Krav fastsat i henhold til EU-forordning 2016/631 – Requirements for grid connection of Generators (RfG)

TEKST	VERSION	DATO
Krav godkendt af Forsyningstilsynet i forbindelse med gennemførelse af EU-forordning 2016/631 inkl. ændringer iht. FSTS's høring	1	19.11.2018
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Normativt krav - behandles ikke

Krav færdigbehandlet

Art. nr.	Art. stk.	Art. afsn.	Art. enh.	Artikel emne			Rev.
General requirements for type A power-generating modules							
13	1			Type A power generating modules shall fulfil the following requirements relating to frequency stability:	-		
13	1	a		With regard to frequency ranges:	-		
13	1	a	i	a power generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 2;	Tabel 2 CE: 47,5 – 48,5 Hz: 30 min. 48,5 – 49,0 Hz: 30 min. N: 48,5 – 49,0 Hz: 30 min. Teknisk præciserende tekst: Det betyder, minimum 30 minutter i frekvensområdet 48,5 Hz til 49 Hz samt 30 minutter i frekvensområdet 47,5 Hz til 48,5 Hz. Den samlede drift under 49 Hz kan dog ikke overstige 60 minutter.		

13	1	a	ii	the relevant system operator, in coordination with the relevant TSO, and the power generating facility owner may agree on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations to ensure the best use of the technical capabilities of a power generating module, if it is required to preserve or to restore system security;	Transmissionssystem: ej relevant Distributionssystem: ej relevant		
13	1	a	iii	the power generating facility owner shall not unreasonably withhold consent to apply wider frequency ranges or longer minimum times for operation, taking account of their economic and technical feasibility.	-		
13	1	b		With regard to the rate of change of frequency withstand capability, a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection. Table 2 Minimum time periods for which a power-generating module has to be capable of operating on different frequencies, deviating from a nominal value, without disconnecting from the network.	ROCOF: 2,0 Hz/s *ROCOF* er betegnelsen for frekvensændringen som funktion af tiden. Frekvensændringen, *ROCOF*, beregnes efter nedenstående eller ækvivalent princip. Frekvensmålingen anvendt til beregning af frekvensændringen er baseret på en 200 ms måleperiode, hvor middelværdien beregnes. Frekvensmålingerne skal foregå løbende så der beregnes en ny værdi for hver 20 ms. *ROCOF [Hz/s]* skal beregnes som forskellen mellem den netop udførte middelværdifrekvensberegning og den middelværdi frekvensberegning der blev foretaget for 20 ms siden. (df/dt = (middelværdi 2 – middelværdi 1)/0,020 [Hz/s]) LOM detektering: SPGM/PPM/Type A, B, C og D Der anvendes ROCOF i DN, middelværdi/måling beregnes som beskrevet i forbindelse med ROCOF robusthed ROCOF – Udkobling overfrekvens: hvor beregnet ROCOF værdi er > +2,5 Hz/s i mere end i 80 ms ROCOF – Udkobling underfrekvens: hvor beregnet ROCOF værdi er > -2,5 Hz/s i mere end i 80 ms Underspændingstrin 2 kan anvendes for A anlæg som alternativ til ROCOF. Underspænding (trin 2): Uc < 0,8 pu i 200ms		R1

13	2			With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas:	-		
13	2	a		the power generating module shall be capable of activating the provision of active power frequency response according to figure 1 at a frequency threshold and droop settings specified by the relevant TSO;	a) vælges Pn anvendes som Pref for PPM Frekvensparametrene i reguleringsfunktionerne for aktiv effekt skal kunne indstilles med en opløsning på 10 mHz eller bedre. - Reguleringsstatikkerne skal kunne indstilles med en opløsning på 1 % eller bedre. - For reguleringsfunktionen for frekvensrespons for overfrekvens gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen < 5 % af *Pn* målt over en periode på 1 minut. - Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre. Teknisk præciserende tekst: Ved LFSM-O tilstand skal anlæggets aktive effekt følge den krævede statik, når netfrekvensen er større end den specificerede grænseværdi, knækfrekvens, for LFSM-O, uanset om netfrekvensen er stigende eller faldende.		
13	2	b		instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the cooperation of power generating modulefacility owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;	b) vælges ikke.		
13	2	c		the frequency threshold shall be between 50.2 Hz and 50.5 Hz inclusive;	CE: 50,2 Hz N: 50,5Hz		
13	2	d		the droop settings shall be between 2 % and 12 %;			

					CE: SPG: 5 % PPM: 5 % N: SPG: 4 % PPM: 4 %		
13	2	e		the power generating module shall be capable of activating a power frequency response with an initial delay that is as short as possible. If that delay is greater than two seconds, the power generating facility owner shall justify the delay, providing technical evidence to the relevant TSO;			
13	2	f		the relevant TSO may require that upon reaching minimum regulating level, the power generating module be capable of either:	-		
13	2	f	i	continuing operation at this level; or	i) vælges		
13	2	f	ii	further decreasing active power output;	ii) vælges ikke		
13	2	g		the power generating module shall be capable of operating stably during LFSM-O operation. When LFSM-O is active, the LFSM-O setpoint will prevail over any other active power setpoints.			
13	3			The power generating module shall be capable of maintaining constant output at its target active power value regardless of changes in frequency, except where output follows the changes specified in the context of paragraphs 2 and 4 of this Article or points (c) and (d) of Article 15(2) as applicable.			
13	4			The relevant TSO shall specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 2:	6 % af Pn per Hz, start ved 49,0 Hz.		
13	4	a		below 49 Hz falling by a reduction rate of 2 % of the maximum capacity at 50 Hz per 1 Hz frequency drop;			
13	4	b		below 49.5 Hz falling by a reduction rate of 10 % of the maximum capacity at 50 Hz per 1 Hz frequency drop.			
13	5			The admissible active power reduction from maximum output shall:			
13	5	a		clearly specify the ambient conditions applicable;	Under normale driftsforhold og efter bedste evne i forhold til det aktuelle driftspunkt samt ved omgivelseskonditioner som jf. anlægsproducentens tydelige anlægsspecifikationer er bekendtgjort for anlægsejer samt valideret i form af relevant produktionsanlægsperformancetest.		R1
13	5	b		take account of the technical capabilities of power generating modules.			
13	6			The power generating module shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. The relevant system operator shall have the right to specify requirements for	Dx krav. Ikke relevant for Tx.		

				equipment to make this facility operable remotely.			
13	7			The relevant TSO shall specify the conditions under which a power generating module is capable of connecting automatically to the network. Those conditions shall include:			
13	7	a		frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and	Dk1: 47,5 - 50,2 Hz Dk2: 47.5 - 50.5 Hz Automatisk indkobling af et anlæg må tidligst finde sted tre minutter efter, at spændingen er inden for den normale driftsspænding og frekvensen er inden for de specificerede områder. Synkroniseringen mellem anlæg og det kollektive elforsyningsnet skal foregå automatisk.		
13	7	b		(b) maximum admissible gradient of increase in active power output. Automatic connection is allowed unless specified otherwise by the relevant system operator in coordination with the relevant TSO.	RSO krav: 20 % Pn/min		
General requirements for type B power-generating modules							
14	1			Type B power generating modules shall fulfil the requirements set out in Article 13, except for Article 13(2)(b).	-		
14	2			Type B power generating modules shall fulfil the following requirements in relation to frequency stability:	-		
14	2	a		to control active power output, the power generating module shall be equipped with an interface (input port) in order to be able to reduce active power output following an instruction at the input port; and	-		
14	2	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.	A og B anlæg		
14	3			Type B power generating modules shall fulfil the following requirements in relation to robustness:	-		
14	3	a		with regard to fault-ride-through capability of power generating modules:	-		
14	3	a	i	each TSO shall specify a voltage-against-time-profile in line with Figure 3 at the connection point for fault conditions, which describes the conditions in which the power generating module is capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults on the transmission system;	Krav Jf. Bilag 1.C		

					<table><tr><td colspan="4">CE/N – PPM - #1 - A14(3)(a)</td></tr><tr><td colspan="2">Spænding (pu)</td><td colspan="2">Tid [sekunder]</td></tr><tr><td>U_{ret}:</td><td>0,15</td><td>t_{clear}:</td><td>0,25</td></tr><tr><td>U_{clear}:</td><td>0,15</td><td>t_{rec1}:</td><td>0,25</td></tr><tr><td>U_{rec1}:</td><td>0,15</td><td>t_{rec2}:</td><td>0,25</td></tr><tr><td>U_{rec2}:</td><td>0,9</td><td>t_{rec3}:</td><td>1,5</td></tr></table> <table><tr><td colspan="4">CE/N – SPGM - #2 - A14(3)(a)</td></tr><tr><td colspan="2">Spænding (pu)</td><td colspan="2">Tid [sekunder]</td></tr><tr><td>U_{ret}:</td><td>0,3</td><td>t_{clear}:</td><td>0,25</td></tr><tr><td>U_{clear}:</td><td>0,7</td><td>t_{rec1}:</td><td>0,25</td></tr><tr><td>U_{rec1}:</td><td>0,7</td><td>t_{rec2}:</td><td>0,70</td></tr><tr><td>U_{rec2}:</td><td>0,9</td><td>t_{rec3}:</td><td>1,5</td></tr></table>		
14	3	a	ii	the voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault;	Jf. A14(3)(a)(i)		
14	3	a	iii	the lower limit referred to in point (ii) shall be specified by the relevant TSO using the parameters set out in Figure 3, and within the ranges set out in Tables 3.1 and 3.2;	Jf. A14(3)(a)(i)		
14	3	a	iv	each TSO shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of: – the calculation of the pre-fault minimum short circuit capacity at the connection point; – pre-fault active and reactive power operating point of the power generating module at the connection point and voltage at the connection point; and – calculation of the post-fault minimum short circuit capacity at the connection point.	Kortslutningskatalog fastlægger metode for beregning af kortslutningseffekt samt beregner konditioner i kendte tilslutningspunkter Anlægskonditioner: Anlægsegenskaber er specificeret ved Pn og PF = 1		
14	3	a	v	at the request of a power generating facility 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 point as specified in point (iv) regarding: – pre-fault minimum short circuit capacity at each connection point expressed in MVA; – pre-fault operating point of the power generating module expressed in active power output and reactive power output at the connection point and voltage at the connection point; and – post-fault minimum short circuit capacity at each connection point expressed in MVA. Alternatively, the relevant system operator may provide generic values derived from typical cases;	Fastlagt beregningsmetode anvendes		
14	3	a	vi	the power generating module shall be capable of remaining connected to the network and continuing to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, given the pre-fault and post-fault conditions in points (iv) and (v) of paragraph (3)(a), remain above the lower limit specified in point (ii) of paragraph (3)(a), unless the protection scheme for internal electrical faults requires the disconnection of the power generating module from the network. The			

