November 2022

Guide for connection of power-generating plants to the medium and high-voltage grid (>1 kV)

Type B, C and D

Version 1.2

VERSION LOG

Version	Change	Date
1.0	A translated version of the Danish Guide for Power generating plants MV and HV	30-04-2019
1.1	Update of annex	29-10-2021
1.2	Layout update.	18-11-2022

TABLE OF CONTENTS

1. INTRODUCTION

This document describes the requirements for power-generating plants connected to the medium and high-voltage grid. The requirements for power-generating plants are divided into four main types based on the plant's active power capacity:

A. Plants up to 125 kW
B. Plants from 125 kW up to 3 MW
C. Plants from 3 MW up to 25 MW
D. Plants from 25 MW

This document only contain requirements for power-generating plants in types B, C and D as only plants in these types can be connected to the medium and high-voltage grid. Smaller plants are connected to the low-voltage grid.

Requirements for type B power-generating plants are also available in '*Technical requirements for connection of power-generating plants to the low-voltage grid (≤1 kV)*'.

Chapter 2 contains the administrative provisions. This chapter describes, among other things, the purpose, statutory authority, appeal procedures and exceptions. The chapter also contains a list of normative and informative references.

Definitions and abbreviations used in these requirements are included in Chapter 3.

Chapters 4, 5 and 6 contain requirements for power-generating plants in types B, C and D, respectively. All requirements specified in these requirements apply at the Point of Connection (POC) unless otherwise specified.

If you are to connect a type B power-generating plant to the grid, you only need to read Chapters 2 and 3 and the chapter on type B plants, including the relevant annex. This also applies to power-generating plants in types C and D which have their own chapters and annex.

The term 'power-generating plant' is used to cover **common** requirements for power park modules and synchronous power-generating plants. Where **specific** requirements apply to 'power park modules' or 'synchronous power-generating plants', they are designated as such.

For clarity purposes, supplementary or additional requirements for synchronous power-generating plants are marked with **(a)** and for power park modules with **(b)**.

The sections are structured so that general requirements are stated first followed by specific requirements for synchronous power-generating plants and power park modules, respectively.

2. PURPOSE AND ADMINISTRATIVE PROVISIONS

2.1. Purpose

The purpose of these requirements is to describe the applicable technical and functional requirements for a power-generating plant connected – or planned to be connected – to the public medium and high-voltage distribution grid.

If these requirements are complied with, the power-generating plant is deemed to be in compliance with applicable rules and regulations for connection to the public electricity supply grid.

2.1.1. Legal framework and terms and conditions

This guide is written based on the technical requirements set by distribution system operators and Energinet. These requirements are derived from 'COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators'.

In addition, this guide also includes requirements to power-generating plants based on the Danish Electricity Supply Act paragraph 26, 73a, and 73b.

In case of doubt about the interpretation of the technical requirements, the version of the requirements registered with Danish authorities has precedence.

2.1.2. New power-generating plants

New power-generating plants connected to the grid after 27 April 2019 must comply with the requirements set out in these requirements. Existing power-generating plants connected to the grid after this date are exempt from the requirements, see section 2.1.3.

2.1.3. Existing power-generating plants

A power-generating plant is considered existing if it was connected to the grid before 27 April 2019 or if the plant owner entered into a final and binding purchase agreement regarding the main generating plant before 17 Maj 2018.

An existing power-generating plant must comply with the requirements applicable at the time of connection to the grid, or at the time when the plant owner entered into a final and binding purchase agreement regarding the main generating plant.

2.1.4. Modification of existing power-generating plants

An existing power-generating plant, or parts thereof, to which substantial technical modifications are made must comply with the technical and functional requirements provided in these requirements.

A substantial modification of a power-generating plant changes the electrical properties of the plant at the Point of Connection (POC) and may, for example, include replacement of vital components.

Before any modification is made, the power-generating plant owner is obliged to notify the DSO about the modification.

2.2. Scope

The requirements for power-generating plants are divided into four types based on the plant's active power capacity.

A. Plants up to 125 kW*
B. Plants from 125kW up to 3 MW(*)
C. Plants from 3MW up to 25 MW
D. Plants from 25MW

**These power-generating plant types are covered in 'Technical requirements for connection of power-generating plants to the low-voltage grid (≤1 kV)'. Type A plants connected to medium voltage must comply with the requirements for type A plants in the 'Technical requirements for connection of power-generating plants to the low-voltage grid (≤1 kV)'.*

(*) Type B power-generating plants can be connected to both the low and medium-voltage grid depending on the size of the plant. This type is therefore included in both requirements documents.

Back-up power generating units operated in parallel with the public electricity supply grid for less than five minutes per month, excluding unit maintenance and commissioning testing, are not required to comply with the requirements in this document. If the Back-up power generating unit is operated for more than five minutes per month at normal operation, the unit must comply with the requirements for power quality and protection as provided in these requirements.

These requirements do not include the financial aspects related to grid connection and settlement metering of power-generating plants.

If a power-generating plant comprises both consumption and generation, these will be evaluated separately.

2.3. Complaints about grid connection of power-generating plants

Complaints about the DSO in relation to grid connection of power-generating plants can be lodged with the Danish Utility Regulator.

2.4. Sanctions in case of noncompliance

If a power-generating plant does not comply with applicable rules and conditions, the DSO may ultimately withdraw the operational notification and disconnect the plant until the requirements are met.

2.5. Exemption from grid connection requirements

It is possible to apply for an exemption from the requirements in this document under special circumstances.

The power-generating plant owner must send an exemption application to the DSO. Depending on the nature of the application, it will be forwarded to the Danish Utility Regulator, which will make a decision.

An exemption application must contain a detailed description, which at least includes:

- Identification of the power-generating plant owner, as well as a contact person.
- A description of the power-generating plant(s) which the requested exemption concerns.
- A reference to the provisions which the requested exemption concerns as well as a description of the requested exemption.
- A detailed description of the reasons for the requested exemption supported by relevant documentation and a cost-benefit analysis.
- Documentation showing that the requested exemption does not have an adverse effect on open power trading.

2.6. Determination of voltage level and Point of Connection

The DSO determines the Point of Connection (POC) and associated voltage level in accordance with the provisions of the Danish Electricity Supply Act.

All requirements apply to the Point of Connection (POC), unless otherwise specified.

2.7. References

2.7.1. Normative

EU Regulation 2016/631

Joint Regulation 2017 (Fællesregulativet 2017)

The Danish Electricity Supply Act (Elforsyningsloven)

Requirements for Generators (RfG) – requirements for simulation models, Energinet 2019

DS/EN 50160: Voltage characteristics of electricity supplied by public distribution networks.

prEN 50549-2: Requirements for generating plants to be connected in parallel with distribution networks – Part 2: Connection to a MV distribution network.

DS/EN 61000-4-30: Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods.

DS/EN 61400-21:2008: Wind turbines – Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines.
DS/EN 60034-16-1:2011: 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions'.
DS/CLC/TR 60034-16-3:2004: 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance'.

2.7.2. Informative

IEC/TR 61000-3-6: Electromagnetic compatibility (EMC) – Part 3-6: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.
IEC/TR 61000-3-7: Electromagnetic compatibility (EMC) – Part 3-7: Limits – Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems.
DS/EN 61000-3-11: Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤75A and subject to conditional connection.
DS/EN 61000-3-12: Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16A and ≤75A per phase.
IEC/TR 61000-3-13: Electromagnetic compatibility (EMC) – Part 3-13: Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems.
IEC/TR 61000-3-15: Electromagnetic compatibility (EMC) – Part 3-15: Limits – Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network.
Research Association of the Danish Electric Utilities (DEFU) report RA 557: 'Maximum emission of voltage disturbances from wind power plants >11 kW', June 2010.
DS/CLC/TS 50549-2: Requirements for generating plants to be connected in parallel with distribution networks – Part 2: Connection to a MV distribution network.
IEEE C37.111-24:2013: Measuring relays and protection equipment – Part 24: Common format for transient data exchange (COMTRADE) for power systems.

3. DEFINITIONS/TERMS

3.1. ABBREVIATIONS

3.1.1. ψ_k

ψ_k denotes the short-circuit angle at the Point of Connection (POC).

3.1.2. C_f

C_f denotes the flicker co-efficient. For a more detailed description, see DS/EN 61400-21.

3.1.3. COMTRADE

COMTRADE (Common Format for Transient Data) is a standardised file format specified in IEEE C37.111-2013.

3.1.4. d(%)

d(%) denotes rapid voltage changes. For a more detailed description, see 3.2.29.

3.1.5. DK1

Western Denmark. For a more detailed description, see 3.2.67.

3.1.6. DK2

Eastern Denmark. For a more detailed description, see 3.2.70.

3.1.7. df/dt

df/dt denotes frequency change. For a more detailed description, see 3.2.23.

3.1.8. DSO

Distribution system operator, see 3.2.10.

3.1.9. $f_<$

$f_<$ denotes the operational setting for underfrequency in the relay protection.
For a more detailed description, see sections 4.5, 5.5 and 6.5.

3.1.10. $f_>$

$f_>$ denotes the operational setting for overfrequency in the relay protection.
For a more detailed description, see sections 4.5, 5.5 and 6.5.

3.1.11. f_{RO}

f_{RO} denotes the frequency at which a power-generating plant is to begin downward regulation with the agreed droop. For a more detailed description, see sections 4.3.1, 5.3.1 and 6.3.1.

3.1.12. f_{RU}

f_{RO} denotes the frequency at which a power-generating plant is to begin upward regulation with the agreed droop. For a more detailed description, see sections 5.3.2 and 6.3.2.

3.1.13. I_h

I_h denotes individual harmonic currents, where h denotes the harmonic order.

3.1.14. I_n

I_n denotes nominal current. For a more detailed description, see 3.2.44.

3.1.15. I_Q

I_Q denotes fast fault current. For a more detailed description, see 3.2.53.

3.1.16. k_u

k_u denotes voltage change factor. The voltage change factor is calculated as a function of ψ_k.

3.1.17. $P_{possible}$

$P_{possible}$ denotes the maximum active power, which it is possible to produce under given circumstances.

3.1.18. P_{min}

P_{min} denotes the minimum possible active power generation from a power-generating plant.

3.1.19. P_n

P_n denotes nominal active power. For a more detailed description, see 3.2.41.

3.1.20. P_{lt}

P_{lt} denotes long-term flicker emissions from a power-generating plant. P_{lt} stands for 'long term' and is evaluated over a period of two hours. For a more detailed description, see IEC 61000-3-7.

3.1.21. P_{st}

P_{st} denotes short-term flicker emissions from a power-generating plant. P_{st} stands for 'short term' and is evaluated over a period of ten minutes. For a more detailed description, see IEC 61000-3-7.

3.1.22. PCC

Abbreviation for Point of Common Coupling. For a more detailed description, see 3.2.38.

3.1.23. PCI

Abbreviation for Point of Connection in Installation. For a more detailed description, see 3.2.31.

3.1.24. PCOM

Abbreviation for Point of Communication. PCOM is defined in section 3.2.34.

3.1.25. PF

Abbreviation for Power Factor. For a more detailed description, see 3.2.8.

3.1.26. PGC

Abbreviation for Point of Generator Connection. For a more detailed description, see 3.2.25.

3.1.27. POC

Abbreviation for Point of Connection. POC is defined in section 3.2.40.

3.1.28. PWHD

Abbreviation for Partial Weighted Harmonic Distortion. For a more detailed description, see 3.2.49.

3.1.29. Q_n

Q_n denotes nominal reactive power. For a more detailed description, see 3.2.42.

3.1.30. S_i

S_i denotes apparent power of power-generating unit no. i.

3.1.31. S_k

S_k denotes short-circuit power. For a more detailed description, see 3.2.35.

3.1.32. S_n

S_n denotes nominal apparent power. For a more detailed description, 3.2.45.

3.1.33. SCR

Abbreviation for Short-Circuit Ratio. For a more detailed description, see 3.2.37.

3.1.34. THD

Abbreviation for Total Harmonic Distortion. For a more detailed description, see 3.2.65.

3.1.35. U_c

U_c denotes normal operating voltage. For a more detailed description, see 3.2.46.

3.1.36. U_h

U_h denotes individual harmonic voltages, where h denotes the harmonic order.

3.1.37. U_n

U_n denotes nominal voltage. For a more detailed description, see 3.2.43.

3.1.38. UTC

Abbreviation for Universal Time, Coordinated.

3.1.39. $Z_{net,h}$

$Z_{net,h}$ denotes grid impedance of the harmonic order h.

3.2. Definitions

3.2.1. Absolute power limit

A control function which limits a power-generating plant's supply of active power into the public electricity supply grid. This limit can be specified with a set point. The control function is described in detail in sections 4.3.2.1, 5.3.4.1 and 6.3.4.1.

3.2.2. Power-generating plant owner

The legal owner of a power-generating plant. In some contexts, the term 'company' is used instead of 'power-generating plant owner'. The plant owner can transfer the operational responsibility to a plant operator.

3.2.3. Power-generating plant types

In this document, the requirements are divided into different power-generating plant types based on the total size of the plant at the Point of Connection (POC). An overview of the types in relation to their total active power capacity is included in table 3.1 below.

Type A	Type B	Type C	Type D
< 125 kW	≥ 125 kW and < 3 MW	≥ 3 MW and < 25 MW	≥ 25 MW

Table 3.1 – Power-generating plant types.

3.2.4. Plant operator

The company which has the operational responsibility for the power-generating plant through ownership or contractual obligation.

3.2.5. Automatic Power Factor control

A control function for reactive power, where the Power Factor is adjusted according to a set point, and where the set point for the Power Factor varies as a function of active power. The control function is described in detail in section 4.4.3.

3.2.6. DC content

A DC current which results in an AC offset, meaning that the AC current is asymmetric around zero at the Point of Connection (POC).

3.2.7. Delta power limit

A control function for active power with a set point-determined deviation (delta) between possible and actual power. The control function is described in detail in sections 5.3.4 and 6.3.4.

3.2.8. Power Factor (PF)

The Power Factor, $\cos \varphi$, for AC systems indicates the relationship between the active power P and the apparent power S, where $P = S \cdot \cos\varphi$. Similarly, the reactive power is $Q = S \cdot \sin\varphi$. The angle between current and voltage is denoted by ϕ.

3.2.9. Power Factor control

A control function for reactive power, where the Power Factor is adjusted according to a set point, and the Power Factor set point is fixed. The control function is described in detail in sections 4.4.2, 5.4.2 and 6.4.2.

3.2.10. Distribution system operator (DSO)

The company who owns the grid a power-generating plant is electrically connected to. Responsibilities in the public electricity supply grid are distributed among several DSOs and one transmission system operator.

The DSO is the company licensed to operate the public electricity supply grid **up to** 100 kV.

The transmission system operator is the company licensed to operate the public electricity supply grid **above** 100 kV.

3.2.11. Power park module

An power-generating unit or a collection of power-generating units producing electricity which are not synchronously connected to the public electricity supply grid. Thus, all power-generating plants which are not synchronous power-generating plants constitute power park modules.

3.2.12. Power-generating unit

A source of electrical energy which is connected to the public electricity supply grid.

3.2.13. Flicker

A visual perception of light flickering caused by voltage fluctuations. Flicker occurs if the luminance or the spectral distribution of light fluctuates with time. At a certain intensity, flicker becomes an irritant to the eye.

3.2.14. Distortions in the 2-9 kHz frequency range

Distortions in the 2-9 kHz frequency range can be found in the public electricity supply grid. Such frequencies may interfere with other customers. Interference with other customers typically occurs when emissions in this frequency range interfere with one or more resonant frequencies in the public electricity supply grid.

3.2.15. Disconnect

When a power-generating plant breaks the electrical connection to the public electricity supply grid.

3.2.16. Frequency

Frequency is measured in Hertz (Hz). The grid frequency in the public electricity supply grid is 50 Hz. There are also other frequencies related to power quality. Such frequencies are referred to as harmonics, interharmonic overtones and distortions in the 2-9 kHz frequency range. In connection with power quality, grid frequency is referred to as the fundamental frequency.

3.2.17. Frequency deviation

When the grid frequency is outside the normal operating range.

3.2.18. Frequency control (FSM)

A control function for active power controlling the active power in order to stabilise the grid frequency. The control function is described in detail in sections 5.3.3 and 6.3.3.

In the RfG, this type of control is called FSM (frequency-sensitive mode).

3.2.19. Power response to overfrequency (LFSM-O)

A control function for active power which automatically reduces active power as a function of the grid frequency in order to stabilise the grid frequency. Downward regulation is initiated when the grid frequency exceeds a certain f_{RO}. The control function is described in detail in sections 4.3.1, 5.3.1 and 6.3.1.

In the RfG, this type of control is called LFSM-O (limited frequency sensitive mode at overfrequency).

3.2.20. Power response to underfrequency (LFSM-U)

A control function for active power which automatically increases active power as a function of the grid frequency in order to stabilise the grid frequency. Upward regulation is initiated when the grid frequency is below a certain f_{RU}. The control function is described in detail in sections 5.3.2 and 6.3.2.

In the RfG, this type of control is called LFSM-U (limited frequency sensitive mode at underfrequency).

3.2.21. Frequency control droop

The percentage frequency change which will cause an active power change corresponding to the nominal active power of the power-generating plant.

Formula for frequency control droop:

$$droop\ [\%] = 100 \cdot \frac{|\Delta f|}{f_n} \cdot \frac{P_n}{|\Delta P|}$$

3.2.22. Frequency response droop

The percentage frequency change which will cause an active power change corresponding to the nominal active power of the power-generating plant.

Formula for frequency response droop:

$$droop\ [\%] = 100 \cdot \frac{|f - f_R|}{f_n} \cdot \frac{P_n}{|\Delta P|}$$

3.2.23. Frequency change

A change of frequency, ROCOF or df/dt, is a change of the grid frequency in the public electricity supply grid over a period of time.

3.2.24. Generator convention

These requirements apply the generator convention as shown in figure 3.1.

The sign for active/reactive power indicates the power flow as seen from the generator. Consumption/import of active/reactive power is stated with a negative sign, while the generation/export of active/reactive power is stated with a positive sign.

The desired Power Factor control is effected with a Power Factor set point, and the sign determines if control is to be performed in the first or the fourth quadrant.

Power Factor set points thus combine two pieces of information in a single signal: a set point value and choice of control quadrant.

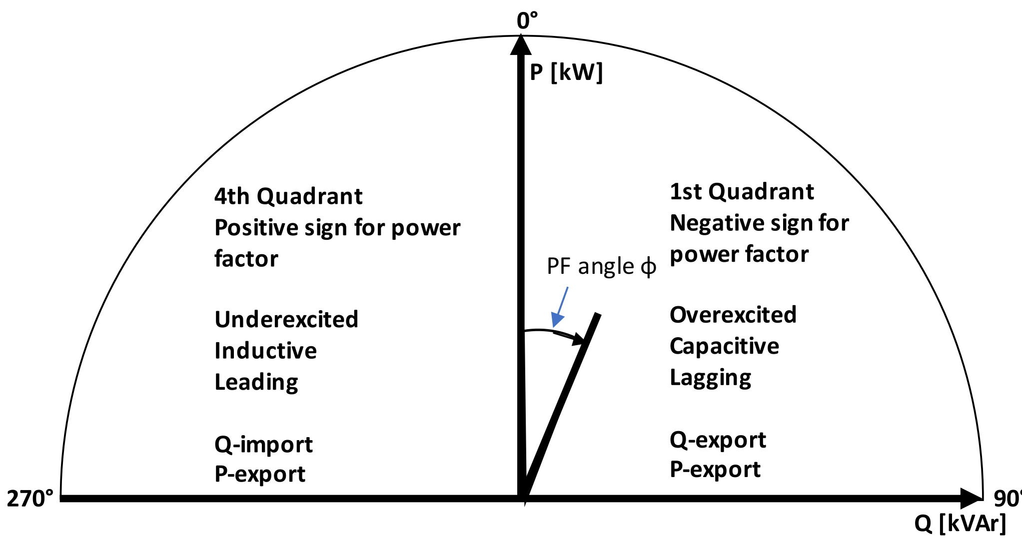

Figure 3.1 – Definition of signs for active and reactive power, Power Factor and reference for Power Factor angle.

3.2.25. Point of Generator Connection (PGC)

The point in the power-generating plant infrastructure where the terminals for the power-generating unit are located. The power-generating unit's Point of Generator Connection is the point which the manufacturer defines as being the power-generating unit's terminals. See figure 3.3 and figure 3.4.

3.2.26. Reconnection

Connecting after an event where the power-generating plant has been disconnected from the public electricity supply grid.

3.2.27. Ramp rate limit

A control function for active power limiting the maximum increase/reduction (gradient) of the active power. The control function is described in detail in sections 4.3.2.2, 5.3.4.2 and 6.3.4.2.

3.2.28. Harmonics

Electrical disturbances caused by overharmonic currents or voltages. Harmonics are frequencies which are a whole multiple (h) of the fundamental frequency (50 Hz).

3.2.29. Rapid voltage change

A transient isolated change of the RMS voltage. A rapid voltage change is expressed as a percentage of the normal operating voltage.

3.2.30. Connection

When a power-generating plant is electrically connected to the public electricity supply grid, thereby becoming energised from the public electricity supply grid.

3.2.31. Point of Connection in Installation (PCI)

The point in the installation where power-generating units are connected or can be connected, see figure 3.3 for typical location.

3.2.32. Interharmonic overtones

Electrical disturbances caused by interharmonic currents or voltages. Interharmonic overtones are frequencies that are not a whole multiple of the fundamental frequency (50 Hz). These frequencies are located between the harmonics.

3.2.33. The public electricity supply grid

Publicly regulated transmission and distribution grids with the purpose of transporting electricity between suppliers and consumers of electricity.

The distribution grid is defined as the public electricity supply grid with a nominal voltage **below** 100 kV.

The transmission grid is defined as the public electricity supply grid with a nominal voltage **above** 100 kV.

