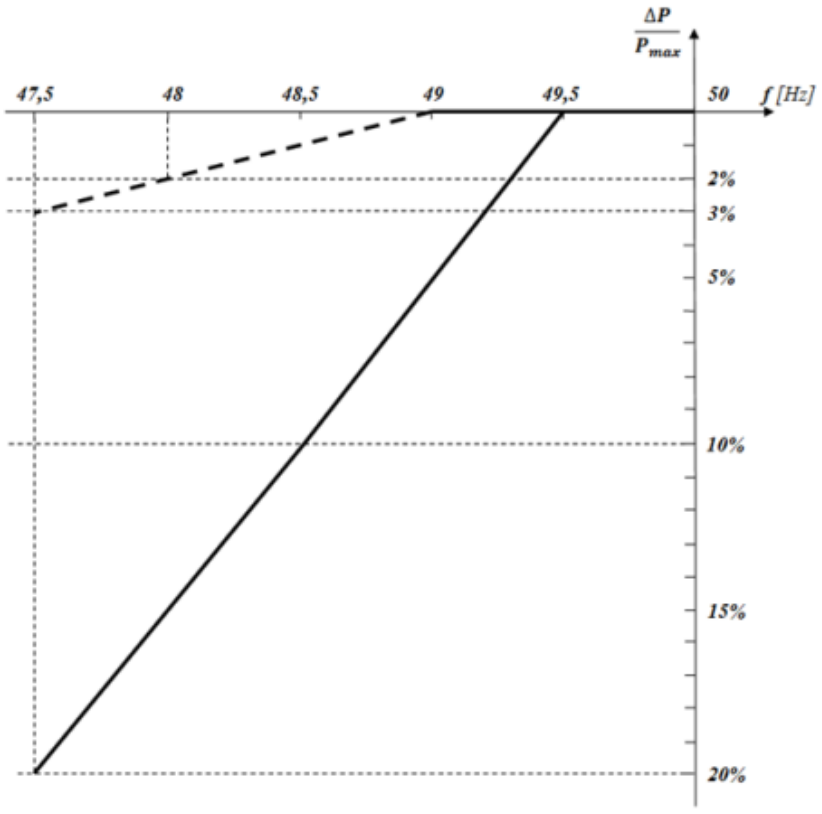


Figure 2B. Admissible limits for power reduction established by the TSO in case of underfrequency

Article 24. (1) The admissible active power reduction compared to the maximum active power output in case of frequency deviations below 49.5 Hz is established:

(a) under standard environmental conditions related to a temperature of 20 degrees Celsius;

(b) depending on the technical capability of synchronous power-generating modules.

(2) The type B synchronous power-generating module owner shall provide the relevant system operator with the dependency diagram of the active power in terms of temperature factors and the technical data regarding the synchronous power-generating module's technical capability as set forth in Annex no. 2.

(3) The data provided in paragraph (2) shall be submitted during the solution study stage within the connection process.

Article 25. (1) The type B synchronous power-generating module shall be equipped with a logic interface or corresponding protections in order to reduce the active power output to the point of shut-down in a time period of no more than five seconds after receiving the disconnect command at the interface.

(2) The relevant system operator is entitled to establish the technical requirements for the logic interface described in paragraph (1) and its connection method with the RSO's own SCADA system.

Article 26. (1) The relevant system operator sets forth the requirements for the automatic connection of a type B synchronous power-generating module to the network, after these requirements have been agreed upon with the TSO.

(2) The requirements set forth in paragraph (1) include:

(a) the frequency range within which an automatic connection is admissible, specified according to table 1B, and a corresponding delay time, usually of 15 minutes;

(b) the slope admitted for the active power increase after connection, usually of (10-30)% of P_{max}/min (indicated by the synchronous power-generating module manufacturer).

Article 27. Type B synchronous power-generating modules shall fulfil the following requirements in relation to active load-frequency control:

(a) in order to control active power output, the synchronous power-generating module shall be equipped with an interface (input port) in order to be able to receive a setpoint for the purposes of reducing power; and

(b) the relevant system operator shall have the right to specify the requirements for further equipment to allow active power output to be remotely operated.

Article 28. Type B synchronous power-generating modules shall fulfil the following requirements in relation to robustness, in terms of:

(a) fault-ride-through capability:

i) the synchronous power-generating module must be capable to remain connected to the network, continuing its stable operation following a correctly secured fault in the network, according to the voltage-time dependency described in figure 3B, with respect to the connection/interface point, as the case may be;

ii) the voltage-against-time-profile represents a lower admissible limit of the actual course of the voltages at the connection/interface point, as the case may be, during a symmetrical fault, as a function of time before, during and after the fault;

iii) the TSO shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of:

- the pre-fault minimum short-circuit power calculation at the connection/interface point, as the case may be;
- the pre-fault active and reactive power operating point of the synchronous power-generating module at the connection/interface point, as the case may be, and voltage at the connection/interface point, as the case may be; and
- the post-fault minimum short-circuit power calculation at the connection/interface point, as the case may be.

iv) upon request by a synchronous power-generating module owner, the relevant system operator shall provide the pre-fault and post-fault conditions to be considered for fault-ride-through capability as an outcome of the calculations at the connection/interface point, as the case may be, as specified in Article 28 (a) (iii) regarding:

- the pre-fault minimum short-circuit power at every connection/interface point, as the case may be, expressed in MVA;

- the pre-fault operating point of the synchronous power-generating module, expressed in active power, reactive power and voltage at the connection/interface point, as the case may be; and
- the post-fault minimum short-circuit power at the connection/interface point, as the case may be, expressed in MVA.

v) the synchronous power-generating module shall remain connected to the network and shall continue to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection/interface point, as the case may be, during a symmetrical fault, given the pre-fault and post-fault conditions described in Article 28 (a) (iii) and (iv), remains above the lower limit specified in Article 28 (a) (ii), except the triggers via the protections for internal electrical faults. The protection schemes and settings for internal electrical faults must not jeopardize fault-ride-through performance;

vi) considering the requirements provided in point (v), the synchronous power-generating module owner establishes the undervoltage protection (either the fault-ride-through capability, or the minimum voltage defined at the connection/interface point, as the case may be) according to the maximum voltage range corresponding to the synchronous power-generating module, except if the relevant system operator requires a narrower range, according to the provisions of Article 30 (b). The settings shall be justified by the synchronous power-generating module owner in accordance with the provisions set forth in point (vi);

(b) fault-ride-through capability in case of asymmetrical faults which must comply with the requirements set forth in Article 28 (a) (i).

(c) post-fault active power recovery.

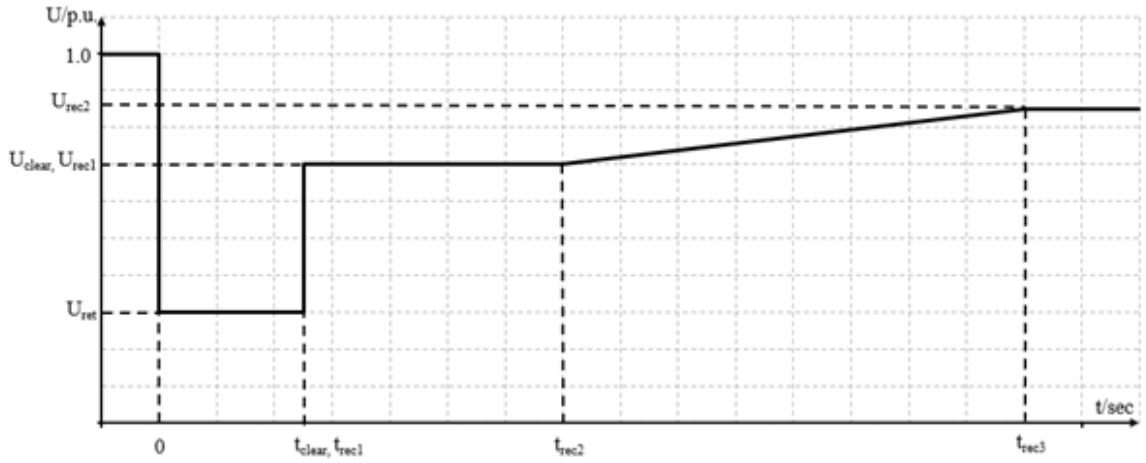


Figure 3B. Fault-ride-through profile of a type B synchronous power-generating module

Note: The diagram in figure 3B represents the lower limit of a voltage-against-time profile of the voltage at the connection/interface point, as the case may be, expressed in relative units as the ratio of its actual value and its reference value before, during and after a fault. U_{ret} is the retained voltage at the connection/interface point, as the case may be, during a fault, and t_{clear} is the instant when the fault has been cleared. U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} represent certain points of lower limits of retained voltage after fault clearance. The parameters related to the fault-ride-through are provided in table 2B.

Table 2B. Parameters related to the fault-ride-through capability of type B synchronous power-generating modules

Voltage parameters [r.u.]		**Time parameters [seconds]**	
U_{ret}:	0.3	t_{clear}:	0.25
U_{clear}:	0.7	t_{rec1}:	0.25
U_{rec1}:	0.7	t_{rec2}:	0.7
U_{rec2}:	0.85	t_{rec3}:	1.5

Article 29. Type B synchronous power-generating modules shall fulfil the following requirements in relation to system restoration:

(a) they shall be capable to reconnect to the network following an accidental disconnection caused by an event in the network, according to the dispatch instructions and under the conditions defined by the TSO;

(b) installation of automatic reconnection systems shall be subject to prior authorization both by the relevant system operator, and the TSO, in order to specify the automatic reconnection requirements;

(c) the requirements and conditions for the automatic reconnection provided in letters (a) and (b) shall be notified to the synchronous power-generating module owner during the grid connection process.

Article 30. Type B synchronous power-generating modules shall fulfil the following general operational requirements in relation to:

(a) control and automation schemes and related settings:

i) the control and automation schemes, such as ASC, AVR and related settings, including the control parameters, necessary for the network stability calculations and emergency measures analysis, shall be submitted by the synchronous power-generating module owner to the relevant system operator or the TSO respectively, no later than 3 months before the receving of the energisation operational notification (EON) for the beginning of the testing period, in order for them to be coordinated and agreed upon between the TSO, the relevant system operator and the synchronous power-generating module owner;

ii) any changes to the control and automation schemes and settings, as mentioned in point (i), of the different control devices of the synchronous power-generating module shall be coordinated and agreed upon between the TSO, the relevant system operator and the synchronous power-generating module owner.

(b) electrical protection schemes and related settings:

i) the protection systems needed for the synchronous power-generating module and the network, as well as the relevant settings to the synchronous power-generating module shall be coordinated and agreed upon between the relevant system operator and the synchronous power-generating module owner, during the connection process. The functions of the protections shall

be prescribed by the relevant system operator who may request a different protection control than the one proposed by the power-generating module owner. The protection systems and settings for internal electrical faults must not jeopardize the performance of the synchronous power-generating module. The protection and automation systems shall fulfill at least the following requirements:

- they shall ensure protection against internal faults of the synchronous power-generating module and against abnormal operation states and faults from the network to which this is connected;

- they shall be efficient, highly reliable and organized in groups which are selective, sensitive, capable to detect internal and external faults, physically and galvanically separated from the power supplies with operative voltage, from voltage and current metering transformers to command execution devices. The protection systems shall be equipped with extended self-testing and self-diagnosis functions, as well as with events recording and oscillography functions. The electrical protections system shall be equipped with standard communication interfaces aiming for the integration in a local system for data acquisition, supervision and control.
  - the internal faults electrical protections system shall be capable to detect at least the short-circuit currents in the power-generating module, the current asymmetry, stator and rotor electrical overloads, excitation loss of the synchronous power-generating module, maximum/minimum voltage in the synchronous power-generating module terminals, maximum/minimum frequency in the power-generating module terminals.
  - the external faults electrical protections system, as backup protections, shall be capable to detect at least the symmetrical and asymmetrical short-circuits from the network to which it is connected, the current asymmetry, the transition in the motor regime, the current and voltage electrical overloads.

ii) the electrical protection of the synchronous power-generating module shall take precedence over dispatch instructions, taking into account the operational security of the system, the health and safety of staff and of the public, as well as mitigating any damage to the synchronous power-generating module.

iii) following the coordination and agreement between the relevant system operator and the synchronous power-generating module owner, the protections systems shall cover at least the following:

- synchronous power-generating module protections covered by the synchronous power-generating module owner:

1. internal faults of the synchronous power-generating module (short-circuits or groundings);

2. short-circuits or groundings on the connection power line;

3. short-circuits or groundings in the network, as backup protection;

4. maximum and minimum voltage at the power-generating module terminals.

- protections covered by the synchronous power-generating module owner and/or the relevant system operator, as the case may be:

1. short-circuits or groundings on the power output evacuation line;

2. maximum and minimum voltage at the connection/interface point, as the case may be;

3. maximum and minimum frequency at the connection/interface point, as the case may be;

4. short-circuits or groundings in the network, as backup protection.

iv) changes to the protections schemes, needed for the synchronous power-generating module and the network and to the relevant settings to the generation plant shall be agreed upon in advance between the relevant system operator and the synchronous power-generating module owner;

(c) the organization by the synchronous power-generating module owner of the protection and control devices according to the following prioritization:

i) the network's and synchronous power-generating module's protection;

ii) frequency control (active power adjustment);

iii) power restrictions;

iv) limiting the ramping rate of power variations.

(d) information exchange:

i) protection/control and automation systems of synchronous power-generating modules shall be capable of exchanging information with the relevant system operator or within an aggregation of units, in real-time or periodically with time stamping. In the case of aggregations, according to

the functions agreed to be aggregated, the exchanged information shall be communicated to the relevant system operator and the TSO;

ii) the relevant system operator, in coordination with the TSO, sets the content of the information exchanges, which shall comprise at least: active power, reactive power, voltage and frequency at the connection/interface point, as the case may be, the state signals and commands regarding the breaker position and the separators position.

Article 31. Type B synchronous power-generating modules shall fulfil the following requirements in relation to voltage stability:

(a) the limits in which the power-generating module shall absorb/generate reactive power in the network, specified by the relevant system operator, according to a 0.9 inductive/capacitive power factor at the connection/interface point, as the case may be;

(b) the synchronous power-generating modules shall be equipped with an automated excitation control system (AVR), capable of permanently controlling the terminal voltage of synchronous power-generating modules at any setpoint within the operation limits.

Article 32. (1) The type B synchronous power-generating module owner shall ensure continuity in the submission of status and operation values provided in Article 30 (d) to the relevant system operator.

(2) The data provided shall be integrated in the DMS-SCADA system of the relevant system operator and shall ensure at least the active power signal. The relevant system operator is entitled to request the integration of other values into DMS-SCADA.

(3) The communication path shall be specified by the relevant system operator.

(4) The DMS-SCADA integration falls under the responsibility of the synchronous power-generating module owner.

Article 33. The type B synchronous power-generating module owner has the obligation to ensure compatibility of data exchange equipment at the relevant system operator's DMS-SCADA system interface level, according to the particularities requested by it.

Article 34. The connection solution of type B synchronous power-generating modules shall not allow their island operation and must foresee the endowment with

protections which trip the synchronous power-generating module at the occurrence of such an operation state.

CHAPTER VII

GENERAL CONDITIONS FOR TYPE C SYNCHRONOUS POWER-GENERATING MODULES

Article 35. Type C synchronous power-generating modules shall fulfil the following requirements in relation to frequency stability:

(a) the synchronous power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in table 1C;

(b) the synchronous power-generating module shall be capable of remaining connected to the network and operate at frequency variation rates of 1 Hz/sec.

Table 1C. Minimum duration for which a type C synchronous power-generating module has to be capable to remain connected to the network and to operate at different frequencies, deviating from the nominal value

Frequency range	Time period for operation
47.5 Hz – 49.0 Hz	30 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	30 minutes

Article 36. Type C synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency increases above the nominal value of 50 Hz (LFSM-O), thus:

(a) at overfrequencies, the synchronous power-generating module shall decrease the active power output according to the frequency variation, in accordance with figure 1C and with the following parameters:

i) the frequency threshold from which the synchronous power-generating module ensures overfrequency response is 50.2 Hz;

ii) the droop settings shall be between 2% and 12%, shall be specified at the synchronous power-generating module's commissioning and may be changed by the relevant system operator via dispatch instructions.

iii) the synchronous power-generating module shall be capable of decreasing the active power related to the frequency variation with an initial delay (called time delay and marked with t_1 in figure 5C) that is as short as possible. If that delay is greater than two seconds, the synchronous power-generating module owner shall justify the delay, providing technical evidence to the TSO.

(b) when reaching the power related to the minimum control level, the synchronous power-generating module shall be capable of:

i) continuing its operation at this level; or

ii) continuing to reduce the active power output according to the dispatch instructions and in accordance with the functional particularities of synchronous power-generating modules of the same type;

(c) the synchronous power-generating module shall be stable during operation in the LFSM-O mode during frequency increases over 50.2 Hz. So long LFSM-O is active, the LFSM-O setpoint shall prevail over any other active power setpoints.