				protection schemes and settings for internal electrical faults must not jeopardise fault-ride-through performance;			
14	3	a	vii	without prejudice to point (vi) of paragraph (3)(a), undervoltage protection (either fault-ride-through capability or minimum voltage specified at the connection point voltage) shall be set by the power generating facility owner according to the widest possible technical capability of the power generating module, unless the relevant system operator requires narrower settings in accordance with point (b) of paragraph (5). The settings shall be justified by the power generating facility owner in accordance with this principle;	-		
14	3	b		Fault-ride-through capabilities in case of asymmetrical faults shall be specified by each TSO.	FRT krav er gældende for symmetriske såvel som asymmetriske fejl.		
14	4			Type B power generating modules shall fulfil the following requirements relating to system restoration:	-		
14	4	a		the relevant TSO shall specify the conditions under which a power generating module is capable of reconnecting to the network after an incidental disconnection caused by a network disturbance; and	Dk1: 47,5 - 50,2 Hz Dk2: 47.5 - 50.5 Hz I spændingsområdet for ubegrænset driftstid. Genindkobling efter 3 min. Gradient: 20 % Pn/min. Kobling med eget udstyr et tilladt så længe nettet er spændingssat. Kobling med andres udstyr er efter aftale med anlægsejer		
14	4	b		installation of automatic reconnection systems shall be subject both to prior authorisation by the relevant system operator and to the reconnection conditions specified by the relevant TSO.	Dx: (A14.4.a.) Tx: n/a		
14	5			Type B power generating modules shall fulfil the following general system management requirements:	-		
14	5	a		with regard to control schemes and settings:	-		
14	5	a	i	the schemes and settings of the different control devices of the power generating module that are necessary for transmission system stability and for taking emergency action shall be coordinated and agreed between the relevant TSO, the relevant system operator and the power generating facility owner;	Systemværn: Systemoperatøren – i samarbejde med den systemansvarlige virksomhed - skal oplyse, om der er krav til etablering af et systemværn i forbindelse med fastlæggelse af POC. Absolut effektbegrænser: Absolut effektbegrænser bruges til at beskytte det kollektive elforsyningsnet mod overbelastning i kritiske situationer.		

14	5	a	ii	any changes to the schemes and settings, mentioned in point (i), of the different control devices of the power generating module shall be coordinated and agreed between the relevant TSO, the relevant system operator and the power generating facility owner, in particular if they apply in the circumstances referred to in point (i) of paragraph (5) (a);	-		
14	5	b		with regard to electrical protection schemes and settings:	-		
14	5	b	i	the relevant system operator shall specify the schemes and settings necessary to protect the network, taking into account the characteristics of the power generating module. The protection schemes needed for the power generating module and the network as well as the settings relevant to the power generating module shall be coordinated and agreed between the relevant system operator and the power generating facility owner. The protection schemes and settings for internal electrical faults must not jeopardise the performance of a power generating module, in line with the requirements set out in this Regulation;	RSO anvender: Linjebeskyttelse. Transformerbeskyttelse. Reaktorbeskyttelse. Hjælpekrafttransformer -beskyttelse. Samleskinnebeskyttelse. Anlægsejer: Anlægget sikres mod skader fra fejl og hændelser i nettet. Anlægget sikres mod interne kortslutninger. Anlægget sikres mod udkobling i ukritiske situationer. Alle relevante indstillinger specificeres med udgangspunkt i relevant net- og anlægsanalyse. Indstillinger indføres i driftsaftalen. Det kollektive elforsyningssystem sikres i videst mulige omfang mod uønskede påvirkninger fra anlægget. Anlægget skal kunne håndtete de opstillede FRT-krav, hvor ENDK sikrer, at fejl m.m. udkobles iht. disse.		
14	5	b	ii	electrical protection of the power generating module shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the power generating module;	-		
14	5	b	iii	protection schemes may cover the following aspects: – external and internal short circuit; – asymmetric load (negative phase sequence); – stator and rotor overload; – over-/underexcitation; – over-/undervoltage at the connection point; – over-/undervoltage at the alternator terminals; – inter-area oscillations; – inrush current; – asynchronous operation (pole slip); – protection against inadmissible shaft torsions (for example, subsynchronous resonance); – power generating module line protection; – unit transformer protection; – backup against protection and switchgear malfunction; – overfluxing (U/f); – inverse power;	Anlægsejeren er ansvarlig for gennemførelsen af et beskyttelses-koordineringsstudie. Det er anlægsejers ansvar, at anlægget dimensioneres og udstyres med de nødvendige beskyttelsesfunktioner, så at: - anlægget sikres mod skader som følge af fejl og hændelser i det kollektive elforsyningsnet - anlægget beskyttes mod udkoblinger i ikke-kritiske situationer for		

				– rate of change of frequency; and – neutral voltage displacement.	anlægget Relæbeskyttelse specielt rettet mod fejl i anlægget, herunder kortslutninger, overhastighed, magnetiseringsovervågning, retureffekt etc. må ikke udkoble enheden ved kortslutninger i eller omlægninger i nettet. Anlægsbeskyttelsen skal ved kortslutninger i anlægget vare selektiv med netbeskyttelsen. Anvendelsen af vektorspringsrelæer som beskyttelsesfunktion mod ø-drift/netudfald er ikke tilladt. Synkront underspændingsrelæ er kun et krav i det tilfalde, at asynkron sammenkobling ved automatisk genindkobling kan forekomme. Hvis et anlæg isoleres med en del af det kollektive elforsyningsnet, må anlægget ikke give anledning til temporære overspændinger, der kan medføre skader på anlægget eller det kollektive elforsyningsnet.		
14	5	b	iv	changes to the protection schemes needed for the power generating module and the network and to the settings relevant to the power generating module shall be agreed between the system operator and the power generating facility owner, and agreement shall be reached before any changes are made;	-		
14	5	c		the power generating facility owner shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest):	-		
14	5	c	i	network and power generating module protection;	-		
14	5	c	ii	synthetic inertia, if applicable;	-		
14	5	c	iii	frequency control (active power adjustment);	-		
14	5	c	iv	power restriction; and	-		
14	5	c	v	power gradient constraint.	-		
14	5	d		with regard to information exchange:	-		
14	5	d	i	power generating facilities shall be capable of exchanging information with the relevant system operator or the relevant TSO in real time or periodically with time stamping, as specified by the relevant system operator or the relevant TSO;	Informationsudveksling: realtid eller periodisk – med tidsstempling. Maksimal opdateringstid af funktionsstatus (aktiveret/de-aktiveret) er 10 ms.		

					Maksimal opdateringstid af parameterværdi er 1 sekund. Maksimal opdateringsværdi af måleværdier er 1 sekund. Øvrige krav specificeres under A14(5)(d)(ii).		
14	5	d	ii	the relevant system operator, in coordination with the relevant TSO, shall specify the content of information exchanges including a precise list of data to be provided by the power generating facility.	Krav Jf. Bilag 1.A		R1
General requirements for type C power-generating modules							
15	1			Type C power generating modules shall fulfil the requirements laid down in Articles 13 and 14, except for Article 13(2)(b) and(6) and Article14(2).	-		
15	2			Type C power generating modules shall fulfil the following requirements relating to frequency stability:	-		
15	2	a		with regard to active power controllability and control range, the power generating module control system shall be capable of adjusting an active power setpoint in line with instructions given to the power generating facility owner by the relevant system operator or the relevant TSO. The relevant system operator or the relevant TSO shall establish the period within which the adjusted active power setpoint must be reached. The relevant TSO shall specify a tolerance (subject to the availability of the prime mover resource) applying to the new setpoint and the time within which it must be reached;	SPM: minimum 1 % af Pn /minut, desuden 10 minutters reaktionstid til teknologineutralitet hvis nødvendigt. PPM: minimum 20 % af Pn /minut. Angivelse af setpunkter for aktiv effekt skal kunne ske med en opløsning på 1 % af Pn eller bedre. Frekvensparametrene i reguleringsfunktionerne for aktiv effekt skal kunne indstilles med en opløsning på 10 mHz eller bedre. Regulerings*statikkerne* skal kunne indstilles med en opløsning på 1 % eller bedre af P_n. For alle reguleringsfunktioner for aktiv effekt gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen på 2 % af *Pn målt* over en periode på 1 minut. (gælder dog ikke for LFSM-O og LFSMU) Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre.		
15	2	b		manual, local measures shall be allowed in cases where the automatic remote control devices are out of service. The relevant system operator or the relevant TSO shall notify the regulatory authority of the time required to reach the setpoint together with the tolerance for the active power;	Jf. A15(2)(a)		
15	2	c		In addition to paragraph 2 of Article 13,(2), the following requirements shall apply to type C			

				power generating modules with regard to limited frequency sensitive mode – underfrequency (LFSM-U):			
15	2	c	i	the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified by the relevant TSO in coordination with the TSOs of the same synchronous area as follows: – the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive; – the droop settings specified by the TSO shall be in the range 2 – 12 %. This is represented graphically in Figure 4;	CE: 49,8 Hz Droop range: 2 – 12 %. Droop: SPG/PPM = 5 % N: 49.5 Hz Droop range: 2 – 12 %. Droop: SPG/PPM = 4 % Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre. Reguleringsfunktionens følsomhed skal være ± 10 mHz eller bedre.		
15	2	c	ii	the actual delivery of active power frequency response in LFSM-U mode shall take into account: – ambient conditions when the response is to be triggered; – the operating conditions of the power generating module, in particular limitations on operation near maximum capacity at low frequencies and the respective impact of ambient conditions according to paragraphs 4 and 5 of Article 13; and – the availability of the primary energy sources.			
15	2	c	iii	the activation of active power frequency response by the power generating module shall not be unduly delayed. In the event of any delay greater than two seconds, the power generating facility owner shall justify it to the relevant TSO;	-		
15	2	c	iv	in LFSM-U mode the power generating module shall be capable of providing a power increase up to its maximum capacity;	-		
15	2	c	v	stable operation of the power generating module during LFSM-U operation shall be ensured; Figure 4: active power frequency response capability of power generating modules in LFSM-U. Pref is the reference active power to which DP is related and may be specified differently for synchronous power generating modules and power park modules. DP is the change in active power output from the power generating module. fn is the nominal frequency (50 Hz) in the network and Df is the frequency deviation in the network. At underfrequencies where Df is below Df1 the power generating module has to provide a positive active power output change according to the droop S2.	Pn anvendes som Pref for både SPG og PPM.		
15	2	d		in addition to point (c) of paragraph (2), the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating:	-		
15	2	d	i	the power generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4. In specifying those parameters, the relevant TSO shall take account of the following facts: – in case of overfrequency, the active power frequency response is limited by the minimum regulating level;	CE: Interval for aktiv effekt: 1,5 – 10% (minimum krav) FRI: 10 mHz FRD: 0 – 200 mHz		R1