3.2.34. Point of Communication (PCOM)

The point where information is exchanged between the power-generating plant and other actors. The information exchanged comprises signals, such as measurements, status, set points and commands.

3.2.35. Short-circuit power (S_k)

The magnitude of the three-phase short-circuit power at the Point of Connection (POC).

3.2.36. Short-circuit power quality ($S_{k,powerquality}$)

The magnitude of the three-phase short-circuit power at the Point of Connection (POC), which is used to calculate power quality.

3.2.37. Short-Circuit Ratio (SCR)

The relationship between the short-circuit power at the Point of Connection (POC) $S_{k,powerquality}$ and the power-generating plant's nominal apparent power S_n.

$$SCR = \frac{S_{k,powerquality}}{S_n}$$

3.2.38. Point of Common Coupling (PCC)

The point in the public electricity supply grid where consumers are or can be connected.

Electrically speaking, the Point of Common Coupling and the Point of Connection (POC) may coincide. The Point of Common Coupling (PCC) is always the point deepest inside the public electricity supply grid, i.e. furthest away from the power-generating plant, see figure 3.3 and figure 3.4.

The DSO determines the Point of Common Coupling (PCC).

3.2.39. Excitation system

An excitation system is a system in synchronous power-generating plants which delivers a constant voltage at a selectable reference point at the Point of Connection (POC). See figure 3.2.

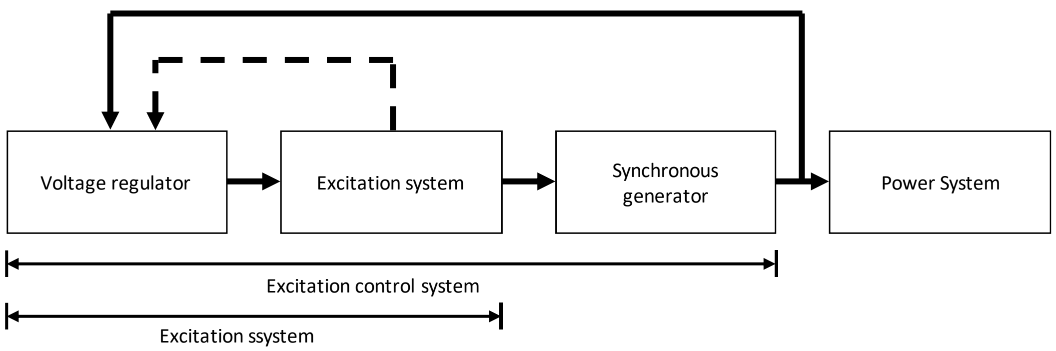

Figure 3.2 – Excitation system for synchronous generator

3.2.40. Point of Connection (POC)

The point in the public electricity supply grid where a power-generating plant is or can be connected, see figure 3.3 and figure 3.4 for typical location.

All requirements specified in this document apply to the Point of Connection (POC), unless otherwise specified.

Power-generating plants which have the same Point of Common Coupling (PCC) and the same owner are deemed to be one plant.

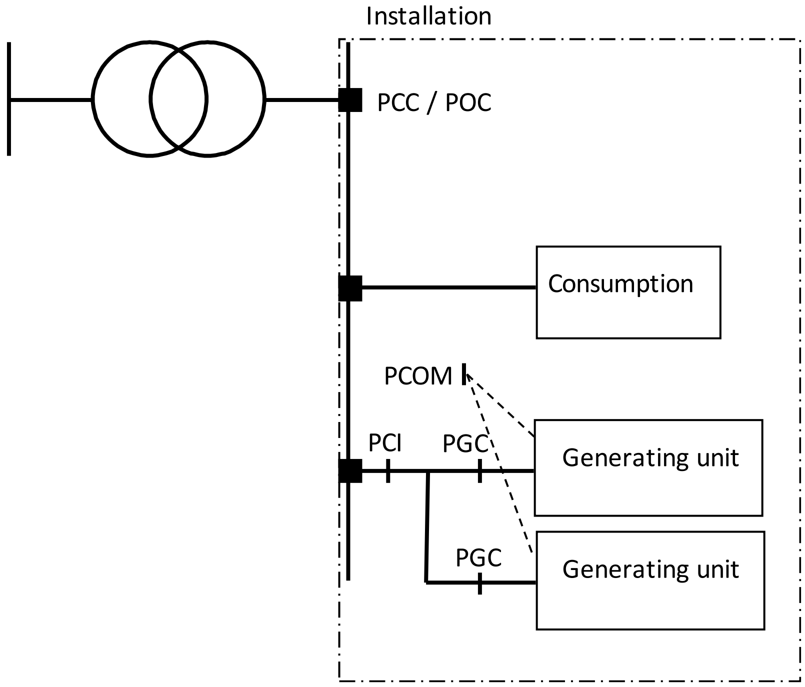

Figure 3.3 – Installation-connected generation with indication of the PGC, PCI, POC and PCC.

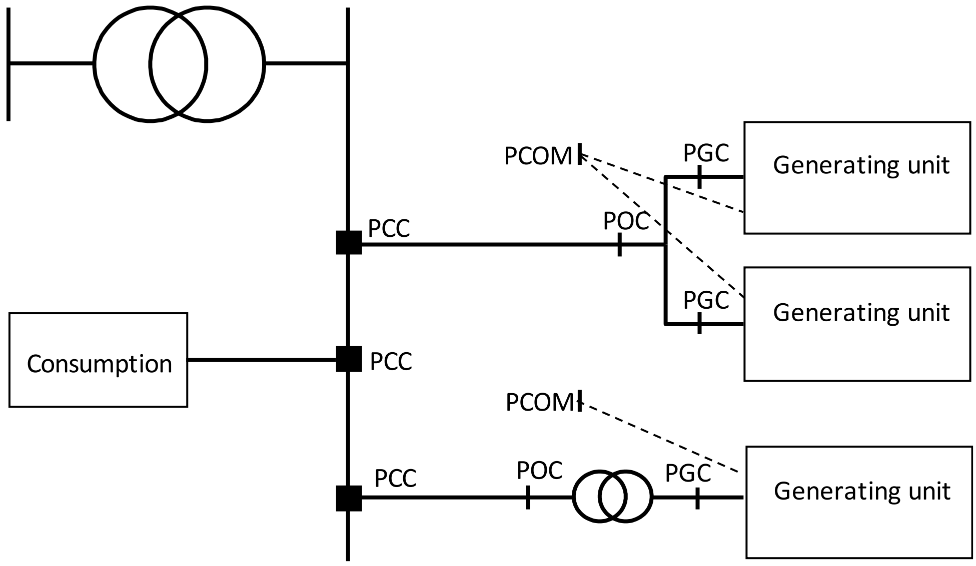

Figure 3.4 Grid-connected generation with indication of the PGC, POC, PCC and PCOM.

Figure figure 3.3 shows a typical installation connection of one or more power-generating plants with indication of the typical locations of Point of Generator Connection (PGC), Point of Connection (POC), Point of Connection in Installation (PCI) and Point of Common Coupling (PCC). In the illustrated example, the Point of Common Coupling (PCC) coincides with the Point of Connection (POC).

3.2.41. Nominal active power/rated power (P_n)

The highest level of active power that the power-generating plant is designed to continuously supply at the Point of Connection (POC). The rated power or nominal active power is denoted by P_n.

3.2.42. Nominal reactive power (Q_n)

The highest level of reactive power that the power-generating plant is designed to continuously supply at the Point of Connection (POC). Nominal reactive power is denoted by Q_n.

3.2.43. Nominal voltage (U_n)

The voltage of a grid or component. The voltage is stated phase-to-phase for three-wire systems and phase-to-null for four-wire systems. Nominal voltage is denoted by U_n.

3.2.44. Nominal current/rated current (I_n)

The maximum continuous current at the Point of Connection (POC) that a power-generating plant is designed to continuously supply under normal operating conditions, see DS/CLC/TS 50549-1:2015 and DS/CLC/TS 50549-2:2015. Rated current is denoted by I_n.

3.2.45. Nominal apparent power (S_n)

The highest level of power consisting of both active and reactive components that a power-generating plant is designed to continuously supply at the Point of Connection (POC). Nominal apparent power is denoted by S_n.

3.2.46. Normal operating voltage (U_c)

The voltage at which the grid is operated, and therefore the voltage that can be expected at the Point of Connection (POC). Normal operating voltage is denoted by U_c.

Normal operating voltage is determined by the DSO and is used to determine the normal operating range and protection.

3.2.47. Normal operation

The voltage and frequency range within which a power-generating plant must be capable of continuous generation. For further information about normal operation, see sections 4.1.1, 5.1.1 and 6.1.1.

3.2.48. Back-up power generating unit

A system installed to supply emergency power to an installation, and which is not intended for operation in parallel with the public electricity supply grid.

3.2.49. Partial weighted harmonic distortion (PWHD)

Square sum of the total harmonic distortion from a limited group of the higher harmonic orders (Y_h), weighted according to the individual order of harmonics (h). PWHD is calculated from and including the 14th harmonic order (h = 14) up to and including the 40th harmonic order (h = 40), calculated as a percentage of the fundamental frequency (h = 1).

$$PWHD_Y = \sqrt{\sum_{h=14}^{h=40} h \cdot \left(\frac{Y_h}{Y_1}\right)^2}$$

Where Y is either RMS currents ($PWHD_I$) or RMS voltages ($PWHD_U$).

3.2.50. Power-generating plants

General term covering both synchronous power-generating plants and power park modules.

This designation is used when requirements apply to both synchronous power-generating plants and power park modules.

3.2.51. Q control

A control function for reactive power which controls the reactive power independently of the active power generated.

3.2.52. Reactive power

The imaginary component of the apparent power, usually expressed in VAr or kVAr.

3.2.53. Fast fault current (I_Q)

Fast fault current used to counteract voltage dips during faults in the public electricity supply grid.

3.2.54. Tolerance

Tolerance of voltage and frequency deviations to ensure that a power-generating plant does not disconnect from the public electricity supply grid but instead maintains some form of operation to support the public electricity supply grid.

3.2.55. Signal

A measurement, status, set point or command which is exchanged between the power-generating plant and the DSO via the PCOM.

3.2.56. Voltage dip

Transient voltage change resulting in the effective value of the voltage at the Point of Connection (POC) being between 5% and 90% of normal operating voltage.

3.2.57. Voltage level

For the purpose of these requirements, the voltage levels in the distribution and transmission grids are defined according to the standard DS/EN/IEC 60038 and are as follows:

Designation of voltage level	Nominal voltage U_n [kV]	System operator

Designation of voltage level	Nominal voltage U_n [kV]	System operator
Extra high voltage (EHV)	400	Transmission system operator
	220	
High voltage (HV)	150	
	132	
	60	DSO
	50	
Medium voltage (MV)	33	
	30	
	20	
	15	
	10	
Low voltage (LV)	0.4	
	0.23	

Table 3.2 – Definition of voltage levels.

3.2.58. Voltage control

A control function for reactive power regulating the reactive power by means of droop control for the purpose of obtaining the desired voltage at the voltage reference point.

3.2.59. Voltage droop

The percentage voltage change which will cause a reactive power change corresponding to the nominal reactive power of the power-generating plant.

Voltage droop formula:

$$droop\ [\%] = 100 \cdot \frac{|\Delta U|}{U_{ref}} \cdot \frac{Q_{nom}}{|\Delta Q|}$$

3.2.60. Voltage unbalance

Condition in a multiphase system where the effective values of the fundamental frequency of the outer voltages and/or the angles of the successive outer voltages are not the same.

3.2.61. Droop

The control parameter change (e.g. frequency) in per cent which will cause a power output change corresponding to the nominal power of the power-generating plant.

See frequency and voltage droop for more information.

3.2.62. Current unbalance

Condition in a multiphase system where the current amplitude and/or the angles of successive phases are not the same.

3.2.63. Synchronous power-generating plant

A coherent power-generating unit capable of generating electrical energy in such a way that the relationship between voltage frequency, alternator speed and grid frequency is constant and thus synchronous.

3.2.64. Transmission system operator

Company entrusted with the overall responsibility for maintaining security of supply and ensuring the effective utilisation of an interconnected electricity supply system.

The transmission system operator in Denmark is Energinet.

3.2.65. Total Harmonic Distortion (THD)

Square sum of the total harmonic distortion of the individual harmonics (Y_h) from the second harmonic order (h = 2) up to and including the 40th harmonic order (h = 40), calculated as a percentage of the fundamental frequency (h = 1).

$$THD_Y = \sqrt{\sum_{h=2}^{h=40} \left(\frac{Y_h}{Y_1}\right)^2}$$

Where Y is either RMS currents (THD_I) or RMS voltages (THD_U).

3.2.66. Abnormal operation

Operating conditions with frequency or voltage deviations – i.e. operating outside the normal operating range (see section 3.2.47).

3.2.67. Western Denmark (DK1)

The part of the continental European synchronous area covering Denmark west of the Great Belt.

3.2.68. Wind power plant

A power-generating plant using wind as its primary energy source.

3.2.69. Islanding

An operating situation which may occur in the distribution system where part of the distribution grid continues operating without being connected to the public electricity supply grid.

This is an undesirable operating situation, which is typically detected due to frequency change (df/dt) or large voltage deviations. In such situations, the grid protection must automatically disconnect the power-generating plant from the grid.

3.2.70. Eastern Denmark (DK2)

The part of the northern European synchronous area covering Denmark east of the Great Belt.

4. REQUIREMENTS FOR TYPE B POWER-GENERATING PLANTS

4.1. Tolerance of frequency and voltage deviations

A power-generating plant must comply with the following requirements for normal operation and abnormal operation.

4.1.1. Normal operation

A power-generating plant must be capable of continuous generation without disconnecting in the 49.0 Hz - 51.0 Hz frequency range.

U_c at the Point of Connection (POC) is provided by the DSO.

A power-generating plant must be capable of continuous generation when the voltage at the Point of Connection (POC) is within the 90% to 110% range of normal operating voltage.

A power-generating plant must maintain operation at different frequencies for the minimum time periods specified in figure 4.1 without disconnecting from the grid.

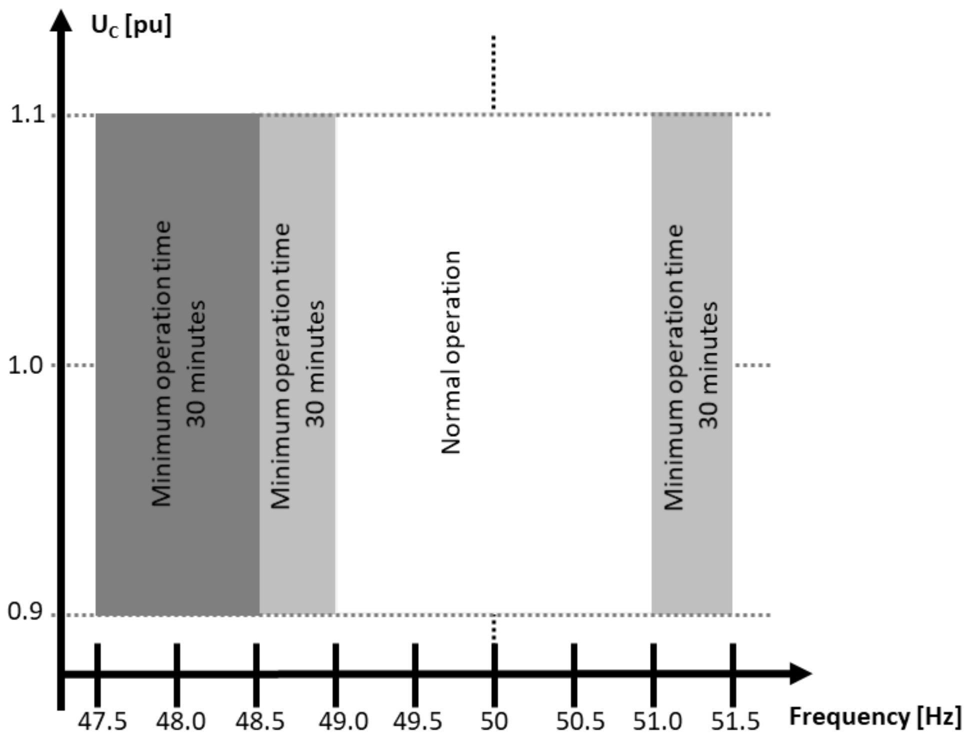

Figure 4.1 – Minimum time periods during which a power-generating plant must be capable of maintaining operation at different frequencies without disconnecting from the grid.

A power-generating plant must be designed to withstand transient voltage phase jumps of up to 20 degrees at the Point of Connection (POC) without any interruption.

4.1.2. Tolerance of frequency deviations

The power-generating plant must be capable of maintaining operation in case of frequency deviations for the time periods specified in figure 4.1 without disconnecting from the public electricity supply grid.

4.1.2.1. Frequency change

A power-generating plant must be capable of continuous generation at frequency changes of up to 2.0 Hz/s.

4.1.2.2. Permitted reduction of active power during underfrequency

A power-generating plant is permitted to reduce the active power within the 49 Hz - 47.5 Hz frequency range. In this range, it is permitted to reduce the active power by 6% of P_n/Hz as shown in figure 4.2.

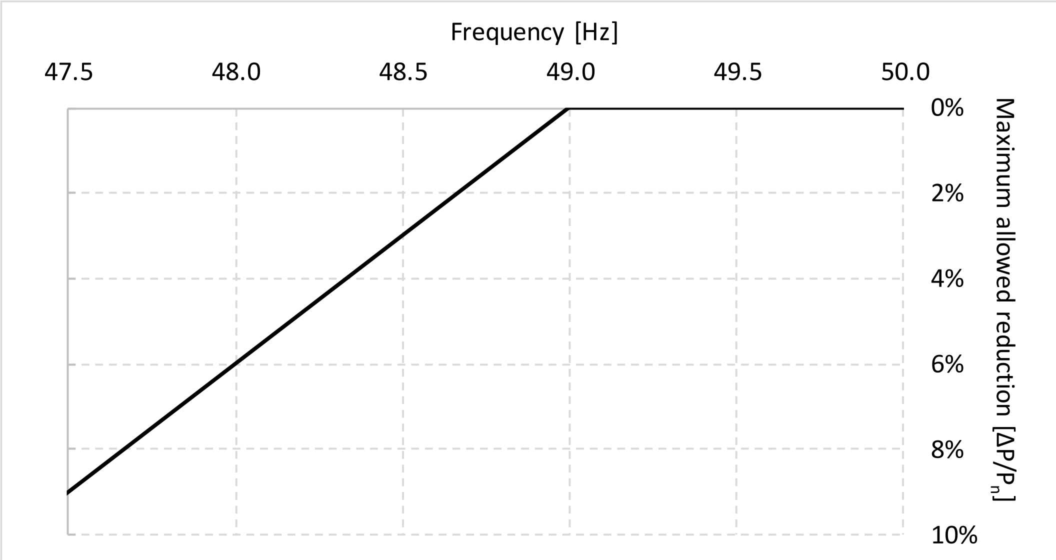

Figure 4.2 – Permitted reduction of active power during underfrequency.

Permitted reduction of active power	
Frequency range	49 Hz - 47.5 Hz
Reduction of P_n/Hz	6%

Table 4.1 – Permitted reduction of active power during underfrequency.

A power-generating plant may only reduce the active power if the plant is technically incapable of continuing to supply of full active power at underfrequency. This applies during normal operating conditions, which are guaranteed for 90% of the time, and must occur to the best of its ability in relation to operating point and available primary energy.

4.1.3. Tolerance of voltage deviations

A power-generating plant must comply with the requirements for tolerances of voltage deviations as specified in this section. Specific requirements apply, depending on plant type.

4.1.3.1. Permitted reduction of active power at undervoltage

When the voltage at the Point of Connection (POC) is less than 95% of nominal value, it is allowed to reduce the generation of active power to comply with the power-generating plant's current limitation. The reduction must be as small as technically possible.

4.1.3.2. Tolerance to voltage swells

A power-generating plant must be capable of remaining connected to the grid during voltage swells as specified in table 4.2.

Voltage	Duration
$1.15{\cdot}U_c$	60 s
$1.20{\cdot}U_c$	5 s

Table 4.2 – Tolerance to voltage swells.

4.1.3.3. Tolerance to voltage dips

(a) Synchronous power-generating plant

A synchronous power-generating plant must be capable of withstanding voltage dips as shown in figure 4.3. A synchronous power-generating plant must be capable of remaining connected to the grid during voltage dips above the solid line in figure 4.3. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 4.3. The requirement is assessed at P_n and Power Factor 1.0. The DSO must, at the power-generating plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

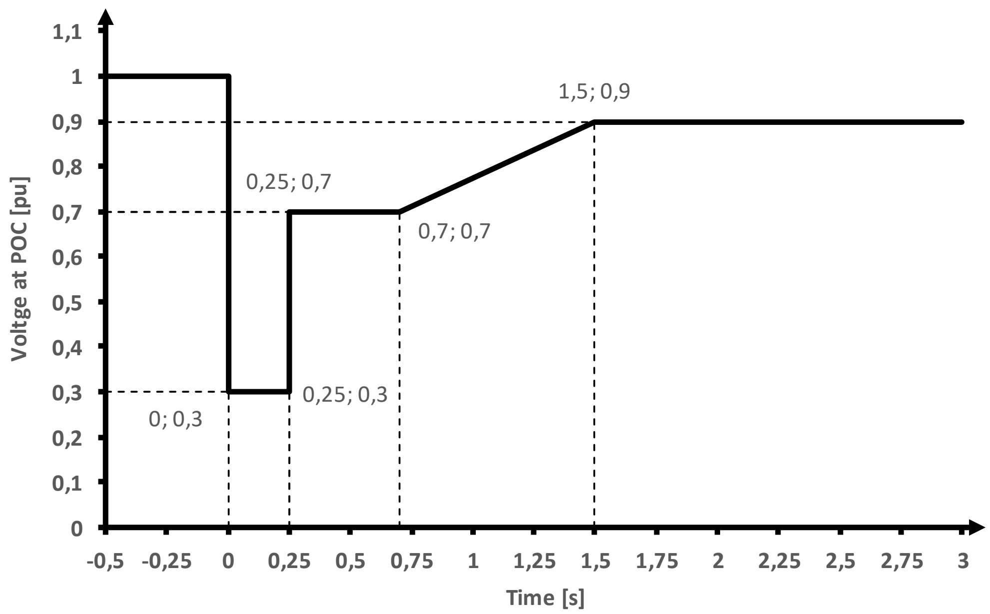

Figure 4.3 – Tolerance to voltage dips for a synchronous power-generating plant.