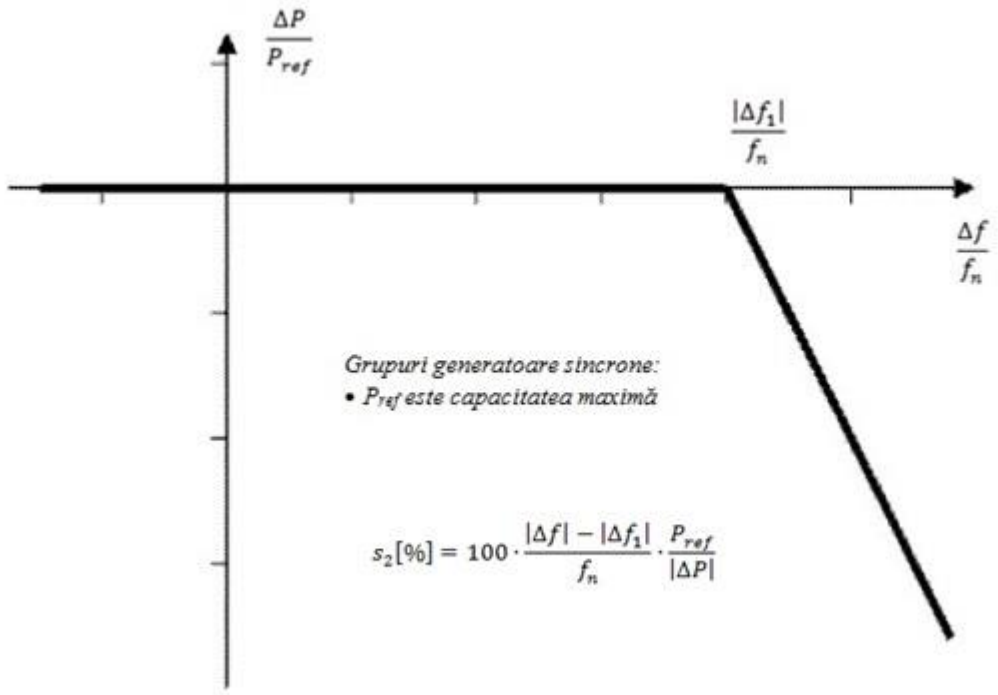


Figure 1C. Active power frequency response capability of type C synchronous power-generating modules in LFSM-O

where: ΔP is the variation of the active power output from a synchronous power-generating module; P_{ref} is the active power reference based on which ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network. At overfrequencies where Δf is above +200 mHz compared to the nominal value (50 Hz), the synchronous power-generating module has to decrease the active power according to the droop s_2.

Article 37. The type C synchronous power-generating module shall be capable of maintaining constant the value of the active power mobilized regardless of the frequency variations, except where synchronous power-generating modules follow frequency increases or have acceptable active power decreases at frequency decreases according to the provisions of Article 36 and Article 38.

Article 38. The TSO sets the reduction of the active power output of the type C synchronous power-generating module compared to the maximum active power output following the frequency decrease, within the admissible limits specified in figure 2C, hence:

(a) at underfrequencies below 49 Hz, a maximum active power reduction is admitted at a percentage of 2% from the maximum active power output at the

frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power output reduction curve depending on the frequency situated above the dotted line is admitted;

(b) at underfrequencies below 49.5 Hz, a maximum active power reduction is admitted at a percentage of 10% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power reduction curve depending on the frequency situated above the continuous line is admitted.

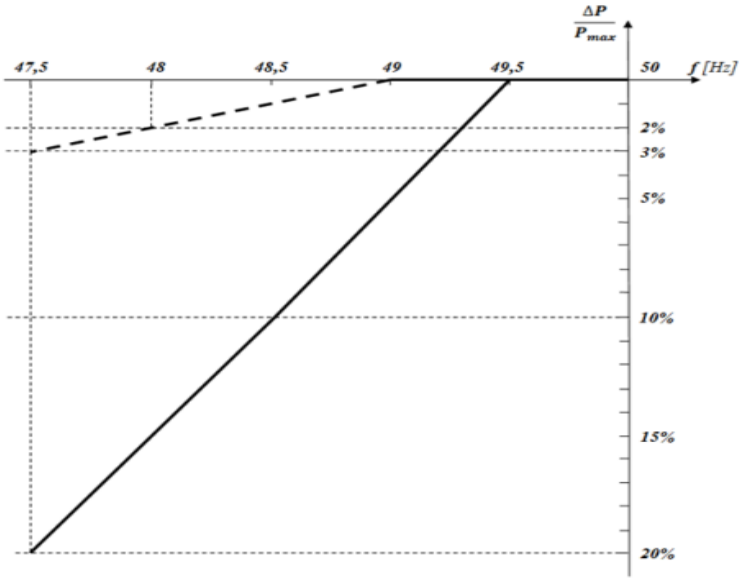


Figure 2C. Admissible limits for power reduction established by the TSO in case of underfrequency

Article 39. (1) The admissible active power reduction compared to the maximum active power output in case of frequency deviations below 49.5 Hz is established:

(a) under standard environmental conditions related to a temperature of 20 degrees Celsius;

(b) depending on the technical capability of synchronous power-generating modules.

(2) The synchronous power-generating module owner shall provide the relevant system operator with the dependency diagram of the active power in terms of temperature factors and the technical data regarding the synchronous power-generating module's technical capability as set forth in Annex no. 3.

(3) The data provided in paragraph (2) shall be submitted during the solution study stage within the connection process.

Article 40. (1) The active power control system of the type C synchronous power-generating module shall be capable of adjusting an active power setpoint in line with the instructions given to the synchronous power-generating module owner by the relevant system operator or the TSO.

(2) The time to reach the active power setpoint or the rate of change of active power output when adjusting the setpoint falls within the (2-10)% P_{max}/min range depending on the technology, while the time delay (the time elapsed until the movement of the primary motor) equals 2 seconds and the setpoint fulfillment tolerance is of 1% P_{max}.

Article 41. Local control shall be allowed in cases where the automatic remote control devices are out of service.

Article 42. (1) The relevant system operator sets forth the requirements for the automatic connection of a type C synchronous power-generating module to the network, after these requirements have been agreed upon with the TSO.

(2) The requirements set forth in paragraph (1) include:

(a) the frequency range within which an automatic connection is admissible, specified according to table 1C, and a corresponding delay time, usually of 15 minutes;

(b) the slope admitted for the active power increase after connection, usually of (10-30)% of P_{max}/min (indicated by the synchronous power-generating module manufacturer).

Article 43. Type C synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency decreases (LFSM-U), thus:

(a) it must be capable to mobilize active power response at underfrequencies below the 49.8 Hz frequency threshold and with a droop set by the TSO for every synchronous power-generating module at the time of PIF or via dispatch instructions within the (2-12)% limits, according to figure 3C.

(b) the delivery of active power in response to the frequency decrease (in LFSM-U mode) shall also take into account, as the case may be, the following:

i) the dependency diagram of active power output in terms of environmental conditions;

ii) the operating requirements of the synchronous power-generating module, in particular the limitations on operation near maximum active power at low

frequencies and the respective impact of external operating requirements according to Article 38 and Article 39;

(c) the activation of active power frequency response by the power-generating module shall not be unduly delayed. If this delay (called time delay and marked with t_1 in figure 5C) is greater than two seconds, the synchronous power-generating module owner shall justify the delay towards the TSO;

(d) while operating in the LFSM-U mode, the synchronous power-generating module shall ensure a power increase up to the maximum power;

(e) the synchronous power-generating module shall operate stably during the LFSM-U mode at frequencies lower than 49.8 Hz.

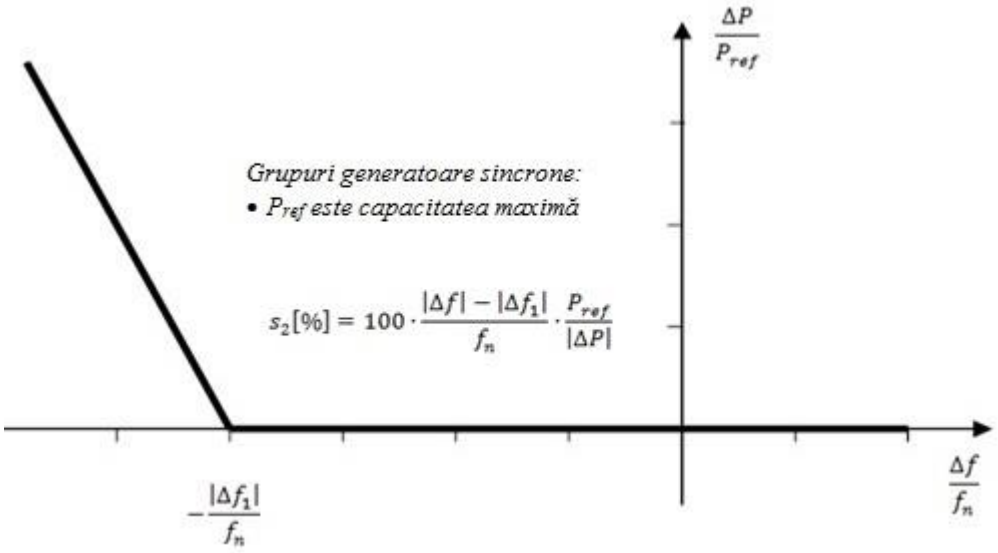


Figure 3C. Active power frequency response capability of type C synchronous power-generating modules in LFSM-U

where: P_{ref} is the active power reference based on which ΔP is established; ΔP is the variation of the active power output from a synchronous power-generating module; f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At underfrequencies below 49.8 Hz where Δf is below -200 mHz, the synchronous power-generating module has to increase the active power according to the droop s_2.

Article 44. If the FSM mode is active, the type C synchronous power-generating module shall fulfill all requirements described below, in addition to the requirements provided in Article 43 according to figure 4C:

(a) the synchronous power-generating module shall provide FSM, according to the parameters specified by the TSO, within the value ranges provided in table 2C, thus:
   i) in case of overfrequency above the 50 Hz value, the active power frequency response is limited by the minimum regulating level;
   ii) in case of underfrequency compared to the 50 Hz value, the active power frequency response is limited by the maximum available active power;
   iii) the actual delivery of active power frequency response depends on the external and operating conditions of the synchronous power-generating module when mobilizing the active power, particularly on the limitations given by the operation of the synchronous power-generating module near maximum power at low frequencies.

(b) the synchronous power-generating module shall be able to modify the frequency deadband and the droop following the TSO's instruction;

(c) in case of a frequency step variation, the synchronous power-generating module shall be capable of activating full active power frequency response, at or above the line shown in figure 5C, in accordance with the parameters specified in table 3C, namely: with an time delay (t_1) of 2 seconds and an activation time of maximum 30 seconds (t_2);

(d) the activation time of active power frequency response (time delay) shall not be greater than 2 seconds and shall not be unduly delayed. If the delay in initial activation of active power is greater than two seconds, the synchronous power-generating module owner shall provide technical evidence demonstrating why a longer time is needed;

(e) the synchronous power-generating module shall be capable to provide active power corresponding to the frequency deviation for a duration of 30 minutes;

(f) the active power control shall not have any adverse impact on the active power frequency response;

(g) if participating to the frequency restoration process at the setpoint and/or exchange powers to the scheduled values, the synchronous power-generating module shall ensure specific functions for performing these services, established via procedures drafted by the TSO;

(h) with regard to disconnection due to underfrequency, the power-generating facility that includes both synchronous power-generating modules and loads, including power-generating modules from pump-storage hydroelectric plants, shall be capable of disconnecting its load in case of underfrequency. The requirement referred to in this point does not apply to auxiliary supply.

Table 2C. Parameters for active power frequency response in FSM (see figure 5C)

Parameters		**Ranges**
Active power range related to maximum power $\frac{\lvert\Delta P_1\rvert}{P_{\max}}$		1.5 – 10%
Frequency response insensitivity	$\lvert\Delta f_i\rvert$	10 mHz
	$\frac{\lvert\Delta f_i\rvert}{f_n}$	0.02 – 0.06%
Frequency response deadband		0 mHz
Droop s_1 depending on the power park type (hydropower plant, thermal power plant, mixed-cycle, etc.)		2 – 12%

Table 3C. Parameters for full activation of active power frequency response resulting from frequency step variation (see figure 5C)

Parameters	Ranges or values
Active power range related to maximum power (frequency response range) $\frac{\lvert\Delta P_1\rvert}{P_{\max}}$	1.5 – 10%
For synchronous power-generating modules with inertia, the maximum admissible initial delay t_1, except when the TSO admits longer activation periods, based on technical evidence provided by the synchronous power-generating module owner	2 seconds
Maximum admissible choice of full activation time t_2, unless longer activation times are allowed by the TSO for reasons of system stability	30 seconds

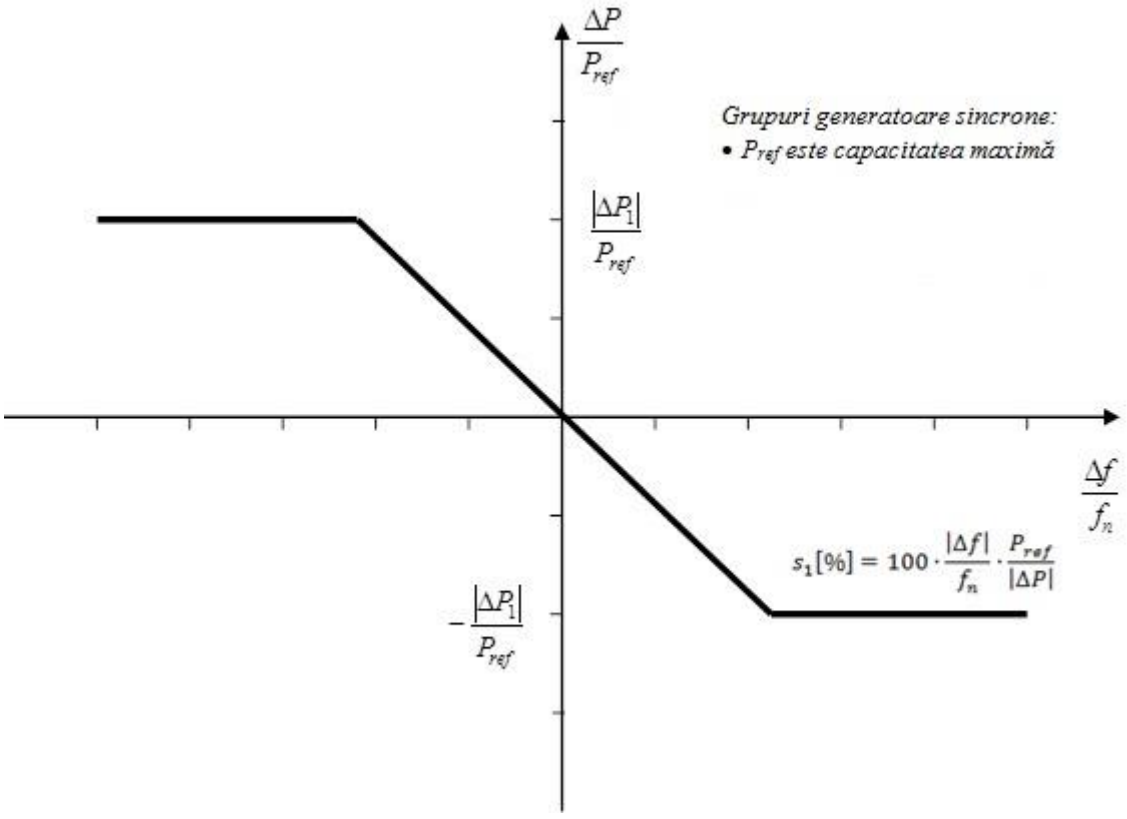


Figure 4C. Active power frequency response capability of type C synchronous power-generating modules in FSM illustrating the case of zero deadband and insensitivity area.

where: ΔP is the variation of the active power output from a synchronous power-generating module; P_{ref} is the active power reference based on which the active power change ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network.