				– in case of underfrequency, the active power frequency response is limited by maximum capacity; – the actual delivery of active power frequency response depends on the operating and ambient conditions of the power generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources; Parameters Ranges Active power range related to maximum capacity 1.5 – 10 % Frequency response insensitivity 10 – 30 mHz 0.02 – 0.06 % Frequency response deadband 0 – 500 mHz Droop 2 – 12 % Table 4: Parameters for active power frequency response in FSM (explanation for Figure 5) Figure 5: Active power frequency response capability of power generating modules in FSM illustrating the case of zero deadband and insensitivity. Pref is the reference active power to which DP is related. DP is the change in active power output from the power generating module. fn is the nominal frequency (50 Hz) in the network and Df is the frequency deviation in the network.	Droop: 2 - 12% Pn anvendes som Pref for både SPG og PPM N: Interval for aktiv effekt: 1,5 – 10% (minimum krav) FRI: 10 mHz FRD: 0 – 500 mHz Droop: 2 - 12% Pn anvendes som Pref for både SPG og PPM		
15	2	d	ii	the frequency response deadband of frequency deviation and droop must be able to be reselected repeatedly;	-		
15	2	d	iii	in the event of a frequency step change, the power generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power generating module) within the ranges given in Table 5. The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account;	PGM: 30 sekunder		
15	2	d	iv	The initial activation of active power frequency response required shall not be unduly delayed. If the delay in initial activation of active power frequency response is greater than two seconds, the power generating facility owner shall provide technical evidence demonstrating why a longer time is needed. For power generating modules without inertia, the relevant TSO may specify a shorter time than two seconds. If the power generating facility owner cannot meet this requirement they shall provide technical evidence demonstrating why a longer time is needed for the initial activation of active power frequency response; ~~Figure 6: Active power frequency response capability. Pmax is the maximum capacity to which DP relates. DP is the change in active power output from the power generating module. The power generating module has to provide active power output DP up to the point DP1 in accordance with the times t1 and t2 with the values of DP1, t1and t2 being specified by the relevant TSO according to Table 5. t1 is the initial delay. t2 is the time for full activation.~~	så kort som muligt, skal begrundes hvis tid > 2 sekunder.		
15	2	d	v	the power generating module shall be capable of providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO. In specifying the period, the TSO shall have regard to active power headroom and primary energy source of the power generating module;	15 minutter.		
15	2	d	vi	within the time limits laid down in point (v) of paragraph (2) (d), active power control must not	-		

				have any adverse impact on the active power frequency response of power generating modules;			
15	2	d	vii	the parameters specified by the relevant TSO in accordance with paragraphs 1, 2, 3points (i), (ii), (iii) and (v)5 shall be notified to the relevant regulatory authority. The modalities of that notification shall be specified in accordance with the applicable national regulatory framework; Parameters Ranges or values Active power range related to maximum capacity (frequency response range) 1.5 – 10 % For power generating modules with inertia, the maximum admissible initial delay unless justified otherwise in line with Article 15 (2) (d) (iv) 2 seconds For power generating modules without inertia, the maximum admissible initial delay unless justified otherwise in line with Article 15 (2) (d) (iv) as specified by the relevant TSO. Maximum admissible choice of full activation time, unless longer activation times are allowed by the relevant TSO for reasons of system stability 30 seconds Table 5: Parameters for full activation of active power frequency response resulting from frequency step change (explanation for Figure 6).			
15	2	e		with regard to frequency restoration control, the power generating module shall provide functionalities complying with specifications specified by the relevant TSO, aiming at restoring frequency to its nominal value or maintaining power exchange flows between control areas at their scheduled values;			
15	2	f		with regard to disconnection due to underfrequency, power generating facilities capable of acting as a load, including hydro pump-storage power generating facilities, shall be capable of disconnecting their load in case of underfrequency. The requirement referred to in this point does not extend to auxiliary supply;	CE/Dk1: 49,0 Hz N/Dk2: 48,5 Hz		
15	2	g		with regard to real-time monitoring of FSM:	-		
15	2	g	i	to monitor the operation of active power frequency response, the communication interface shall be equipped to transfer in real time and in a secured manner from the power generating facility to the network control centre of the relevant system operator or the relevant TSO, at the request of the relevant system operator or the relevant TSO, at least the following signals: – status signal of FSM (on/off); – scheduled active power output; – actual value of the active power output; – actual parameter settings for active power frequency response; – droop and deadband;	Krav og liste defineret jf. A14(5)(d)(1) + (ii)		
15	2	g	ii	the relevant system operator and the relevant TSO shall specify additional signals to be provided by the power generating facility by monitoring and recording devices in order to verify the performance of the active power frequency response provision of participating power generating modules.	Krav og liste defineret jf. A14(5)(d)(1) + (ii)		
15	3			With regard to voltage stability, type C power generating modules shall be capable of automatic disconnection when voltage at the connection point reaches levels specified by the relevant system operator in coordination with the relevant TSO. The terms and settings for actual automatic disconnection of power generating modules shall be specified by the relevant system operator in coordination with the relevant TSO.	Dx krav. Overspænding (trin 3) = 1,2 pu i 100 ms Overspænding (trin 2) = 1,15 pu i 200 ms		

					Overspænding (trin 1) = 1,1 pu i 60 sekunder Underspænding (trin 1) = 0,9 pu i 60 sekunder		
15	4			Type C power generating modules shall fulfil the following requirements relating to robustness:	-		
15	4	a		in the event of power oscillations, power generating modules shall retain steady-state stability when operating at any operating point of the P-Q-capability diagram;	-		
15	4	b		without prejudice to paragraph 4 and 5 of Article 13, power generating modules shall be capable of remaining connected to the network and operating without power reduction, as long as voltage and frequency remain within the specified limits pursuant to this Regulation;	-		
15	4	c		power generating modules shall be capable of remaining connected to the network during single-phase or three-phase auto-reclosures on meshed network lines, if applicable to the network to which they are connected. The details of that capability shall be subject to coordination and agreements on protection schemes and settings as referred to in point (b) of Article 14(5).	*Anlægget* skal være designet til uden afbrydelse, at kunne tolerere et momentant spændingsfasespring på op til 20° i *nettilslutningspunktet*.		
15	5			Type C power generating modules shall fulfil the following requirements relating to system restoration:	-		
15	5	a		with regard to black start capability:	-		
15	5	a	i	black start capability is not mandatory without prejudice to the Member State's rights to introduce obligatory rules in order to ensure system security;	-		
15	5	a	ii	power generating facility owners shall, at the request of the relevant TSO, provide a quotation for providing black start capability. The relevant TSO may make such a request if it considers system security to be at risk due to a lack of black start capability in its control area;			
15	5	a	iii	a power generating module with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a timeframe specified by the relevant system operator in coordination with the relevant TSO;	R-TSO laver behovsanalyse, arrangerer tilbudsindhentning og indgår aftale med relevante aktører		
15	5	a	iv	a power generating module with black start capability shall be able to synchronise within the frequency limits laid down in point (a) of Article 13(1) and, where applicable, voltage limits specified by the relevant system operator or in paragraph 2 of Article 16;(2);	-		
15	5	a	v	a power generating module with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand;	-		
15	5	a	vi	a power generating module with black start capability shall: – be capable of regulating load connections in block load; – be capable of operating in LFSM-O and LFSM-U, as specified in point (c) of paragraph 2 and Article 13(2); – control frequency in case of overfrequency and underfrequency within the whole active power output range between minimum regulating level and maximum capacity as well as at houseload	-		

				level; – be capable of parallel operation of a few power generating modules within one island; and – control voltage automatically during the system restoration phase;			
15	5			with regard to the capability to take part in island operation:	-		
15	5	b	i	power generating modules shall be capable of taking part in island operation if required by the relevant system operator in coordination with the relevant TSO and: – the frequency limits for island operation shall be those established in accordance with point (a) of Article 13(1); – the voltage limits for island operation shall be those established in accordance with paragraph 3 of Article 15(3) or paragraph 2 of Article 13,(2), where applicable;	D anlæg skal kunne deltage i område ø-drift.		
15	5	b	ii	power generating modules shall be able to operate in FSM during island operation, as specified in point (d) of paragraph 2. In the event of a power surplus, 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 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;	-		
15	5	b	iii	the method for detecting a change from interconnected system operation to island operation shall be agreed between the power generating facility owner and the relevant system operator in coordination with the relevant TSO. The agreed method of detection must not rely solely on the system operator's switchgear position signals;	ESKC ændre driftsstatus til "Skærpet drift". Detektering: PMU data med ø-drift detekteringsmodul		
15	5	b	iv	power generating modules shall be able to operate in LFSM-O and LFSM-U during island operation, as specified in point of paragraph 2 and Article 13(2).	-		
15	5	c		with regard to quick re-synchronisation capability:	-		
15	5	c	i	in case of disconnection of the power generating module from the network, the power generating module shall be capable of quick re-synchronisation in line with the protection strategy agreed between the relevant system operator in coordination with the relevant TSO and the power generating facility;	Hurtig gensynkronisering krævet for D anlæg.		
15	5	c	ii	a power generating module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply 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 system operator's switchgear position signals;			
15	5	c	iii	power generating modules shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology.	SPGM: 0 min. PPM: 0 min da re-synkroniseringstid er < 15 minutter.		
15	6			Type C power generating modules shall fulfil the following general system management requirements:	-		

15	6	a		with regard to loss of angular stability or loss of control, a power generating module shall be capable of disconnecting automatically from the network in order to help preserve system security or to prevent damage to the power generating module . The power generating facility owner and the relevant system operator in coordination with the relevant TSO shall agree on the criteria for detecting loss of angular stability or loss of control;	produktionsanlægget skal være udstyret med beskyttelse til detektering af polslip eller tab af synkronisme. Ved konstateret polslip eller tab af synkronisme skal produktionsanlægget udkobles momentant af hensyn til "system- og anlægssikkerheden". De anvendte beskyttelsesfunktioner må ikke påvirke produktionsanlæggets "FRT-egenskaber", idet anvendte beskyttelsesindstillinger fastlægges på baggrund af simulering af relevante fejlscenarier.		
15	6	b		with regard to instrumentation:	-		
15	6	b	i	Power generating facilities shall be equipped with a facility to provide fault recording and monitoring of dynamic system behaviour. This facility shall record the following parameters: – voltage; – active power; – reactive power; and – frequency. The relevant system operator shall have the right to specify quality of supply parameters to be complied with on condition that reasonable prior notice is given;	For anlæg der levere systemydelser, skal der installeres en PMU-enhed til verificering af den specificerede ydelse, herunder produktionsanlæggets dynamiske respons.		
15	6	b	ii	the settings of the fault recording equipment, including triggering criteria and the sampling rates shall be agreed between the power generating facility owner and the relevant system operator in coordination with the relevant TSO;	Logning skal realiseres via et elektronisk udstyr, der kan opsættes til, som minimum, at logge relevante hændelser for nedennævnte signaler i nettilslutningspunktet ved fejl i det kollektive elforsyningsnet. Anlægsejer installerer i nettilslutningspunktet et logningsudstyr (fejlskriver), der som minimum registrerer: -Spænding for hver fase for anlægget -Strøm for hver fase for anlægget -Aktiv effekt for anlægget (kan være beregnede størrelser) -Reaktiv effekt for anlægget (kan være beregnede størrelser) -Frekvens for anlægget -Frekvensafvigelser -Hastighedsafvigelser (synkrongenerator) -Aktivering af interne beskyttelsesfunktioner Specifikke krav til målinger beskrives i nettilslutningsaftalen. Logning skal udføres som sammenhængende tidsserier af måleværdier		R1