A synchronous power-generating plant must be capable of restoring normal generation of active power after a fault as quickly as possible after voltage and frequency have returned to the normal range, see section 4.1.1. The power-generating plant's natural ability to restore generation of active power must not be artificially or unnecessarily restricted.

(b) Power park modules

A power park module must be capable of withstanding voltage dips as shown in figure 4.4. A power park module must be capable of remaining connected to the grid during voltage dips above the solid line in figure 4.4. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 4.4. The requirement is assessed at P_n and Power Factor 1.0. The DSO must, at the plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

A power park module must be capable of restoring normal generation of active power after a fault as quickly as possible; however, no later than five seconds after voltage and frequency have returned to the normal operating range, see section 4.1.1. During the recovery process, upward regulation of active power must be performed with a gradient of at least 20% P_n/s.

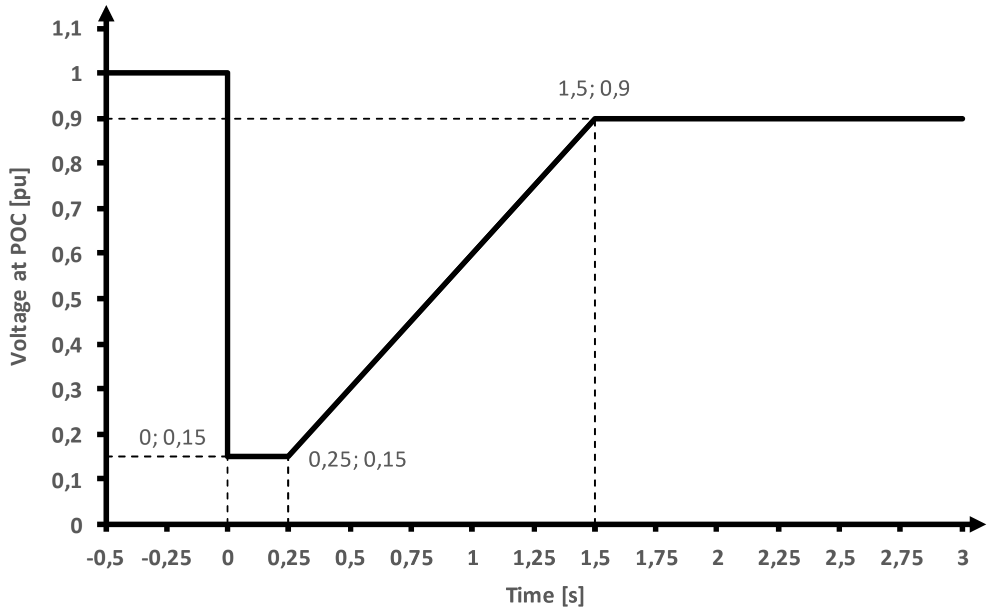

Figure 4.4 – Tolerance to voltage dips for a power park module.

Supply of fast fault current

A power park module must be capable of supplying fast fault current, I_Q, at the Point of Generator Connection in case of a symmetrical fault (three-phase fault) to maintain grid voltage stability during and after a fault.

A power park module must be capable of supplying fast fault current (positive sequence component) in the area above the solid line in figure 4.4 and up to 90% of normal operating voltage at the Point of Generator Connection.

Control of fast fault current from a power park module must follow figure 4.5.

It must be possible to supply fast fault current within 100 ms with an accuracy of ±20% of I_n.

During a fault sequence, a power park module must prioritise the fast fault current before supplying the active power in the range from 90% to 15% of U_c, see the hatched area in figure 4.5.

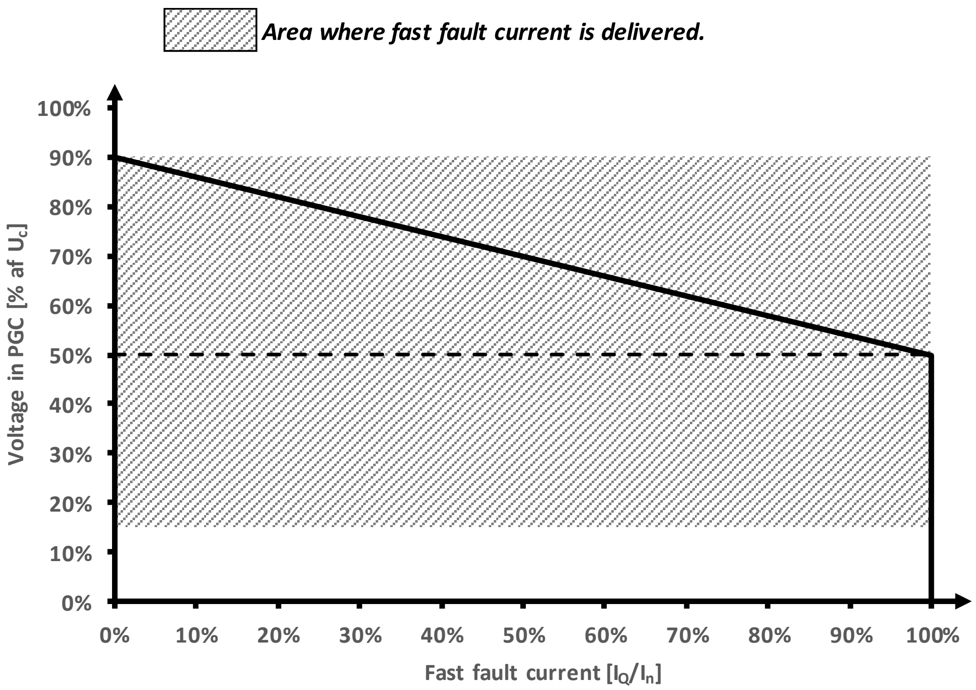

Figure 4.5 – Supply of fast fault current from a power park module.

4.2. Start-up and reconnection of a power-generating plant

Start-up and reconnection of a power-generating plant is only permitted when the frequency and voltage are within the following ranges:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency range	47.5 Hz - 50.2 Hz	47.5 Hz - 50.5 Hz
Voltage range	90% - 110% U_c	90% - 110% U_c
Observation time	Three minutes	Three minutes

Table 4.3 – Criteria for start-up and reconnection of a power-generating plant.

When a power-generating plant has been connected, the active power must not increase by more than 20% of nominal power per minute.

4.2.1. Synchronisation

A power-generating plant must be capable of automatically synchronising to the public electricity supply grid. It must not be possible to manually circumvent the automatic synchronisation and allow the plant to connect without synchronisation.

4.3. Active power control

A power-generating plant must be capable of controlling its active power. It must be possible to indicate set points in steps of 1% of P_n or better.

Control must be performed with an accuracy of ±2% of power-generating plant nominal active power. The control accuracy is measured over a period of one minute.

4.3.1. Power response to overfrequency

A power-generating plant must be capable of downward regulation of its active frequency at overfrequency. Downward regulation of active power must be initiated within two seconds at the Point of Connection (POC).

To be able to detect islanding, downward regulation of the active power at the Point of Connection (POC) must not be commenced until after an intentional delay of 500 ms.

If the plant's natural delay (recovery time) for commencement of downward regulation is 500 ms or more, the requirement for delay is met.

If the plant's natural delay (recovery time) for commencement of downward regulation is less than 500 ms, the delay must be extended to 500 ms. The intentional delay is only imposed when transitioning to frequency response, i.e. when the frequency threshold f_{RO} is crossed.

Example

A plant's natural delay (recovery time) for commencement of downward regulation is 300 ms. An additional intentional delay (recovery time) of 200 ms is added to make the total delay (recovery time) for the plant 500 ms.

The downward regulation of active power must be commenced at a frequency threshold (f_{RO}) and follow a droop as indicated in figure 4.6, regardless of whether the frequency increases or decreases.

When a power-generating plant's lower limit for active power is reached in connection with the downward regulation, the plant must keep this minimum level of active power until the grid frequency drops again or until the plant is disconnected for other reasons.

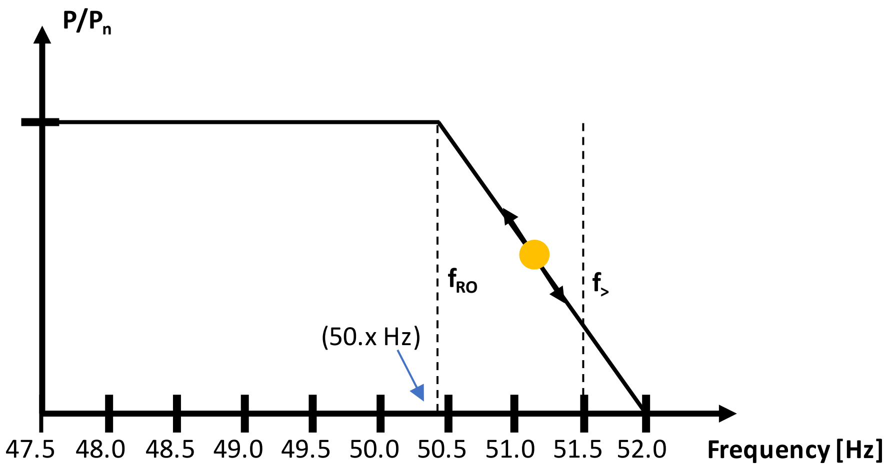

Figure 4.6 – Frequency response droop to overfrequency.

The frequency threshold for commencement of frequency response must be set in the 50.2 Hz - 50.5 Hz frequency range, both values inclusive, with a resolution of 10 mHz or better.

The droop of the active power reduction must be in the 2-12% range with a resolution of 1% or better.

The settings for frequency response to overfrequency for Western and Eastern Denmark are as follows:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency threshold f_{RO}	50.2 Hz	50.5 Hz
Droop	5%	4%
Intentional delay for islanding detection	500 ms	500 ms

Table 4.4 – Default settings for power response to overfrequency for DK1 and DK2.

When the frequency response is enabled, the active power must follow the droop with a deviation of 5% of nominal active power or better, measured over a period of one minute.

Frequency must be measured with an accuracy of ±10 mHz or better.

4.3.2. Constraint functions

4.3.2.1. Absolute power limit

A power-generating plant must be capable of limiting its maximum active power.

Absolute power limit is used to limit the active power from a power-generating plant to a set point-defined maximum power limit at the Point of Connection (POC).

Absolute power limit is used to protect the public electricity supply grid against overload in critical situations.

Control using a new parameter for the absolute power limit must be completed within five minutes of receiving the parameter change order.

4.3.2.2. Ramp rate limit

A power-generating plant must be capable of limiting the gradient of the active power. Unless another functionality, including market services, requires a higher gradient, e.g. active power recovery after a fault etc., the gradient must not exceed more than 20% of P_n/min. This applies to both upward and downward regulation, taking the availability of the primary energy source into consideration.

> *Ramp rate limit is used for reasons of system operation to prevent changes in active power from adversely impacting the stability of the public electricity supply grid.*

4.3.2.3. System protection scheme

The requirement for system protection applies to power park modules. For synchronous power-generating plants, the need is assessed when assigning the Point of Connection (POC).

A power-generating plant must be equipped with system protection scheme which is an emergency control function that, following a downward regulation order, is capable of quickly adjusting the active power supplied from a plant to one or more predefined set points. Set points are determined by the DSO during commissioning.

The power-generating plant must have at least five different configurable adjustment positions.

The following default set points are:

1. To 70% of rated power
2. To 50% of rated power
3. To 40% of rated power
4. To 25% of rated power
5. To 0% of rated power, i.e. the power-generating plant is stopped.

Control must be initiated within one second and completed within ten seconds of receipt of a downward regulation order.

If the system protection receives an upward regulation order, e.g. from step 4 (25%) to step 3 (40%), it is acceptable that completion of the order may take additional time due to the design limits of power-generating plant generators or other plant units.

4.4. Reactive power control

A power-generating plant must be capable of supplying reactive power. Only one of the following required control functions can be active at a time.

The power-generating plant must be capable of controlling its reactive power using the functions and characteristics described in sections 4.4.2 to 4.4.4. It must be possible to indicate set points in steps of 1% of S_n or better for power and 0.01 or better for Power Factor.

Control must be performed with an accuracy of ±2% of power-generating plant nominal apparent power. The control accuracy is measured over a period of one minute.

The control accuracy may be less than ±2% of S_n when active power generation is below 10% of power-generating plant nominal apparent power. However, the exchange of uncontrolled reactive power must never be greater than 10% of plant nominal apparent power.

When one or more power-generating units of a power park module are taken out of operation for scheduled maintenance, the plant's supply of reactive power may be reduced proportionate to the number of units taken out of operation.

4.4.1. Reactive power range

At maximum production, a power-generating plant must be capable of supplying active power at different voltages at the Point of Connection (POC) as specified in figure 4.7.

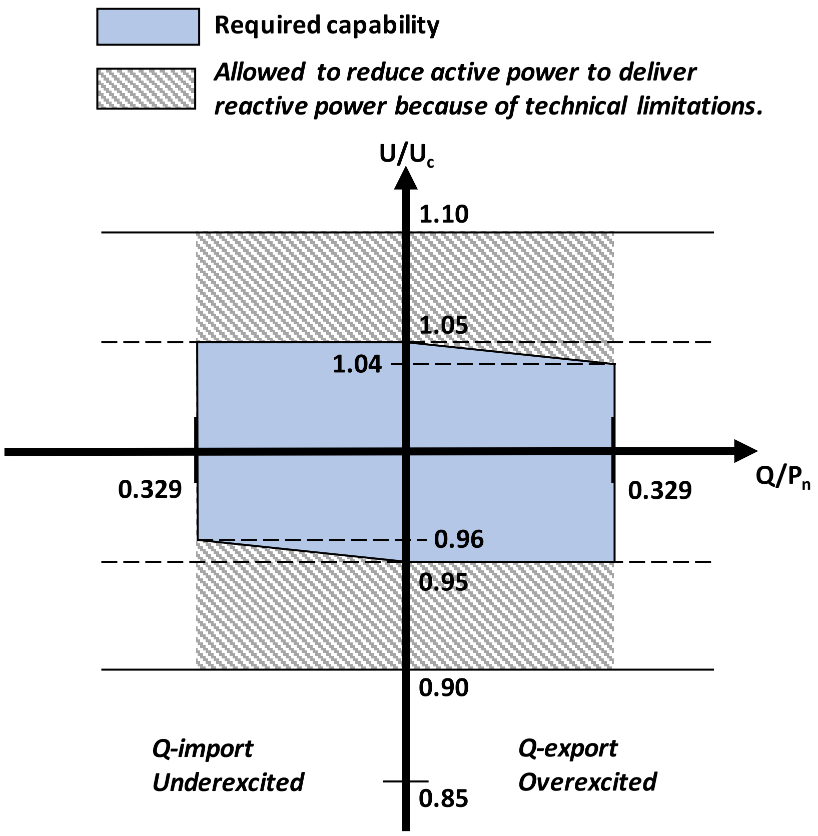

Figure 4.7 – Requirements for supply of reactive power at maximum active power generation.

Inside the shaded blue area in figure 4.7, the power-generating plant must supply stable reactive power in accordance with the selected control mode, which may only be limited by the technical performance of the plant, e.g. saturation or undercompensation.

When the active power generation is below the maximum capacity, a power-generating plant must be capable of operating within the area specified in figure 4.8.

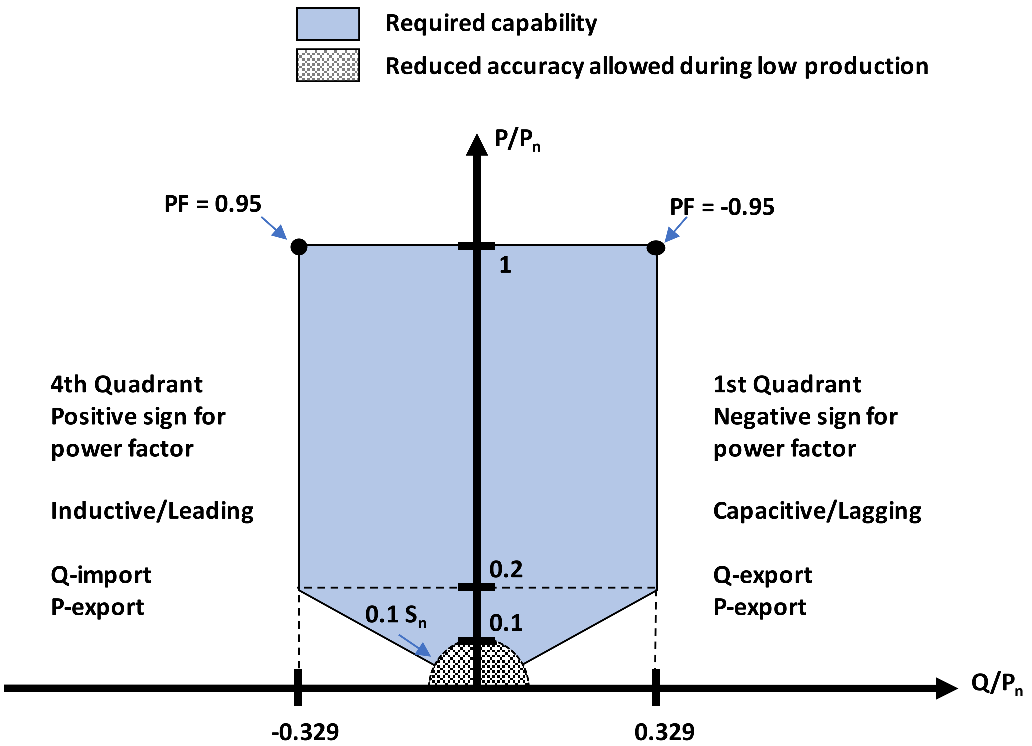

Figure 4.8 – Requirements for supply of reactive power at different active power levels.

4.4.2. Power Factor control

A power-generating plant must be capable of performing Power Factor control allowing the reactive power to be controlled by means of a fixed Power Factor, see figure 4.9 .

When a new Power Factor set point is set, the control must be completed within one minute.

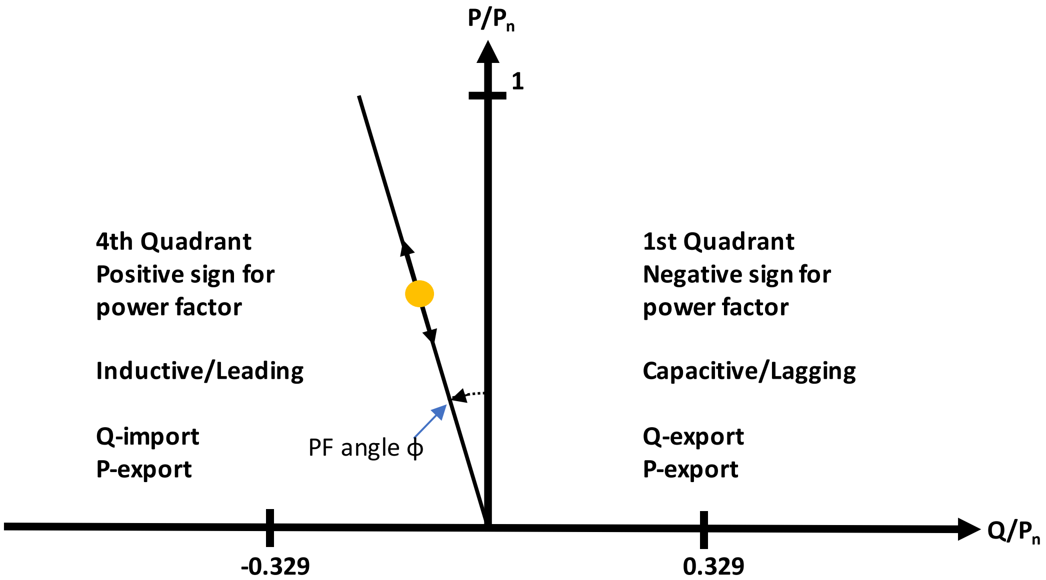

Figure 4.9 – Example of Power Factor control [cos ϕ fixed].

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

4.4.3. Automatic Power Factor control

A power-generating plant must be capable of performing automatic Power Factor control as shown in figure 4.10.

Reactive power control must be completed within ten seconds of the active power having been stabilised.

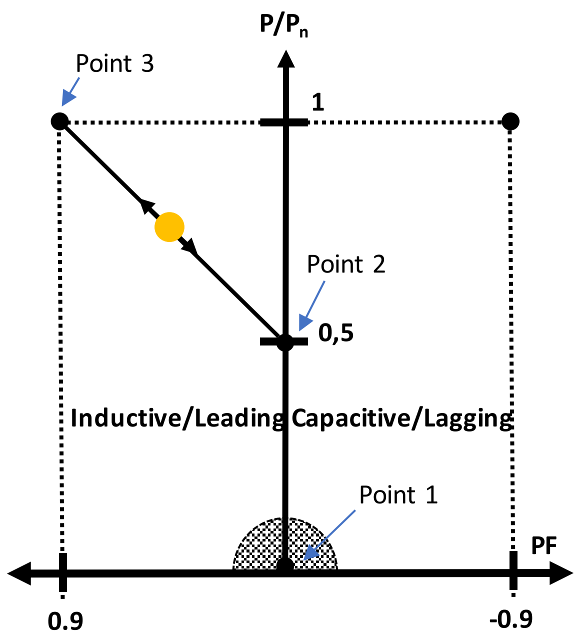

Figure 4.10 – Default setting for automatic Power Factor control [cos ϕ (P)].

Default settings for the characteristics are specified in table 4.5 .