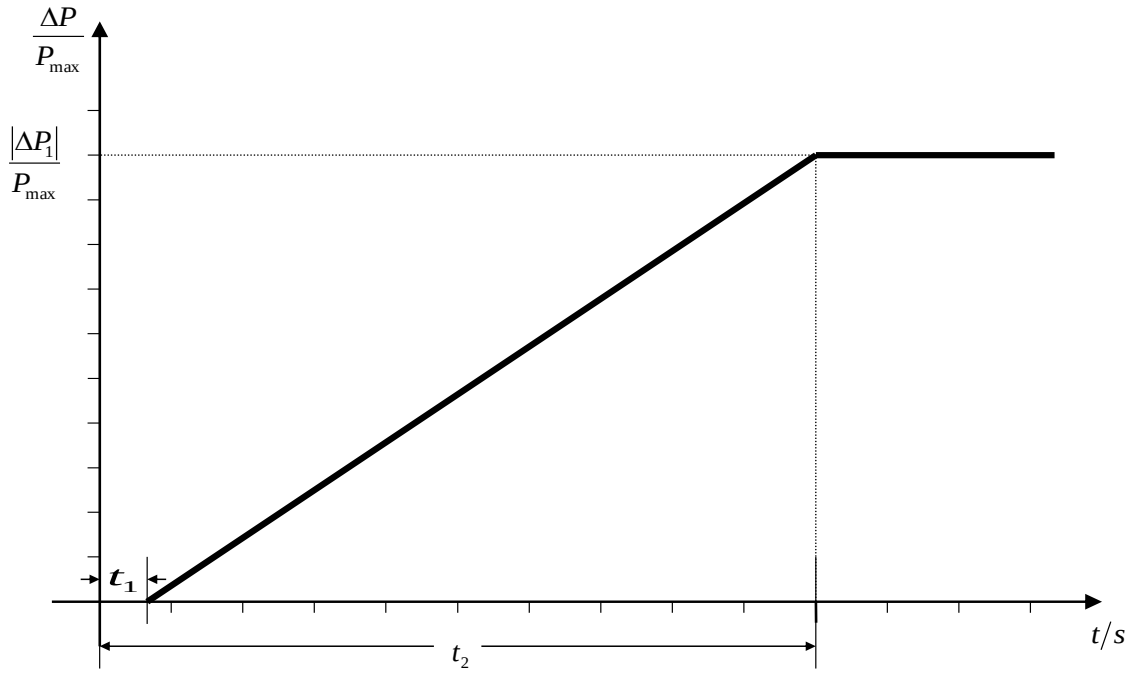


Figure 5C. Frequency response capability

where: P_{max} is the maximum power based on which the active power range ΔP is established; ΔP is the variation of the active power of the synchronous power-generating module. The synchronous power-generating module shall activate an active power ΔP up to the point ΔP_1, according to the t_1 and t_2 times, while the ΔP_1, t_1 and t_2 values are specified by the TSO according to the provisions from table 3C; t_1 is the initial delay (time delay); t_2 is the duration until the full activation of active power.

Article 45. (1) Real-time monitoring of the active power frequency automated response of the type C synchronous power-generating module shall be ensured by transmitting, in real-time and in a secured way, from an interface of the synchronous power-generating module to the dispatching center of the relevant system operator, upon request by the RSO, of at least the following signals:

i) the operation condition signal with/without active power frequency automated response;

ii) setpoint (scheduled) active power;

iii) actual value of the active power output;

iv) load-frequency response deadband.

(2) i) the relevant system operator shall specify additional signals to be provided by the synchronous power-generating module via monitoring and recording devices in order to verify the performance of the active power frequency response provision;

ii) the additional signals are: frequency at the connection/interface point, as the case may be, state signals and commands regarding the breaker position and the separators position;

iii) the synchronous power-generating module owner ensures the redundancy of transmission of signals via two independent communication paths; usually, the main path is ensured via optical fiber equipment.

iv) the synchronous power-generating module owner shall ensure, as the case may be, via local control schemes measurements, the recording of the following parameters: pressure, the flow and temperature of steam entering the turbine, the gas flow, the opening of the governing device and the rotor blades, the opening of control valves, etc.

(3) Parameter settings for active power frequency response and droop are established via dispatch instructions.

Article 46. Type C synchronous power-generating modules shall fulfil the following requirements in relation to robustness, in terms of:

(a) the fault-ride-through capability in case of symmetrical faults:

i) the synchronous power-generating module must be capable to remain connected to the network, continuing its stable operation following a correctly secured fault in the network, according to the voltage-time dependency described in figure 6C, with respect to the connection/interface point, as the case may be, and described by the parameters in table 4C;

ii) the voltage-against-time-profile represents a lower admissible limit of the actual course of the voltages at the connection/interface point, as the case may be, during a symmetrical fault, as a function of time before, during and after the fault;

iii) the TSO shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of:
   - the pre-fault minimum short-circuit power calculation at the connection/interface point, as the case may be;
   - the pre-fault active and reactive power operating point of the synchronous power-generating module at the connection/interface point, as the case may be, and voltage at the connection/interface point, as the case may be; and
   - the post-fault minimum short-circuit power calculation at the connection/interface point, as the case may be.

iv) upon request by a synchronous power-generating module owner, the relevant system operator shall provide the pre-fault and post-fault conditions (as relevant values resulted from typical cases) to be considered for fault-ride-through capability as an outcome of the calculations at the connection/interface point, as the case may be, as specified in Article 46 (a) (iii) regarding:
   - the pre-fault minimum short-circuit power at every connection/interface point, as the case may be, expressed in MVA;
   - the pre-fault operating point of the synchronous power-generating module, expressed in active power, reactive power and voltage at the connection/interface point, as the case may be; and
   - the post-fault minimum short-circuit power at the connection/interface point, as the case may be, expressed in MVA.

v) the synchronous power-generating module shall remain connected to the network and shall continue to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection/interface point, as the case may be, during a symmetrical fault, given the conditions existing pre-fault and post-fault described in Article 46 (a) (iii) and (iv), remains above the lower limit specified in Article 46 (a) (ii), except the triggers via the protections for internal electrical faults. The protection schemes and settings for internal electrical faults must not jeopardize fault-ride-through performance;

vi) considering the requirements provided in point (v), the synchronous power-generating module owner establishes the undervoltage protection (either the

fault-ride-through capability, or the minimum voltage defined at the connection/interface point, as the case may be) according to the maximum voltage range corresponding to the synchronous power-generating module, except if the relevant system operator requires a narrower range, according to the provisions of Article 48 (b). The settings shall be justified by the synchronous power-generating module owner in accordance with this principle;

(b) fault-ride-through capability in case of asymmetrical faults shall comply with the provisions set forth in Article 46 (a) (i) for symmetrical faults;

(c) post-fault active power recovery;

(d) maintaining stable operation at every point within the P-Q-capability diagram in case of power oscillations;

(e) synchronous power-generating modules shall be capable of remaining connected to the network without reducing power, so long the frequency and voltage fall within the limits provided in table 1C, namely ±10% U_n;

(f) synchronous power-generating modules shall be capable of remaining connected to the network during single-phase or three-phase AR on the lines of the loop network to which they are connected. The specific technical details shall be subject to coordination and instructions on protection schemes and settings agreed upon with the relevant system operator.

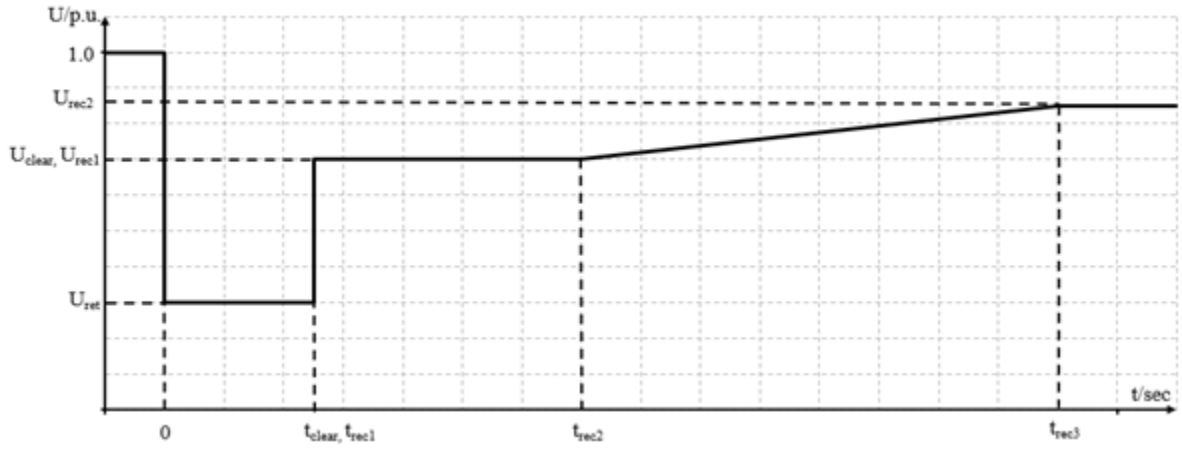


Figure 6C. Fault-ride-through profile of a type C synchronous power-generating module

Note: The diagram in figure 6C represents the lower limit of a voltage-against-time profile of the voltage at the connection/interface point, as the case may be, expressed in relative units as the ratio of its actual value and its reference value before, during and after a fault. U_{ret} is the

retained voltage during a fault at the connection/interface point, as the case may be, and t_{clear} is the instant when the fault has been cleared. U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} represent certain points of lower limits of retained voltage after fault clearance.

Table 4C. Parameters related to the fault-ride-through capability of type C synchronous power-generating modules

Voltage parameters [r.u.]		**Time parameters [seconds]**	
U_{ret}	0.3	t_{clear}	0.25
U_{clear}	0.7	t_{rec1}	0.25
U_{rec1}	0.7	t_{rec2}	0.7
U_{rec2}	0.85	t_{rec3}	1.5

Article 47. (1) Type C synchronous power-generating modules shall fulfil the following requirements in relation to system restoration:

(a) they shall be capable to reconnect to the network following an accidental disconnection caused by an event in the network, under the conditions defined by the TSO;

(b) installation of automatic reconnection systems shall be subject to prior authorization both by the relevant system operator, and the TSO, in order to specify the automatic reconnection conditions;

(c) they shall be capable of fulfilling the following requirements with respect to black start capability:

i) the black start capability is not mandatory, but may be requested by the TSO during the grid connection stage in order to ensure the system's operational security;

ii) the synchronous power-generating module owner, upon request by the TSO, shall provide an offer for providing black start capability. The TSO may request the provision of black start capability if it considers system

security to be at risk due to a lack of black start capability in its control area where the synchronous power-generating module is located;

iii) a synchronous power-generating module with black start capability shall be capable of starting from the shutdown state, without any external electrical energy supply within a time frame specified by the TSO, usually (15-30) minutes from the instant the instruction is received;

iv) a synchronous power-generating module with black start capability shall be able to synchronize within the frequency limits of (47.5-51.5) Hz and the voltage limits specified by the relevant system operator of (0.85-1.1) U_n;

v) a synchronous power-generating module with black start capability shall be capable of automatically regulating dips in voltage occurred during the restoration process;

vi) a synchronous power-generating module with black start capability shall:
- be capable of regulating load connections in block load;
- be capable of participating to frequency variations, both for an increase above 50.2 Hz (in the LFSM-O mode) and for a decrease below 49.8 Hz (in the LFSM-U mode);
- participate to frequency containment in case of overfrequency or underfrequency within the whole active power output range, as well as at houseload operation level;
- be capable of parallel operation with other synchronous power-generating modules within one island;
- control voltage automatically during system restoration within the ±10% U_n range.

(d)the synchronous power-generating modules shall fulfill the following requirements with regard to the capability to take part in island operation:

i) they shall be capable of island operation or taking part in island operation if required by the relevant system operator. This requirement shall be specified during the TCA issuance stage; and
- the frequency limits for island operation shall be (47.5-51.5) Hz;
- the voltage range for island operation shall be U_n ± 10 % for U_n values smaller than 110 kV.

ii) they shall be able to operate with active frequency control mode during island operation. In case of a power surplus, synchronous power-generating

modules shall be capable of reducing the active power output from a previous operating point to any new operating point within the P-Q-capability diagram. In that regard, the synchronous power-generating module shall be capable of reducing active power output as much as inherently technically feasible, but to at least 55% of its maximum capacity (which corresponds to a reduction of at least 45% of its maximum capacity);

iii) the method for detecting a change from interconnected system operation to island operation shall be agreed between the synchronous power-generating module owner and the relevant system operator in coordination with the TSO. The agreed method of detection may be active or passive and must not rely solely on the switchgear position signals from the relevant system operator's network;

iv) they shall be capable of operation in limited frequency sensitive mode – overfrequency (LFSM-O) and limited frequency sensitive mode – underfrequency (LFSM-U), within the ranges specified in table 1C and depending on the specific particularities at the connection/interface point, as the case may be.

(e) they shall fulfill the following requirements with regard to quick re-synchronization capability:

i) in case of disconnection from the network, the synchronous power-generating module shall be able to quickly re-synchronize, usually within 15 minutes, according to the protection program agreed upon with the relevant system operator;

ii) after disconnection from the network (system), a synchronous power-generating module with a minimum re-synchronization time greater than 15 minutes must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the switchgear position signals at the connection point of the synchronous power-generating module;

iii) synchronous power-generating modules shall be capable of continuing operation following tripping to houseload and to support any power variations associated with houseload operation. The minimum duration for houseload operation shall be specified by the relevant system operator in

coordination with the TSO and shall be, usually, equal to at least 1 hour, depending on the particularities of the technology corresponding to the primary source/prime movers.

(2) the requirements and conditions for the automatic reconnection provided in paragraphs (a) and (b) shall be notified to the synchronous power-generating module owner during the grid connection process.

Article 48. Type C synchronous power-generating modules shall fulfil the following general operational requirements in relation to:

(a) control and automation schemes and related settings:

i) the control and automation schemes, such as ASC, AVR and related settings, including the control parameters, necessary for the network stability calculations and emergency measures analysis, shall be submitted by the synchronous power-generating module owner to the relevant system operator or the TSO respectively, no later than 3 months before the receving of the energisation operational notification (EON) for the beginning of the testing period, in order for them to be coordinated and agreed upon between the TSO, the relevant system operator and the synchronous power-generating module owner;

ii) any changes to the control and automation schemes and related settings, as mentioned in point (i), of the different control devices of the synchronous power-generating module shall be coordinated and agreed upon between the TSO, the relevant system operator and the synchronous power-generating module owner, if they apply in the situations specified in point (i).

(b) electrical protection schemes and related settings:

i) the protection systems needed for the synchronous power-generating module and the network, as well as the relevant settings to the synchronous power-generating module shall be coordinated and agreed upon between the relevant system operator and the synchronous power-generating module owner, during the connection process. The protection systems and related settings for internal electrical faults must not jeopardize the performance of the synchronous power-generating module. The electrical protection systems shall fulfill at least the following requirements:

- the electrical protection system shall ensure protection against internal faults of the synchronous power-generating module and shall ensure

backup protection against abnormal operation states and faults from the network to which the synchronous power-generating module is connected;

- the electrical protection system shall be efficient, highly reliable and organized in groups with redundant functionality; the protections shall be selective, sensitive, capable to detect internal and external faults, physically and galvanically separated from the power supplies with operative voltage, from voltage and current metering transformers to command execution devices. The electrical protection system shall be equipped with extended self-testing and self-diagnosis functions, as well as with events recording and oscillography functions. The electrical protections system shall be equipped with standard communication interfaces aiming for the integration in a local system for data acquisition, supervision and control.
- the electrical protections system may be organized in two groups of independent and redundant protections, both for the synchronous power-generating module as well as for the connection, as the case may be.
- the internal faults electrical protections system shall be capable to detect at least the short-circuit currents in the synchronous power-generating module, the current asymmetry, stator and rotor electrical overloads, excitation loss of the power-generating module, maximum/minimum voltage in the synchronous power-generating module terminals, maximum/minimum frequency in the power-generating module terminals.
- the external faults electrical protections system, as backup protections, shall be capable to detect at least the symmetrical and asymmetrical short-circuits from the network to which the synchronous power-generating module is connected, the power oscillations and asynchronous operation, the current asymmetry, the transition in the motor regime, the current and voltage electrical overloads.

ii) the electrical protection of the synchronous power-generating module shall take precedence over dispatch instructions, taking into account the operational security of the system, the health and safety of staff and of the public, as well as mitigating any damage to the synchronous power-generating module.

iii) together with the synchronous power-generating module owner, the relevant system operator shall coordinate and commonly agree that the protection systems must cover at least the following faults:

- protections of the synchronous power-generating module, of the step-up transformer and of the houseload or ancillary services transformer, covered by the synchronous power-generating module owner, for:

  1. internal faults of the synchronous power-generating module, of the step-up transformer and potentially of the houseload transformer (short-circuits or groundings);

  2. internal faults of the step-up transformer;

  3. short-circuits or groundings on the evacuation line of the power output network;

  4. short-circuits or groundings in the network, as backup protection;

  5. maximum and minimum voltage at the power-generating module terminals.

- protections covered by the synchronous power-generating module owner and/or the relevant system operator, as the case may be, for:

  1. short-circuits or groundings on the evacuation line of the power output network;

  2. maximum and minimum voltage at the connection/interface point, as the case may be;

  3. maximum and minimum frequency at the connection/interface point, as the case may be;

  4. short-circuits or groundings in the network, as backup protection.

iv) changes to the protections schemes, needed for the synchronous power-generating module and the network and to the relevant settings to the generation plant shall be agreed upon in advance between the relevant system operator and the synchronous power-generating module owner;

(c) the protection and control devices, organized by the synchronous power-generating module owner according to the following prioritization:

i) the network's and synchronous power-generating module's protection;

ii) frequency control (active power adjustment);

iii) power restrictions;

iv) limiting the ramping rate of power variations.