					fra 10 sekunder før hændelse til 60 sekunder efter hændelsestidspunktet. Minimum samplefrekvens for alle fejllogninger skal være 1 kHz. De specifikke opsætninger af hændelsesbaseret logning aftales med den systemansvarlige virksomhed ved opstart af anlægget. Alle målinger og data, der skal opsamles iht. TF 5.8.1 skal logges med en tidsstempling og en nøjagtighed, som sikrer, at disse kan korreleres med hinanden og med tilsvarende registreringer i det kollektive elforsyningsnet. Logninger skal arkiveres i minimum tre måneder fra fejlsituationen, dog maksimalt op til 100 hændelser. Elforsyningsvirksomheden og den systemansvarlige virksomhed skal på forlangende have adgang til loggede og relevante registrerede informationer.		
15	6	b	iii	the dynamic system behaviour monitoring shall include an oscillation trigger specified by the relevant system operator in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations;	Inkluderet i trigger signaler fra 15.6.b.ii		
15	6	b	iv	the facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the power generating facility owner, and the relevant system operator and the relevant TSO to access the information. The communications protocols for recorded data shall be agreed between the power generating facility owner, the relevant system operator and the relevant TSO;	Filformat: COMTRADE IEEE C37.111:1999, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*		
15	6	c		with regard to the simulation models:	-		
15	6	c	i	at the request of the relevant system operator or the relevant TSO, the power generating facility owner shall provide simulation models which properly reflect the behaviour of the power generating module in both steady-state and dynamic simulations (50 Hz component) or in electromagnetic transient simulations. The power generating facility owner shall ensure that the models provided have been verified against the results of compliance tests referred to in Chapters 2, 3 and 4 of Title IV, and shall notify the results of the verification to the relevant system operator or relevant TSO. Member States may require that such verification be carried out by an authorised certifier;	Krav Jf. Bilag 1.B		R1
15	6	c	ii	the models provided by the power generating facility owner shall contain the following sub-models, depending on the existence of the individual components: – alternator and prime mover; – speed and power control; – voltage control, including, if applicable, power system stabiliser ('PSS') function and excitation control system; – power generating module protection models, as agreed between the relevant system operator	-		

				and the power generating facility owner; and – converter models for power park modules;			
15	6	c	iii	the request by the relevant system operator referred to in point (i) shall be coordinated with the relevant TSO. It shall include: – the format in which models are to be provided; – the provision of documentation on a model's structure and block diagrams; – an estimate of the minimum and maximum short circuit capacity at the connection point, expressed in MVA, as an equivalent of the network;	Krav præciseres i A15.6.c.i.		
15	6	c	iv	the power generating facility owner shall provide recordings of the power generating module's performance to the relevant system operator or relevant TSO if requested. The relevant system operator or relevant TSO may make such a request, in order to compare the response of the models with those recordings;	-		
15	6	d		with regard to the installation of devices for system operation and devices for system security, if the relevant system operator or the relevant TSO considers that it is necessary to install additional devices in a power generating facility in order to preserve or restore system operation or security, the relevant system operator or relevant TSO and the power generating facility owner shall investigate that matter and agree on an appropriate solution;	Systemværn: For SGM gælder; Krav om synkrongeneratorers behov for systemværn afdækkes når POC er tildelt For PPM gælder; Et anlæg skal være udstyret med et systemværn, som er en nødreguleringsfunktion, der på baggrund af en nedreguleringsordre meget hurtigt skal kunne regulere den aktive effekt leveret fra et produktionsanlæg til et eller flere foruddefinerede setpunkter. Setpunkterne fastlægges af elforsyningsvirksomheden ved idriftsættelsen. Anlægget skal have mulighed for minimum fem forskellige konfigurerbare reguleringstrin. Som standardværdier anbefales følgende reguleringstrin: 1. Til 70 % af mærkeeffekt 2. Til 50 % af mærkeeffekt 3. Til 40 % af mærkeeffekt 4. Til 25 % af mærkeeffekt 5. Til 0 % af mærkeeffekt, dvs. anlægget er stoppet. Reguleringen skal påbegyndes inden for 1 sekund og skal være fuldført indenfor 10 sekunder fra modtagelse af ordre om nedregulering. I det tilfælde at der til systemværnet beordres en opregulering, f.eks. fra		

trin 4

(25 %) til 3 (40 %), accepteres det, at designmæssige grænser for anlæggets generatorer eller øvrige anlægsenheder kan give en forøget tid for fuldførelse af ordren.

Automatisk nedreguleringsfunktion af aktiv effekt ved stopvindhastighed:

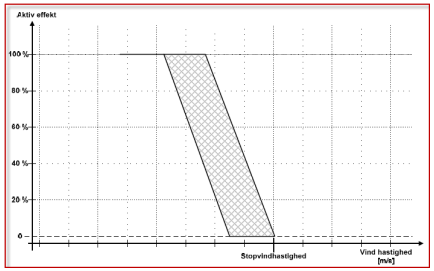
Et produktionsanlæg, hvor primær energi er vind, skal anlægget kunne nedregulere den aktive effektproduktion, når der optræder høje vindhastigheder, inden vindmøllernes indbyggede beskyttelsesfunktion ved høje vindhastigheder (stopvindhastighed) aktiveres.

Produktionsanlægget skal kunne regulere den aktive effekt til en vilkårlig værdi i intervallet fra 100 % til 10 % af Pn.

Reguleringsfunktionen skal kunne aktiveres / de-aktiveres via ordrer.

Nedregulering kan foretages som en kontinuert regulering eller en diskret regulering.

Diskret regulering må maksimalt have en trinstørrelse på 25 % af mærkeeffekten inden for det skraverede område vist i Figur x.



Nedreguleringsbåndet aftales med elforsyningsvirksomheden ved idriftsættelse af produktionsanlægget. Bredden af nedreguleringsbåndet kan afhænge af de lokale vindforhold.

Den automatiske nedreguleringsfunktion præciseres som minimum ved;

Vindhastighed - aktivering nedregulering [m/s], Vindhastighed - 10 % af Pn [m/s], vindhastighed – cutout [m/s]

15	6	e		the relevant system operator shall specify, in coordination with the relevant TSO, 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 power generating module, taking into consideration the specific characteristics of prime mover technology;	Op: Min: 1 % af Pn/min Op: Max: 20 % af Pn dog højest 60 MW/min Ned: Min: 1 % af Pn/min Ned: Max: 20 % af Pn dog højest 60 MW/min Kravene til minimum og maksimum gradienter for ændring af aktiv effekt er gældende, hvis andre betingelser/regler ikke fastsætter respektive gradienter herunder også systemydelser, energimarked etc.		
15	6	f		earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.	Stjernepunktet skal være isoleret og ført ud således at det kan direkte jordes eller jordes gennem en reaktans. Øvrige krav er defineret i netdimensioneringskriterier for net over 100 kV.		
General requirements for type D power-generating modules							
16	1			In addition to fulfilling the requirements listed in Article 13, except for Article 13(2)(b), (6) and (7), Article 14, except for Article 14(2), and Article 15, except for Article 15(3), type D power generating modules shall fulfil the requirements set out in this Article.	-		
16	2			Type D power generating modules shall fulfil the following requirements relating to voltage stability:	-		
16	2	a		with regard to voltage ranges:	-		
16	2	a	i	without prejudice to point (a) of Article 14(3) and point (a) of Article 13(3),paragraph 3 a power generating module shall be capable of staying connected to the network and operating within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to the reference 1 pu voltage, and for the time periods specified in Tables 6.1 and 6.2;	**6.1: (110 – 300 kV)** **CE** 0,85 – 0,90 pu/ 60 min 1,118 – 1,15 pu/ 60 min **N** 1,05 – 1,1 pu/60 min **6.2 (300 – 400 kV)** **CE** 0,85 – 0,90 pu/ 60 min 1,05 – 1,1 pu/ 60 min **N** 1,05 – 1,1 pu/ 60 min		
16	2	a	ii	the relevant TSO may specify shorter periods of time during which power generating modules shall be capable of remaining connected to the network in the event of simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency;	n/a		
16	2	a	iii	notwithstanding the provisions of point (i), the relevant TSO in Spain may require power generating modules be capable of remaining connected to the network in the voltage range between 1.05 pu and 1.0875 pu for an unlimited period;	n/a		

16	2	a	iv	for the 400 kV grid voltage level (or alternatively commonly referred to as 380 kV level) the reference 1 pu value is 400 kV, for other grid voltage levels the reference 1 pu voltage may differ for each system operator in the same synchronous area;	-		
16	2	a	v	notwithstanding the provisions of point (i), the relevant TSOs in the Baltic synchronous area may require power generating modules to remain connected atto the 400kV network in the voltage range limits and for the time periods that apply in the Continental Europe synchronous area. Synchronous area Voltage range Time period for operation Continental Europe 0.85 pu – 0.90 pu 60 minutes 0.90 pu – 1.118 pu Unlimited 1.118 pu – 1.15 pu To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes Nordic 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu 60 minutes Great Britain 0.90 pu–1.10 pu Unlimited Ireland and Northern Ireland 0.90 pu – 1.118 pu Unlimited Baltic 0.85 pu – 0.90 pu 30 minutes 0.90 pu – 1.118 pu Unlimited 1.118 pu – 1.15 pu 20 minutes ~~Table 6.1: The table shows the minimum time periods during which a power generating module must be capable of operating for voltages deviating from the reference 1 pu value at the connection point without disconnecting from the network, where the voltage base for pu values is from 110 kV to 300 kV.~~ Synchronous area Voltage range Time period for operation Continental Europe 0.85 pu – 0.90 pu 60 minutes 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes Nordic 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu To be specified by each TSO, but not more than 60 minutes Great Britain 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu 15 minutes Ireland and Northern Ireland 0.90 pu – 1.05 pu Unlimited Baltic 0.88 pu – 0.90 pu 20 minutes 0.90 pu – 1.097 pu Unlimited 1.097 pu – 1.15 pu 20 minutes ~~Table 6.2: The table shows the minimum time periods during which a power generating module must be capable of operating for voltages deviating from the reference 1 pu value at the connection point without disconnecting from the network where the voltage base for pu values is from 300 kV to 400 kV.~~	n/a		
16	2	b		wider voltage ranges or longer minimum time periods for operation may be agreed between the	Transmissionssystemet: pt ikke relevant		

<table>
<tr><td></td><td></td><td></td><td></td><td>relevant system operator and the power generating facility owner in coordination with the relevant TSO. If wider voltage ranges or longer minimum times for operation are economically and technically feasible, the power generating facility owner shall not unreasonably withhold an agreement;</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>2</td><td>c</td><td></td><td>Without prejudice to point (a), the relevant system operator in coordination with the relevant TSO shall have the right to specify voltages at the connection point at which a power generating module is capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator and the power generating facility owner.</td><td>Transmissionssystemet: pt ikke relevant