Characteristics points		
Point	P/P_n	Power Factor
1	0.0	1.0
2	0.5	1.0
3	1	0.9 inductive

Table 4.5 – Characteristics points.

The function is normally activated at 105% of U_c, and deactivated at 100% of U_c.

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default always produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

4.4.4. Q control

A power-generating plant must be capable of performing Q control as shown in figure 4.11.

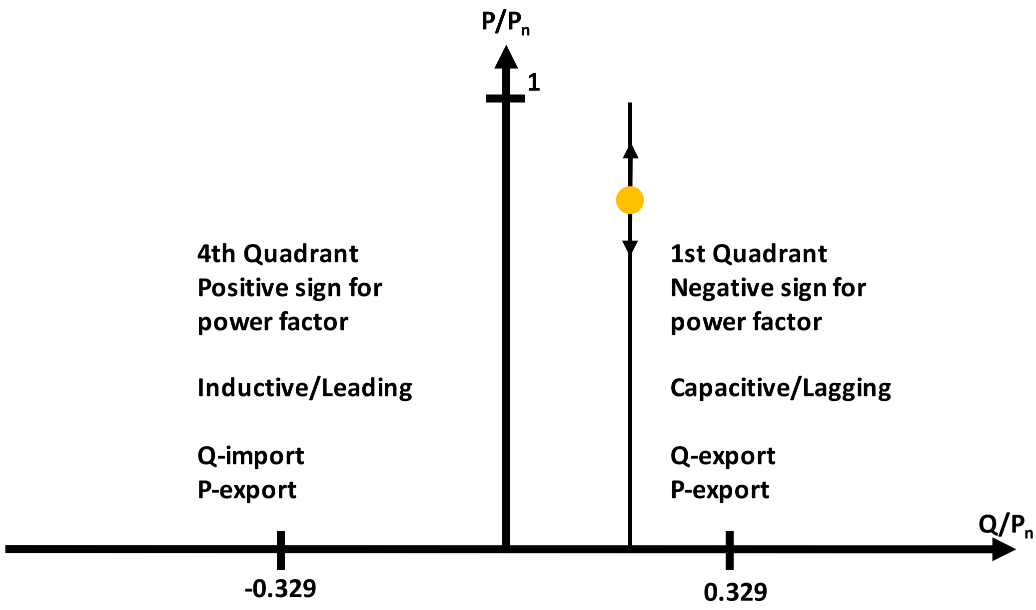

Figure 4.11 – Example of Q control [Q set point].

Control from one set point to another must be completed within one minute.

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

4.4.5. (a) Synchronous power-generating plants – additional requirements

In addition to the general requirements for reactive power, synchronous power-generating plants must also be equipped with an automatic excitation system. The excitation system must be capable of supplying stable and constant voltage at the PGC. It must be possible to select the voltage set point in the entire voltage range for normal operation.

4.5. Protection

4.5.1. General

Power-generating plant protection must both protect the plant and help ensure stability in the public electricity supply grid.

Relay settings cannot prevent specified power-generating plant functions from working properly.

The power-generating plant owner is responsible for ensuring that the plant is dimensioned and equipped with the necessary protection functions so that the plant:

- Is protected against damage due to faults and incidents in the public electricity supply grid
- Protects the public electricity supply grid against unwanted impacts from the power-generating plant
- Is protected against damage as a result of asynchronous connections
- Is protected against disconnection in non-critical situations for the power-generating plant
- Is not damaged and does not switch off during voltage dips as specified in section 4.1.3.

The DSO or the transmission system operator may demand that the setting values for protection functions be changed after commissioning if it is deemed to be of importance to the operation of the public electricity supply grid.

Following disconnection of a power-generating plant due to a fault in the public electricity supply grid, the plant must not reconnect automatically earlier than specified in section 4.2.

A power-generating plant which has been disconnected by an external signal prior to a fault occurring in the public electricity supply grid must not be connected until the external signal has been eliminated and the voltage and frequency are once again within the range specified in section 4.2.

At the power-generating plant owner's request, the DSO must state the highest and lowest short-circuit current that can be expected at the Point of Connection (POC) as well as any other information about the public electricity supply grid as may be necessary to configure the plant's protection functions.

Voltage and frequency must be measured simultaneously for the phases which the power-generating plant is connected to at the Point of Connection (POC).

4.5.2. Requirements for protection functions and settings

The power-generating plant's protection functions and associated settings must be as specified in the following subsections. Settings deviating from the default values, e.g. in the event of problems with local overvoltages, may only be used with the DSO's permission.

In connection with internal short circuits in the power-generating plant, the relay protection must be selective with the grid protection. This means that short circuits in the power-generating plant must be disconnected within 100 ms.

All settings are stated as RMS values.

The power-generating plant must be disconnected or shut down if a measuring signal deviates more from its nominal value than the setting.

The trip time stated is the measuring period during which the trip condition must constantly be fulfilled in order for the protection function to release a trip signal.

The accuracy of voltage and frequency measurements must be ±1% of U_c and ±0.05 Hz or better respectively.

The frequency change is calculated according to the following or equivalent principle.

The frequency measurement used to calculate the frequency change is based on a 200 ms measuring period where the mean value is calculated.

Frequency measurements must be made continuously, calculating a new value every 20 ms.

ROCOF [Hz/s] must be calculated as the difference between the currently performed frequency mean value calculation and the calculation performed 20 ms before.

(df/dt = (mean value 2 – mean value 1)/0.020 [Hz/s])

If a power-generating plant is isolated with part of the public electricity supply grid, the plant must not cause temporary overvoltages that can damage the plant or the public electricity supply grid.

4.5.3. Requirements for grid protection

A power-generating plant must have protection functions as specified in table 4.6. Unless otherwise agreed with the DSO, the default values in the table are to be used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Overvoltage (step 2)	$U_{>>}$	1.0-1.3/0.01 Default: 1.15	U_c	0.1-5/0.05 Default: 0.2	s
Overvoltage (step 1)	$U_{>}$	1.0-1.2/0.01 Default: 1.10	U_c	0.1-100/0.1 Default: 60	s
Undervoltage (step 1)	$U_{<}$	0.2 - 1.0/0.01 Default: 0.90	U_c	0.1 - 100/0.1 Default: 60	s
Overfrequency	$f_{>}$	50.0 - 52.0/0.1 Default: 51.5	Hz	0.1 - 5/0.05 Default: 0.2	s
Underfrequency	$f_{<}$	47.0 - 50.0/0.1 Default: 47.5	Hz	0.1 - 5/0.05 Default: 0.2	s

Table 4.6 – Requirements for protection of all type B power-generating plants.

4.5.3.1. (a) Additional requirements for grid protection of synchronous power-generating plants

In addition to the general protection functions and settings, synchronous power-generating plants must also have the protection functions and settings specified in table 4.7.

A synchronous undervoltage relay is only required when asynchronous connection at automatic reconnection may occur. The DSO determines the setting values for the synchronous undervoltage relay.

The DSO to whose grid the plant is connected calculates the setting values for the synchronous undervoltage relay using the principles in the Research Association of the Danish Electric Utilities (DEFU) technical report no. 293, 3rd edition on 'Relay protection at local production with synchronous generators', March 2018.

It is allowed to use a fuse instead of overcurrent (step 1). In this case, the fuse size and characteristics must be approved by the DSO.

Protection function	Symbol [IEC]	Setting		Trip time	
Synchronous undervoltage*	-	Determined by the DSO	V	≤50	ms
Overcurrent (step 2)**	$I_{>>}$	Determined by the DSO	A	50	ms
Overcurrent (step 1)	$I_{>}$	1.2	I_n	2	s
*** If synchronous undervoltage relay is used. Synchronous undervoltage relay: The setting is dependent on local generator and grid data. The current setting is calculated by the DSO. ** If synchronous undervoltage relay is not used, the generator manufacturer's settings for overcurrent protection are used.**					

Table 4.7 – Additional protection settings for synchronous power-generating plants.

4.5.4. Requirements for islanding detection

A power-generating plant must be capable of detecting unintentional islanding and must disconnect from the public electricity supply grid if unintentional islanding is detected.

In Denmark, only passive islanding detection methods are used. The use of vector jump relays (ANSI 78) or active islanding detection is not allowed on power-generating plants connected to the Danish public electricity supply grid.

A power-generating plant must have the functions for islanding detection specified in table 4.8. Unless otherwise agreed with the DSO, the default value in the table is used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Frequency change	df/dt	2 - 3.5/0.1 Default: ±2.5	Hz/s	0.02 - 5/0.01 Default: 0.08	s

Table 4.8 – Requirements for islanding detection.

4.5.5. Earthing

Conditions related to earthing of the power-generating plant must be agreed with the DSO.

4.6. Power quality

A power-generating plant must not cause unacceptable power quality in the electricity grid. To avoid this, the power-generating plant must comply with the requirements specified in the following sections.

4.6.1. Emission limits

A power-generating plant must comply with the requirements described in the following sections.

4.6.1.1. DC content

A power-generating plant must not inject DC currents into the grid. This requirement is met if the DC content of the current injected by the plant into the grid is below 0.5% of the nominal current of the plant.

If the power-generating plant is connected to the grid by means of a plant transformer, it is assumed that this requirement is met.

The reason for having a limit value for DC content is that DC currents are undesirable in the public electricity supply grid and may have an adverse effect on grid operation and protection. The limit value is set based on IEC/TR 61000-3-15, which provides recommendations for requirements for local production connected to the public electricity supply grid at low-voltage level.

4.6.1.2. Voltage unbalance

A power-generating plant must have balanced three-phase load so as not to cause voltage unbalance.

Requirements for unbalance are made because unbalance in phase voltages between phases is undesirable in the public electricity supply grid as it may have an adverse effect on grid operation and the units connected to the public electricity supply grid.

According to the international standard DS/EN 50160, the limit for the total voltage unbalance in the public electricity supply grid is 2%. Voltage unbalance can be distributed in accordance with the method described in IEC/TR 61000-3-13, but this will yield impractically low limit values for the individual plant, which are lower than the measurement uncertainty for measurement of unbalance.

When the plant has a balanced three-phase load, it will generally not add to the voltage unbalance already present in the public electricity supply grid. Documentation showing that the plant has balanced three-phase production will often be sufficient to establish that the plant will not give rise to voltage unbalance in the public electricity supply grid.

To ascertain that the plant does not give rise to voltage unbalance, the voltage unbalance can be measured at the Point of Connection (POC) before and after commissioning of the plant. If there is no significantly increased voltage unbalance after commissioning of the plant compared to the measurements made before commissioning, the voltage unbalance requirement is met.

Voltage unbalance is measured according to DS/EN 61000-4-30 as the negative sequence component divided by the positive sequence component.

4.6.1.3. Rapid voltage changes

A power-generating plant must not cause rapid voltage changes exceeding the limit values specified in table 4.9.

Voltage level	Limit value
Medium voltage	d(%) = 4%
High voltage	d(%) = 3%

Table 4.9 – Limit value for rapid voltage changes.

Requirements for rapid voltage changes are based on DS/EN 61000-3-11 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-7.

4.6.1.4. Flicker

A power-generating plant must not cause flicker contributions exceeding the limit values for short-term and long-term flicker as specified in table 4.10.

	Short-term flicker (P_{st})	Long-term flicker (P_{lt})
Limit value	0.3	0.2

Table 4.10 – Limit value for short-term and long-term flicker.

Flicker limit values are based on DS/EN 61000-3-11 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-7.

4.6.1.5. Harmonics

A power-generating plant may not emit harmonic currents exceeding the limit values in table 4.11 for the individual harmonics, which are expressed as a percentage of the nominal current of the plant (I_h/I_n (%)).

Odd-order harmonics h							Even-order harmonics h					
3	5	7	9	11	13	15	2	4	6	8	10	12
3.4	3.8	2.5	0.5	1.2	0.7	0.35	0.5	0.5	1.0	0.8	0.6	0.5

Table 4.11 – Limit values for harmonic currents I_h/I_n (% of I_n).

In addition to the limit values for the individual harmonics, there are also limit values for total harmonics. Limit values for THD_I and $PWHD_I$ are specified in table 4.12.

THD_I	$PWHD_I$
4.4	4.4

Table 4.12 – Limit values for THD_I and $PWHD_I$ in current (% I_n).

The requirements for individual harmonics, THD_I and $PWHD_I$, are based on DS/EN 61000-3-12 Table 3 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-6.

The 2nd and 4th harmonic order are reduced compared to the method in RA 557, because they may indicate DC content in the current supplied to the public electricity supply grid. Any exceeding of the limit values for the 2nd or 4th harmonic orders may indicate that the plant does not meet the requirement for DC content.

Triplen harmonics are added based on their ratio of the limit values in DS/EN 50160. Triplen harmonics should not occur at all in balanced three-phase equipment. However, three-phase inverters have been observed to produce these harmonics at times due to the inverter control. Therefore, it has been decided to add a limit value for them. In practice, the limit values for triplen harmonics in these instructions have been set so high that they should never constitute a problem in a balanced three-phase plant. If a plant exceeds these limits, this will indicate that the plant cannot be categorised as being balanced, and it can therefore not be connected, because it does not comply with the unbalance requirements.

4.6.1.6. Interharmonic overtones

A power-generating plant must comply with the limit values for interharmonic overtones specified in table 4.13.

Frequency (Hz)		
75 Hz	125 Hz	>175 Hz
0.44	0.66	$\frac{83}{f}$ *)
*) However, not less than the measurement uncertainty.		

Table 4.13 – Limit values for interharmonic overtones in current (% of I_n).

Limit values for interharmonic overtones are based on DS/EN 61000-3-12 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-6.

4.6.1.7. Distortions in the 2-9 kHz frequency range

A power-generating plant must comply with the limit value in table 4.14 for all 200 Hz frequency groups between 2 kHz and 9 kHz.

Limit value
0.2%

Table 4.14 – Limit value for harmonic currents for all frequencies between 2 kHz and 9 kHz stated in per cent of I_n.

Limit value for distortions in the 2-9 kHz frequency range is based on the Research Association of the Danish Electric Utilities (DEFU) report RA 557.

4.6.2. Division of responsibilities

4.6.2.1. The power-generating plant owner's obligations

As a rule, the power-generating plant owner must ensure that the plant is designed, constructed and configured to comply with all limit values.

The power-generating plant owner must verify that emission limits at the Point of Connection (POC) are complied with.

For calculation of power quality, the power-generating plant owner uses the typical three-phase short-circuit power, $S_{k,powerquality}$ at the Point of Connection (POC).

Subject to agreement, the plant owner can buy additional services (higher short-circuit power or scope) from the DSO in order to comply with the specified limit values.

4.6.2.2. The DSO's obligations

The DSO is responsible for setting emission limits at the Point of Connection (POC).

The DSO must specify the short-circuit level $S_{k,powerquality}$ with associated impedance angle ψ_k at the Point of Connection (POC).

4.6.3. Measuring method

Measurements of various power quality parameters must be carried out in accordance with the European standard DS/EN 61000-4-30 (class A).

Measurement of harmonic distortion of voltage and current must be carried out as defined in IEC 61000-4-7 in accordance with the principles (harmonic subgroup) and with the accuracies specified for class I.

Measurement of interharmonic distortion up to 2 kHz must be carried out as defined in IEC 61000-4-7 Annex A and must be measured as interharmonic subgroups.

Alternatively, it is allowed to measure harmonic distortion up to 2 kHz with grouping enabled (harmonic groups) as specified in IEC 61000-4-7 and with the accuracies specified for class I. If harmonic distortion up to 2 kHz is measured with grouping enabled, it is not required to measure interharmonic distortion up to 2 kHz separately.

Measurement of distortions in the 2-9 kHz frequency range must be carried out as defined in IEC 61000-4-7 Annex B and must be measured in 200 Hz windows with centre frequencies from 2100 Hz to 8900 Hz.

4.7. Exchange of information

A power-generating plant must be equipped with an interface at the PCOM enabling real-time exchange of signals.

If a power-generating plant consists of more units, a plant controller must be installed to allow control of the plant as a complete plant at the PCOM, see figure 3.3 and figure 3.4.

A power-generating plant must be capable of ceasing its active power generation. Generation must be stopped no later than five seconds after the command to this effect has been received. Furthermore, a power-generating plant must be capable of reducing active power upon receiving a command.

4.7.1. Requirements for time stamping and update speed

The information must be time stamped. The time stamps must have the following update times:

- Maximum time to update functional status (enabled/disabled) is 10 ms.
- Maximum time to update parameter value is one second.
- Maximum time to update metering values is one second.

4.7.2. Information exchange requirements for power-generating plants below 1 MW

A power-generating plant below 1 MW must at a minimum be capable of exchanging the following information:

Signal description	Signal type
Stop signal	Command
Hold signal – 'Released for start'	Command

Figure 4.12 – Requirements for information which a power-generating plant below 1MW must be capable of exchanging.

Remote control of these signals is assessed by the DSO at the time of grid connection.

A power-generating plant may start production after the requirements for reconnection are fulfilled (see sect.4.2), and "Released for start" is received.

4.7.3. Requirements for information exchange for power-generating plants of 1 MW and above.

Power-generating plants of 1 MW and above must at a minimum be capable of exchanging the following information in real time:

Signal description	Signal type
Stop signal	Command
Hold signal – 'Released for start'	Command
Absolute power limit	Set point
Absolute power limit	Enabled/disabled
Main circuit breaker indicator	Status
Generator circuit breaker indicator	Status
Active power	Measurement
Reactive power	Measurement
Current	Measurement
Voltage	Measurement
Power Factor (PF)	Measurement (may also be computed values)
Q control	Set point
Q control	Enabled/disabled
Power Factor control	Set point
Power Factor control	Enabled/disabled

Table 4.15– Requirements for information which a power-generating plant of 1 MW or more must be capable of exchanging in real time in the PCOM interface.

A power-generating plant may start production after the requirements for reconnection are fulfilled (see sect. 4.2), and "Released for start" is received.

4.8. Verification and documentation

This section describes the documentation to be provided by the power-generating plant owner or a third party to the DSO in order to obtain operational notification.

The power-generating plant owner is responsible for complying with the requirements described in this document and for documenting such compliance.

The DSO may at any time request verification and documentation showing that the power-generating plant meets the requirements described in this document.

4.8.1. Documentation requirements

- CE Declaration of Conformity
- Protection functions
- Single-line diagram
- Power quality
- Tolerance of voltage dips
- Annex B1.1 complete with technical documentation in support of the answers given.
- Annex 0 completed.

Product certificates issued by an approved certification body may also be used. The product certificates may cover some of the documentation requirements.

In connection with documentation of the power-generating plant's technical properties, testing and simulations must be performed as described in sections 4.8.2 and 4.8.3.

4.8.2. Tests

As part of the documentation of the power-generating plant's technical properties, testing must be performed to demonstrate compliance with the requirements of this document. The tests to be carried out include:

- Power response to overfrequency (LFSM-O)

Results must be presented in a report.

Product certificates issued by an approved certification body may be used instead of simulations.

4.8.3. Simulations

As part of the documentation of the power-generating plant's technical properties, simulations must be performed to demonstrate compliance with the requirements of this document. The simulations to be carried out include:

- Power response to overfrequency (LFSM-O)
  - Must be carried out for frequency changes in both steps and ramps.
  - Must show how the power-generating plant reacts when reaching the lower active power limit.

- Tolerance to voltage dips
- Active power recovery
- Supply of fast fault current (only power park modules)

Simulation results and simulation model must be validated against the tests carried out to demonstrate that model and simulations are accurate.

Product certificates issued by an approved certification body may be used instead of simulations.

CE Declaration of Conformity
CE Declarations of Conformity must be submitted for each of the main components. The CE Declaration of Conformity must contain a list of relevant standards, codes of practice and directives which the component or plant complies with.

Protection functions
Documentation of protection settings is a list of all relay configurations at the time of commissioning.

Single-line diagram
A single-line diagram is a drawing that shows the plant's main components and how they are electrically interconnected. In addition, the location of the protection and measuring points are included in the diagram.

Power quality
Power quality is a collection of parameters characterising the electricity supplied. A certificate or report demonstrating that the requirements are complied with must be presented.

Tolerance of voltage dips
Tolerance of voltage dips is the plant's ability to stay connected to the public electricity supply grid during a voltage dip as well as power park modules' ability to supply fast fault current. The plant's ability to stay connected to the grid and supply fast fault current may be documented in two ways: simulation or testing.

Completion of annexes
A completed Annex B1.1 means that the annex in these instructions must be completed, and that technical documentation verifying the correctness of the answers given in the annex must be attached. Technical documentation may include a test report, product certificate, user manual, simulations, etc.

5. REQUIREMENTS FOR TYPE C POWER-GENERATING PLANTS

5.1. Tolerance of frequency and voltage deviations

A power-generating plant must comply with the following requirements for normal operation and abnormal operation.

5.1.1. Normal operation

A power-generating plant must be capable of continuous generation without disconnecting in the 49.0 Hz - 51.0 Hz frequency range.

U_c at the Point of Connection (POC) is provided by the DSO.

A power-generating plant must be capable of continuous generation when the voltage at the Point of Connection (POC) is within the 90% to 110% range of normal operating voltage.

A power-generating plant must maintain operation at different frequencies for the minimum time periods specified in figure 5.1 without disconnecting from the grid.