(d) information exchange:

i) protection/control and automation systems of synchronous power-generating modules shall be capable of exchanging information with the relevant system operator or within aggregations of units, in real-time or periodically with time stamping. In the case of aggregations, according to the functions agreed to be aggregated, the exchanged informations shall be communicated to the relevant system operator and the TSO;

ii) the relevant system operator, in coordination with the TSO, shall specify the content of informations exchanges including a precise list of data to be provided to the TSO by the relevant system operator and by the synchronous power-generating module owner. The real-time submitted data are: active power, reactive power, voltage and frequency at the connection/interface point, as the case may be, state signals and commands regarding the breaker position and the separators position. The synchronous power-generating module owner ensures the redundancy of transmission of signals via two independent communication paths; usually, the main path is ensured via optical fiber equipment.

(e) the possibility of the synchronous power-generating module to automatically disconnect from the network when losing robustness. The disconnection criteria regarding the detection of asynchronous operation, the loss of excitation, the motor regime, the protection against current asymmetry, phase interruption and critical disconnection time, shall be agreed upon between the synchronous power-generating module owner, the relevant system operator and the TSO.

(f) measuring and control devices:

i) synchronous power-generating modules shall be equipped with devices to provide fault recording and monitoring of dynamic system behavior; these devices are usually oscilloperturbographs or equipment that can replace functions covered by oscilloperturbographs. These devices shall record the following parameters:

1. voltages in all three phases;
2. current in each phase;
3. active power in all three phases;
4. reactive power in all three phases;
5. frequency.

The relevant system operator shall have the right to specify quality of supply parameters to be complied with, provided via the aforementioned devices, on condition that they are previously agreed upon with the synchronous power-generating module owner.

ii) the settings of the fault recording equipment, including triggering criteria and the sampling rates shall be commonly agreed between the synchronous power-generating module owner and the relevant system operator at the time of PIF and shall be documented via written arrangements. These shall also include a criterion for detecting oscillations established by the TSO;

iii) the relevant system operator, the TSO and the synchronous power-generating module owner commonly agree upon the need to include a criterion for detecting oscillations in order to monitor the dynamic system behavior, specified by the TSO in order to detect poorly damped power oscillations (undamped);

iv) the dynamic system behavior monitoring system shall include arrangements for the synchronous power-generating module owner and the relevant system operator to access the information. The communications protocols for registered data shall be commonly agreed between the synchronous power-generating module owner, the relevant system operator and the TSO, prior to choosing the monitoring equipment.

(g) synchronous power-generating module operation simulation models:

i) upon request by the relevant system operator or the TSO, the synchronous power-generating module owner shall provide the synchronous power-generating module operation simulation models that reflect the synchronous power-generating module's behavior both in steady-state regime, as well as in dynamic regime (including for transient electromagnetic phenomena, if requested). The models provided shall be validated via the compliance test results. The synchronous power-generating module owner submits to the relevant system operator or the TSO the results of these tests for the synchronous power-generating module or for heat engines that gear the synchronous power-generating modules, proven by means of check-up certificates recognized on European level, carried out by an authorized certifier;

ii) the models provided by the synchronous power-generating module owner shall contain the following sub-models, depending on the existence of individual components:
- generating unit and prime mover;
- speed and active power control;
- voltage control, including, if applicable, power system stabilizer ("PSS") function and excitation control system;
- synchronous power-generating module protection models, as agreed between the relevant system operator and the synchronous power-generating module owner.

iii) upon request by the relevant system operator, as referred to in point (i), the TSO shall specify:
- the format in which simulation models are to be provided, including the utilized calculation program;
- the documentation on a mathematical model's structure and block diagrams;
- the estimate of the minimum and maximum short-circuit power at the connection/interface point, as the case may be, expressed in MVA, as an equivalent of the network.

iv) upon request by the relevant system operator, the synchronous power-generating module owner shall provide it with the recordings of the synchronous power-generating module's performance. The relevant system operator or the TSO may make such a request, in order to compare the response of the models and model simulations performed with actual operational recordings.

(h) the installation of devices for system operation and devices for system operational security, if the relevant system operator or the TSO considers that it is necessary to install additional devices in a synchronous power-generating module (e.g. quick closing control valves) in order to preserve or restore system operation or system operational security. The relevant system operator and the synchronous power-generating module owner, together with the TSO, shall analyze and agree upon the adequate solution;

(i) the minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction of change of active power

output for a synchronous power-generating module are specified by the relevant system operator, in coordination with the TSO, taking into consideration the specific characteristics of prime mover technology. Usually, this rate of change falls within the (1-20)% P_{max}/min range and is equal in both directions;

(j) earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.

Article 49. Type C synchronous power-generating modules shall fulfil the following requirements in relation to voltage stability:

(a) the synchronous power-generating modules shall be equipped with an automated excitation control system (AVR), capable of permanently controlling the terminal voltage of the synchronous power-generating module at any setpoint within the operation limits.

(b) they shall be capable to automatically disconnect when the voltage at the connection/interface point, as the case may be, exceeds the levels specified by the relevant system operator within the (0.85-1.1) U_n range. The requirements and settings for actual automatic disconnection of synchronous power-generating modules shall be specified by the relevant system operator in coordination with the TSO.

(c) they shall be capable of providing additional reactive power, specified by the relevant system operator, which shall be provided if the connection/interface point, as the case may be, of the synchronous power-generating module is neither located at the high-voltage terminals of the step-up transformer, nor at the terminals of the synchronous power-generating module, if there is no step-up transformer. The additional reactive power shall compensate the reactive power exchange of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power-generating module or the terminals of the synchronous power-generating module, if there is no step-up transformer, and the connection/interface point, as the case may be. The additional reactive power shall be covered via dedicated equipment provided by the synchronous power-generating module owner. This additional reactive power is specified via a reactive power offset study at the connection/interface point, as the case may be.

(d) they shall be capable to generate reactive power at full capacity, whilst complying with the following requirements:

i) the synchronous power-generating module owner shall provide an envelope of the U-Q/P_{max}-profile, which may take any shape within the limits of which the synchronous power-generating module shall be capable to provide/absorb reactive power at voltage variations and full capacity operation; the envelope shall be analyzed and approved by the TSO in coordination with the relevant system operator;

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

— the U-Q/P_{max}-envelope shall not exceed the U-Q/P_{max}-profile envelope represented by the inner envelope in figure 7C;

— the dimensions of the U-Q/P_{max}-profile envelope (Q/P_{max} range and voltage range) shall be within the maximum values specified in table 5C;

— the position of the U-Q/P_{max}-profile shall be within the limits of the fixed outer envelope in figure 7C; and

— the U-Q/P_{max}-profile specified for the synchronous power-generating module may take any shape, having regard to the potential costs of delivering the capability to provide reactive power production at low voltages and reactive power consumption at high voltages.

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

iv) synchronous power-generating modules shall be capable of moving to any operating point within the U-Q/P_{max} profile in appropriate timescales to target values requested by the relevant system operator, usually within the (1-20)% P_{max}/minute range for active power variation and up to 10% of the maximum reactive power from the P-Q-profile, per minute.

(e) when operating at an active power output below the maximum power ($P < P_{max}$), the type C synchronous power-generating module shall be capable of operating at every possible operating point in the P-Q-capability diagram, at least down to

minimum stable operating level. Even at reduced active power output, reactive power supply at the interface point, as the case may be, shall correspond fully to the P-Q-diagram, taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account.

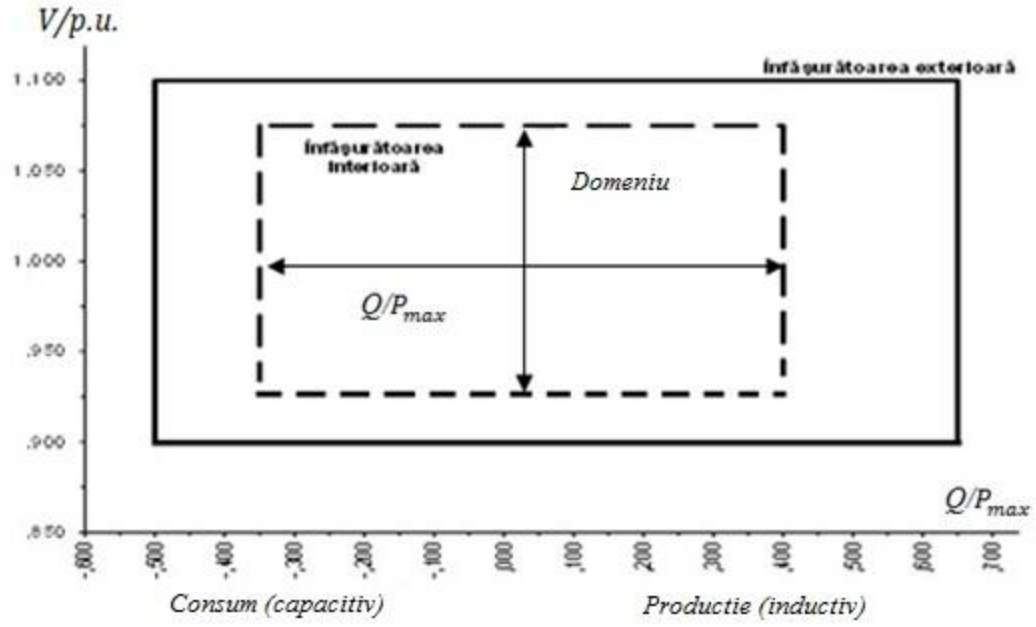


Figure 7C. U-Q/P_{max}-profile of a synchronous power-generating module

Figure 7C represents the boundaries of a U-Q/P_{max}-profile by the voltage at the connection/interface point, as the case may be, expressed in relative units by the ratio of its actual voltage value and the reference value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the envelope are indicative.

Table 5C: Parameters for the inner envelope in figure 7C

Maximum Q/P_{max} range	**Maximum range of steady-state voltage level (r.u.)**
0.95	0.200

Article 50. (1) The type C synchronous power-generating module owner shall ensure continuity in the submission of status and operation values provided in Article 46 to the relevant system operator.

(2) The type C synchronous power-generating module shall be integrated in the DMS-SCADA system of the relevant system operator, ensuring at least the following signal exchange: active power, reactive power, voltage and frequency at the connection/interface point, as the case may be, set values for active power and reactive power, state signals and commands regarding the breaker position and the separators position.

(3) The type C synchronous power-generating module owner ensures the redundancy of transmission of signals via two independent communication paths. Usually, the main path is ensured via optical fiber equipment.

Article 51. The type C synchronous power-generating module owner has the obligation to ensure compatibility of data exchange equipment at the relevant system operator's DMS-SCADA system interface level, according to the particularities requested by it.

Article 52. If several synchronous power-generating modules are connected in the same electrical node (bar), for which the sum of installed capacities of all energy sources exceeds the maximum power of type C, these must commonly provide voltage control at the connection/interface point, as the case may be.

CHAPTER VIII

GENERAL CONDITIONS FOR TYPE D SYNCHRONOUS POWER-GENERATING MODULES

Article 53. Type D synchronous power-generating modules shall fulfil the following requirements in relation to frequency stability:

(a) the synchronous power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in table 1D;

(b) the synchronous power-generating module shall be capable of remaining connected to the network and operate at frequency variation rates of 1 Hz/sec.

Table 1D. Minimum duration for which a type D synchronous power-generating module has to be capable to remain connected to the network and to operate at different frequencies, deviating from the nominal value

Frequency range	Time period for operation
47.5 Hz – 49.0 Hz	30 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	30 minutes

Article 54. Type D synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency increases above the nominal value of 50 Hz (LFSM-O), thus:

(a) at overfrequencies, the synchronous power-generating module shall decrease the active power output according to the frequency variation, in accordance with figure 1D and with the following parameters:

i) the frequency threshold from which the synchronous power-generating module ensures overfrequency response is 50.2 Hz;

ii) the droop settings shall be between 2% and 12%, shall be specified at the synchronous power-generating module's commissioning and may be changed by the relevant system operator via dispatch instructions.

iii) the synchronous power-generating module shall be capable of decreasing the active power related to the frequency variation with an initial delay (called time delay and marked with t_1 in figure 5D) that is as short as possible. If that delay is greater than two seconds, the synchronous power-generating module owner shall justify the delay, providing technical evidence to the TSO.

(b) when reaching the power related to the minimum control level, the synchronous power-generating module shall be capable of:

i) continuing its operation at this level; or

ii) continuing to reduce the active power output according to the dispatch instructions and in accordance with the functional particularities of synchronous power-generating modules of the same type.

(c) the synchronous power-generating module shall be stable during operation in the LFSM-O mode during frequency increases over 50.2 Hz. So long LFSM-O is active, the LFSM-O setpoint shall prevail over any other active power setpoints.

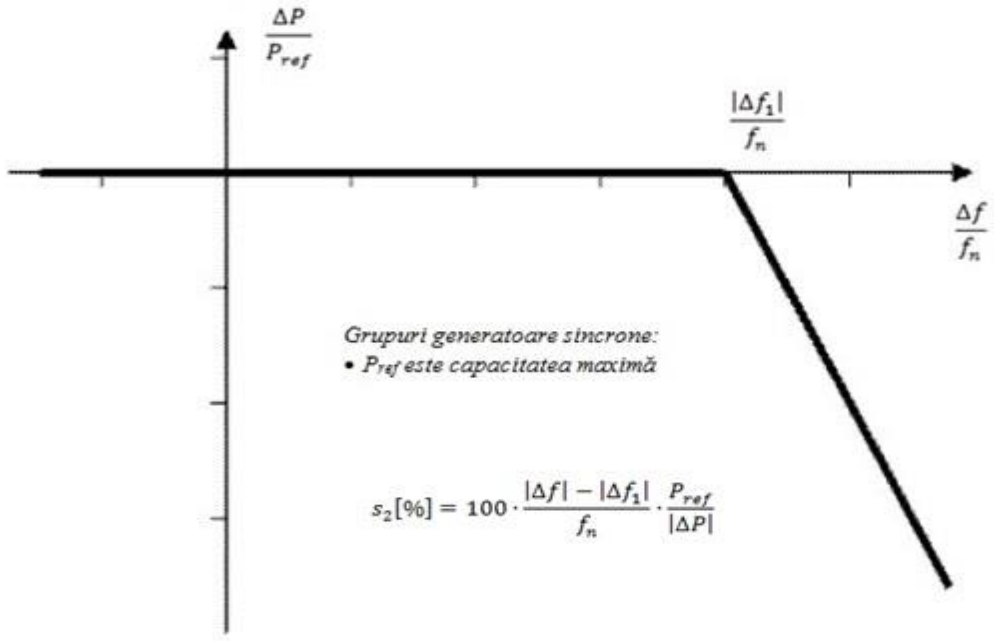


Figure 1D. Active power frequency response capability of type D synchronous power-generating modules in LFSM-O

where: ΔP is the variation of the active power output from a synchronous power-generating module; P_{ref} is the active power reference based on which ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network. At overfrequencies where Δf is above +200 mHz compared to the nominal value (50 Hz), the synchronous power-generating module has to decrease the active power according to the droop s_2.

Article 55. The type D synchronous power-generating module shall be capable of maintaining constant the value of the active power mobilized regardless of the frequency variations, except where synchronous power-generating modules in the power park follow frequency increases or have acceptable active power decreases at frequency decreases according to the provisions of Article 54 and Article 56.

Article 56. The TSO sets the reduction of the active power output of the type D synchronous power-generating module compared to the maximum active power

output following the frequency decrease, within the admissible limits specified in figure 2D, hence:

(a) at underfrequencies below 49 Hz, a maximum power output reduction is admitted at a percentage of 2% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power output reduction curve depending on the frequency situated above the dotted line is admitted;

(b) at underfrequencies below 49.5 Hz, a maximum active power reduction is admitted at a percentage of 10% from the maximum active power output at the frequency of 50 Hz, for every 1 Hz of frequency decrease. Any maximum active power output reduction curve depending on the frequency situated above the continuous line is admitted.

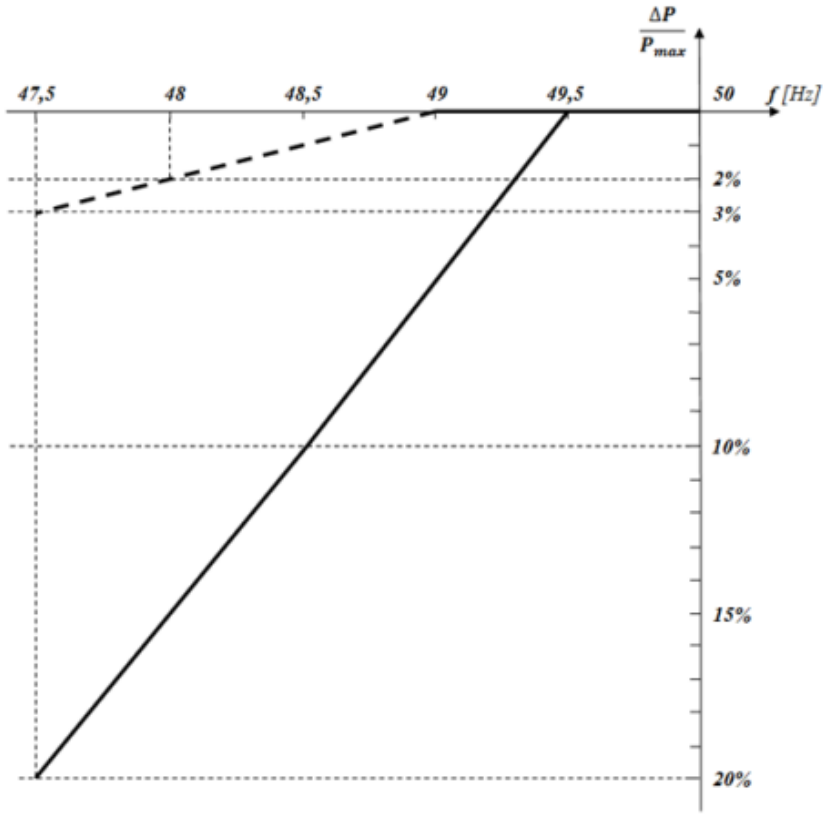


Figure 2D. Admissible limits for power reduction established by the TSO in case of underfrequency

Article 57. (1) The admissible active power reduction compared to the maximum active power output in case of frequency deviations below 49.5 Hz is established:

(a) under standard environmental conditions related to a temperature of 20 degrees Celsius;

(b) depending on the technical capability of synchronous power-generating modules.