Distributionssystemskrav.
Overspænding (trin 3) = 1,2 pu i 100 ms

Overspænding (trin 2) = 1,15 pu i 200 ms

Overspænding (trin 1) = 1,1 pu i 60 sekunder

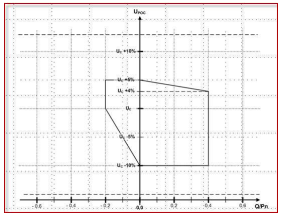
Underspænding (trin 1) = 0,9 pu i 60 sekunder</td><td></td><td></td></tr>
<tr><td>16</td><td>3</td><td></td><td></td><td>Type D power generating modules shall fulfil the following requirements in relation to robustness:</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>3</td><td>a</td><td></td><td>with regard to fault-ride-through capability:</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>3</td><td>a</td><td>i</td><td>power generating modules shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. That capability shall be in accordance with a voltage-against-time profile at the connection point for fault conditions specified by the relevant TSO.
The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault.
That lower limit shall be specified by the relevant TSO, using the parameters set out in Figure 3 and within the ranges set out in Tables 7.1 and 7.2 for type D power generating modules connected at or above the 110 kV level.
That lower limit shall also be specified by the relevant TSO, using parameters set out in Figure 3 and within the ranges set out in Tables 3.1 and 3.2 for type D power generating modules connected below the 110 kV level.;</td><td>Krav jf. Bilag 1.C

CE – PPM - #3- A16(3)(a)
Spænding (pu) / Tid [sekunder]
U_{ret}: 0 — t_{clear}: 0,15
U_{clear}: 0 — t_{rec1}: 0,15
U_{rec1}: 0 — t_{rec2}: 0,15
U_{rec2}: 0,85 — t_{rec3}: 1,5

CE – SPGM - #4- A16(3)(a)
Spænding (pu) / Tid [sekunder]
U_{ret}: 0 — t_{clear}: 0,15
U_{clear}: 0,6 — t_{rec1}: 0,15
U_{rec1}: 0,6 — t_{rec2}: 0,75
U_{rec2}: 0,85 — t_{rec3}: 1,5</td><td></td><td></td></tr>
</table>

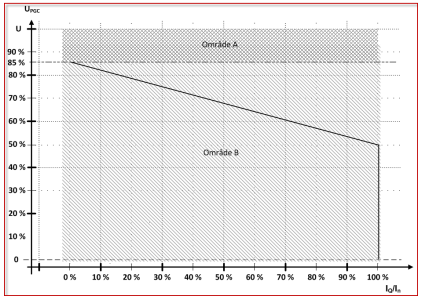
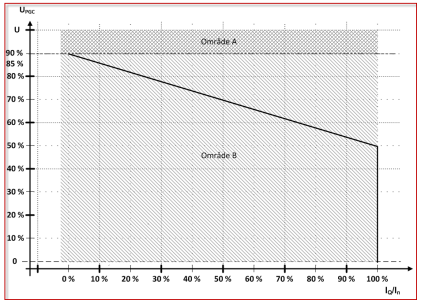
					N – PPM - #5- A16(3)(a) Spænding (pu) / Tid [sekunder] U_{ret}: 0 / t_{clear}: 0,15 U_{clear}: 0 / t_{rec1}: 0,15 U_{rec1}: 0 / t_{rec2}: 0,15 U_{rec2}: 0,9 / t_{rec3}: 1,5 N – SPGM - #6- A16(3)(a) Spænding (pu) / Tid [sekunder] U_{ret}: 0 / t_{clear}: 0,15 U_{clear}: 0,6 / t_{rec1}: 0,15 U_{rec1}: 0,6 / t_{rec2}: 0,75 U_{rec2}: 0,9 / t_{rec3}: 1,5 Spændingens synkronkomposant skal indgå ved spændingsevalueringen.		
16	3	a	ii	each TSO shall specify the pre-fault and post-fault conditions for the fault-ride-through capability referred to in point (iv) of Article 14(3)(a). The specified pre-fault and post-fault conditions for the fault-ride-through capability shall be made publicly available; Voltage parameters [pu] Time parameters [seconds] Uret: 0 tclear: 0.14 – 0.15 (or 0.14 - 0.25 if system protection and secure operation so require) Uclear: 0.25 trec1: tclear – 0.45 Urec1: 0.5 – 0.7 trec2: trec1 – 0.7 Urec2: 0.85 – 0.9 trec3: trec2 – 1.5 Table 7.1: Parameters for Figure 3 for fault-ride-through capability of synchronous power generating modules. Voltage parameters [pu] Time parameters [seconds] Uret: 0 tclear: 0.14 – 0.15 (or 0.14 - 0.25 if system protection and secure operation so require) Uclear: Uret trec1: tclear Urec1: Uclear trec2: trec1 Urec2: 0.85 trec3: 1.5 – 3.0 Table 7.2: Parameters for Figure 3 for fault-ride-through capability of power park modules.	Kortslutningskatalog fastlægge metode for beregning af kortslutningseffekt samt beregner konditioner i kendte tilslutningspunkter		
16	3	b		at the request of a power generating facility 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 point as specified in point (iv) of Article 14(3) (a) regarding:	A14(3)(a)(iv)		
16	3	b	i	pre-fault minimum short circuit capacity at each connection point expressed in MVA;	A14(3)(a)(iv)		
16	3	b	ii	pre-fault operating point of the power generating module expressed as active power output and reactive power output at the connection point and voltage at the connection point; and	Anlægskonditioner: Anlægstolerancen er specificeret ved Pn og Qmin.		

16	3	b	iii	post-fault minimum short circuit capacity at each connection point expressed in MVA;	A14(3)(a)(iv)		
16	3	c		fault-ride-through capabilities in case of asymmetrical faults shall be specified by each TSO.	Angivne FRT-krav gælder for symmetrisk og asymmetriske fejl, hvor referencen er spændingens synkronkomposant		
				Supplerende krav:	Robusthedskrav overfor gentagene fejl Det påhviler anlægsejer, at sikre produktionsanlægget mod mekaniske og elektriske følgevirkninger i forbindelse med mulig genindkobling efter symmetriske såvel som asymmetriske fejl i transmissionssystemet. Foranstaltningerne i forbindelse med dette må ikke kompromittere produktionsanlæggets specificerede øvrige egenskaber.		
16	4			Type D power generating modules shall fulfil the following general system management requirements:	-		
16	4	a		with regard to synchronisation, when starting a power generating module, synchronisation shall be performed by the power generating facility owner only after authorisation by the relevant system operator;			
16	4	b		the power generating module shall be equipped with the necessary synchronisation facilities;	-		
16	4	c		synchronisation of power generating modules shall be possible at frequencies within the ranges set out in Table 2;	-		
16	4	d		the relevant system operator and the power generating facility owner shall agree on the settings of synchronisation devices to be concluded prior to operation of the power generating module. This agreement shall cover:	-		
16	4	d	i	voltage;	-		
16	4	d	ii	frequency;	-		
16	4	d	iii	phase angle range;	-		
16	4	d	iv	phase sequence;	-		
16	4	d	v	deviation of voltage and frequency.	-		
Requirements for type B synchronous power-generating modules							
17	1			Type B synchronous power generating modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b), and 14.	-		
17	2			Type B synchronous power generating modules shall fulfil the following additional requirements relating to voltage stability:	-		
17	2	a		with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a synchronous power generating module to provide reactive power;	-		

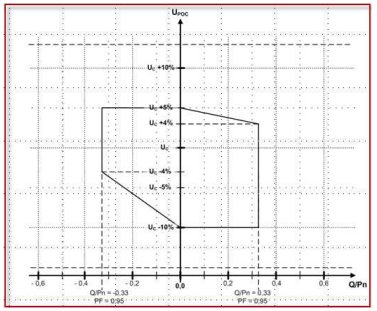
17	2	b		with regard to the voltage control system, a synchronous power generating module shall be equipped with a permanent automatic excitation control system that can provide constant alternator terminal voltage at a selectable setpoint without instability over the entire operating range of the synchronous power generating module.	-		
17	3			With regard to robustness, type B synchronous power generating modules shall be capable of providing post-fault active power recovery. The relevant TSO shall specify the magnitude and time for active power recovery.	Der specificeres ikke yderlig robustness respons krav end der er specificeret i de øvrige artikler. Anlægsegenskaber for robustness må ikke forsinkes eller begrænses ved et specifikt design med udgangspunkt i denne artikel.		
Requirements for type C synchronous power-generating modules							
18	1			Type C synchronous power generating modules shall fulfil the requirements laid down in Articles 13, 14, 15 and 17, except for Article 13 (2)(b) and 13(6), Article 14(2) and Article 17(2)(a).	-		
18	2			Type C synchronous power generating modules shall fulfil the following additional requirements in relation to voltage stability:	-		
18	2	a		with regard to reactive power capability, the relevant system operator may specify supplementary reactive power to be provided if the connection point of a synchronous power generating module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power generating module or its alternator terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.	Det påhviler *anlægsejer* at kompensere for *anlægsinfrastrukturens* reaktive effekt i situationer, hvor *anlægget* er udkoblet eller ikke producerer aktiv effekt.		
18	2	b		with regard to reactive power capability at maximum capacity:	-		
18	2	b	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements in the context of varying voltage. For that purpose the relevant system operator shall specify a U-Q/Pmax-profile within the boundaries of which the synchronous power generating module shall be capable of providing reactive power at its maximum capacity. The specified U-Q/Pmax profile may take any shape, having regard to the potential costs of delivering the capability to provide reactive power production at high voltages and reactive power consumption at low voltages;	Krav jf. Bilag 1.D 		
18	2	b	ii	the U-Q/Pmax-profile shall be specified by the relevant system operator in coordination with the relevant TSO, in conformity with the following principles: – the U-Q/Pmax-profile shall not exceed the U-Q/Pmax-profile envelope, represented by the inner envelope in Figure 7; – the dimensions of the U-Q/Pmax-profile envelope (Q/Pmax range and voltage range) shall be within the range specified for each synchronous area in Table 8; and – the position of the U-Q/Pmax-profile envelope shall be within the limits of the fixed outer	-		

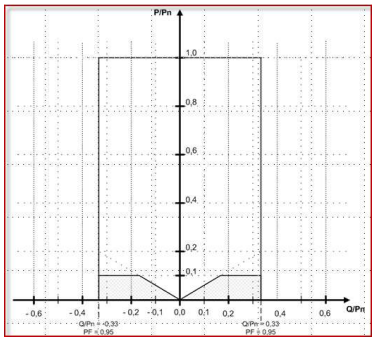
				envelope in Figure 7; Figure 7: U-Q/Pmax-profile of a synchronous power generating module. The diagram represents boundaries of a U-Q/Pmax-profile by the voltage at the connection point, expressed by the ratio of its actual value and its the reference 1 pu value, against the ratio of the reactive power (Q) and the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative. Synchronous area Maximum range of Q/Pmax Maximum range of steady-state voltage level in PU Continental Europe 0.95 0.225 Nordic 0.95 0.150 Great Britain 0.95 0.225 Ireland and Northern Ireland 1.08 0.218 Baltic 1.0 0.220 Table 8: Parameters for the inner envelope in Figure 7			
18	2	b	iii	the reactive power provision capability requirement applies at the connection point. For profile 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;	-		
18	2	b	iv	the synchronous power generating module shall be capable of moving to any operating point within its U-Q/Pmax profile in appropriate timescales to target values requested by the relevant system operator;			R1
18	2	c		with regard to reactive power capability below maximum capacity, when operating at an active power output below the maximum capacity (P<Pmax), the synchronous power generating modules shall be capable of operating at every possible operating point in the P-Q-capability diagram of the alternator of that synchronous power generating module, at least down to minimum stable operating level. Even at reduced active power output, reactive power supply at the connection point shall correspond fully to the P-Q-capability diagram of the alternator of that synchronous power generating module, taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account.			
Requirements for type D synchronous power-generating modules							
19	1			Type D synchronous power generating modules shall fulfil the requirements laid down in Article 13, except for Article 13(2)(b), (6) and (~~6~~7), Article 14 except for Article 14(2), Article 15, except for Article 15(3), Article 16, Article 17, except for Article 17(2) and Article 18.	-		
19	2			Type D synchronous power generating modules shall fulfil the following additional requirements in relation to voltage stability:	-		
19	2	a		the parameters and settings of the components of the voltage control system shall be agreed between the power generating facility owner and the relevant system operator, in coordination with the relevant TSO;	Se note bagerst i dokumentet.		
19	2	b		the agreement referred to in subparagraph (a) 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. The latter shall include:	-		