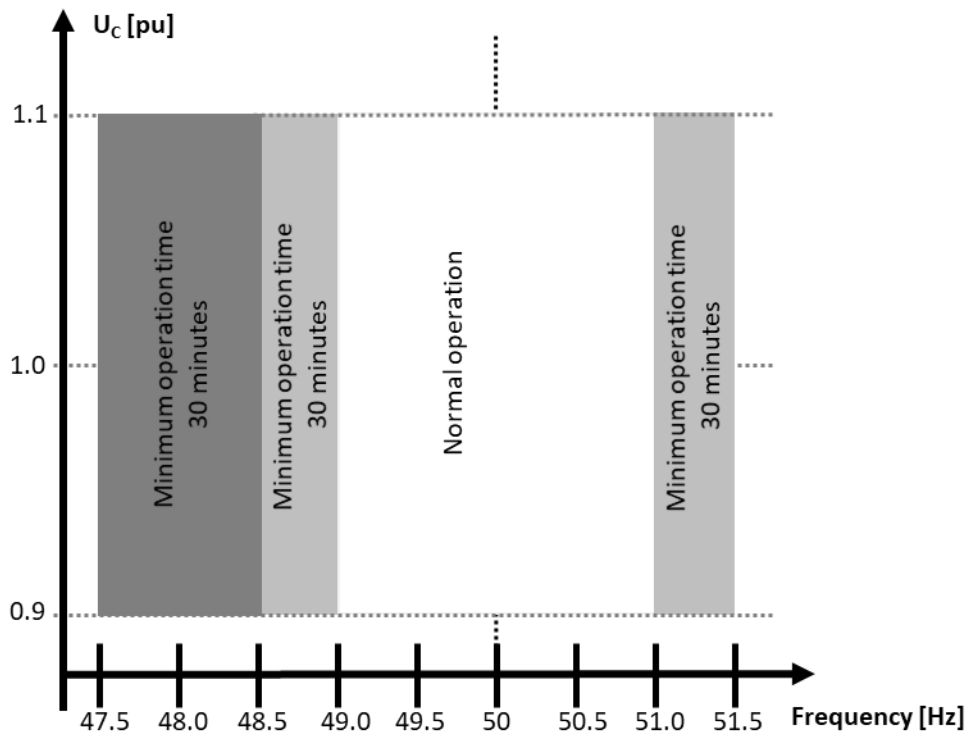

Figure 5.1 – Minimum time periods during which a power-generating plant must be capable of maintaining operation at different frequencies without disconnecting from the grid.

A power-generating plant must be designed to withstand transient voltage phase jumps of up to 20 degrees at the Point of Connection (POC) without any interruption.

5.1.2. Tolerance of frequency deviations

The power-generating plant must be capable of maintaining operation in case of frequency deviations for the time periods specified in figure 5.1 without disconnecting from the public electricity supply grid.

5.1.2.1. Frequency change

A power-generating plant must be capable of continuous generation at frequency changes of up to 2.0 Hz/s.

5.1.2.2. Permitted reduction of active power during underfrequency

A power-generating plant is permitted to reduce the active power within the 49 Hz - 47.5 Hz frequency range. In this range, it is permitted to reduce the active power by 6% of P_n/Hz as shown in figure 5.2.

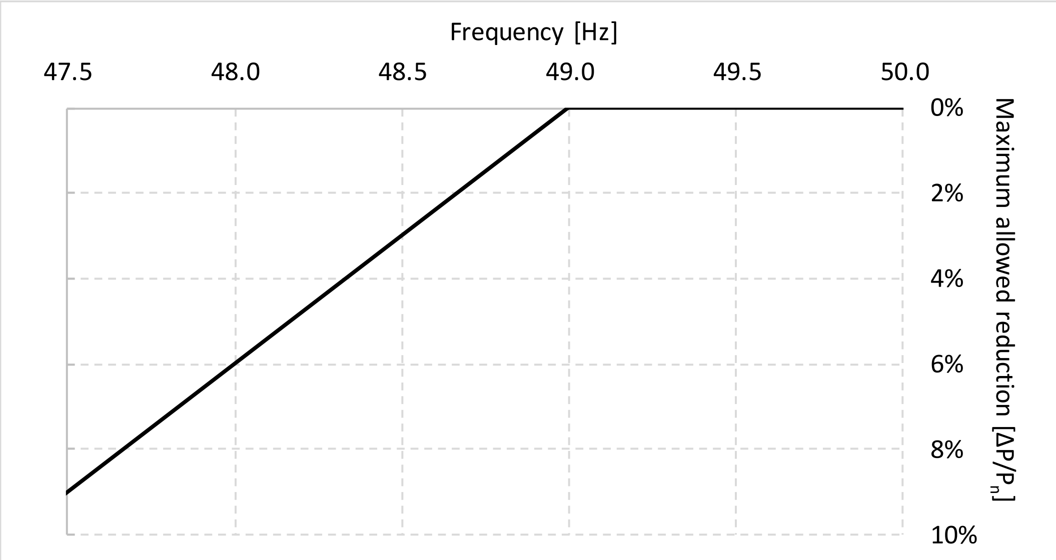

Figure 5.2 – Permitted reduction of active power during underfrequency.

Permitted reduction of active power	
Frequency range	49 Hz - 47.5 Hz
Reduction of P_n/Hz	6%

Table 5.1 – Permitted reduction of active power during underfrequency.

A power-generating plant may only reduce the active power if the plant is technically incapable of continuing to supply of full active power at underfrequency. This applies during normal operating conditions, which are guaranteed for 90% of the time, and must occur to the best of its ability in relation to operating point and available primary energy.

5.1.3. Tolerance of voltage deviations

A power-generating plant must comply with the requirements for tolerances of voltage deviations as specified in this section. Specific requirements apply, depending on plant type.

5.1.3.1. Permitted reduction of active power at undervoltage

When the voltage at the Point of Connection (POC) is less than 95% of nominal value, it is allowed to reduce the generation of active power to comply with the power-generating plant's current limitation. The reduction must be as small as technically possible.

5.1.3.2. Tolerance to voltage swells

A power-generating plant must be capable of remaining connected to the grid during voltage swells as specified in table 5.2.

Voltage	Duration
$1.15 \cdot U_c$	60 s
$1.20 \cdot U_c$	5 s

Table 5.2 – Tolerance to voltage swells.

5.1.3.3. Tolerance to voltage dips

(a) Synchronous power-generating plant

A synchronous power-generating plant must be capable of withstanding voltage dips as shown in figure 5.3. A synchronous power-generating plant must be capable of remaining connected to the grid during voltage dips above the solid line in figure 5.3. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 5.3. The requirement is assessed at P_n and Power Factor 1.0. The DSO must, at the power-generating plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

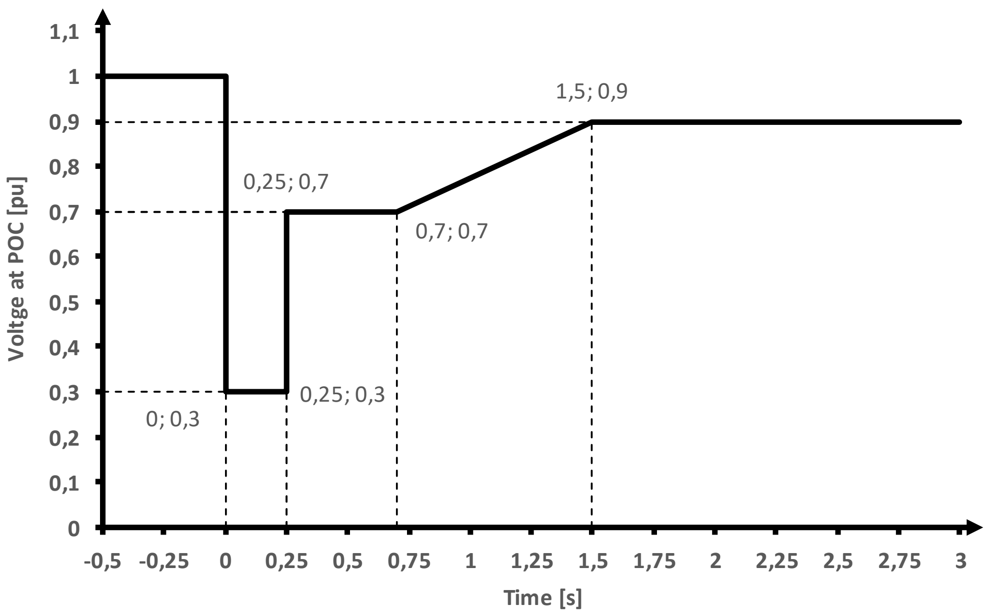

Figure 5.3 – Tolerance to voltage dips for a synchronous power-generating plant.

A synchronous power-generating plant must be capable of restoring normal generation of active power after a fault as quickly as possible after voltage and frequency have returned to the normal range, see section 5.1.1. The power-generating plant's natural ability to restore generation of active power must not be artificially or unnecessarily restricted.

(b) Power park modules

A power park module must be capable of withstanding voltage dips as shown in figure 5.4. A power park module must be capable of remaining connected to the grid during voltage dips above the solid line in figure 5.4. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 5.4. The requirement is assessed at P_n and Power Factor 1.0. The DSO must, at the plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

A power park module must be capable of restoring normal generation of active power after a fault as quickly as possible; however, no later than five seconds after voltage and frequency have returned to the normal operating range, see section 5.1.1. During the recovery process, upward regulation of active power must be performed with a gradient of at least 20% P_n/s.

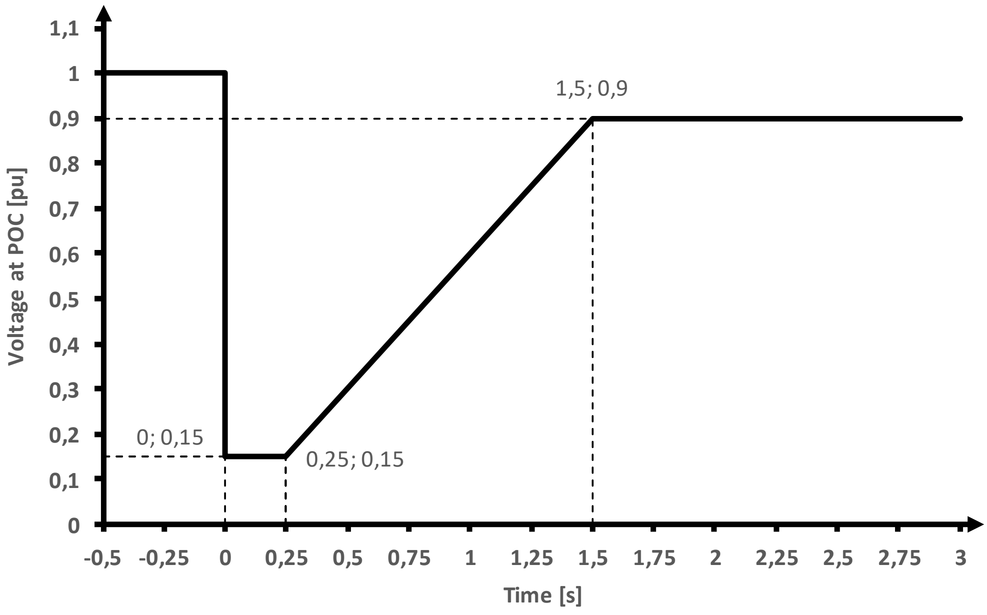

Figure 5.4 – Tolerance to voltage dips for a power park module.

Supply of fast fault current

A power park module must be capable of supplying fast fault current, I_Q, at the Point of Generator Connection in case of a symmetrical fault (three-phase fault) to maintain grid voltage stability during and after a fault.

A power park module must be capable of supplying fast fault current (positive sequence component) in the area above the solid line in figure 5.4 and up to 90% of normal operating voltage at the Point of Generator Connection.

Control of fast fault current from a power park module must follow figure 5.5.

It must be possible to supply fast fault current within 100 ms with an accuracy of ±20% of I_n.

During a fault sequence, a power park module must prioritise the fast fault current before supplying the active power in the range from 90% to 15% of U_c, see the hatched area in figure 5.5.

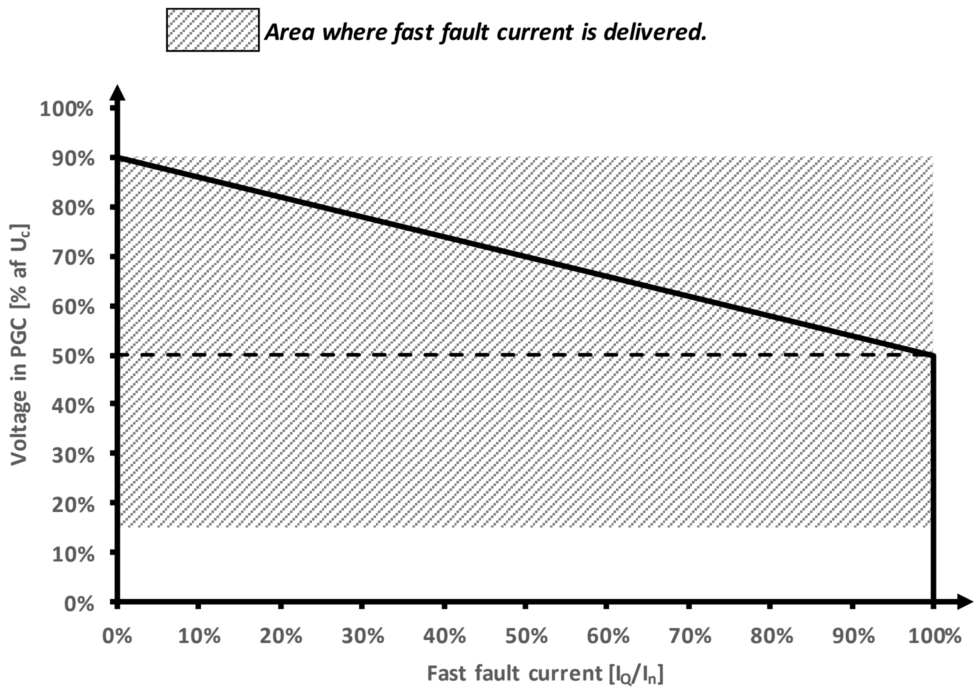

Figure 5.5 – Supply of fast fault current from a power park module.

5.2. Start-up and reconnection of a power-generating plant

Start-up and reconnection of a power-generating plant is only permitted when the frequency and voltage are within the following ranges:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency range	47.5 Hz - 50.2 Hz	47.5 Hz - 50.5 Hz
Voltage range	90% - 110% U_c	90% - 110% U_c
Observation time	Three minutes	Three minutes

Table 5.3 – Criteria for start-up and reconnection of a power-generating plant.

When a power-generating plant has been connected, the active power must not increase by more than 20% of nominal power per minute.

5.2.1. Synchronisation

A power-generating plant must be capable of automatically synchronising to the public electricity supply grid. It must not be possible to manually circumvent the automatic synchronisation and allow the plant to connect without synchronisation.

5.3. Active power control

A power-generating plant must be capable of controlling its active power. It must be possible to indicate set points in steps of 1% of P_n or better.

Active power control must be performed with a gradient of at least 1% P_n/min for synchronous power-generating plants and at least 20% P_n/min for power park modules. For synchronous generators, there is also a 10 minutes reaction time, if required.

Control must be performed with an accuracy of ±2% of power-generating plant nominal active power. The control accuracy is measured over a period of one minute.

5.3.1. Power response to overfrequency

A power-generating plant must be capable of downward regulation of its active frequency at overfrequency. Downward regulation of active power must be initiated within two seconds at the Point of Connection (POC).

To be able to detect islanding, downward regulation of the active power at the Point of Connection (POC) must not be commenced until after an intentional delay of 500 ms.

If the plant's natural delay (recovery time) for commencement of downward regulation is 500 ms or more, the requirement for delay is met.

If the plant's natural delay (recovery time) for commencement of downward regulation is less than 500 ms, the delay must be extended to 500 ms. The intentional delay is only imposed when transitioning to frequency response, i.e. when the frequency threshold f_{RO} is crossed.

Example

A plant's natural delay (recovery time) for commencement of downward regulation is 300 ms. An additional intentional delay (recovery time) of 200 ms is added to make the total delay (recovery time) for the plant 500 ms.

The downward regulation of active power must be commenced at a frequency threshold (f_{RO}) and follow a droop as indicated in figure 5.6, regardless of whether the frequency increases or decreases.

When a power-generating plant's lower limit for active power is reached in connection with the downward regulation, the plant must keep this minimum level of active power until the grid frequency drops again or until the plant is disconnected for other reasons.

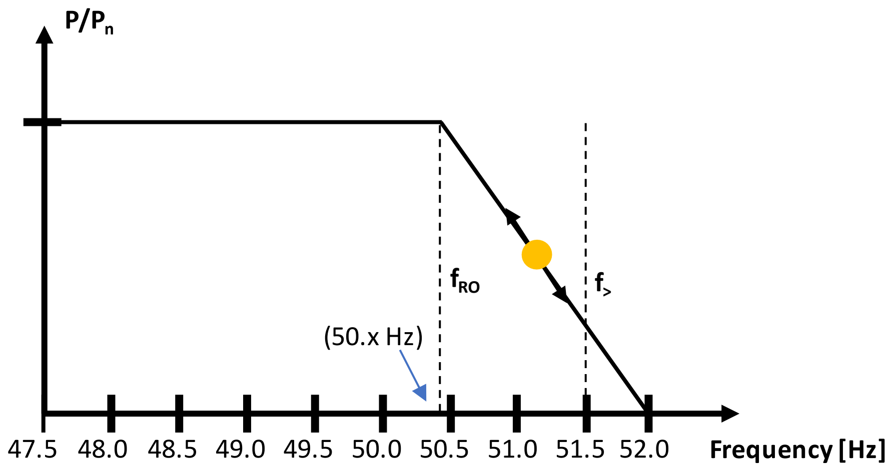

Figure 5.6 – Frequency response droop to overfrequency.

The frequency threshold for commencement of frequency response must be set in the 50.2 Hz - 50.5 Hz frequency range, both values inclusive, with a resolution of 10 mHz or better.

The droop of the active power reduction must be in the 2-12% range with a resolution of 1% or better.

The settings for frequency response to overfrequency for Western and Eastern Denmark are as follows:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency threshold f_{RO}	50.2 Hz	50.5 Hz
Droop	5%	4%
Intentional delay for islanding detection	500 ms	500 ms

Table 5.4 – Default settings for power response to overfrequency for DK1 and DK2.

When the frequency response is enabled, the active power must follow the droop with a deviation of 5% of nominal active power or better, measured over a period of one minute.

Frequency must be measured with an accuracy of ±10 mHz or better.

5.3.2. Power response to underfrequency

A power-generating plant must be capable of upward regulation of active power during underfrequency if the plant does not already produce at its nominal power. Upward regulation of active power must be initiated within two seconds at the Point of Connection (POC).

To be able to detect islanding, upward regulation of the active power at the Point of Connection (POC) must not be initiated until after an intentional delay of 500 ms.

If the plant's natural delay (recovery time) for commencement of upward regulation is 500 ms or more, the requirement for minimum delay is met.

If the plant's natural delay (recovery time) for commencement of upward regulation is less than 500 ms, the delay must be extended to 500 ms. The intentional delay is only imposed when transitioning to frequency response, i.e. when the frequency threshold f_{RU} is crossed.

Example

A plant's natural delay (recovery time) for commencement of upward regulation is 300 ms. An additional intentional delay (recovery time) of 200 ms is added to make the total delay/recovery time for the plant 500 ms.

Upward regulation of active power must be initiated at a frequency threshold (f_{RU}) and follow a droop as indicated in figure 5.7.

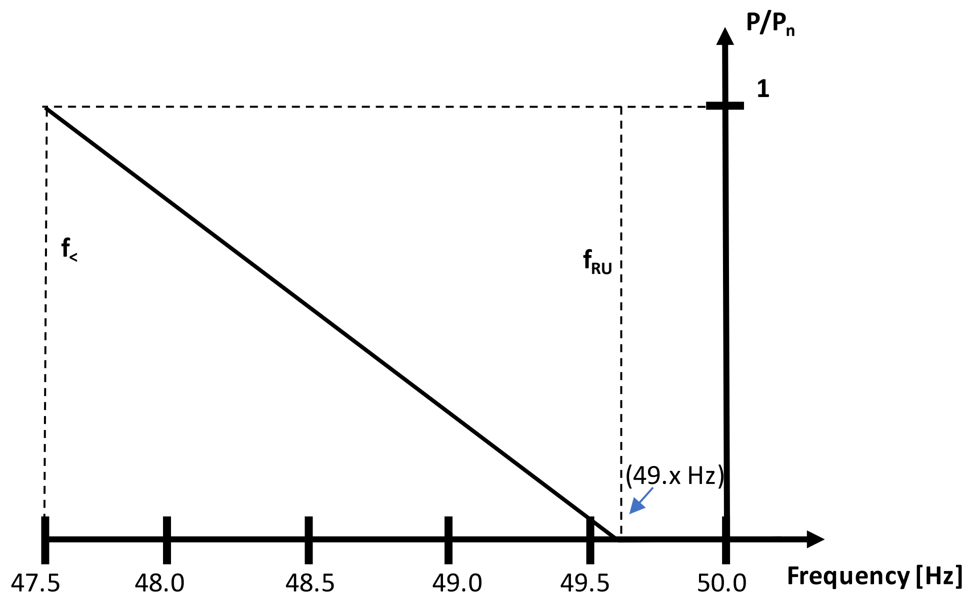

Figure 5.7 – Frequency response droop at underfrequency.

The frequency threshold for commencement of frequency response (f_{RU}) must be set in the 49.5 Hz - 49.8 Hz frequency range, both values inclusive, with a resolution of 10 mHz or better.

The droop of the active power increase must be in the 2-12% range with a resolution of 1% or better.

The settings for frequency response during underfrequency for Western and Eastern Denmark are as follows:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Start frequency f_{RU}	49.8 Hz	49.5 Hz
Droop (of P_n)	5%	4%
Intentional delay for islanding detection	500 ms	500 ms

Table 5.5 – Default settings for frequency response – underfrequency.

When the frequency response is enabled, the active power must follow the droop with an accuracy of 5% of nominal active power or better, measured over a period of one minute.

Frequency must be measured with an accuracy of ±10 mHz or better.

Supply of frequency response in case of underfrequency must take the availability of the primary energy source into consideration as well as the permitted reduction of active power at underfrequency, see section 5.1.2.2.

Consumption which is not part of power-generating plant operation must be disconnected in case of underfrequency. In DK1, consumption must be disconnected at 49.0 Hz, and in DK2 at 48.5 Hz.