(2) The synchronous power-generating module owner shall provide the relevant system operator with the dependency diagram of the active power in terms of temperature factors and the technical data regarding the synchronous power-generating module's technical capability as set forth in Annex no. 4.

(3) The data provided in paragraph (2) shall be submitted during the solution study stage within the connection process.

Article 58. (1) The active power control system of the type D synchronous power-generating module shall be capable of adjusting an active power setpoint in line with the instructions given to the synchronous power-generating module owner by the relevant system operator or the TSO.

(2) The time to reach the active power setpoint or the rate of change of active power output when adjusting the setpoint falls within the (2-10)% P_{max}/min range depending on the technology, while the time delay (the time elapsed until the movement of the primary motor) equals 2 seconds and the setpoint fulfillment tolerance is of 1% P_{max}.

Article 59. Local control shall be allowed in cases where the automatic remote control devices are out of service.

Article 60. Type D synchronous power-generating modules shall be capable to ensure a limited frequency response, namely to frequency decreases (LFSM-U), thus:

(a) it must be capable to mobilize active power response at underfrequencies below the 49.8 Hz frequency threshold and with a droop set by the TSO for every synchronous power-generating module at the time of PIF or via dispatch instructions within the (2-12)% limits, according to figure 3D;

(b) the delivery of active power in frequency response at underfrequencies (in LFSM-U mode) shall also take into account, as the case may be, the following:

i) the dependency diagram of active power output in terms of environmental conditions;

ii) the operating requirements of the synchronous power-generating module, in particular the limitations on operation near maximum active power at

low frequencies and the respective impact of external operating requirements according to Article 56 and Article 57;

(c) the activation of active power frequency response by the power-generating module shall not be unduly delayed. If this delay (called time delay and marked with t_1 in figure 5D) is greater than two seconds, the synchronous power-generating module owner shall justify the delay towards the TSO;

(d) while operating in the LFSM-U mode, the synchronous power-generating module shall ensure an active power increase up to the maximum power;

(e) the synchronous power-generating module shall operate stably during the LFSM-U mode at frequencies below 49.8 Hz.

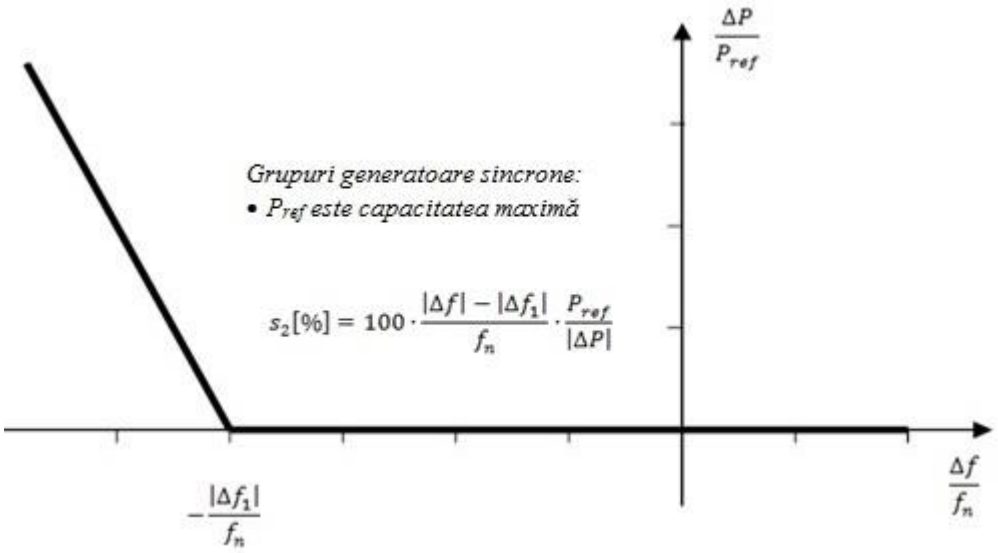


Figure 3D. Active power frequency response capability of type D synchronous power-generating modules in LFSM-U

where: P_{ref} is the active power reference based on which ΔP is established; ΔP is the variation of the active power output from a synchronous power-generating module; P_{ref} is the active power setpoint based on which ΔP is established; Δf is the frequency deviation in the network; f_n is the nominal frequency (50 Hz) in the network. At underfrequencies below 49.8 Hz where Δf is below -200 mHz, the synchronous power-generating module has to increase the active power according to the droop s_2.

Article 61. If the FSM mode is active, the type D synchronous power-generating module shall fulfill all requirements described below, in addition to the requirements provided in Article 60 according to figure 4D:

(a) the synchronous power-generating module shall provide FSM, according to the parameters specified by the TSO (within the value ranges provided in table 2D), thus:

i) in case of overfrequency above the 50 Hz value, the active power frequency response is limited by the minimum regulating level;

ii) in case of underfrequency compared to the 50 Hz value, the active power frequency response is limited by the maximum active power available;

iii) the actual delivery of active power frequency response depends on the external and operating conditions of the synchronous power-generating module when mobilizing the active power, particularly on the limitations given by its operation near maximum power.

(b) the synchronous power-generating module shall be able to modify the frequency deadband and the droop following the relevant system operator's instruction;

(c) in case of a frequency step variations, the synchronous power-generating module shall be capable of activating full active power frequency response, at or above the line shown in figure 5D, in accordance with the parameters specified in table 3D, namely: with an time delay (t_1) of 2 seconds and an activation time of maximum 30 seconds (t_2);

(d) the activation time of active power frequency response (time delay) shall not be greater than 2 seconds and shall not be unduly delayed. If the delay in initial activation of active power is greater than two seconds, the synchronous power-generating module owner shall provide technical evidence demonstrating why a longer time is needed;

(e) the synchronous power-generating module shall be capable to provide active power corresponding to the frequency deviation for a duration of 30 minutes;

(f) the active power control shall not have any adverse impact on the active power frequency response.

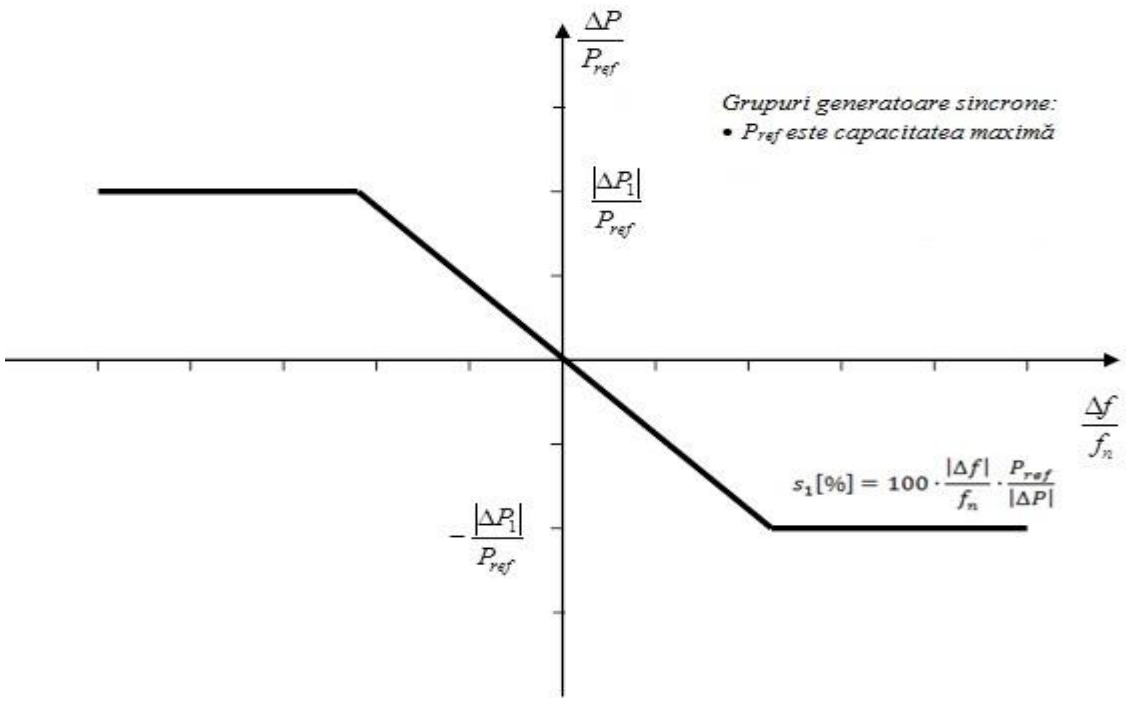
(g) if participating to the frequency restoration process at the setpoint and/or exchange powers to the scheduled values, the synchronous power-generating module shall ensure specific functions for performing these services, established via procedures drafted by the TSO;

(h) with regard to disconnection due to underfrequency, the power-generating facility that includes both synchronous power-generating modules and loads, including power-generating modules from pump-storage hydroelectric plants, shall be capable of disconnecting its load in case of underfrequency. The requirement referred to in this point does not apply to auxiliary supply.

Table 2D. Parameters for active power frequency response in FSM (see figure 5D)

Parameters		**Ranges**
Active power range related to maximum power $\frac{\lvert\Delta P_1\rvert}{P_{\max}}$		1.5 – 10%
Frequency response insensitivity	$\lvert\Delta f_i\rvert$	10 mHz
	$\frac{\lvert\Delta f_i\rvert}{f_n}$	0.02 – 0.06%
Frequency response deadband		0 mHz
Droop s_1 depending on the power park type (hydropower plant, thermal power plant, mixed-cycle, etc.)		2 – 12%

Figure 4D. Active power frequency response capability of synchronous power-generating modules in FSM illustrating the case of zero deadband and insensitivity area.



where: P_{ref} is the active power reference based on which the active power change ΔP is established; ΔP is the variation of the active power output from a synchronous power-generating module; f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network.

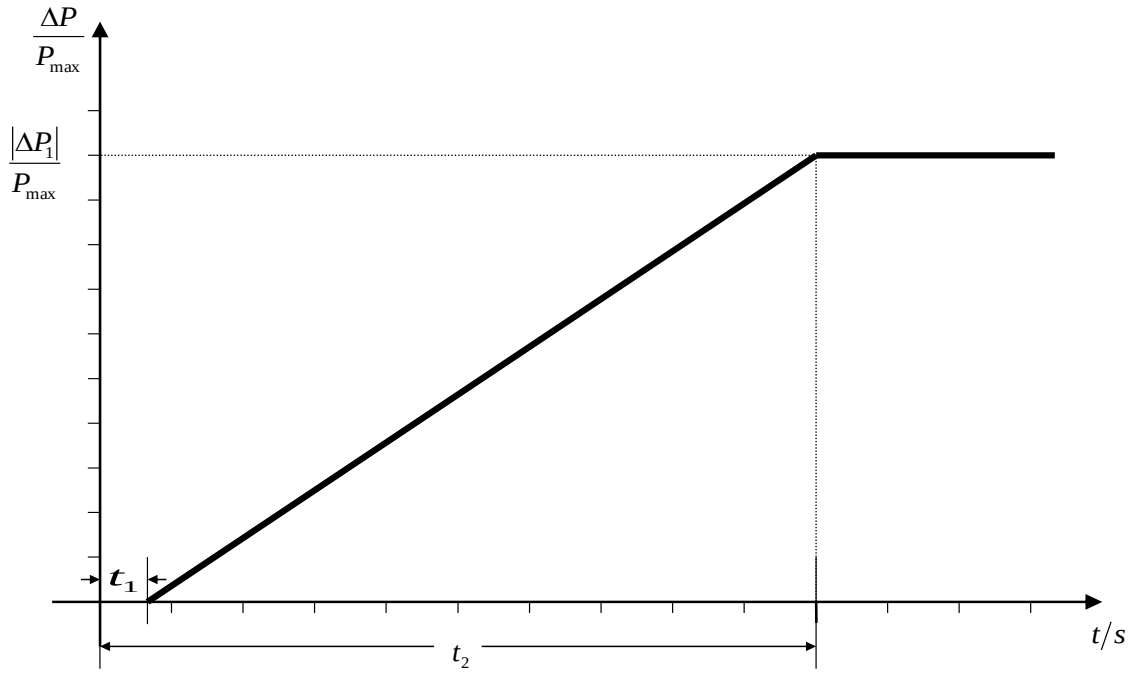


Figure 5D. Frequency response capability

where: P_{max} is the maximum power based on which the active power range ΔP is established; ΔP is the variation of the active power of the synchronous power-generating module. The synchronous power-generating module shall activate an active power ΔP up to the point $ΔP_1$, according to the t_1 and t_2 times, while the $ΔP_1$, t_1 and t_2 values are specified by the TSO according to the provisions from table 3D; t_1 is the initial delay (time delay); t_2 is the duration until the full activation of active power.

Table 3D. Parameters for full activation of active power frequency response resulting from frequency step variation (explanation for figure 5D)

Parameters	Ranges or values
Active power range related to maximum power (frequency response range) $\frac{\lvert\Delta P_1\rvert}{P_{\max}}$	1.5 – 10%
For synchronous power-generating modules with inertia, the maximum admissible initial delay t_1, except when the TSO admits longer activation periods, based on technical evidence provided by the synchronous power-generating module owner	2 seconds
Maximum admissible choice of full activation time t_2, unless longer activation times are allowed by the TSO for reasons of system stability	30 seconds

Article 62. (1) Real-time monitoring of the active power frequency automated response of the type D synchronous power-generating module shall be ensured by transmitting, in real-time and in a secured way, from an interface of the synchronous power-generating module to the dispatching center of the relevant system operator, upon request by the RSO, of at least the following signals:

i) the operation condition signal with/without active power frequency automated response;

ii) setpoint (scheduled) active power;

iii) actual value of the active power output;

iv) load-frequency response deadband.

(2) i) the relevant system operator shall specify additional signals to be provided by the synchronous power-generating module via monitoring and recording devices in order to verify the performance of the active power frequency response provision;

ii) the additional signals are: frequency at the connection/interface point, as the case may be, state signals and commands regarding the breaker position and the separators position;

iii) the synchronous power-generating module owner ensures the redundancy of transmission of signals via two independent communication paths; usually, the main path is ensured via optical fiber equipment.

iv) the synchronous power-generating module owner shall ensure, as the case may be, via local control schemes measurements, the recording of the following

parameters: pressure, the flow and temperature of steam entering the turbine, the gas flow, the opening of the governing device and the rotor blades, the opening of control valves, etc.

(3) Parameter settings for active power frequency response and droop are established via dispatch instructions.

Article 63. Type D synchronous power-generating modules shall fulfil the following requirements in relation to robustness, in terms of:

(a) the fault-ride-through capability in case of symmetrical faults:

i) the synchronous power-generating module must be capable to remain connected to the network, continuing its stable operation following a correctly secured fault in the network, according to the voltage-time dependency described in figure 6D, with respect to the connection/interface point, as the case may be, and described by the parameters in table 4D;

ii) the voltage-against-time-profile represents a lower admissible limit of the actual course of the voltages at the connection/interface point, as the case may be, during a symmetrical fault, as a function of time before, during and after the fault;

iii) the TSO shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of:

- the pre-fault minimum short-circuit power calculation at the connection/interface point, as the case may be;
- the pre-fault active and reactive power operating point of the synchronous power-generating module at the connection/interface point, as the case may be, and voltage at the connection/interface point, as the case may be; and
- the post-fault minimum short-circuit power calculation at the connection/interface point, as the case may be.

iv) upon request by a synchronous power-generating module owner, the relevant system operator shall provide the pre-fault and post-fault conditions (as relevant values resulted from typical cases) to be considered for fault-ride-through capability as an outcome of the calculations at the connection/interface point, as the case may be, as specified in Article 62 (a) (iii) regarding:

- the pre-fault minimum short-circuit power at every connection/interface point, as the case may be, expressed in MVA;
- the pre-fault operating point of the synchronous power-generating module, expressed in active power, reactive power and voltage at the connection/interface point, as the case may be; and
- the post-fault minimum short-circuit power at the connection/interface point, as the case may be, expressed in MVA.