19	2	b	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;			
19	2	b	ii	an underexcitation limiter to prevent the AVR from reducing the alternator excitation to a level which would endanger synchronous stability;			
19	2	b	iii	an overexcitation limiter to ensure that the alternator excitation 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;			
19	2	b	iv	a stator current limiter; and			
19	2	b	v	a PSS function to attenuate power oscillations, if the synchronous power generating module size is above a value of maximum capacity specified by the relevant TSO.	D anlæg.		
19	3			The relevant TSO and the power generating facility owner shall enter into an agreement regarding technical capabilities of the power generating module to aid angular stability under fault conditions.	Der specificeres ikke yderlige vinkelstabilitetskrav end der er specificeret i de øvrige artikler.		
Requirements for type B power park modules							
20	1			Type B power park modules shall fulfil the requirements laid down in Articles 13, except for Article 13(2)(b), and Article 14.	-		
20	2			Type B power park modules shall fulfil the following additional requirements in relation to voltage stability:	-		
20	2	a		with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a power park module to provide reactive power;			
20	2	b		the relevant system operator in coordination with the relevant TSO shall have the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults, under the following conditions:	CE: IQ/In linear from 0% - 100 % at Upgc: 0,85 p.u to 0,5 p.u. N: IQ/In linear from 0% - 100 % at Upgc: 0,9 p.u to 0,5 p.u. Regulering skal følge Figur x, så den reaktive tillægsstrøm (synkronkomposanten) efter 100 ms følger karakteristikken med en tolerance på ±20 %. På Figur x angiver Y-aksen den anvendte styrespænding for 50 Hz-komponenten. Med hensyn til styringskoncept for levering af reaktiv tillægsstrøm under et spændingsdyk er det op til PPM-leverandøren at specificere, hvilken styrespænding der benyttes. Dette kan være mindste eller højeste		

					yderspænding, respektive fasespænding. Alternativt kan den synkrone spændingskomposant benyttes, så længe karakteristikken angivet på Figur x kan overholdes for trefasefejl og efter bortkobling af alle typer af asymmetriske fejl. I område B har levering af reaktiv strøm første prioritet, mens levering af aktiv effekt har anden prioritet. CE:  N:  		
20	2	b	i	the power park module shall be capable of activating the supply of fast fault current either by: – ensuring the supply of the fast fault current at the connection point; or – measuring voltage deviations at the terminals of the individual units of the power park module and providing a fast fault current at the terminals of these units;	-		
20	2	b	ii	the relevant system operator in coordination with the relevant TSO shall specify: – how and when a voltage deviation is to be determined as well as the end of the voltage deviation; – the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current, for which current and voltage may be measured	CE: Uc < 0,85 pu: start Uc > 0,85 pu: stop N:		

				differently from the method specified in Article 2; – the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance;	Uc < 0,9 pu: start Uc > 0,9 pu: stop Karakteristik af fast fault current er specificeret under A20.2.b.		
20	2	c		with regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the relevant system operator in coordination with the relevant TSO shall have the right to specify a requirement for asymmetrical current injection.	Ingen krav om asymmetrisk fejlstrømsinjektion for nuværende.		
20	3			Type B power park modules shall fulfil the following additional requirements in relation to robustness:	-		
20	3	a		the relevant TSO shall specify the post-fault active power recovery that the power park module is capable of providing and shall specify:	Anlægget skal efter et indsvingningsforløb levere normal produktion senest 5 sekunder efter, at driftsforholdene i nettilslutningspunktet er tilbage i området kontinuert drift. Effektreguleringen skal ske med en gradient på mindst 20 % af anlæggets nominelle effekt".		
20	3	a	i	when the post-fault active power recovery begins, based on a voltage criterion;			
20	3	a	ii	a maximum allowed time for active power recovery; and			
20	3	a	iii	a magnitude and accuracy for active power recovery;			
20	3	b		the specifications shall be in accordance with the following principles:			
20	3	b	i	interdependency between fast fault current requirements according to points (b) and (c) of paragraph (2) and active power recovery;			
20	3	b	ii	dependence between active power recovery times and duration of voltage deviations;			
20	3	b	iii	a specified limit of the maximum allowed time for active power recovery;			
20	3	b	iv	adequacy between the level of voltage recovery and the minimum magnitude for active power recovery; and			
20	3	b	v	adequate damping of active power oscillations.			
Requirements for type C power park modules							
21	1			Type C power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b) and (6), Article 14, except for Article 14(2), Article 15 and Article 20, except for Article 20(2)(a), unless referred to otherwise in point (v) of paragraph (3)(d).	-		
21	2			Type C power park modules shall fulfil the following additional requirements in relation to frequency stability:	-		
21	2	a		the relevant TSO shall have the right to specify that power park modules be capable of providing synthetic inertia during very fast frequency deviations;	Krav til syntetisk inerti er ikke specificeret. Behov for syntetisk inerti vil blive påbegyndt afklaret i perioden 2018 – 2019.		
21	2	b		the operating principle of control systems installed to provide synthetic inertia and the	n/a jf. A21.2(a)		

				associated performance parameters shall be specified by the relevant TSO.			
21	3			Type C power park modules shall fulfil the following additional requirements in relation to voltage stability:	-		
21	3	a		with regard to reactive power capability, the relevant system operator may specify supplementary reactive power to be provided if the connection point of a power park module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the convertor terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the power park module or its convertor terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.	Det påhviler *anlægsejer* at kompensere for *anlægsinfrastrukturens* reaktive effekt i situationer, hvor *anlægget* er udkoblet eller ikke producerer aktiv effekt.		
21	3	b		with regard to reactive power capability at maximum capacity:			
21	3	b	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements in the context of varying voltage. To that end, it shall specify a U-Q/Pmax-profile that may take any shape within the boundaries of which the power park module shall be capable of providing reactive power at its maximum capacity;	Krav jf. Bilag 1.D  		
21	3	b	ii	the U-Q/Pmax-profile shall be specified by each relevant system operator in coordination with the relevant TSO in conformity with the following principles: – the U-Q/Pmax-profile shall not exceed the U-Q/Pmax-profile envelope, represented by the inner envelope in Figure 8; – the dimensions of the U-Q/Pmax-profile envelope (Q/Pmax range and voltage range) shall be within the values specified for each synchronous area in Table 9; – the position of the U-Q/Pmax-profile envelope shall be within the limits of the fixed outer envelope set out in Figure 8; and – the specified U-Q/Pmax profile may take any shape, having regard to the potential costs of delivering the capability to provide reactive power production at high voltages and reactive power consumption at low voltages; Figure 8: U-Q/Pmax-profile of a power park module. The diagram represents boundaries of a U-Q/Pmax-profile by the voltage at the connection point, expressed by the ratio of its actual value and its reference 1 pu value, against the ratio of the reactive power (Q) and the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative. Synchronous area Maximum range of Q/Pmax Maximum range of steady-state voltage level in PU Continental Europe 0.75 0.225 Nordic 0.95 0.150			

				Great Britain 0.66 0.225 Ireland and Northern Ireland 0.66 0.218 Baltic 0.80 0.220 Table 9: Parameters for the inner envelope in Figure 8			
21	3	b	iii	the reactive power provision capability requirement applies at the connection point. For profile 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;	-		
21	3	c		With regard to reactive power capability below maximum capacity:	-		
21	3	c	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements and shall specify a P-Q/Pmax-profile that may take any shape within the boundaries of which the power park module shall be capable of providing reactive power below maximum capacity;	Krav jf. Bilag 1.D  I dette område tillades det, at de reaktive egenskaber for PPM, kan være begrænset af et reduceret antal enheder i PPM som er i drift, grundet vedligehold eller fejl. I dette område tillades det, at de reaktive egenskaber for PPM, kan være begrænset af et reduceret antal enheder i PPM som er i drift, grundet opstart og nedlukning som funktion af primær energi, vedligehold eller fejl.		
21	3	c	ii	the P-Q/Pmax-profile shall be specified by each relevant system operator in coordination with the relevant TSO, in conformity with the following principles: – the P-Q/Pmax-profile shall not exceed the P-Q/Pmax-profile envelope, represented by the inner envelope in Figure 9; – the Q/Pmax range of the P-Q/Pmax-profile envelope is specified for each synchronous area in Table 9; – the active power range of the P-Q/Pmax-profile envelope at zero reactive power shall be 1 pu; – the P-Q/Pmax-profile can be of any shape and shall include conditions for reactive power capability at zero active power; and – the position of the P-Q/Pmax-profile envelope shall be within the limits of the fixed outer			

				envelope set out in Figure 9;			
21	3	c	iii	when operating at an active power output below maximum capacity (P<Pmax), the power park module shall be capable of providing reactive power at any operating point inside its P-Q/Pmax-profile, if all units of that power park module which generate power are technically available that is to say they are not out of service due to maintenance or failure, otherwise there may be less reactive power capability, taking into consideration the technical availabilities; ~~Figure 9: P-Q/Pmax-profile of a power park module. The diagram represents boundaries of a P-Q/Pmax-profile at the connection point by the active power, expressed by the ratio of its actual value and the maximum capacity pu, against the ratio of the reactive power (Q) and the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative.~~	-		
21	3	c	iv	the power park module shall be capable of moving to any operating point within its P-Q/Pmax profile in appropriate timescales to target values requested by the relevant system operator;			
21	3	d		with regard to reactive power control modes:	-		
21	3	d	i	the power park module shall be capable of providing reactive power automatically by either voltage control mode, reactive power control mode or power factor control mode;	-		
21	3	d	ii	for the purposes of voltage control mode, the power park module shall be capable of contributing to voltage control at the connection point by provision of reactive power exchange with the network with a setpoint voltage covering 0.95 to 1.05 pu in steps no greater than 0.01 pu, with a slope having a range of at least 2 to 7 % in steps no greater than 0.5 %. The reactive power output shall be zero when the grid voltage value at the connection point equals the voltage setpoint;	-		
21	3	d	iii	the setpoint may be operated with or without a deadband selectable in a range from zero to +-5 % of reference 1 pu network voltage in steps no greater than 0.5 %;	-		
21	3	d	iv	following a step change in voltage, the power park module shall be capable of achieving 90 % of the change in reactive power output within a time t1 to be specified by the relevant system operator in the range of 1 to 5 seconds, and must settle at the value specified by the slope within a time t2 to be specified by the relevant system operator in the range of 5 to 60 seconds, with a steady-state reactive tolerance no greater than 5 % of the maximum reactive power. The relevant system operator shall specify the time specifications;	t1: 1-5 sec: t1 = 1 sek. t2: 5-60 sec: t2 = 5 sek.		
21	3	d	v	for the purpose of reactive power control mode, the power park module shall be capable of setting the reactive power setpoint anywhere in the reactive power range, specified by point (a) of Article 20(2) and by points (a) and (b) of Article 21(3), with setting steps no greater than 5 MVAr or 5 % (whichever is smaller) of full reactive power, controlling the reactive power at the connection point to an accuracy within plus or minus 5 MVAr or plus or minus 5 % (whichever is smaller) of the full reactive power;	-		
21	3	d	vi	for the purpose of power factor control mode, the power park module shall be capable of controlling the power factor at the connection point within the required reactive power range, specified by the relevant system operator according to point (a) of Article 20(2) or specified by points (a) and (b) of Article 1821(3), with a target power factor in steps no greater than 0.01. The relevant system operator shall specify the target power factor value, its tolerance and the period	Target: Opløsning på 0.01 Tolerance og tid til nyt setpunkt: For reguleringsfunktionen gælder, at nøjagtigheden for en fuldført		