5.3.3. Frequency control

A power-generating plant must be capable of supplying frequency control and contributing to stabilising the grid frequency.

Frequency control must be set in the 47.5 Hz - 51.5 Hz frequency range, both values inclusive. This frequency range includes frequency response for both underfrequency and overfrequency as well as frequency control with deadband as shown in figure 5.8.

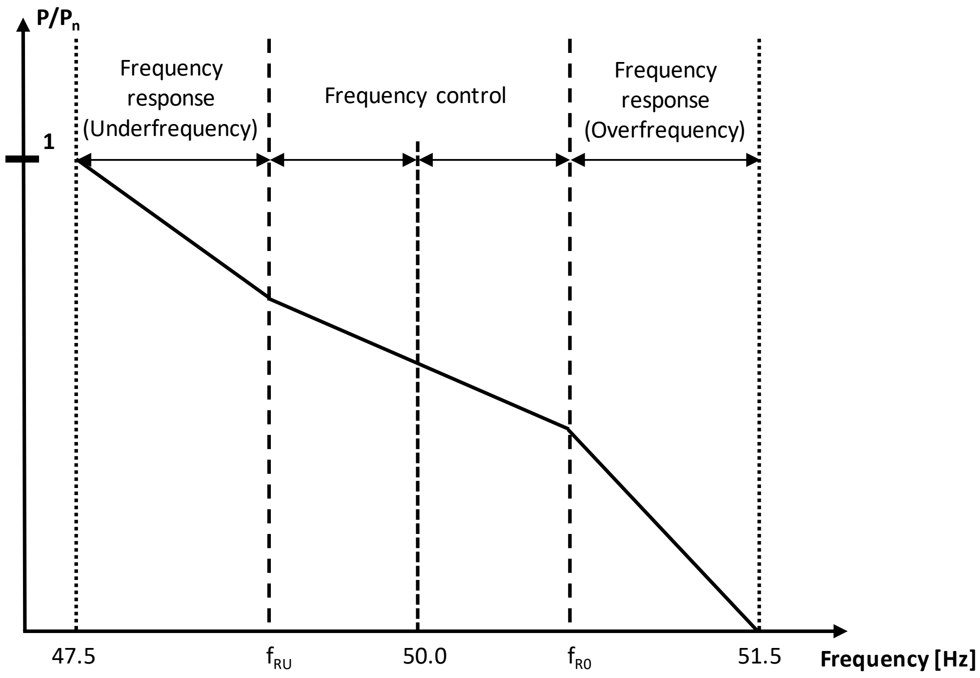

Figure 5.8 – Frequency control and frequency response.

The actual frequency control is between f_{RU} and f_{RO}, which are the activation frequencies for frequency response for underfrequency and overfrequency.

Control of power-generating plant active power with respect to frequency must be initiated within two seconds of a grid frequency change.

The measurement accuracy for the grid frequency must be ±10 mHz or better.

Frequency control must follow a droop as shown in figure 5.8. It must be possible to set a negative slope droop in the 2-12% range with a resolution of 1% or better.

The active power $\Delta P/P_n$, which is used for frequency control, must be set in the 1.5%-10% range of power-generating plant maximum power capacity.

It must be possible to set a deadband around the nominal frequency in the 49.5 - 50.5 Hz frequency range with a width of 0 - 500 mHz.

It must also be possible to set an insensitivity to frequency changes so that frequency changes below the set threshold value do not result in active power changes. The control insensitivity must be set to 10 mHz.

A power-generating plant must be capable of supplying full frequency control for 15 minutes. Full frequency control means that the plant must be capable of delivering the power $\Delta P/P_n$ continuously throughout the required period.

A synchronous power-generating plant must be capable of activating full frequency control within the parameters in table 5.6 within 30 seconds.

Setting intervals for frequency control are stated in table 5.6.

		DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency control range		49.8 - 50.2 Hz	49.5 - 50.5 Hz
Active power in proportion to the nominal output $\Delta P/P_n$		1.5 - 10%	1.5 - 10%
Control insensitivity	$\lvert\Delta f_i\rvert$	±10 mHz	±10 mHz
Deadband		0 - 200 mHz	0 - 500 mHz
Droop slope		2 - 12%	2 - 12%

Table 5.6 – Setting intervals for frequency control.

5.3.4. Constraint functions

A power-generating plant must be equipped with a number of active power constraint functions. The requirements depend on plant type.

5.3.4.1. Absolute power limit

A power-generating plant must be capable of limiting its maximum active power.

Absolute power limit is used to limit the active power from a power-generating plant to a set point-defined maximum power limit at the Point of Connection (POC).

Absolute power limit is used to protect the public electricity supply grid against overload in critical situations.

Control using a new parameter for the absolute power limit must be completed within five minutes of receiving the parameter change order.

5.3.4.2. Ramp rate limit

A power-generating plant must be capable of limiting the gradient of the active power. Unless another functionality, including ancillary services, requires a higher gradient, e.g. active power recovery after fault, the gradient must be within maximum and minimum gradients in connection with upward and downward regulation.

Upward regulation	Max.	20% of P_n/min; however, max. 60 MW/min.
	Min.	1% of P_n/min.
Downward regulation	Max.	20% of P_n/min; however, max. 60 MW/min.
	Min.	1% of P_n/min.

Table 5.7 – Maximum and minimum gradients in connection with upward and downward regulation.

5.3.4.3. System protection scheme

The requirement for system protection applies to power park modules. For synchronous power-generating plants, the need is assessed when assigning the Point of Connection (POC).

A power-generating plant must be equipped with system protection scheme which is an emergency control function that, following a downward regulation order, is capable of quickly adjusting the active power supplied from a plant to one or more predefined set points. Set points are determined by the DSO during commissioning.

The power-generating plant must have at least five different configurable adjustment positions.

The following default set points are:

1. To 70% of rated power
2. To 50% of rated power
3. To 40% of rated power
4. To 25% of rated power
5. To 0% of rated power, i.e. the power-generating plant is stopped.

Control must be initiated within one second and completed within ten seconds of receipt of a downward regulation order.

If the system protection receives an upward regulation order, e.g. from step 4 (25%) to step 3 (40%), it is acceptable that completion of the order may take additional time due to the design limits of power-generating plant generators or other plant units.

5.3.4.4. (b) Power park modules – additional requirements

Delta power limit

The delta power limit is used to limit the active power from a power-generating plant to a required constant value relative to available active power $P_{possible}$.

Control to a new parameter value for the delta power limit must be initiated within two seconds and completed within five minutes of receipt of a parameter change.

Delta power constraint is typically used to obtain a control reserve for upward regulation in connection with frequency control of plants with varying availability of the primary energy source, e.g. solar and wind power.

Reduction of active power during high winds

For wind power plants, the requirements for ramp rate limit for reduction of active power during high winds.

To ensure system stability, a wind power plant must be capable of gradually reducing active power at high wind speeds to prevent sudden loss of active power when the wind speed exceeds the wind power plant's overspeed limitation.

The active power reduction must be within the shaded blue band as shown in figure 5.9. Reduction can be continuous or in discrete steps. If the reduction is performed in discrete steps, the step size must not exceed 25% of P_n. The settings for reduction of active power at high winds must be agreed with the DSO prior to commissioning the wind power plant.

Automatic downward regulation is specified at minimum three points:

- Wind speed – activation of downward regulation [m/s]
- Wind speed – 10% of P_n [m/s]
- Wind speed – cut-out [m/s]

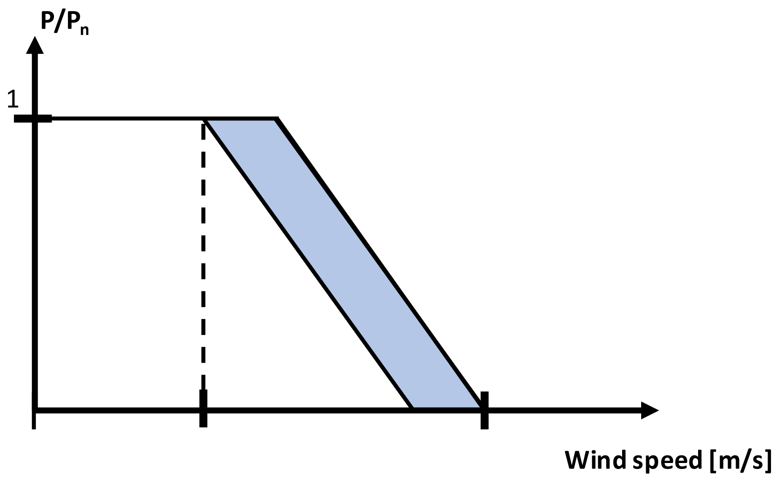

Figure 5.9 – Downward regulation at high winds.

5.4. Reactive power control

A power-generating plant must be capable of delivering reactive power. Only one of the following required control functions can be active at a time.

The power-generating plant must be capable of controlling its reactive power using the functions and characteristics described in sections 5.4.2 to 5.4.4. It must be possible to indicate set points in steps of 100 kVAr or better for reactive power and 0.01 or better for Power Factor.

Control accuracy must be ±3% of Q_n or better. The control accuracy is measured over a period of one minute.

When one or more units of a power park module are taken out of operation for scheduled maintenance, the plant's supply of reactive power may be reduced proportionate to the number of units taken out of operation.

The power-generating plant owner must compensate for the plant infrastructure's reactive power in situations where the plant is disconnected or not generating active power.

5.4.1. Reactive power range

The requirements concerning the ability to supply reactive power (the operating range) depend on the type of power-generating plant.

5.4.1.1. (a) A synchronous power-generating plant

At maximum production, a synchronous power-generating plant must be capable of supplying reactive power at different voltages at the Point of Connection (POC) as specified in figure 5.10.

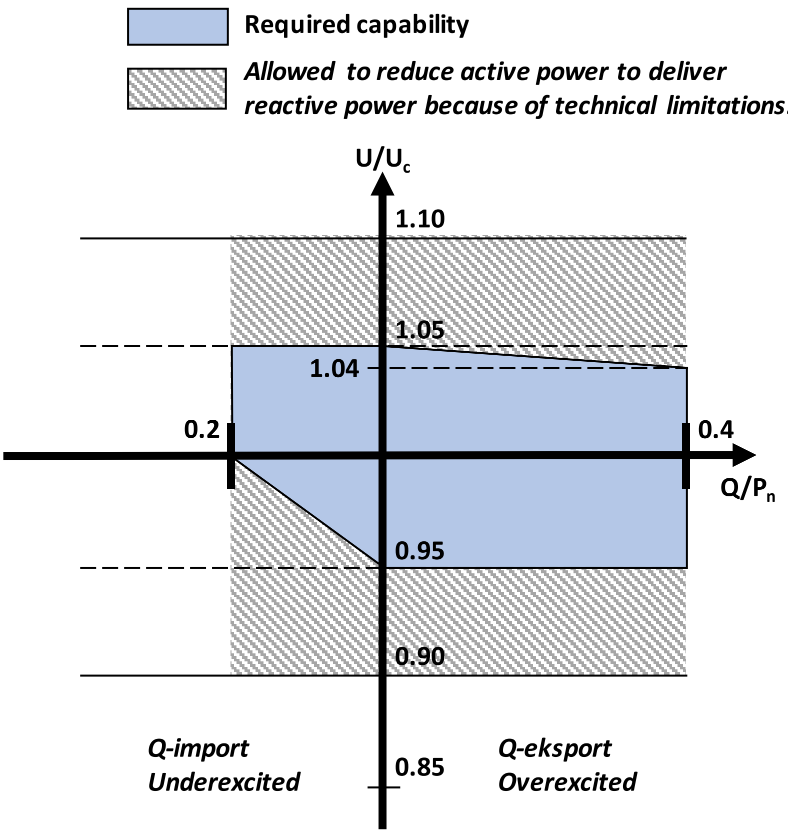

Figure 5.10 – Requirements for supply of reactive power at maximum active power generation.

Inside the hatched grey region in figure 5.10, the synchronous power-generating plant must supply stable reactive power in accordance with the selected control mode, which may only be limited by the technical performance of the plant, e.g. saturation or under-compensation.

When generating active power under maximum capacity, a synchronous power-generating plant must be capable of operating at every point inside the synchronous power-generating plant's P-Q capability curve.

5.4.1.2. (b) A power park module

At maximum production, a power park module must be capable of supplying reactive power at different voltages at the Point of Connection (POC) as specified in figure 5.11.

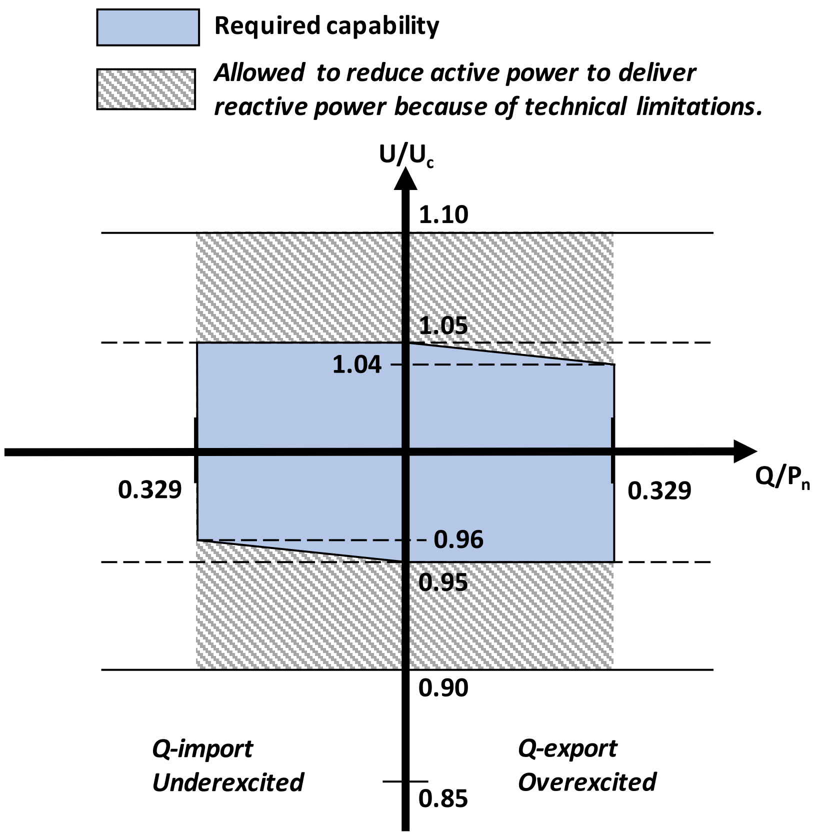

Figure 5.11 – Requirements for supply of reactive power at maximum active power generation.

Inside the hatched grey region in figure 5.11, the power park module must supply stable reactive power in accordance with the selected control mode, which may only be limited by the technical performance of the plant, e.g. saturation or undercompensation.

When active power generation is below the maximum capacity, a power park module must be capable of operating within the area specified in figure 5.12.

In the solid blue area on figure 5.12, it is accepted that the ability to supply reactive power may be limited by a reduced number of units in operation due to start-up and shutdown of power park modules as a result of lacking primary power.

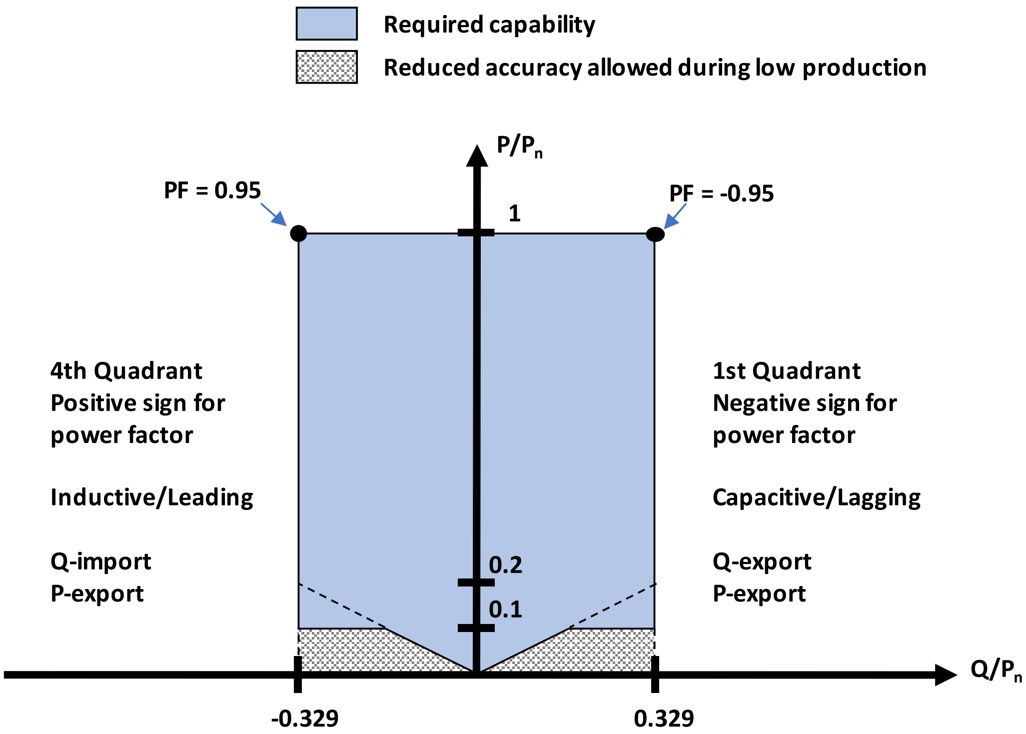

Figure 5.12 – Requirements for supply of reactive power at different active power levels.

5.4.2. Power Factor control

A power-generating plant must be capable of performing Power Factor control allowing the reactive power to be controlled by means of a fixed Power Factor, see figure 5.13.

When a new Power Factor set point is set, the control must be initiated within two seconds and completed within 30 seconds,

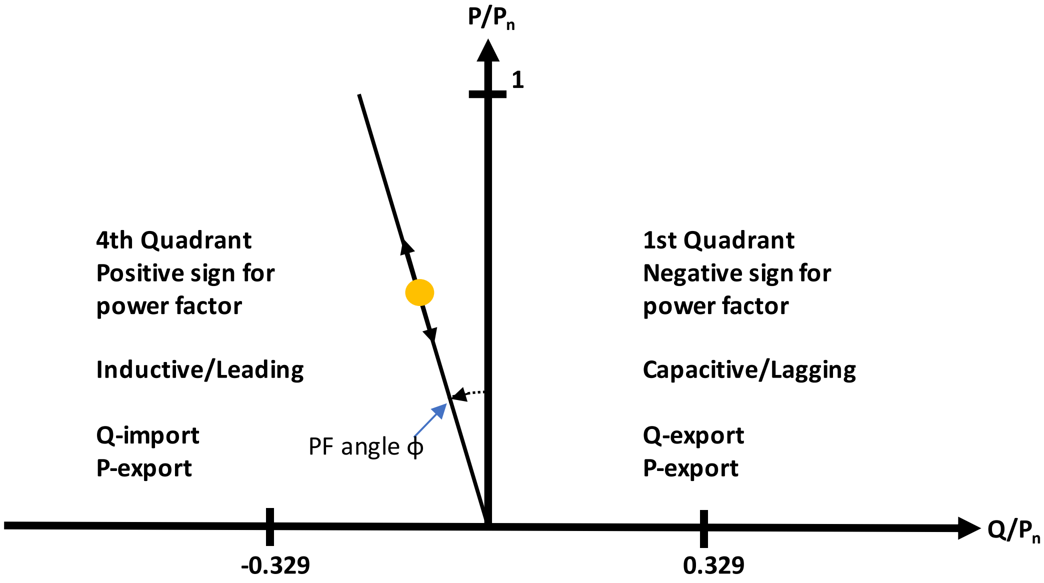

Figure 5.13 – Example of Power Factor control [cos ϕ fixed].

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

5.4.3. Voltage control

A power-generating plant must be capable of performing voltage control with a droop and deadband as shown in figure 5.14.

The voltage control droop slope must be set within the 2% - 7% range in steps no greater than 0.5%.

The deadband must be set within ±5% of U_{ref} with a step size of not more than 0.5% of U_{ref} and must be symmetric around the voltage control set point.

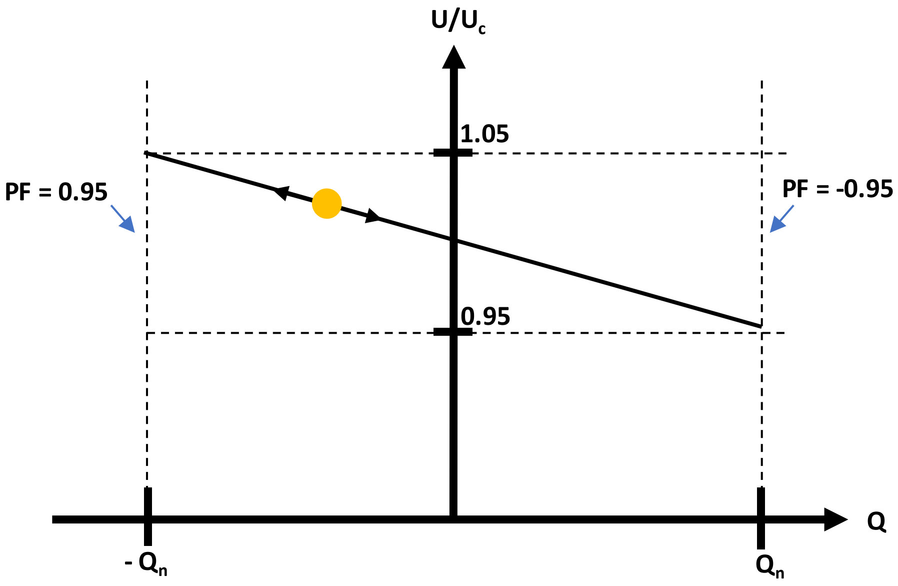

Figure 5.14 – Voltage control droop [Q(U)].

The power-generating plant must be capable of achieving 90% of the reactive power change within one second, and control must be completed within five seconds.