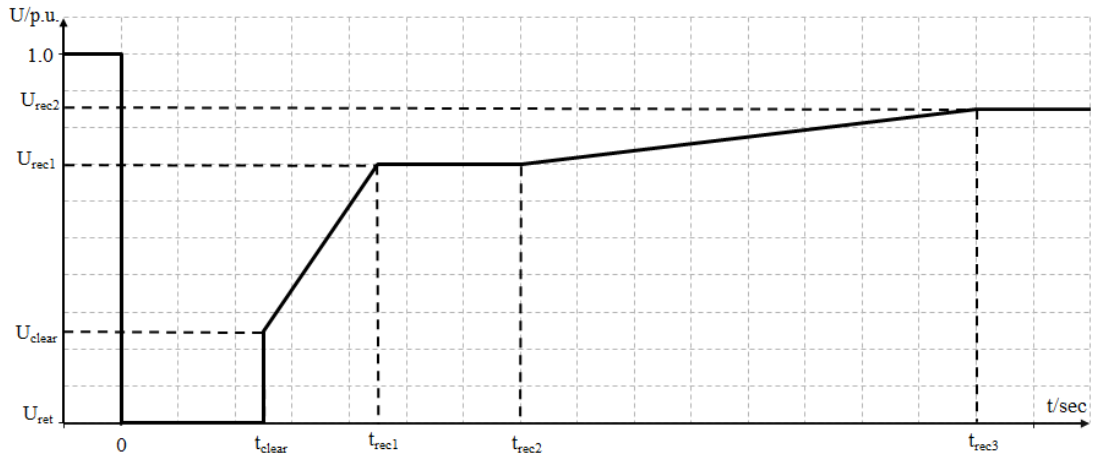


Figure 6D. Fault-ride-through profile of a type D synchronous power-generating module

Note: The diagram in figure 6D represents the lower limit of a voltage-against-time profile of the voltage at the connection/interface point, as the case may be, expressed in relative units as the ratio of its actual value and its reference value before, during and after a fault. U_{ret} is the retained voltage during a fault at the connection/interface point, as the case may be, and t_{clear} is the instant when the fault has been cleared. U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3} represent certain points of lower limits of retained voltage after fault clearance. The parameters related to the fault-ride-through are provided in table 4D.

Table 4D. Parameters related to the fault-ride-through capability of type D synchronous power-generating modules

Voltage parameters [r.u.]		**Time parameters [seconds]**	
U_{ret}:	0	t_{clear}:	0.25
U_{clear}:	0.25	t_{rec1}:	0.45
U_{rec1}:	0.7	t_{rec2}:	0.7
U_{rec2}:	0.85	t_{rec3}:	1.5

v) the synchronous power-generating module shall remain connected to the network and shall continue to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection/interface point, as the case may be, during a symmetrical fault, given the conditions existing pre-fault and post-fault described in Article 63 (a) (iii) and (iv), remains above the lower limit specified in Article 63 (a) (ii), except the triggers via the protections for internal electrical faults. The protection schemes and settings for internal electrical faults must not jeopardize fault-ride-through performance;

vi) considering the conditions provided in point (v), the synchronous power-generating module owner establishes the undervoltage protection (either the fault-ride-through capability, or the minimum voltage defined at the connection/interface point, as the case may be) according to the maximum voltage range corresponding to the synchronous power-generating module, except if the relevant system operator requires a narrower range, according to the provisions of Article 68 (f). The settings shall be justified by the synchronous power-generating module owner in accordance with the provisions set forth in point (vi);

(b) fault-ride-through capability in case of asymmetrical faults shall comply with the provisions set forth in Article 63 (a) (i) for symmetrical faults;

(c) post-fault active power recovery;

(d) maintaining stable operation at every point within the P-Q-capability diagram in case of power oscillations;

(e) synchronous power-generating modules shall be capable of remaining connected to the network without reducing power, so long the frequency and voltage fall within the limits provided in table 1D, namely ±10% U_n;

(f) synchronous power-generating modules shall be capable of remaining connected to the network during single-phase or three-phase AR on the lines of the loop network to which they are connected. The specific technical details shall be subject to coordination and instructions on protection schemes and settings agreed upon with the relevant system operator.

Article 64. (1) Type D synchronous power-generating modules shall fulfil the following requirements in relation to system restoration:

(a) they shall be capable to reconnect to the network following an accidental disconnection caused by an event in the network, under the conditions defined by the TSO;

(b) installation of automatic reconnection systems shall be subject to prior authorization both by the relevant system operator, and the TSO, in order to specify the automatic reconnection requirements;

(c) they shall be capable of fulfilling the following requirements with respect to black start capability:

i) the black start capability is not mandatory, but may be requested by the TSO during the grid connection stage in order to ensure the system's operational security;

ii) the synchronous power-generating module owner, upon request by the TSO, shall provide an offer for providing black start capability. The TSO may request the provision of black start capability if it considers system security to be at risk due to a lack of black start capability in its control area where the synchronous power-generating module is located;

iii) a synchronous power-generating module with black start capability shall be capable of starting from the shutdown state, without any external electrical energy supply within a time frame specified by the TSO, usually (15-30) minutes from the instant the instruction is received;

iv) a synchronous power-generating module with black start capability shall be able to synchronize within the frequency limits of (47.5-51.5) Hz and the voltage limits specified by the relevant system operator of (0.85-1.1) U_n;

v) a synchronous power-generating module with black start capability shall be capable of automatically regulating dips in voltage occurred during the restoration process;

vi) a synchronous power-generating module with black start capability shall:

- be capable of regulating load connections in block load;
- be capable of participating to frequency variations, both for an increase above 50.2 Hz (in the LFSM-O mode) and for a decrease below 49.8 Hz (in the LFSM-U mode);

- participate to frequency containment in case of overfrequency or underfrequency within the whole active power output range, as well as at houseload operation level;
- be capable of parallel operation with other synchronous power-generating modules within one island;
- control voltage automatically during system restoration within the ±10% U_n range.

(d) the synchronous power-generating modules shall fulfill the following requirements with regard to the capability to take part in island operation:

i) when separating from the NPS, synchronous power-generating modules shall be capable of switching to island operation (houseload operation) from any operating point on the P-Q-profile and to operate with auxiliary supply for at least 1 hour, in order to contribute to the NPS restoration. When switching to island operation, synchronous power-generating modules shall be capable of operating above the minimum stable power value and to control voltage and frequency within the standardized range (according to the data provided in table 1D and 6D) for at least 3 hours, until the NPS is resynchronized.

ii) they shall be capable of island operation or taking part in island operation if required by the relevant system operator. This requirement shall be specified during the TCA issuance stage; and
- the frequency limits for island operation shall be (47.5-51.5) Hz;
- the voltage limits for island operation shall be:
  - ±10% for network nominal voltages lower than 110 kV;
  - according to table 6D, for network nominal voltages higher than 110 kV.

iii) they shall be able to operate with active frequency control mode during island operation. In case of a power surplus, synchronous power-generating modules shall be capable of reducing the active power output from a previous operating point to any new operating point within the P-Q-capability diagram. In that regard, the synchronous power-generating module shall be capable of reducing active power output as much as inherently technically feasible, but to at least 55% of its maximum

capacity (which corresponds to a reduction of at least 45% of its maximum capacity);

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

v) they shall be capable of operation in limited frequency sensitive mode – overfrequency (LFSM-O) and limited frequency sensitive mode – underfrequency (LFSM-U), within the ranges specified in table 1D, table 6D/7D and depending on the specific particularities at the connection/interface point, as the case may be.

(e) they shall fulfill the following requirements with regard to quick re-synchronization capability:

i) in case of disconnection from the network, the synchronous power-generating module shall be able to quickly re-synchronize, usually within 15 minutes, according to the protection program agreed upon with the relevant system operator;

ii) after disconnection from the network (system), a synchronous power-generating module with a minimum re-synchronization time greater than 15 minutes must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the switchgear position signals at the connection point of the synchronous power-generating module;

iii) synchronous power-generating modules shall be capable of continuing operation following tripping to houseload and to support any power variations associated with houseload operation. The minimum duration for houseload operation shall be specified by the relevant system operator in coordination with the TSO and shall be, usually, equal to at least 1 hour, depending on the particularities of the technology corresponding to the primary source/prime movers.

(2) The requirements for the automatic reconnection provided in letters (a) and (b) shall be notified to the synchronous power-generating module owner during the grid connection process.

Article 65. Type D synchronous power-generating modules shall fulfil the following general requirements related to system operation:

(a) the start-up of a synchronous power-generating module and the synchronization are performed by the synchronous power-generating module owner following the relevant system operator's approval only;

(b) the power-generating module shall be equipped with the necessary synchronization facilities;

(c) synchronization shall be performed at frequencies within the ranges set out in table 1D;

(d) the relevant system operator and the synchronous power-generating module owner shall agree upon and specify, prior to commissioning, the settings of synchronization devices in order to allow the synchronization of the synchronous power-generating module, as follows:

i) voltage range, ±10% U_n (at terminals);

ii) frequency range, (47.5-51) Hz;

iii) phase angle range, smaller than 10º;

iv) phase sequence;

v) deviation of voltage smaller than 10% U_n and deviation of frequency smaller than 50 mHz.

(e) the following requirements with regard to control and automation schemes and their related settings shall be complied with:

i) the control and automation schemes, such as ASC, AVR and related settings, including the control parameters, necessary for the network stability calculations and emergency measures analysis, shall be submitted by the synchronous power-generating module owner to the relevant system operator or the TSO respectively, no later than 6 months before the receving of the energisation operational notification (EON) for the beginning of the testing period, in order for them to be coordinated and agreed upon between the TSO, the relevant system operator and the synchronous power-generating module owner;

ii) any changes to the control and automation schemes and related settings, as mentioned in point (i), of the different control devices of the synchronous power-generating module shall be coordinated and agreed upon between the TSO, the grid operator and the synchronous power-generating module owner, if they apply in the situations specified in point (i).

(f) the following requirements with regard to electrical protection schemes and related settings shall be complied with:

i) the protection systems needed for the synchronous power-generating module and the network, as well as the relevant settings to the synchronous power-generating module shall be coordinated and agreed upon between the relevant system operator and the synchronous power-generating module owner, during the connection process. The protection systems and related settings for internal electrical faults must not jeopardize the performance of the synchronous power-generating module. The electrical protection systems shall fulfill at least the following requirements:

– the electrical protection system shall ensure protection against internal faults of the synchronous power-generating module and shall ensure backup protection against abnormal operation states and faults from the network to which this is connected;

– the electrical protection system shall be efficient, highly reliable and organized in groups with redundant functionality; the protections shall be selective, sensitive, capable to detect internal and external faults, physically and galvanically separated from the power supplies with operative voltage, from voltage and current metering transformers to command execution devices. The electrical protection system shall be equipped with extended self-testing and self-diagnosis functions, as well as with events recording and oscillography functions. The electrical protections system shall be equipped with standard communication interfaces aiming for the integration to a local data acquisition, supervision and control system;

– the electrical protections system may be organized in two groups of independent and redundant protections, both for the synchronous power-generating module as well as for the connection, as the case may be.

– the internal faults electrical protections system shall be capable to detect at least the short-circuit currents in the synchronous power-generating module,

the current asymmetry, stator and rotor electrical overloads, excitation loss of the power-generating module, maximum/minimum voltage in the synchronous power-generating module terminals, maximum/minimum frequency in the power-generating module terminals.

– the external faults electrical protections system, as backup protections, shall be capable to detect at least the symmetrical and asymmetrical short-circuits from the network to which the synchronous power-generating module is connected, the power oscillations and asynchronous operation, the current asymmetry, the transition in the motor regime, the current and voltage electrical overloads.

ii) the electrical protection of the synchronous power-generating module shall take precedence over dispatch instructions, taking into account the operational security of the system, the health and safety of staff and of the public, as well as mitigating any damage to the synchronous power-generating module.

iii) together with the synchronous power-generating module owner, the relevant system operator shall coordinate and commonly agree that the protection systems must cover at least the following faults:

- protections of the synchronous power-generating module, of the step-up transformer and of the houseload or ancillary services transformer, covered by the synchronous power-generating module owner, for:

    1. internal faults of the synchronous power-generating module, of the step-up transformer and potentially of the houseload transformer (short-circuits or groundings);

    2. internal faults of the step-up transformer of the synchronous power-generating module;

    3. short-circuits or groundings on the evacuation line of the power output network;

    4. short-circuits or groundings in the network, as backup protection;

    5. maximum and minimum voltage at the power-generating module terminals.

- protections covered by the synchronous power-generating module owner and/or the relevant system operator, as the case may be, for:

1. short-circuits or groundings on the evacuation line of the power output network;

2. maximum and minimum voltage at the connection/interface point, as the case may be;

3. maximum and minimum frequency at the connection/interface point, as the case may be;

4. short-circuits or groundings in the network – as backup protection.

iv) changes to the protections schemes, needed for the synchronous power-generating module and the network and to the relevant settings to the generation plant shall be agreed upon in advance between the relevant system operator and the synchronous power-generating module owner;

(g) the protection and control devices shall organized by the synchronous power-generating module owner according to the following prioritization:

i) the network's and synchronous power-generating module's protection;

ii) frequency control (active power adjustment);

iii) power restrictions;

iv) limiting the ramping rate of power variations.

(h) with regard to information exchange:

i) protection/control and automation systems of synchronous power-generating modules shall be capable of exchanging information with the relevant system operator or within an aggregation of units, in real-time or periodically with time stamping. In the case of aggregations, according to the functions agreed to be aggregated, the exchanged informations shall be communicated to the relevant system operator and the TSO;

ii) the relevant system operator, in coordination with the TSO, shall specify the content of informations exchanges including a precise list of data to be provided to the TSO by the relevant system operator and by the synchronous power-generating module owner. The real-time submitted data are: active power, reactive power, voltage and frequency at the connection/interface point, as the case may be, state signals and commands regarding the breaker position and the separators position. The synchronous power-generating module owner ensures the redundancy of transmission of signals via two independent communication paths; usually, the main path is ensured via optical fiber equipment. As the case may be and upon request,

the data from the local control schemes shall be transmitted, namely: pressure, the flow and temperature of steam entering the turbine, the gas flow, the opening of the governing device and the rotor blades, the opening of control valves.

(i) the synchronous power-generating module shall be capable to automatically disconnect from the network when losing robustness. The disconnection criteria regarding the detection of asynchronous operation, the loss of excitation, the motor regime, the protection against current asymmetry, phase interruption and critical disconnection time, shall be agreed upon between the synchronous power-generating module owner, the relevant system operator and the TSO.

(j) measuring and control devices:

i) synchronous power-generating modules shall be equipped with devices to provide fault recording and monitoring of dynamic system behavior; these devices are usually oscilloperturbographs or equipment that can replace functions covered by oscilloperturbographs. These devices shall record the following parameters:

1. voltages in all three phases;
2. current in each phase;
3. active power in all three phases;
4. reactive power in all three phases;
5. frequency.

The relevant system operator shall have the right to specify quality of supply parameters to be complied with, provided via the aforementioned devices, on condition that they are previously agreed upon with the synchronous power-generating module owner.

ii) the settings of the fault recording equipment, including triggering criteria and the sampling rates shall be commonly agreed between the synchronous power-generating module owner and the relevant system operator at the time of PIF and shall be documented via written arrangements. These shall also include a criterion for detecting oscillations established by the TSO;

iii) the relevant system operator, the TSO and the synchronous power-generating module owner commonly agree upon the need to include a criterion for detecting oscillations in order to monitor the dynamic system

behavior, specified by the TSO in order to detect poorly damped power oscillations (undamped);

iv) the dynamic system behavior monitoring system shall include arrangements for the synchronous power-generating module owner and the relevant system operator to access the information. The communications protocols for registered data shall be commonly agreed between the synchronous power-generating module owner, the relevant system operator and the TSO, prior to choosing the monitoring equipment.

(k) regarding the synchronous power-generating module operation simulation models:

i) upon request by the relevant system operator or the TSO, the synchronous power-generating module owner shall provide the synchronous power-generating module operation simulation models that reflect the synchronous power-generating module's behavior both in steady-state regime, as well as in dynamic regime (including for transient electromagnetic phenomena, if requested). The models provided shall be validated via the compliance test results. The synchronous power-generating module owner submits to the relevant system operator or the TSO the results of these tests for the synchronous power-generating module or for heat engines that gear the synchronous power-generating modules, proven by means of check-up certificates recognized on European level, carried out by an authorized certifier;

ii) the models provided by the synchronous power-generating module owner shall contain the following sub-models, depending on the existence of individual components:

- generating unit and prime mover;
- speed and active power control;
- voltage control, including, if applicable, power system stabilizer ("PSS") function and excitation control system;
- synchronous power-generating module protection models, as agreed between the relevant system operator and the synchronous power-generating module owner.

iii) upon request by the relevant system operator, as referred to in letter (k), the TSO shall specify:

- the format in which simulation models are to be provided, including the utilized calculation program;
- the documentation on a mathematical model's structure and block diagrams;
- the estimate of the minimum and maximum short-circuit power at the connection/interface point, as the case may be, expressed in MVA, as an equivalent of the network.

iv) upon request by the relevant system operator, the synchronous power-generating module owner shall provide it with the recordings of the synchronous power-generating module's performance. The relevant system operator or the TSO may make such a request, in order to compare the response of the models and model simulations performed with actual operational recordings.