				of time to achieve the target power factor following a sudden change of active power output. The tolerance of the target power factor shall be expressed through the tolerance of its corresponding reactive power. This reactive power tolerance shall be expressed by either an absolute value or by a percentage of the maximum reactive power of the power park module;	regulering, over en periode på 1 minut, maksimalt må afvige 2 % af Qn. Regulering til et nyt setpunkt for effektfaktor skal påbegyndes inden for 2 sekunder og skal være fuldført inden for 30 sekunder fra modtagelse af ordre om setpunktsændring.		
21	3	d	vii	the relevant system operator, in coordination with the relevant TSO and with the power park module owner, shall specify which of the above three reactive power control mode options and associated setpoints is to apply, and what further equipment is needed to make the adjustment of the relevant setpoint operable remotely;	Driftsmode betinget af ydelseslevering. Produktionstelegraf anvendes til drift- og driftspunktændringer. For et transmissionstilsluttet *anlæg* i kategori D fastsattes den maksimalt tilladelige størrelse af maskintransformerens/nettransformerens kortslutningsreaktans i samarbejde med den *systemansvarlige virksomhed* på baggrund af anlægsejers anlægsdesignstudier og stabilitetsanalyser. Den tilladelige værdi skal fremgå af nettilslutningsaftalen for anlægget. Hvor der anvendes viklingskobler på maskintransformer/nettransformer, kan det aftales med den systemansvarlige virksomhed, at viklingskobleren må anvendes til opfyldelse af krav til reaktive reguleringsegenskaber. Hvis aftale indgås skal det fremgå af nettilslutningsaftalen for anlægget. Hvis der anvendes viklingskobler på maskintransformeren/nettransformer, er anlægsejer ansvarlig for den rette koordinering mellem anlæggets reaktive reguleringsfunktioner og viklingskoblerreguleringen.		
21	3	e		with regard to prioritising active or reactive power contribution, the relevant TSO shall specify whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception;	Reaktiv strøm prioriteres		
21	3	f		with regard to power oscillations damping control, if specified by the relevant TSO a power park module shall be capable of contributing to damping power oscillations. The voltage and reactive power control characteristics of power park modules must not adversely affect the damping of power oscillations.	PPM POD behov og performance afklares med aktørinddragelse i 2018/2019.		
Requirements for type D power park modules							
22				Type D power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b), (6) and (~~6~~7), Article 14, except for Article 14(~~3~~2), Article 15, except for Article 15(3), Article 16, Article 20 except for Article 20(2)(a) and Article 21.	-		

General provisions							
23	1			The requirements set out in this Chapter apply to the connection to the network of AC-connected power park modules located offshore. An AC-connected power park module located offshore which does not have an offshore connection point shall be considered as an onshore power park module and thus shall comply with the requirements governing power park modules situated onshore.	-		
23	2			The offshore connection point of an AC-connected offshore power park module shall be specified by the relevant system operator.	-		
23	3			AC-connected offshore power park modules within the scope of this Regulation shall be categorised in accordance with the following offshore grid connection system configurations:	-		
23	3	a		configuration 1: AC connection to a single onshore grid interconnection point whereby one or more offshore power park modules that are interconnected offshore to form an offshore AC system are connected to the onshore system;	-		
23	3	b		configuration 2: Meshed AC connections whereby a number of offshore power park modules are interconnected offshore to form an offshore AC system and the offshore AC system is connected to the onshore system at two or more onshore grid interconnection points.	-		
Frequency stability requirements applicable to AC-connected offshore power park modules							
24				Frequency stability requirements applicable to AC-connected offshore power park modules The frequency stability requirements laid down respectively in Article 13(1) to (5), except for Article 13(2)(b), Article 15(2) and Article 21(2) shall apply to any AC-connected offshore power park module.	-		
Voltage stability requirements applicable to AC-connected offshore power park modules							
25	1			Without prejudice to point (a) of Article 14(3) and point (a) of Article 16(3), an AC-connected offshore power park module shall be capable of staying connected to the network and operating within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to reference 1 pu voltage , and for the time periods specified in Table 10.	**CE** **(110 – 300 kV)** 1,118 – 1,15 pu/ 60 min **(300 – 400 kV)** 1,05 – 1,1 pu/ 60 min **N** **(300 – 400 kV)** 1,05 – 1,1 pu/60 min		
25	2			Notwithstanding the provisions of paragraph 1, the relevant TSO in Spain may require AC-connected offshore power park modules to remain connected to the network in the voltage range between 1.05 pu and 1.0875 pu for an unlimited period.	n/a		
25	3			Notwithstanding the provisions of paragraph 1, the relevant TSOs in the Baltic synchronous area may require AC-connected offshore power park modules to remain connected atto the 400 kV network in the voltage range and for the time periods that apply to the Continental Europe synchronous area.	n/a		

				---------- Synchronous area Voltage range Time period for operation Continental Europe 0.85 pu – 0.90 pu 60 minutes 0.9 pu – 1.118 pu* Unlimited 1.118 pu – 1.15 pu* To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes 0.90 pu – 1.05 pu** Unlimited 1.05 pu – 1.10 pu** To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes Nordic 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu* 60 minutes 1.05 pu – 1.10 pu** To be specified by each TSO, but not more than 60 minutes Great Britain 0.90 pu – 1.10 pu* Unlimited 0.90 pu – 1.05 pu** Unlimited 1.05 pu – 1.10 pu** 15 minutes Ireland and Northern Ireland 0.90 pu – 1.10 pu Unlimited Baltic 0.85 pu – 0.90 pu* 30 minutes 0.90 pu – 1.118 pu* Unlimited 1.118 pu – 1.15 pu* 20 minutes 0.88 pu – 0.90 pu** 20 minutes 0.90 pu – 1.097 pu** Unlimited 1.097 pu – 1.15 pu** 20 minutes * The voltage base for pu values is below 300 kV. ** The voltage base for pu values is from 300 kV to 400 kV. ~~Table 10: The table shows the minimum period during which an AC-connected offshore power park module must be capable of operating over different voltage ranges deviating from the reference 1 pu value without disconnecting.~~			
25	4			The voltage stability requirements specified respectively in points (b) and (c) of Article 20(2) as well as in Article 21(3) shall apply to any AC-connected offshore power park module.	-		
25	5			The reactive power capability at maximum capacity specified in point (b) of Article 21(3) shall apply to AC-connected offshore power park modules, except for Table 9. Instead, the requirements of Table 11 shall apply. Synchronous area Maximum range of Q/Pmax Maximum range of steady-state voltage level in PU Continental Europe 0.75 0.225 Nordic 0.95 0.150 Great Britain 0* 0.33** 0.225 Ireland and Northern Ireland 0.66 0.218 Baltic 0.8 0.22 *) at the offshore connection point for configuration 1 **) at the offshore connection point for configuration 2 Table 11: Parameters for Figure 8			
Robustness requirements applicable to AC-connected offshore power park modules							

26	1			The robustness requirements of power generating modules laid down in Article 15(4) and Article 20(3) shall apply to AC-connected offshore power park modules.	-		
26	2			The fault-ride-through capability requirements laid down in point (a) of Article 14(3) and point (a) of Article 16(3) shall apply to AC-connected offshore power park modules.	-		
System restoration requirements applicable to AC-connected offshore power park modules							
27				System restoration requirements applicable to AC-connected offshore power park modules The system restoration requirements laid down respectively in paragraph 4 of Article 14(4) and paragraph 5 of Article 15(5) shall apply to AC-connected offshore power park modules.	-		
General system management requirements applicable to AC-connected offshore power park modules							
28				General system management requirements applicable to AC-connected offshore power park modules The general system management requirements laid down in paragraph 5 of Article 14, paragraph 6 of(5), Article 15(6) and paragraph 4 of Article 16(4) shall apply to AC-connected offshore power park modules.	-		

Note til artikel 19 (2)(a)

Artikel 19 (2)(a)

Parametre og indstillinger af komponenter til spændingsregulering aftales og defineres med udgangspunkt i en specifik analyse.

Anlægskomponenter
I dette afsnit specificeres generelle stabilitetskrav til generator og maskintransformer for et anlæg. (forklaring)

Maskintransformer/nettransformer
For et anlæg i kategori D fastsattes den maksimalt tilladelige størrelse af maskintransformerens/nettransformerens kortslutningsreaktans i samarbejde med den systemansvarlige virksomhed på baggrund af anlægsejers anlægsdesignstudier og stabilitetsanalyser. Den tilladelige værdi skal fremgå af nettilslutningsaftalen for anlægget.

Hvor der anvendes viklingskobler på maskintransformer/nettransformer, kan det aftales med den systemansvarlige virksomhed, at viklingskobleren må anvendes til opfyldelse af krav til reaktive reguleringsegenskaber. Hvis aftale indgås skal det fremgå af nettilslutningsaftalen for anlægget.

Hvis der anvendes viklingskobler på maskintransformeren/nettransformer, er anlægsejer ansvarlig for den rette koordinering mellem anlæggets reaktive reguleringsfunktioner og viklingskoblerreguleringen.

Generator
For et anlæg i kategori D fastsættes krav til kortslutningsforhold og transient reaktans i samarbejde med den systemansvarlige virksomhed på baggrund af anlægsejers anlægsdesignstudier og stabilitetsanalyser. De tilladelige værdier skal fremgå af nettilslutningsaftalen for anlægget.

Magnetiseringssystem

Et SGM skal være udstyret med et kontinuert fungerende automatisk magnetiseringssystem. Formålet er at sikre stabil drift af anlægget, samt give mulighed for at bidrage til regulering af spænding og/eller den reaktive effektbalance i det kollektive elforsyningsnet.

Magnetiseringssystemet skal konstrueres i overensstemmelse med den europæiske standard DS/EN 60034-16-1:2011 "Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions", [Ref. 21] og DS/CLC/TR 60034-16-3:2004 "Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance".