Unless otherwise agreed, this control function must be disabled. If the function is to be enabled, the parameter values for the control function are agreed with the DSO.

5.4.4. Q control

A power-generating plant must be capable of performing Q control as shown in figure 5.15.

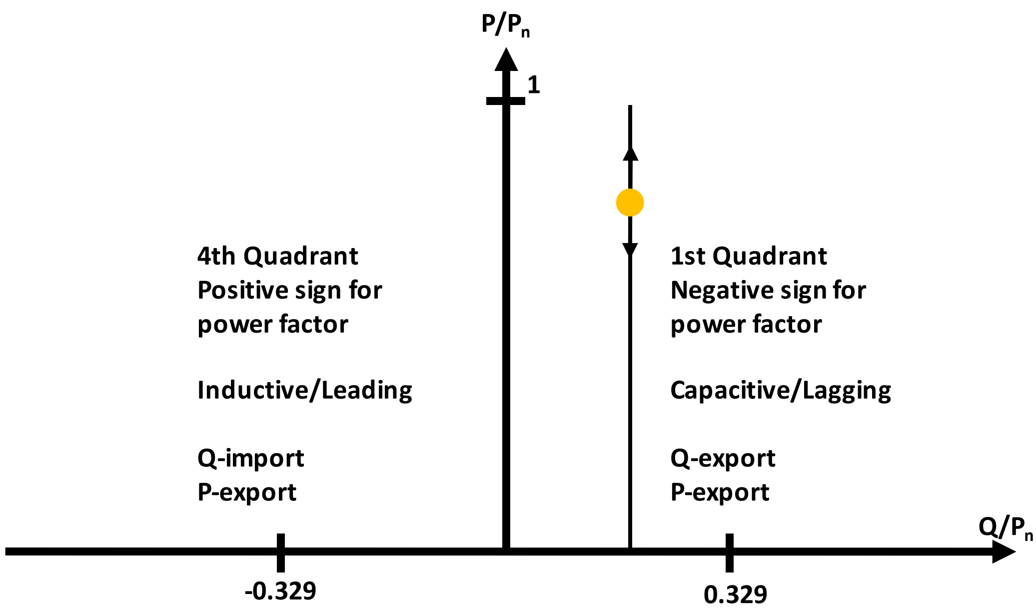

Figure 5.15 – Example of Q control [Q set point].

Control from one set point to another must be initiated within 2 seconds and completed within 30 seconds.

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

5.4.5. (a) Synchronous power-generating plants – additional requirements

In addition to the general requirements for reactive power, synchronous power-generating plants must also be equipped with an automatic excitation system. The excitation system must be capable of supplying stable and constant voltage at the PGC. It must be possible to select the voltage set point in the entire voltage range for normal operation.

5.5. Protection

5.5.1. General

Power-generating plant protection must both protect the plant and help ensure stability in the public electricity supply grid.

Relay settings cannot prevent specified power-generating plant functions from working properly.

The power-generating plant owner is responsible for ensuring that the plant is dimensioned and equipped with the necessary protection functions so that the plant:

- Is protected against damage due to faults and incidents in the public electricity supply grid
- Protects the public electricity supply grid against unwanted impacts from the power-generating plant
- Is protected against damage as a result of asynchronous connections
- Is protected against disconnection in non-critical situations for the power-generating plant
- Is not damaged and does not switch off during voltage dips as specified in section 5.1.3.

The DSO or the transmission system operator may demand that the setting values for protection functions be changed after commissioning if it is deemed to be of importance to the operation of the public electricity supply grid.

Following disconnection of a power-generating plant due to a fault in the public electricity supply grid, the plant must not reconnect automatically earlier than specified in section 5.2.

A power-generating plant which has been disconnected by an external signal prior to a fault occurring in the public electricity supply grid must not be connected until the external signal has been eliminated and the voltage and frequency are once again within the range specified in section 5.2.

At the power-generating plant owner's request, the DSO must state the highest and lowest short-circuit current that can be expected at the Point of Connection (POC) as well as any other information about the public electricity supply grid as may be necessary to configure the plant's protection functions.

Voltage and frequency must be measured simultaneously for the phases which the power-generating plant is connected to at the Point of Connection (POC).

5.5.2. Requirements for protection functions and settings

The power-generating plant's protection functions and associated settings must be as specified in the following subsections. Settings deviating from the default values, e.g. in the event of problems with local overvoltages, may only be used with the DSO's permission.

In connection with internal short circuits in the power-generating plant, the relay protection must be selective with the grid protection. This means that short circuits in the power-generating plant must be disconnected within 100 ms.

All settings are stated as RMS values.

The power-generating plant must be disconnected or shut down if a measuring signal deviates more from its nominal value than the setting.

The trip time stated is the measuring period during which the trip condition must constantly be fulfilled in order for the protection function to release a trip signal.

The accuracy of voltage and frequency measurements must be ±1% of U_c and ±0.05 Hz or better respectively.

The frequency change is calculated according to the following or equivalent principle.

The frequency measurement used to calculate the frequency change is based on a 200 ms measuring period where the mean value is calculated.

Frequency measurements must be made continuously, calculating a new value every 20 ms.

ROCOF [Hz/s] must be calculated as the difference between the currently performed frequency mean value calculation and the calculation performed 20 ms before.

(df/dt = (mean value 2 – mean value 1)/0.020 [Hz/s])

If a power-generating plant is isolated with part of the public electricity supply grid, the plant must not cause temporary overvoltages that can damage the plant or the public electricity supply grid.

5.5.3. Requirements for grid protection

Requirements for protection functions and settings depend on the type of power-generating plant.

5.5.3.1. (a) Requirements for grid protection of synchronous power-generating plants

Protection functions and settings of synchronous power-generating plants must be agreed with the DSO and the transmission system operator.

5.5.3.2. (b) Requirements for grid protection of power park modules

A power park module must have protection functions as specified in table 5.8. Unless otherwise agreed with the DSO, the default values in the table are to be used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Overvoltage (step 3)	$U_{>>>}$	1.0 - 1.3/0.01 Default: 1.20	U_c	0.1 - 5/0.05 Default: 0.1	s
Overvoltage (step 2)	$U_{>>}$	1.0 - 1.3/0.01 Default: 1.15	U_c	0.1 - 5/0.05 Default: 0.2	s
Overvoltage (step 1)	$U_{>}$	1.0 - 1.2/0.01 Default: 1.10	U_c	0.1 - 100/0.1 Default: 60	s
Undervoltage (step 1)	$U_{<}$	0.2 - 1.0/0.01 Default: 0.90	U_c	0.1 - 100/0.1 Default: 60	s
Overfrequency	$f_{>}$	50.0 - 52.0/0.1	Hz	0.1 - 5/0.05	s

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
		Default: 51.5		Default: 0.2	
Underfrequency	$f_<$	47.0 - 50.0/0.1 Default: 47.5	Hz	0.1 - 5/0.05 Default: 0.2	s

Table 5.8 – Protection settings for power park modules in type C.

5.5.4. Requirements for islanding detection

A power-generating plant must be capable of detecting unintentional islanding and must disconnect from the public electricity supply grid if unintentional islanding is detected.

In Denmark, only passive islanding detection methods are used. The use of vector jump relays (ANSI 78) or active islanding detection is not allowed on power-generating plants connected to the Danish public electricity supply grid.

A power-generating plant must have the functions for islanding detection specified in table 5.9. Unless otherwise agreed with the DSO, the default value in the table is used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Frequency change	df/dt	2 - 3.5/0.1 Default: ±2.5	Hz/s	0.02 - 5/0.01 Default: 0.08	s

Table 5.9 – Requirements for islanding detection.

5.5.5. Earthing

Conditions related to earthing of the power-generating plant must be agreed with the DSO.

5.6. Power quality

A power-generating plant must not cause unacceptable power quality in the grid. To avoid this, the plant must comply with the requirements specified in the following sections.

In cases when a power-generating plant may have a significant impact on the public electricity supply grid (the distribution system and/or the transmission system), additional requirements may apply, see section 5.6.2.

A three-step procedure for power quality assessment is applied, which in brief comprises:

1. *Checking if the Short-Circuit Ratio (SCR) ≥500.*
2. *Assessing power quality by calculation.*
3. *Measuring noise in the grid before and after connection of the plant and agreeing on a solution to the problem.*

5.6.1. Emission limits

A power-generating plant must comply with the requirements described in the following sections.

5.6.1.1. DC content

A power-generating plant must not inject DC currents into the grid. This requirement is met if the DC content of the current injected by the plant into the grid is below 0.5% of the nominal current of the plant.

If the power-generating plant is connected to the grid by means of a plant transformer, it is assumed that this requirement is met.

The reason for having a limit value for DC content is that DC currents are undesirable in the public electricity supply grid and may have an adverse effect on grid operation and protection. The limit value is set based on IEC/TR 61000-3-15, which provides recommendations for requirements for local production connected to the public electricity supply grid at low-voltage level.

5.6.1.2. Voltage unbalance

A power-generating plant must have balanced three-phase load so as not to cause voltage unbalance.

Requirements for unbalance are made because unbalance in phase voltages between phases is undesirable in the public electricity supply grid as it may have an adverse effect on grid operation and the units connected to the public electricity supply grid.

According to the international standard DS/EN 50160, the limit for the total voltage unbalance in the public electricity supply grid is 2%. Voltage unbalance can be distributed in accordance with the method described in IEC/TR 61000-3-13, but this will yield impractically low limit values for the individual plant, which are lower than the measurement uncertainty for measurement of unbalance.

When the plant has a balanced three-phase load, it will generally not add to the voltage unbalance already present in the public electricity supply grid. Documentation showing that the plant has balanced three-phase production will often be sufficient to establish that the plant will not give rise to voltage unbalance in the public electricity supply grid.

To ascertain that the plant does not give rise to voltage unbalance, the voltage unbalance can be measured at the Point of Connection (POC) before and after commissioning of the plant. If there is no significantly increased voltage unbalance after commissioning of the plant compared to the measurements made before commissioning, the voltage unbalance requirement is met.

Voltage unbalance is measured according to DS/EN 61000-4-30 as the negative sequence component divided by the positive sequence component.

5.6.1.3. Rapid voltage changes

A power-generating plant must not cause rapid voltage changes exceeding the limit values specified in table 5.10.

Voltage level	Limit value
Medium voltage	d(%) = 4%
High voltage	d(%) = 3%

Table 5.10 – Limit value for rapid voltage changes.

Requirements for rapid voltage changes are based on DS/EN 61000-3-11 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-7.

5.6.1.4. Flicker

The power-generating plant must comply with the flicker limit defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-7.

5.6.1.5. Harmonics

The power-generating plant must comply with the voltage limit values for harmonics emissions defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

5.6.1.6. Interharmonic overtones

The power-generating plant must comply with the voltage limit values for interharmonic overtones defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

5.6.1.7. Distortions in the 2-9 kHz frequency range

The power-generating plant must comply with the voltage limit values for distortions in the 2-9 kHz frequency range defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

5.6.2. Division of responsibilities

5.6.2.1. The power-generating plant owner's obligations

As a rule, the power-generating plant owner must ensure that the plant is designed, constructed and configured to comply with all emission limits.

The power-generating plant owner must verify that emission limits at the Point of Connection (POC) are complied with.

For calculation of power quality, the power-generating plant owner uses the typical three-phase short-circuit power, $S_{k,powerquality}$ at the Point of Connection (POC).

The DSO and the transmission system operator will perform a joint assessment of whether or not a power-generating plant may have significant impact on the public electricity supply grid.

For power-generating plants with a significant impact on the public electricity supply grid, the plant owner must also:

- Use frequency-dependent impedance loci to calculate power quality
- Verify that emission limits are also complied with towards the transmission system

- Be capable of supplying an impedance model for the power-generating plant, see section 5.8.

Compliance with emission limits for plants with a significant impact on the electricity supply grid is typically verified by performing calculations on a model model given by the DSO, where one or two points in the model will contain emission limits to be complied with.

Subject to agreement, the plant owner can buy additional services (higher short-circuit power or subscribed capacity) from the DSO in order to comply with the specified limit values.

5.6.2.2. The DSO's obligations

The DSO is responsible for setting emission limits at the Point of Connection (POC).

The DSO must specify the short-circuit level $S_{k,powerquality}$ with associated short-circuit angle ψ_k at the Point of Connection (POC).

When it is impossible to calculate $S_{k,powerquality}$ for a connection point, $S_{k,powerquality}$ is estimated as $(S_{k,min} + S_{k,max})/2$.

The DSO must also state the frequency-dependent grid impedance at the Point of Connection (POC) $Z_{net,h}$. The DSO may choose to state the grid impedance as a measured value or as an approximate model. Using impedance loci, the grid company passes on the impedance loci from the transmission system operation, adjusted to account for any intermediate systems.

$Z_{net,h}$ is generally stated as an approximate model using the approximation method described below. When it is deemed necessary with respect to the impact on the public electricity supply grid, frequency-dependent impedance loci are stated instead.

For frequencies up to and including 2 kHz:

$$|Z_{net,h}| = \sqrt{R_{50}^2 + (h \cdot X_{50})^2}\ , for\ h = [1; 40]$$

For frequencies above 2 kHz:

$$|Z_{net,h}| = \sqrt{R_{50}^2 + (40 \cdot X_{50})^2}\ , for\ h > 40$$

R_{50} and X_{50} are resistance and reactance at 50 Hz. They are calculated from $S_{k,powerquality}$ and the matching short-circuit angle ψ_k.

5.6.3. Measuring method

Measurements of various power quality parameters must be carried out in accordance with the European standard DS/EN 61000-4-30 (class A).

Measurement of harmonic distortion of voltage and current must be carried out as defined in IEC 61000-4-7 in accordance with the principles (harmonic subgroup) and with the accuracies specified for class I.

Measurement of interharmonic distortion up to 2 kHz must be carried out as defined in IEC 61000-4-7 Annex A and must be measured as interharmonic subgroups.

Alternatively, it is allowed to measure harmonic distortion up to 2 kHz with grouping enabled (harmonic groups) as specified in IEC 61000-4-7 and with the accuracies specified for class I. If harmonic distortion up to 2 kHz is measured with grouping enabled, it is not required to measure interharmonic distortion up to 2 kHz separately.

Measurement of distortions in the 2-9 kHz frequency range must be carried out as defined in IEC 61000-4-7 Annex B and must be measured in 200 Hz windows with centre frequencies from 2100 Hz to 8900 Hz.

5.7. Exchange of information

A power-generating plant must be equipped with a PCOM enabling real-time exchange of signals.

If a power-generating plant consists of more than one unit, a plant controller must be installed to allow control of the whole plant at the PCOM, see figure 3.3 and figure 3.4.

5.7.1. Requirements for time stamps and update speed

The information must have time stamps. The time stamps shall have the following update times:

- Maximum time to update functional status (enabled/disabled) is 10 ms.
- Maximum time to update parameter value is one second.
- Maximum time to update measured values is one second.

5.7.2. Requirements for information exchange

A power-generating plant must as a minimum be capable of exchanging the following information in real time:

Signal description	Signal type
Absolute power limit	Set point
Absolute power limit	Enabled/disabled
Circuit breaker status at the POC	Status
Circuit breaker status at the PGC	Status
Active power	Measurement
Reactive power	Measurement
Current	Measurement
Voltage	Measurement
Scheduled active power	Set point
Power Factor (PF)	Measurement (may also be a computed value)
Q control	Set point
Q control	Enabled/disabled
Power Factor control	Set point
Power Factor control	Enabled/disabled
Voltage control	Enabled/disabled
Voltage control – requested voltage	Set point
Voltage control – droop	Set point
Downward regulation during high winds*	Enabled/disabled
System protection scheme**	Enabled/disabled
System protection scheme**	Set points for steps
* Only applicable to wind power plants ** Only applicable if a power park module is required to have a system protection scheme.	

Table 5.11 – Requirements for information which a power-generating plant must be capable of exchanging in real time in the PCOM interface.

5.7.3. Fault recording

For a type C power-generating plant, logging must be performed by means of electronic equipment capable, as a minimum, of logging relevant events for the signals mentioned below at the Point of Connection (POC) in case of faults in the public electricity supply grid.

The power-generating plant owner must install logging equipment (a digital fault recorder) at the Point of Connection (POC), which at least records:

- Voltage for each phase of the plant
- Current for each phase of the plant
- Active power for the plant (may be computed values)
- Reactive power for the plant (may be computed values)
- Frequency for the plant
- Frequency deviations
- Speed deviations (only applies to synchronous power-generating plants)
- Activation of internal protection functions

Specific requirements for measurements are described in the grid connection agreement.

Logging must be performed as correlated time series of measuring values from ten seconds before an event until 60 seconds after the event.

The minimum sampling frequency of all fault logs must be 1 kHz.

The specific settings for event-based logging must be agreed with the DSO and the transmission system operator during plant commissioning.

All measurements and data exchanged at the PCOM must be logged with a time stamp and an accuracy ensuring that they can be correlated with each other and with similar records in the public electricity supply grid.

Logs must be kept on file for a minimum of three months after a fault event; up to a maximum 100 event logs.

The DSO and the transmission system operator must, upon request, be given access to log data and other relevant information.

5.8. Simulation model

For power-generating plants with a nominal active power above 10 MW, the plant owner must deliver a simulation model. The requirements for the simulation model have been coordinated with Energinet, therefore reference is made to Energinet's memorandum on requirements for simulation models: [Requirements for Generators (RfG) – krav til simuleringsmodel].

For power-generating plants with a capacity under 10 MW, the DSO can, in exceptional circumstances, require that the plant owner delivers a simulation model. In this case, the requirements are the same as for plants above 10 MW.

5.9. Verification and documentation

This section describes the documentation to be provided by the power-generating plant owner, or a third party, to the DSO in order to obtain operational notification.

The power-generating plant owner is responsible for complying with the requirements described in this document and for documenting such compliance.

The DSO may at any time request verification and documentation showing that the power-generating plant meets the requirements described in this document.

The documentation must be submitted to the DSO as part of the process for obtaining operational notification. During the process, several types of permits must be obtained before the final operational notification is issued. The permit stages are as follows:

1. Energisation operational notification (EON)
2. Interim operational notification (ION)
3. Final operational notification (FON)

To obtain an energization operational notification, the power-generating plant owner must submit Annex B2.1 or B3.1 for respectively power park module or synchronous power-generating plants. The annex must be accompanied by technical documentation in support of the answers given.

To obtain an interim operational notification, the power-generating plant owner must submit Annex 02 or B3.2 for respectively power park module or synchronous power-generating plants. The annex must be accompanied by technical documentation in support of the answers given. Once the documentation is approved, the interim operational notification is issued.

To obtain final operational notification, the plant owner must submit Annex B2.33 or B3.3 for respectively power park module or synchronous power-generating plants. Once the DSO approves the documentation, the final operational notification is issued.

If the DSO does not receive Annex B2.33 or B3.3 before expiry of the interim operational notification, the DSO is entitled to electrically disconnect the plant, as a valid operational notification no longer exists after expiry of the interim operational notification.

If, based on Annex B2.33 or B3.3, the DSO deems that the plant does not comply with the requirements of these instructions, a plan must be prepared for remedying the outstanding items identified. The plan can be used to apply for an extension of the interim operational notification.

Product certificates may be used as part of the documentation for compliance with the requirements of this document.

5.9.1. Documentation requirements

- CE Declaration of Conformity
- Protection functions
- Single-line diagram
- Power quality
- Tolerance of voltage dips
- P-Q capability curve
- Signal list
- Simulation model
- Conformance testing plan
- Verification report
- Annex 0 or B3.1 complete with technical documentation in support of the answers given.
- Annex B2.3 or B3.2 complete with technical documentation in support of the answers given.
- Annex B2.33 or B3.3 complete with technical documentation in support of the answers given.

Product certificates issued by an approved certification body may also be used. The product certificates may cover some of the documentation requirements.

In connection with documentation of the power-generating plant's technical properties, testing and simulations must be performed as described in sections 5.9.2 and 5.9.3.

5.9.2. Tests

As part of the documentation of the power-generating plant's technical properties, testing must be performed to demonstrate compliance with the requirements of this document. The tests to be carried out include:

- Power response to overfrequency
- Power response to underfrequency
- Frequency control
- Frequency recovery test (only synchronous power-generating plants)
- Reactive power operating range
- Voltage control (only power park modules)
- Power Factor control (only power park modules)
- Q control (only power park modules)

Results must be presented in a report.

Product certificates issued by an approved certification body may be used instead of tests.

5.9.3. Simulations

As part of the documentation of the power-generating plant's technical properties, simulations must be performed to demonstrate compliance with the requirements of this document. The simulations to be carried out include:

- Power response to overfrequency (LFSM-O)
  - Must be carried out for frequency changes in both steps and ramps.
  - Must show how the plant reacts when reaching the lower active power limit.
- Tolerance to voltage dips
- Active power recovery
- Supply of fast fault current (only power park modules)
- Power response to underfrequency (LFSM-U)
  - Must be carried out for frequency changes in both steps and ramps.
  - Must show how the plant reacts when reaching the upper active power limit.
- Frequency control (FSM)
  - Must be carried out for frequency changes in both steps and ramps.
  - Must be carried out for frequency changes large enough to cause maximum change of active power.
- Islanding (same characteristics with a weaker grid)
- Reactive power operating range

Simulation results and simulation model must be validated against the tests carried out to demonstrate that model and simulations are accurate.

Product certificates issued by an approved certification body may be used instead of simulations.

Energisation operational notification (EON)

The energisation operational notification entitles the plant owner to energise the plant's internal network and auxiliaries. The plant may, however, not be put into operation or generate electricity for the grid.

Interim operational notification (ION)

The interim operational notification gives the right to operate the plant to the extent necessary to perform conformance testing in accordance with the conformance testing plan submitted.

The maximum period of validity of an interim operational notification is 24 months.

Final operational notification (FON)

The final operational notification entitles the plant owner to operate the plant with a grid connection.