(l) regarding the installation of devices for system operation and devices for system operational security, if the relevant system operator or the TSO considers that it is necessary to install additional devices in a synchronous power-generating module (e.g. quick closing control valves) in order to preserve or restore system operation or system operational security. The relevant system operator and the synchronous power-generating module owner, together with the TSO, shall analyze and agree upon the adequate solution;

(m) the relevant system operator shall specify, in coordination with the TSO, the minimum and maximum limits on rates of change of active power output from the synchronous power-generating module (ramping limits) in both an up and down direction of change, taking into consideration the specific characteristics of prime mover technology. Usually, this rate of change falls within the (1-20)% P_{max}/min range and is equal in both directions;

(n) earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.

Article 66. Type D synchronous power-generating modules shall fulfil the following requirements in relation to voltage stability:

(a) the synchronous power-generating modules shall be equipped with an automated excitation control system (AVR), capable of permanently controlling

the terminal voltage of the synchronous power-generating module at any setpoint within the operation limits;

(b) they shall be capable of providing additional reactive power, specified by the relevant system operator, which shall be provided if the connection/interface point, as the case may be, of the synchronous power-generating module is neither located at the high-voltage terminals of the step-up transformer, nor at the terminals of the synchronous power-generating module, if there is no step-up transformer. The additional reactive power shall compensate the reactive power exchange of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power-generating module or the terminals of the synchronous power-generating module, if there is no step-up transformer, and the connection/interface point, as the case may be. The additional reactive power shall be covered via dedicated equipment provided by the synchronous power-generating module owner. This additional reactive power is specified via a reactive power offset study at the connection/interface point, as the case may be;

(c) they shall be capable to generate reactive power at full capacity, whilst complying with the following requirements:

i) the synchronous power-generating module owner shall provide an envelope of the U-Q/P_{max}-profile, which may take any shape within the limits of which the synchronous power-generating module shall be capable to provide/absorb reactive power at voltage variations and full capacity operation; the envelope shall be analyzed and approved by the TSO in coordination with the relevant system operator;

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

— the U-Q/P_{max}-envelope shall not exceed the U-Q/P_{max}-profile envelope represented by the inner envelope in figure 7D;

— the dimensions of the U-Q/P_{max}-profile envelope (Q/P_{max} range and voltage range) shall be within the maximum values specified in table 5D;

— the position of the U-Q/P_{max}-profile shall be within the limits of the fixed outer envelope in figure 7D; and

— the U-Q/P_{max}-profile specified for the synchronous power-generating module may take any shape, having regard to the potential costs of

delivering the capability to provide reactive power production at low voltages and reactive power consumption at high voltages.

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

iv) synchronous power-generating modules shall be capable of moving to any operating point within the U-Q/P_{max} profile in appropriate timescales to target values requested by the relevant system operator, usually within the (1-20)% P_{max}/minute range for active power variation and up to 10% of the maximum reactive power from the P-Q-profile, per minute.

(d) when operating at an active power output below the maximum power ($P < P_{max}$), the type D synchronous power-generating module shall be capable of operating at every possible operating point in the P-Q-capability diagram, at least down to minimum stable operating level. Even at reduced active power output, reactive power supply at the interface point, as the case may be, shall correspond fully to the P-Q-diagram, taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account.

(e) they shall fulfill the following requirements regarding voltage ranges:

(i) notwithstanding the provisions of Article 64 (a) regarding the fault-ride-through capability, a synchronous power-generating module shall be capable to remain connected to the network and to operate within the voltage range at the connection/interface point, as the case may be, expressed in relative units as ratio between the voltage at the connection/interface point, as the case may be, and the reference 1 r.u. voltage related to the durations specified in tables 6D and 7D;

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

(f) the relevant system operator and the synchronous power-generating module owner, in coordination with the TSO, may agree upon wider voltage ranges or longer minimum time periods for operation. If wider voltage ranges or longer

minimum times for operation are economically and technically feasible, the synchronous power-generating module owner shall not unduly withhold consent;

(g) without prejudice to the provisions of letter (f), the relevant system operator, in coordination with the TSO, shall have the right to specify voltages at the connection/interface point, as the case may be, at which a synchronous power-generating module is capable of automatic disconnection. The requirements and settings for automatic disconnection shall be agreed between the relevant system operator and the synchronous power-generating module owner;

(h) the parameters and settings of the components of the voltage control system shall be commonly agreed between the synchronous power-generating module owner and the relevant system operator, in coordination with the TSO;

(i) the agreement referred to in letter (h) shall cover the specifications and performance of an automatic voltage regulator ("AVR") with regard to steady-state voltage and transient voltage control and the specifications and performance of the excitation control system. This includes:

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

  ii) an under-excitation limiter to prevent the automatic voltage regulator (AVR) from reducing the excitation of the synchronous power-generating module to a level which would endanger synchronous stability;

  iii) an over-excitation limiter to ensure that the excitation of the power-generating module is not limited to less than the maximum value that can be achieved whilst ensuring that the synchronous power-generating module is operating within its design limits;

  iv) a stator current limiter; and

  v) a power system stabilizer (PSS) function to attenuate power oscillations, if the synchronous power-generating module size is above a value of maximum capacity specified by the TSO. This limit usually equals to 150 MW.

(j) the TSO and the synchronous power-generating module owner shall enter into an agreement specifying the measures and/or pieces of equipment to be purchased in order to ensure the technical capabilities of the synchronous

power-generating module to aid angular stability under fault conditions. This agreement shall include the technical solution agreed upon in order to ensure transient stability, including a list of additional equipment to be installed by the synchronous power-generating module owner.

(k) the TSO shall specify in the TCA the need to implement the power containment function aiming to damp cross-zonal active power oscillations (PSS), specified depending on system conditions, installed capacity of the synchronous power-generating module and its position in the network. The settings of the power containment systems shall be specified by the TSO and implemented according to the TSO's instruction.

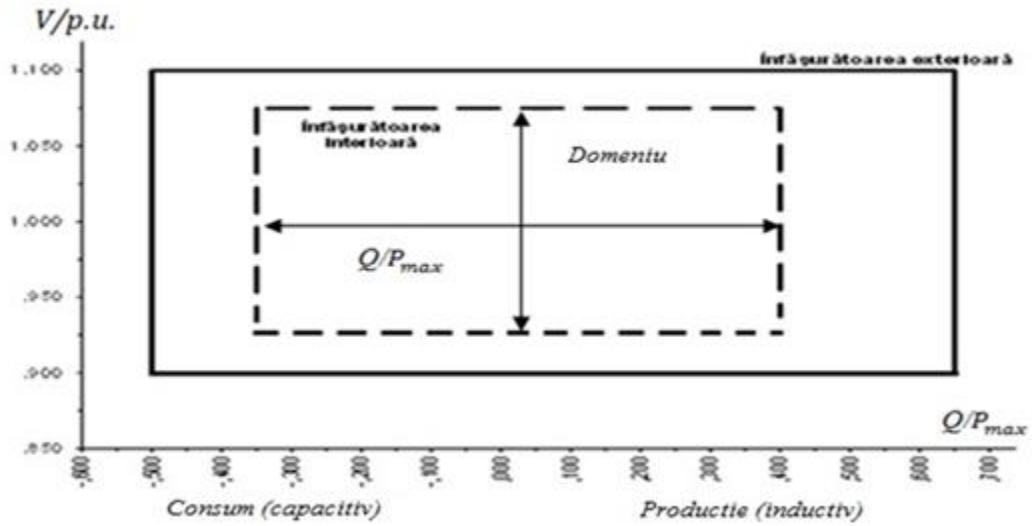


Figure 7D. U-Q/P_{max}-profile of a synchronous power-generating module

Figure 7D represents the boundaries of a U-Q/P_{max}-profile by the voltage at the connection/interface point, as the case may be, expressed in relative units by the ratio of its actual voltage value and the reference value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the envelope are indicative.

Table 5D. Parameters for the inner envelope in figure 7D

Maximum Q/P_{max} range	**Maximum range of steady-state voltage level (r.u.)**

0.95	0.225

Table 6D. Minimum time for operation of a synchronous power-generating module connected at the 110 kV and 220 kV voltage level respectively

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.	60 minutes

Note: Table 6D shows the minimum time periods during which a synchronous power-generating module must be capable of operating without disconnection, for voltages deviating from the reference 1 r.u. value at the connection/interface point, as the case may be, for the case where the setpoint equals 110 kV and 220 kV.

Table 7D. Minimum time for operation of a synchronous power-generating module connected at the 400 kV voltage level

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. – 1.10 r.u.	60 minutes

Note: Table 7D shows the minimum time periods during which a synchronous power-generating module must be capable of operating without disconnection, for voltages deviating from the reference 1 r.u. value at the connection/interface point, as the case may be, for the case where the setpoint equals 400 kV.

Article 67. The type D synchronous power-generating module shall be able to set the rate of change of active power output to the value required by the TSO (MW/minute) of minimum 1% P_{max}/min.

Article 68. The type D synchronous power-generating module owner must ensure protection of facilities and components of the synchronous power-generating module and of auxiliary installations against faults generated from its own facilities

or from the network impact over them when the synchronous power-generating module activation protections are operated properly or upon network incidents (short-circuits with or without grounding, network protections tripping, transient over-voltages, etc.), as well as upon exceptional/abnormal technical operational conditions.

Article 69. The type D synchronous power-generating module owner shall ensure power supply to the monitoring, control and data transmission facilities provided in Article 73, so that they are available for at least three hours after the loss of power supply.

Article 70. (1) The type D synchronous power-generating module owner shall ensure communication paths with reservation from the monitoring facilities or control facilities of the synchronous power-generating module to the interface with the relevant system operator located in a location accepted by it, under quality parameters required by the relevant system operator and according to the provisions of Article 73.

(2) Constructing and maintaining the communication path between the synchronous power-generating module and the relevant system operator's interface falls under the responsibility of the synchronous power-generating module owner or the relevant system operator.

Article 71. (1) The integration in the EMS-SCADA/DMS-SCADA systems, as the case may be, as well as in the electricity monitoring system, falls under the responsibility of the synchronous power-generating module owner.

(2) The control and data acquisition facilities, as interface systems between the synchronous power-generating module and the power transmission/distribution grid, are specified in the TCA.

Article 72. The type D synchronous power-generating module owner has the obligation to ensure compatibility of data exchange equipment at the relevant system operator's DMS-SCADA/EMS-SCADA system interface level, according to the particularities requested by it.

Article 73. The type D synchronous power-generating module owner has the obligation to allow access to the relevant system operator and the TSO to the outputs of its own metering systems for voltage, current, frequency, active and reactive power and to information regarding switching equipment indicating the status of facilities and alarm signals, in order to transfer this information to the interface with the control

and data acquisition system – DMS-SCADA or EMS-SCADA respectively, as well as with the remote metering system.

CHAPTER IX

TRANSITIONAL AND FINAL PROVISIONS

Article 74. The provisions of Article 3 paragraphs (3) – (8) shall apply from the date of entry into force of the Cost-benefit analysis methodology, the Notifications procedure for the connection of generating units/power-generating modules/power park modules and verifying their compliance with the technical requirements regarding the connection to public electricity grids, the Methodology to classify/withdraw classification of a generating unit in the emerging technology power-generating facilities category, the Procedure used to grant derogations for generating units/power-generating modules/power park modules from the obligation to fulfill one or several requirements specified in the technical rules for connection and the Procedure regarding the decommissioning of a generating unit.

Article 75. Until NRA approves the Procedure used to grant derogations for generating units/power-generating modules/power park modules from the obligation to fulfill one or several requirements specified in the technical rules for connection, derogations shall be requested from the relevant system operator, who may decide upon granting the derogation in coordination with the TSO.

Article 76. This technical norm may be revised following the completion of the European harmonization of general requirements set forth in the Regulation or due to the entry into force of other pan-European codes.

Article 77. Annexes no. 1 – 4 form an integral part of this technical norm.

ANNEX 1 to the technical norm

Technical data for type A synchronous power-generating modules

1. The synchronous power-generating module owner shall provide the relevant system operator with technical data specified in table 1, in accordance with the provisions of this technical norm.

2. Within the notification procedure for the connection of synchronous power-generating modules and verifying their compliance with the technical requirements regarding the connection to public electricity grids, the relevant system operator may request additional data for each stage of the notification and compliance verification process.

3. Standard planning data (S), shared via the connection request and used in the solution studies (forms), represent the entirety of the general technical data that characterize the type A synchronous power-generating module.

4. Detailed planning data (D) are technical data which allow special steady-state and transient stability analyses, dimensioning of automation facilities and protections control, as well as other data necessary for operational scheduling; detailed planning data (D) shall be provided to the relevant system operator at least 1 month prior to PIF.

5. The data, validated and completed by the date of PIF, shall be confirmed during the verification process of compliance with technical requirements regarding the connection to public electricity grids (R).

Table 1: Data for type A synchronous power-generating modules

Description of data	**Measuring unit**	**Data category**
Grid connection point	Text, diagram	S, D, R
Standard environmental conditions for which the technical data has been determined	Text	D, R
Nominal voltage at the connection/interface point, as the case may be	kV	S, D, R
Apparent nominal power	MVA	S, D, R
Net power	MW	S, D, R

Description of data	Measuring unit	Data category
Nominal active power output at the terminals	MW	S, D, R
Maximum active power output at the terminals	MW	S, D, R
Nominal voltage	kV	S, D, R
Maximum/minimum operational frequency under nominal parameters	Hz	S, D, R
Maximum reactive power at the terminals	MVAr	S, D, R
Minimum reactive power at the terminals	MVAr	S, D, R
Minimum active power output	MW	S, D, R
Inertia constant of the turbo-generator (H)* or the moment of inertia (GD^2)*	MWs/MVA	D, R
Rated speed *	Rpm	D, R
Short-circuit ratio*		D, R
Nominal stator current*	A	D, R
Saturated and unsaturated reactance		
Nominal reactance [nominal voltage^2/nominal apparent power]	Ohm	S, D, R
Synchronous longitudinal reactance [% of the nominal reactance]	%	D, R
Transient longitudinal reactance [% of the nominal reactance]	%	D, R
Over-transient longitudinal reactance [% of the nominal reactance]	%	D, R

Description of data	Measuring unit	Data category
Synchronous transversal reactance [% of the nominal reactance]	%	D, R
Transient transversal reactance [% of the nominal reactance]	%	D, R
Over-transient transversal reactance [% of the nominal reactance]	%	D, R
Stator leakage reactance [% of the nominal reactance]	%	D, R
Zero sequence reactance [% of the nominal reactance]	%	S, D, R
Negative sequence reactance [% of the nominal reactance]	%	S, D, R
Potier reactance* [% of the nominal reactance]	%	D, R
Time constants		
Transient time constant of closed stator exciter winding (T_d')	s	D, R
Over-transient time constant of closed stator damper winding (T_d")	s	D, R
Transient time constant of open stator exciter winding (T_{d0}')	s	D, R
Over-transient time constant of open stator damper winding (T_{d0}")	s	D, R
Transient time constant of open stator exciter winding, on the q axis (T_{q0}')	s	D, R
Over-transient time constant of open stator damper winding, on the q axis (T_{q0}")	s	D, R

Description of data	Measuring unit	Data category
P-Q-capability diagram	Graphical data	D, R
Variation diagram of technical data depending on the deviations from standard environmental conditions		R

*****Mandatory data depending on the particularities specified by the synchronous power-generating modules manufacturer

Note: Depending on the needs regarding the NPS operational security, the relevant system operator and the TSO may request the synchronous power-generating module owner to provide other information in addition to the ones set forth in table 1.

ANNEX 2 to the technical norm

Technical data for type B synchronous power-generating modules

1. The synchronous power-generating module owner shall provide the relevant system operator with technical data specified in table 2, in accordance with the provisions of this technical norm.

2. Within the notification procedure for the connection of synchronous power-generating modules and verifying their compliance with the technical requirements regarding the connection to public electricity grids, the relevant system operator may request additional data for each stage of the notification and compliance verification process.

3. Standard planning data (S), shared via the connection request and used in the solution studies, represent the entirety of the general technical data that characterize the type B synchronous power-generating module.

4. Detailed planning data (D) are technical data which allow special steady-state and transient stability analyses, dimensioning of automation facilities and protections control, as well as other data necessary for operational scheduling; detailed planning data (D) shall be provided to the relevant system operator at least 3 months prior to PIF.

5. The data, validated and completed by the date of the receving of the energisation operational notification (EON) for the facility for beginning the testing period, shall be confirmed during the verification process of compliance with technical requirements regarding the connection to public electricity grids (R).