I tilfælde af netforstyrrelser der medfører spændingsreduktion, skal generatoren i mindst 10 sekunder kunne overmagnetiseres 1,6 gange magnetiseringsstrøm og -spænding ved nominel effekt og tgϕ = 0,4 i POC og nominel driftsspænding. Hvis overmagnetiseringsegenskaben afhænger af spændingen i POC, skal den nævnte egenskab være tilgængelig ved reduceret netspænding i POC ned til 0,6 pu.

Generatorens overmagnetiseringsbeskyttelse og anden beskyttelse skal konstrueres og indstilles, så generatorens evne til midlertidig overbelastning kan udnyttes uden at overskride generatorens termiske grænser.

Magnetiseringssystemets begrænserfunktioner skal være selektive med anlæggets beskyttelsesfunktioner, og derved muliggøre kortvarig udnyttelse af overbelastningsegenskaber uden udkobling af anlægget.

Magnetiseringssystemets tidsrespons (målt på generatorklemmerne) under tomgang (generatoren er frakoblet nettet og drevet ved nominel omløbshastighed) ved en momentan 10 % ændring af referencespændingen skal vare ikke-oscillerende, og have en stigetid ("rise-time"), som defineret i DS/EN 60034-16-3, på maksimalt 0,3 sekund for et statisk magnetiseringssystem. For et roterende magnetiseringssystem ("rotating exciter") tillades et tidsrespons på maksimalt 0,5 sekund ved en positiv 10 % ændring af referencespandingen og tilsvarende maksimalt 0,8 sekund ved en negativ 10 % ændring af referencespændingen.

Magnetiseringssystemets oversving ("overshoot") målt på generatorklemmerne, som defineret i DS/EN 60034-16-3, ved en momentan 10 % ændring i referencespændingen, må maksimalt være 15 % af ændringen.

Verifikationskrav magnetiseringssystem

Verifikation af ovenstående funktionskrav til magnetiseringsudstyret skal vedlægges som dokumentation. Udførte simuleringer, relevante målinger fra idriftsættelsestest, funktionsbeskrivelser samt "as build" indstillingsværdier skal vedlægges som del af den samlede anlægsdokumentation.

Koordinering mellem begrænserfunktioner og beskyttelsesfunktioner dokumenteres ved et P/Q-diagram for hhv. statisk og dynamisk karakteristik, indeholdende funktionstider og aktiveringsniveauer.

Simulering, analyse og idriftsættelsestest skal anvendes til at dokumentere, at magnetiseringssystemet har tilfredsstillende dynamiske egenskaber.

De udførte simuleringer skal omfatte nedenstående testscenarier:

1. RMS-simulering af spændingsdyk i henholdt til nedstående funktion, hvor maskinens før fejl driftspunkt er defineret ved UPOC = 1 pu, P = 1 pu, QPOC = 0,4 pu:
    a. Upoc(t) = $\begin{cases} 1\ pu\ hvor\ t < 0\ s \\ 0{,}6\ pu\ hvor\ t > 0\ s \end{cases}$
2. RMS-simulering af stepresponstest ved en momentan +/- 10 % ændring af referencespændingen, hvor maskinen drives i tomgang og ved nominel omløbshastighed.

Den udførte idriftsættelse skal indeholde nedenstående tests:

1. Stepresponstest ved en momentan +/- 10 % ændring af referencespændingen, hvor maskinen drives i tomgang og ved nominel omløbshastighed.
2. Test af selektivitet mellem undermagnetiseringsbeskyttelse og undermagnetiseringsbegrænser. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et undermagnetiseret arbejdspunkt, som ligger uden for det tilladelige arbejdsområde for undermagnetiseringsbegrænser.
    b. Oprampning af aktiv effekt, fra Pmin til Pn, hvor maskinen, inden påbegyndelse af test, ligges i et fuldt undermagnetiseret arbejdspunkt.
3. Test af selektivitet mellem overmagnetiseringsbeskyttelse og overmagnetiseringsbegrænseren. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et overmagnetiseret arbejdspunkt, som ligger uden for det tilladelige arbejdsområde for overmagnetiseringsbegrænseren.
    b. Oprampning af aktiv effekt, fra Pmin til Pn, hvor maskinen, inden påbegyndelse af test, ligges i et fuldt overmagnetiseret arbejdspunkt.
4. Test af statorstrømsbegrænsers performance. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for den tilladelige strømværdi for statorstrømsbegrænser. Testen udføres ved reduceret indstillinger.

5. Test af V/Hz-begrænsers performance. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for det tilladelige forhold mellem spænding og frekvens for V/Hz-begrænser. Testen udføres ved reduceret indstillinger og hvor maskinen drives i tomgang og ved nominel omløbshastighed.
    b. Ændring af omløbshastighed, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for det tilladelige forhold mellem spænding og frekvens for V/Hz-begrænser. Testen udføres ved reduceret indstillinger og hvor maskinen drives i tomgang og ved nominel omløbshastighed før ændring af omløbshastighed.

PSS-funktion

PSS-funktionen skal anvende input fra både rotorhastighed/netfrekvens og aktiv effekt (dual input) til at udlede stabilitetssignalet, hvor en dæmpetilsats af typen IEEE PSS2B, jf. IEEE 421.5 er normgivende.

Justering af PSS-funktionen skal være således, at der opnås en positiv dæmpning i frekvensområdet 0,2 til 0,7 Hz.

Fasen af det tilførte dæmpningssignal som produceres af PSS-funktionen skal i frekvensområdet 0,2 til 2 Hz være i fase med hastighedsændringen for generatorens rotor. Afvigelser på op til -30 grader (underkompenseret) kan accepteres.

Dæmpning af anlæggets effektoscillationer (eksponentielt aftagende funktion) skal ved alle arbejdspunkter, og ved enhver forstyrrelse med PSS-funktionen aktiveret, være hurtigere end 1 sekund.

Anlæggets naturlige dæmpning af "local mode" effektoscillationer må ikke påvirkes negativt af PSS-funktionen.

Justeringen af PSS-funktionen skal være således, at ændringer af anlæggets arbejdspunkt (aktiv effekt) under normal drift, eller ved en fejl i fx turbineregulator, kedelanlæg, fødevandsanlæg eller andre hjælpekraftanlæg, ikke må medføre, at spændingen på højspændingssiden af anlæggets maskintransformer ændres mere end 1 %.

PSS-udgangssignalet skal begrænses, således at aktivering af PSS-funktionen ikke medfører en ændring af generatorspændingen større end +/- 5 % af generatorens nominelle spænding. Det er tilladt, at grænserne reduceres automatisk og dynamisk af spændingsregulatoren, fx ved aktivering af magnetiseringssystemets begrænserfunktioner.

PSS-funktionen skal deaktiveres automatisk, når den producerede aktive effekt er mindre end 20 % af nominel effekt.
Det skal vare muligt at ind- og udkoble PSS-funktionen. Ved udkobling af PSS– funktionen skal der afgives en alarm.

Verifikationskrav PSS funktion

Overholdelse af ovenstående funktionskrav til PSS-funktionen skal vedlægges som dokumentation. Udførte simuleringer, relevante målinger fra idriftsættelsestest, funktionsbeskrivelser samt "as build" indstillingsværdier skal vedlægges som en del af den samlede anlægsdokumentation.

Simulering, analyse og idriftsættelsestest skal anvendes til at dokumentere, at de anvendte indstillingsværdier giver PSS-funktionen og det samlede magnetiseringssystem tilfredsstillende dynamiske egenskaber.

De udførte simuleringer skal omfatte nedenstående testscenarier, hvor disse, med undtagelse af Test 5, skal simuleres med PSS-funktionen aktiveret henholdsvis deaktiveret:

1. Verifikation af frekvenskarakteristikken, herunder korrekt fasekompensering af det samlede magnetiseringsanlæg, i form af Bode plots for forstærkning og fase.
2. Steprespons ved en momentan +/- 5 % ændring af referencespændingen. Simuleringer gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt.
3. Generatornær kortslutning.
4. Udkobling af en linje, hvor ændringen i det kollektive elforsyningsnet går fra stærkeste- til svageste netkonfiguration (kortslutningseffekt). Simuleringer gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt.
5. Ændring af generatorens tilførte mekaniske effekt fra drivmaskinen i henholdende til nedstående funktioner (PSS-enhed skal være aktiv):
    a. Sinusfunktion, $p(t) = A \cdot Sin(\omega \cdot t), A = 0{,}1\ pu, \omega = 2 \cdot \pi \cdot \frac{1}{60}\ rad$
    b. Rampefunktion, $p(t) = \begin{cases} 0\ pu\ hvor\ t < 0\ s \\ 0{,}25 \cdot t\ pu\ hvor\ 0\ sec < t \leq 4\ s \\ 1\ pu\ hvor\ t > 4\ s \end{cases}$

c. Stepfunktion, $p(t) = \begin{cases} 1\ pu\ hvor\ t < 0\ s \\ 0{,}6\ pu\ hvor\ t > 0\ s \end{cases}$

Den udførte idriftsættelse skal indeholde nedenstående tests:

1. Måling af fase og forstærkning (bode plot) for overføringsfunktionen Vt(s)/Vref(s) med PSS-funktionen deaktiveret og SGM drevet "off-grid", ved nominel omløbshastighed og -terminalspænding.
2. Måling af fase og forstærkning (bode plot) for overføringsfunktionen Vt(s)/Vref(s) med PSS-funktionen deaktiveret og SGM drevet "on-grid", ved et driftspunkt så tæt på P = 0 og Q = 0, som muligt.
3. Måling af overføringsfunktion for PSS-funktionen.
4. Stepresponstest ved en momentan +/- 5 % ændring af referencespændingen. Testen gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt med PSS-funktionen aktiveret henholdsvis deaktiveret.
5. Forøgelse af PSS-forstærkning med en faktor 3 af den foreslåede værdi.

Reguleringsfunktioner for reaktiv effekt regulering:
Følgende krav til reguleringsfunktioner for reaktiv effekt og spænding.

Reguleringsfunktionerne Q-regulering, effektfaktor og spændingsregulering udelukker gensidigt hinanden, så det kun er en af de tre funktioner, der kan aktiveres ad gangen.

Q-regulering
For reguleringsfunktionen for Q-regulering gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen < 3 % af Qn målt over en periode på 1 minutter. Anlægget skal kunne modtage et setpunkt med minimum opløsning af Q på 100 kVAr.

Effektfaktor regulering
For reguleringsfunktionen effektfaktor-regulering gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen < 3 % af Qn målt over en periode på 1 minutter.

Den aktuelle Q værdi skal omregnes ud fra anlæggets aktuelle effektfaktor setpunkt.

Anlægget skal kunne modtage et setpunkt men minimum opløsning af effektfaktoren på 0,01.

Automatisk spændingsregulering (AVR)
Nøjagtigheden for den fuldførte ændring eller en kontinuerlig regulering, inkl. nøjagtighed på setpunktet, maksimalt må afvige 0,5 % setpunktet af spændingsreguleringen.

Anlægget skal kunne modtage et setpunkt for spændingen med et minimum opløsning på 0,1 kV.

Statikken for automatisk spændingsregulering skal kunne indstilles til en værdi i området mellem 2 og 8 %, begge inklusiv.