Table 2: Data for type B synchronous power-generating modules

Description of data	**Measuring unit**	**Data category**
Grid connection/interface point, as the case may be	Text, diagram	S, D, R
Standard environmental conditions for which the technical data has been determined	Text	D, R
Nominal voltage at the connection/interface point, as the case may be	kV	S, D, R
Apparent nominal power	MVA	S, D, R

Description of data	Measuring unit	Data category
Net power	MW	S, D, R
Nominal active power output at the terminals	MW	S, D, R
Maximum active power output at the terminals	MW	S, D, R
Nominal voltage	kV	S, D, R
Maximum/minimum operational frequency under nominal parameters	Hz	S, D, R
LVRT fault-ride-through capability	diagram	S, D, R
Maximum reactive power at the terminals	MVAr	S, D, R
Minimum reactive power at the terminals	MVAr	S, D, R
Minimum active power output	MW	S, D, R
Inertia constant of the turbo-generator (H) or the moment of inertia (GD^2)	MWs/MVA	D, R
Rated speed	rpm	D, R
Short-circuit ratio		D, R
Nominal stator current	A	D, R
Saturated and unsaturated reactance		
Nominal reactance [nominal voltage^2/nominal apparent power]	ohm	S, D, R
Synchronous longitudinal reactance [% of the nominal reactance]	%	D, R
Transient longitudinal reactance [% of the nominal reactance]	%	D, R

Description of data	Measuring unit	Data category
Over-transient longitudinal reactance [% of the nominal reactance]	%	D, R
Synchronous transversal reactance [% of the nominal reactance]	%	D, R
Transient transversal reactance [% of the nominal reactance]	%	D, R
Over-transient transversal reactance [% of the nominal reactance]	%	D, R
Stator leakage reactance [% of the nominal reactance]	%	D, R
Zero sequence reactance [% of the nominal reactance]	%	S, D, R
Negative sequence reactance [% of the nominal reactance]	%	S, D, R
Potier reactance [% of the nominal reactance]	%	D, R
Time constants		
Transient time constant of closed stator exciter winding (T_d')	s	D, R
Over-transient time constant of closed stator damper winding (T_d")	s	D, R
Transient time constant of open stator exciter winding (T_{d0}')	s	D, R
Over-transient time constant of open stator damper winding (T_{d0}")	s	D, R
Transient time constant of open stator exciter winding, on the q axis (T_{q0}')	s	D, R

Description of data	Measuring unit	Data category
Over-transient time constant of open stator damper winding, on the q axis (T_{q0}”)	s	D, R
P-Q-capability diagram	Graphical data	D, R
Variation diagram of technical data depending on the deviations from standard environmental conditions		

Note: Depending on the needs regarding the NPS operational security, the relevant system operator and the TSO may request the synchronous power-generating module owner to provide other information in addition to the ones set forth in table 2.

ANNEX 3 to the technical norm

Technical data for type C synchronous power-generating modules

1. The synchronous power-generating module owner shall provide the relevant system operator with technical data specified in table 3, in accordance with the provisions of this technical norm.

2. Within the notification procedure for the connection of synchronous power-generating modules and verifying their compliance with the technical requirements regarding the connection to public electricity grids, the relevant system operator may request additional data for each stage of the notification and compliance verification process.

3. Standard planning data (S), shared via the connection request and used in the solution studies, represent the entirety of the general technical data that characterize the type C synchronous power-generating module.

4. Detailed planning data (D) are technical data which allow special steady-state and transient stability analyses, dimensioning of automation facilities and protections control, as well as other data necessary for operational scheduling; detailed planning data shall be provided at least 3 months prior to PIF.

5. The data, validated and completed by the date of the receving of the energisation operational notification (EON) for the facility for beginning the testing period, shall be confirmed during the verification process of compliance with technical requirements regarding the connection to public electricity grids (R).

Table 3: Data for type C synchronous power-generating modules

Description of data	**Measuring unit**	**Data category**
Grid connection/interface point, as the case may be	Text, diagram	S, D, R
Standard environmental conditions for which the technical data has been determined	Text	D, R
Nominal voltage at the connection/interface point, as the case may be	kV	S, D, R

Maximum short-circuit current at the connection/interface point, as the case may be:		
– Symmetrical	kA	D
– Asymmetrical	kA	D
Minimum short-circuit current at the connection/interface point, as the case may be:		
– Symmetrical	kA	D
– Asymmetrical	KA	D
Apparent nominal power	MVA	S, D, R
Nominal power factor (cos φ_n)		S, D, R
Net power	MW	S, D, R
Nominal active power output at the terminals	MW	S, D, R
Maximum active power output at the terminals	MW	S, D, R
Nominal voltage	kV	S, D, R
Maximum/minimum operational frequency under nominal parameters	Hz	S, D, R
Consumption of auxiliary services at maximum power output at the terminals	MW	S, D, R
Maximum reactive power at the terminals	MVAr	S, D, R
Minimum reactive power at the terminals	MVAr	S, D, R
Minimum active power output	MW	S, D, R
LVRT fault-ride-through capability	diagram	S, D, R
Inertia constant of the synchronous power-generating module (H) or the moment of inertia (GD^2)	MWs/MVA	D, R
Short-circuit ratio		D, R

Nominal stator current	A	D, R
Saturated and unsaturated reactance		
Nominal reactance [nominal voltage^2/nominal apparent power]	Ω	S, D, R
Synchronous longitudinal reactance [% of the nominal reactance]	%	S, D, R
Transient longitudinal reactance [% of the nominal reactance]	%	S, D, R
Over-transient longitudinal reactance [% of the nominal reactance]	%	S, D, R
Synchronous transversal reactance [% of the nominal reactance]	%	S, D, R
Transient transversal reactance [% of the nominal reactance]	%	S, D, R
Over-transient transversal reactance [% of the nominal reactance]	%	S, D, R
Stator leakage reactance [% of the nominal reactance]	%	S, D, R
Zero sequence reactance [% of the nominal reactance]	%	S, D, R
Negative sequence reactance [% of the nominal reactance]	%	S, D, R
Potier reactance [% of the nominal reactance]	%	S, D, R
Time constants		
Transient time constant of closed stator exciter winding (T_d')	s	S, D, R
Over-transient time constant of closed stator damper winding (T_d'')	s	S, D, R

Transient time constant of open stator exciter winding (T_{d0}')	s	S, D, R
Over-transient time constant of open stator damper winding (T_{d0}'')	s	S, D, R
Transient time constant of open stator exciter winding, on the q axis (T_{q0}')	s	S, D, R
Over-transient time constant of open stator damper winding, on the q axis (T_{q0}'')	s	S, D, R
Diagrams		
Capability diagram	Graphical data	S, D, R
Variation diagram of technical data depending on the deviations from standard environmental conditions		R
Capability in terms of reactive power:		
Reactive power in inductive regime at maximum power output	MVAr output	S, R
Reactive power in inductive regime at minimum power output	MVAr output	S, R
Short-term reactive power in inductive regime at nominal power, voltage and frequency values	MVAr	R
Reactive power in capacitive regime at maximum/minimum power output	MVAr absorbed	S, R
Excitation system		
Excitation system type	Text	S, D, R
Nominal (excitation) rotor voltage	V	R
Maximum rotor voltage (threshold of excitation)	V	R
Maximum duration admissible for maintaining the	s	S, D, R

threshold of excitation		
Excitation control scheme	V/V	S, R
Maximum speed for the excitation voltage increase	V/s	S, D, R
Maximum speed for the excitation voltage decrease	V/s	S, D, R
Overexcitation particularities dynamics	Text	S, D, R
Under-excitation particularities dynamics	Text	S, D, R
Excitation limiter	Block diagram	S, D, R
Speed controller (ASC):		
Equivalent transfer function, potentially standardized, of the speed controller, values and measurement units	Text	S
Equivalent transfer function, values and measurement units according to the technical project	Text	D, R
Closing/opening time of the turbine control valve	s	R
Power underfrequency response	diagram	R
Power overfrequency response	diagram	R
Droop setting range	%	R
s_1 droop value	%	R
Frequency response deadband	mHz	R
Delay time – t_1)	s	R
Response time (t_2)	s	R
Insensitivity area	mHz	R
Islanding capability	MW	S, D, R
Details regarding the speed controller presented in the	Scheme	R

block diagram pertaining to transfer functions related to individual elements and corresponding measurement units		
Block diagram and parameters for the alternator-turbine automatic speed controller (possibly boiler), for thermoelectric and nuclear groups.	Text	R
Voltage regulator (AVR):		
Regulator type	Text	D, R
Equivalent transfer function, potentially standardized, of the voltage controller, values and measurement units	Text	S
Equivalent transfer function, values and measurement units according to the technical project	Text	D, R
Data regarding protections:		
Possibility to operate asynchronously without excitation (loss of excitation) – maximum active power and duration	Text	D, R
Minimum excitation	Text, diagram	D, R
Maximum excitation	Text, diagram	D, R
Differential	Text	D, R
Protection against asynchronous operation with embedded excitation	Text	D, R
Specification of controls for:		
Maximum excitation limiter	Text, diagram	R
Minimum excitation limiter	Text, diagram	R
Stator current limiter	Text, diagram	R

Transformation units:		
Number of windings	Text	S, D, R
Nominal power on each winding	MVA	S, D, R
Nominal transformation ratio	kV/kV	S, D, R
Short-circuit voltages per winding pairs	% of U_{nom}	S, D, R
Idle run losses	kW	S, D, R
Load losses	kW	S, D, R
Magnetizing current	%	S, D, R
Connections group	Text	S, D, R
Control range	kV-kV	S, D, R
Control scheme (longitudinal or transversal)	Text, diagram	D, R
Size of control step and number of outlets	%	S, D, R
On load control	Yes/No	D, R
Neutral treatment	Text, diagram	S, D, R
Saturation curve	Diagram	R

Note: Depending on the needs regarding the NPS operational security, the relevant system operator and the TSO may request the synchronous power-generating module owner to provide additional information.

ANNEX 4 to the technical norm

Technical data for type D synchronous power-generating modules

1. The synchronous power-generating module owner shall provide the relevant system operator with technical data specified in table 4, in accordance with the provisions of this technical norm.

2. Within the notification procedure for the connection of synchronous power-generating modules and verifying their compliance with the technical requirements regarding the connection to public electricity grids, the relevant system operator may request additional data for each stage of the notification and compliance verification process.

3. Standard planning data (S), shared via the connection request and used in the solution studies, represent the entirety of the general technical data that characterize the type D synchronous power-generating module.

4. Detailed planning data (D) are technical data which allow special steady-state and transient stability analyses, dimensioning of automation facilities and protections control, as well as other data necessary for operational scheduling; detailed planning data (D) shall be provided to the relevant system operator at least 6 months prior to PIF.

5. The data, validated and completed by the date of the receving of the energisation operational notification (EON) for the facility for beginning the testing period, shall be confirmed during the verification process of compliance with technical requirements regarding the connection to public electricity grids (R).

Table 4: Data for type D synchronous power-generating modules

Description of data	**Measuring unit**	**Data category**
Connection/interface point, as the case may be	Text, diagram	S, D, R
Standard environmental conditions for which the technical data has been determined	Text	R
Nominal voltage at the connection/interface point, as the	kV	S, D, R

case may be		
Maximum short-circuit current at the connection/interface point, as the case may be:		
– Symmetrical	kA	D, R
– Asymmetrical	kA	D, R
Minimum short-circuit current at the connection/interface point, as the case may be:		
– Symmetrical	kA	D, R
– Asymmetrical	kA	D, R
Synchronous power-generating module:		
Apparent nominal power	MVA	S, D, R
Nominal power factor (cos φ_n)		S, D, R
Net power	MW	S, D, R
Nominal active power output at the terminals	MW	S, D, R
Maximum active power output at the terminals	MW	S, D, R
Nominal voltage	KV	S, D, R
Maximum/minimum operational frequency under nominal parameters	Hz	S, D, R
Consumption of auxiliary services at maximum power output at the terminals	MW	S, D, R
Maximum reactive power at the terminals	MVAr	S, D, R
Minimum reactive power at the terminals	MVAr	S, D, R
Minimum active power output	MW	S, D, R
LVRT fault-ride-through capability	Diagram	S, D, R
Inertia constant of the synchronous power-generating	MWs/MVA	S, D, R

module (H) or the moment of inertia (GD^2)		
Rated speed	Rpm	D, R
Short-circuit ratio		D, R
Nominal stator current	A	D, R
Saturated and unsaturated reactance		
Nominal reactance [nominal voltage^2/nominal apparent power]	Ω	S, D, R
Synchronous longitudinal reactance [% of the nominal reactance]	%	S, D, R
Transient longitudinal reactance [% of the nominal reactance]	%	S, D, R
Over-transient longitudinal reactance [% of the nominal reactance]	%	S, D, R
Synchronous transversal reactance [% of the nominal reactance]	%	S, D, R
Transient transversal reactance [% of the nominal reactance]	%	S, D, R
Over-transient transversal reactance [% of the nominal reactance]	%	S, D, R
Stator leakage reactance [% of the nominal reactance]	%	S, D, R
Zero sequence reactance [% of the nominal reactance]	%	S, D, R
Negative sequence reactance [% of the nominal reactance]	%	S, D, R
Potier reactance [% of the nominal reactance]	%	S, D, R
Time constants		

Transient time constant of closed stator exciter winding (T_d')	s	S, D, R
Over-transient time constant of closed stator damper winding (T_d'')	s	S, D, R
Transient time constant of open stator exciter winding (T_{d0}')	s	S, D, R
Over-transient time constant of open stator damper winding (T_{d0}'')	s	S, D, R
Transient time constant of open stator exciter winding, on the q axis (T_{q0}')	s	S, D, R
Over-transient time constant of open stator damper winding, on the q axis (T_{q0}'')	s	S, D, R
Diagrams		
Capability diagram	Graphical data	S, D, R
Variation diagram of technical data depending on the deviations from standard environmental conditions		R
Capability in terms of reactive power:		
Reactive power in inductive regime at maximum power output	MVAr output	S, D, R
Reactive power in inductive regime at minimum power output	MVAr output	S, D, R
Short-term reactive power in inductive regime at nominal power, voltage and frequency values	MVAr	R
P-Q-profile depending on U	Graphical data	S, D, R
Reactive power in capacitive regime at maximum/minimum power output	MVAr absorbed	S, D, R
Excitation system		

Excitation system type	Text	R
Nominal (excitation) rotor voltage	V	R
Maximum rotor voltage (threshold of excitation)	V	R
Maximum duration admissible for maintaining the threshold of excitation	s	S, D, R
Excitation control scheme	V/V	R
Maximum speed for the excitation voltage increase	V/s	R
Maximum speed for the excitation voltage decrease	V/s	R
Overexcitation particularities dynamics	Text	R
Under-excitation particularities dynamics	Text	R
Excitation limiter	Block diagram	R
Speed controller (ASC):		
Equivalent transfer function, potentially standardized, of the speed controller, values and measurement units	Text	S
Equivalent transfer function, values and measurement units according to the technical project	Text	D, R
Closing/opening time of the turbine control valve	s	R
Power underfrequency response	Diagram	R
Power overfrequency response	Diagram	R
Droop setting range	%	R
s_1 droop value	%	R
Frequency response deadband	mHz	R
Delay time – t_1	s	R
Response time (t_2)	s	R

Insensitivity area	mHz	R
Islanding capability	MW	D, R
Details regarding the speed controller presented in the block diagram pertaining to transfer functions related to individual elements and measurement units	Scheme	R
Block diagram and parameters for the alternator-turbine automatic speed controller (possibly boiler), for thermoelectric and nuclear groups.	Text	R
Voltage regulator (AVR):		
Regulator type	Text	S, D, R
Equivalent transfer function, potentially standardized, of the voltage controller, values and measurement units	Text	S
Equivalent transfer function, values and measurement units according to the technical project	Text	D, R
Data regarding protections:		
Possibility to operate asynchronously without excitation (loss of excitation), maximum active power and duration	Text	D, R
Minimum excitation	Text, diagram	D, R
Maximum excitation	Text, diagram	D, R
Differential protection	Text	D, R
Protection against asynchronous operation with embedded excitation	Text	D, R
Specification of controls for:		
Maximum excitation limiter	Text, diagram	D, R
Minimum excitation limiter	Text, diagram	D, R
Stator current limiter	Text, diagram	D, R
Transformation units:		

Number of windings	Text	S, D, R
Nominal power on each winding	MVA	S, D, R
Nominal transformation ratio	kV/kV	S, D, R
Short-circuit voltages per winding pairs	% of U_{nom}	S, D, R
Idle run losses	kW	S, D, R
Load losses	kW	S, D, R
Magnetizing current	%	S, D, R
Connections group	Text	S, D, R
Control range	kV-kV	S, D, R
Control scheme (longitudinal or transversal)	Text, diagram	D, R
Size of control step and number of outlets	%	S, D, R
On load control	YES/ NO	D, R
Neutral treatment	Text, diagram	S, D, R
Saturation curve	Diagram	R

Note: Depending on the needs regarding the NPS operational security, the relevant system operator and the TSO may request the synchronous power-generating module owner to provide other information in addition to the ones set forth in table 4.