CE Declaration of Conformity

CE Declarations of Conformity must be submitted for each of the main components. The CE Declaration of Conformity must contain a list of relevant standards, codes of practice and directives which the component or plant complies with.

Protection functions

Documentation of protection settings is a list of all current relay configurations at the time of commissioning.

Single-line diagram

A single-line diagram is a drawing that shows the plant main components and how they are electrically interconnected. In addition, the location of the protection and measuring points are included in the representation.

Power quality

Power quality is a collection of parameters characterising the electricity supplied. A certificate or report demonstrating that the requirements are complied with must be presented.

Tolerance of voltage dips

Tolerance of voltage dips is the plant's ability to stay connected to the public electricity supply grid during a voltage dip as well as power park modules' ability to supply fast fault current. The plant's ability to stay connected to the grid and supply fast fault current may be documented in two ways: simulation or testing.

P-Q capability curve
A diagram showing the plant's operating range for active and reactive power.

Signal list
A list of signals which the plant can exchange with the DSO in accordance with section 5.7.

Simulation model
A simulation model complying with the requirements in section 5.8.

Conformance testing plan
A detailed plan for performance of conformance testing to demonstrate that the plant complies with the requirements of this document.

Verification report
A report which uses the conformance testing to demonstrate that the plant complies with the requirements of this document.

Completion of annexes
Completed annexes 0 and B2.3 means that the annexes in these instructions must be completed, and that technical documentation verifying the correctness of the answers given in the annexes must be attached. Technical documentation may include a test report, product certificate, user manual, simulations, etc.

6. REQUIREMENTS FOR TYPE D POWER-GENERATING PLANTS

6.1. Tolerance of frequency and voltage deviations

A power-generating plant must comply with the following requirements for normal operation and abnormal operation.

6.1.1. Normal operation

A power-generating plant must be capable of continuous generation without disconnecting in the 49.0 Hz - 51.0 Hz frequency range.

U_c at the Point of Connection (POC) is provided by the DSO.

A power-generating plant must be capable of continuous generation when the voltage at the Point of Connection (POC) is within the 90% to 110% range of normal operating voltage.

A power-generating plant must maintain operation at different frequencies for the minimum time periods specified in figure 6.1 without disconnecting from the grid.

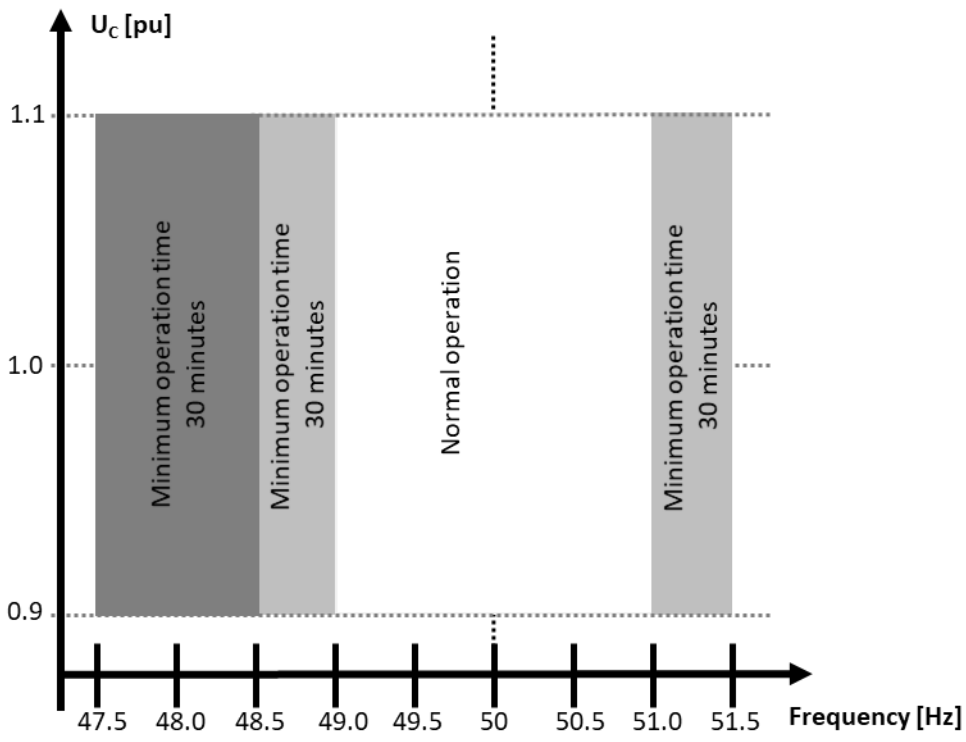

Figure 6.1 – Minimum time periods during which a power-generating plant must be capable of maintaining operation at different frequencies without disconnecting from the grid.

A power-generating plant must be designed to withstand transient voltage phase jumps of up to 20 degrees at the Point of Connection (POC) without any interruption.

6.1.2. Tolerance of frequency deviations

The power-generating plant must be capable of maintaining operation in case of frequency deviations for the time periods specified in figure 6.1 without disconnecting from the public electricity supply grid.

6.1.2.1. Frequency change

A power-generating plant must be capable of continuous generation at frequency changes of up to 2.0 Hz/s.

6.1.2.2. Permitted reduction of active power during underfrequency

A power-generating plant is permitted to reduce the active power within the 49 Hz - 47.5 Hz frequency range. In this range, it is permitted to reduce the active power by 6% of P_n/Hz as shown in figure 6.2.

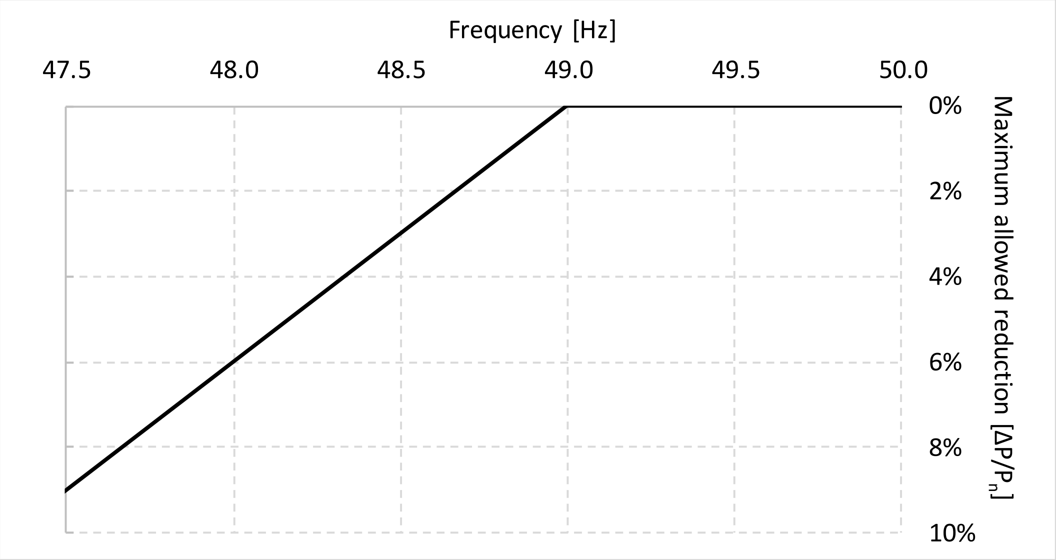

Figure 6.2 – Permitted reduction of active power during underfrequency.

Permitted reduction of active power	
Frequency range	49 Hz - 47.5 Hz
Reduction of P_n/Hz	6%

Table 6.1 – Permitted reduction of active power during underfrequency.

A power-generating plant may only reduce the active power if the plant is technically incapable of continuing to supply of full active power at underfrequency. This applies during normal operating conditions, which are guaranteed for 90% of the time, and must occur to the best of its ability in relation to operating point and available primary energy.

6.1.3. Tolerance of voltage deviations

A power-generating plant must comply with the requirements for tolerances of voltage deviations as specified in this section. Specific requirements apply, depending on plant type.

6.1.3.1. Permitted reduction of active power at undervoltage

When the voltage at the Point of Connection (POC) is less than 95% of nominal value, it is allowed to reduce the generation of active power to comply with the power-generating plant's current limitation. The reduction must be as small as technically possible.

6.1.3.2. Tolerance to voltage swells

A power-generating plant must be capable of remaining connected to the grid during voltage swells as specified in table 6.2.

Voltage	Duration
$1.15 \cdot U_c$	60 s
$1.20 \cdot U_c$	5 s

Table 6.2 – Tolerance to voltage swells.

6.1.3.3. Tolerance to voltage dips

(a) Synchronous power-generating plant

A synchronous power-generating plant must be capable of withstanding voltage dips as shown in figure 6.3. A synchronous power-generating plant must be capable of remaining connected to the grid during voltage dips above the solid line in figure 6.3. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 6.3. The requirement is assessed at P_n and $Q = Q_{min}$. The DSO must, at the power-generating plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

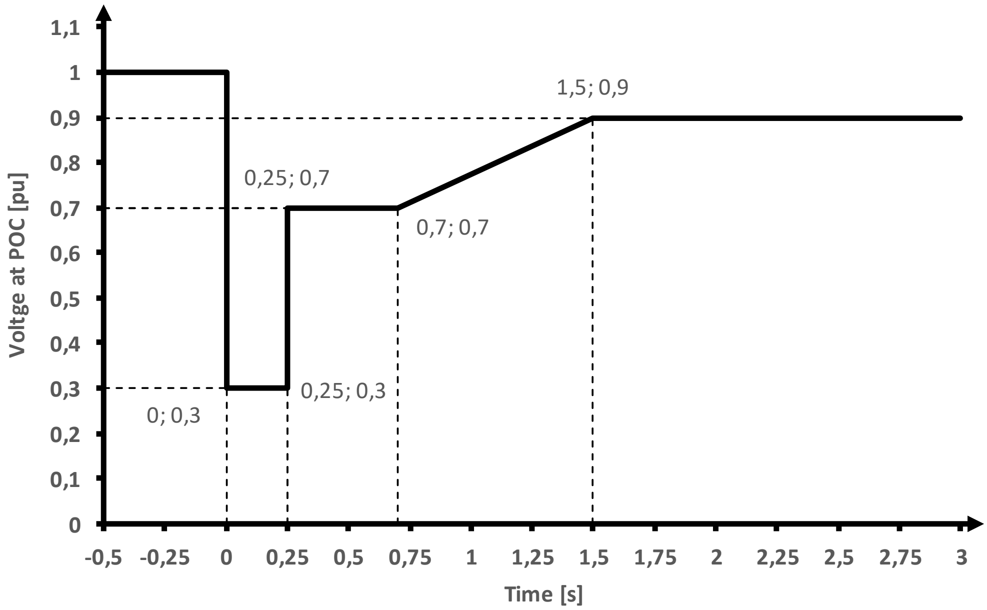

Figure 6.3 – Tolerance to voltage dips for a synchronous power-generating plant.

A synchronous power-generating plant must be capable of restoring normal generation of active power after a fault as quickly as possible after voltage and frequency have returned to the normal range, see section 6.1.1. The power-generating plant's natural ability to restore generation of active power must not be artificially or unnecessarily restricted.

(b) Power park modules

A power park module must be capable of withstanding voltage dips as shown in figure 6.4. A power park module must be capable of remaining connected to the grid during voltage dips above the solid line in figure 6.4. In case of voltage dips below the solid line, it is allowed to disconnect the plant from the grid. This applies to both symmetrical and asymmetrical faults.

The synchronous component of voltage is used to assess the tolerance requirement in figure 6.4. The requirement is assessed at P_n and $Q = Q_n$. The DSO must, at the plant owner's request, state the short-circuit power at the Point of Connection (POC) before and after possible faults. The short-circuit power may be stated as generic values based on typical operating situations.

A power park module must be capable of restoring normal generation of active power after a fault as quickly as possible; however, no later than five seconds after voltage and frequency have returned to the normal operating range, see section 6.1.1. During the recovery process, upward regulation of active power must be performed with a gradient of at least 20% P_n/s.

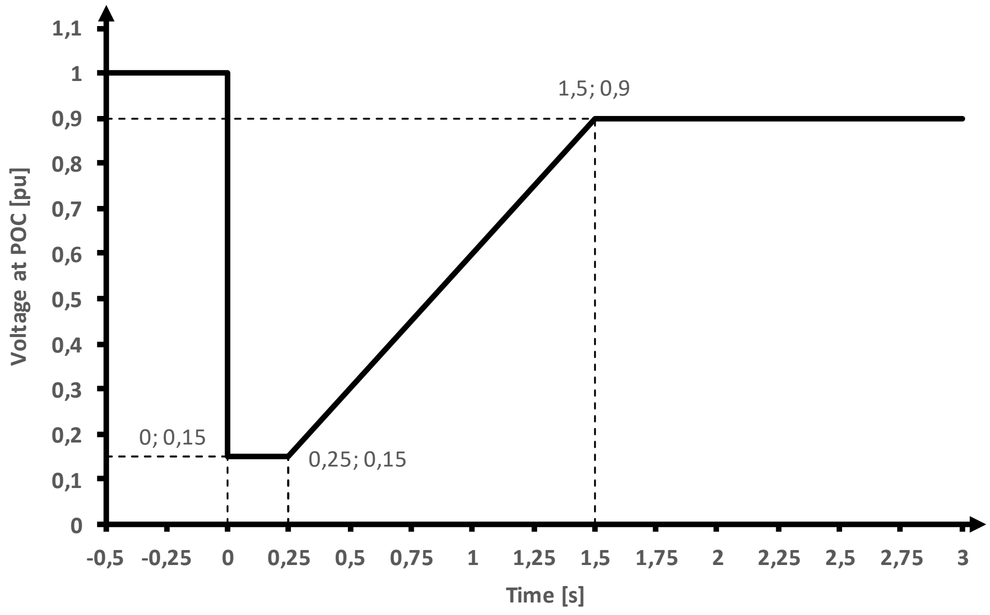

Figure 6.4 – Tolerance to voltage dips for a power park module.

Supply of fast fault current

A power park module must be capable of supplying fast fault current, I_Q, at the Point of Generator Connection in case of a symmetrical fault (three-phase fault) to maintain grid voltage stability during and after a fault.

A power park module must be capable of supplying fast fault current (positive sequence component) in the area above the solid line in figure 6.4 and up to 90% of normal operating voltage at the Point of Generator Connection.

Control of fast fault current from a power park module must follow figure 6.5.

It must be possible to supply fast fault current within 100 ms with an accuracy of ±20% of I_n.

During a fault sequence, a power park module must prioritise the fast fault current before supplying the active power in the range from 90% to 15% of U_c, see the hatched area in figure 6.5.

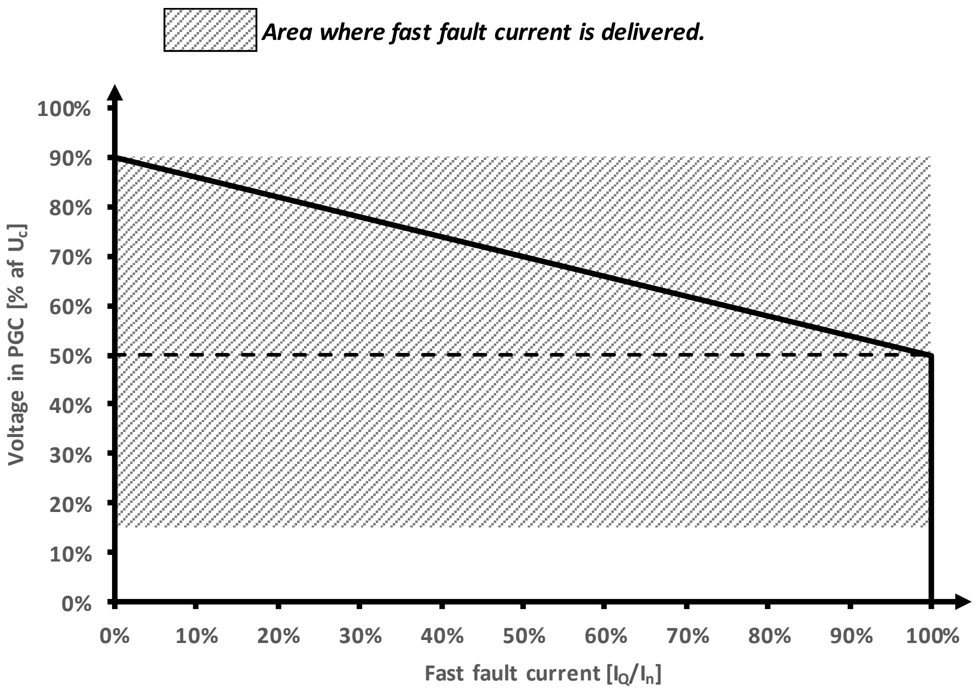

Figure 6.5 – Supply of fast fault current from a power park module.

6.2. Start-up and reconnection of a power-generating plant

A type D power-generating plant must not connect to or synchronise with the grid until it has received permission to do so from the DSO.

A type D power-generating plant must, after having received synchronisation permission, be capable of automatically synchronising with the public electricity supply grid. It must not be possible to manually circumvent the automatic synchronisation and allow the plant to connect without synchronisation.

Synchronisation must be possible when the frequency is within the 47.5 Hz - 51.5 Hz frequency range, both values inclusive.

The specific requirements for the synchronisation devices and their settings must be agreed between the DSO and the plant owner prior to plant commissioning.

6.3. Active power control

A power-generating plant must be capable of controlling its active power. It must be possible to indicate set points in steps of 1% of P_n or better.

Active power control must be performed with a gradient of at least 1% P_n/min for synchronous power-generating plants and at least 20% P_n/min for power park modules. For synchronous generators, there is also a 10 minutes reaction time, if required.

Control must be performed with an accuracy of ±2% of power-generating plant nominal active power. The control accuracy is measured over a period of one minute.

6.3.1. Power response to overfrequency

A power-generating plant must be capable of downward regulation of its active frequency at overfrequency. Downward regulation of active power must be initiated within two seconds at the Point of Connection (POC).

To be able to detect islanding, downward regulation of the active power at the Point of Connection (POC) must not be commenced until after an intentional delay of 500 ms.

If the plant's natural delay (recovery time) for commencement of downward regulation is 500 ms or more, the requirement for delay is met.

If the plant's natural delay (recovery time) for commencement of downward regulation is less than 500 ms, the delay must be extended to 500 ms. The intentional delay is only imposed when transitioning to frequency response, i.e. when the frequency threshold f_{RO} is crossed.

Example
A plant's natural delay (recovery time) for commencement of downward regulation is 300 ms. An additional intentional delay (recovery time) of 200 ms is added to make the total delay (recovery time) for the plant 500 ms.

The downward regulation of active power must be commenced at a frequency threshold (f_{RO}) and follow a droop as indicated in figure 6.6, regardless of whether the frequency increases or decreases.

When a power-generating plant's lower limit for active power is reached in connection with the downward regulation, the plant must keep this minimum level of active power until the grid frequency drops again or until the plant is disconnected for other reasons.

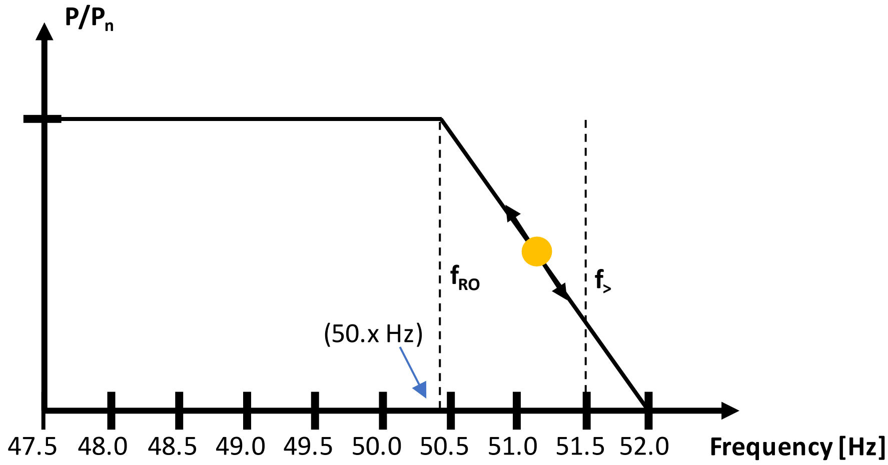

Figure 6.6 – Frequency response droop to overfrequency.

The frequency threshold for commencement of frequency response must be set in the 50.2 Hz - 50.5 Hz frequency range, both values inclusive, with a resolution of 10 mHz or better.

The droop of the active power reduction must be in the 2-12% range with a resolution of 1% or better.

The settings for frequency response to overfrequency for Western and Eastern Denmark are as follows:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency threshold f_{RO}	50.2 Hz	50.5 Hz
Droop	5%	4%
Intentional delay for islanding detection	500 ms	500 ms

Table 6.3 – Default settings for power response to overfrequency for DK1 and DK2.

When the frequency response is enabled, the active power must follow the droop with a deviation of 5% of nominal active power or better, measured over a period of one minute.

Frequency must be measured with an accuracy of ±10 mHz or better.

6.3.2. Power response to underfrequency

A power-generating plant must be capable of upward regulation of active power during underfrequency if the plant does not already produce at its nominal power. Upward regulation of active power must be initiated within two seconds at the Point of Connection (POC).

To be able to detect islanding, upward regulation of the active power at the Point of Connection (POC) must not be initiated until after an intentional delay of 500 ms.

If the plant's natural delay (recovery time) for commencement of upward regulation is 500 ms or more, the requirement for minimum delay is met.

If the plant's natural delay (recovery time) for commencement of upward regulation is less than 500 ms, the delay must be extended to 500 ms. The intentional delay is only imposed when transitioning to frequency response, i.e. when the frequency threshold f_{RU} is crossed.

Example

A plant's natural delay (recovery time) for commencement of upward regulation is 300 ms. An additional intentional delay (recovery time) of 200 ms is added to make the total delay/recovery time for the plant 500 ms.

Upward regulation of active power must be initiated at a frequency threshold (f_{RU}) and follow a droop as indicated in figure 6.7.

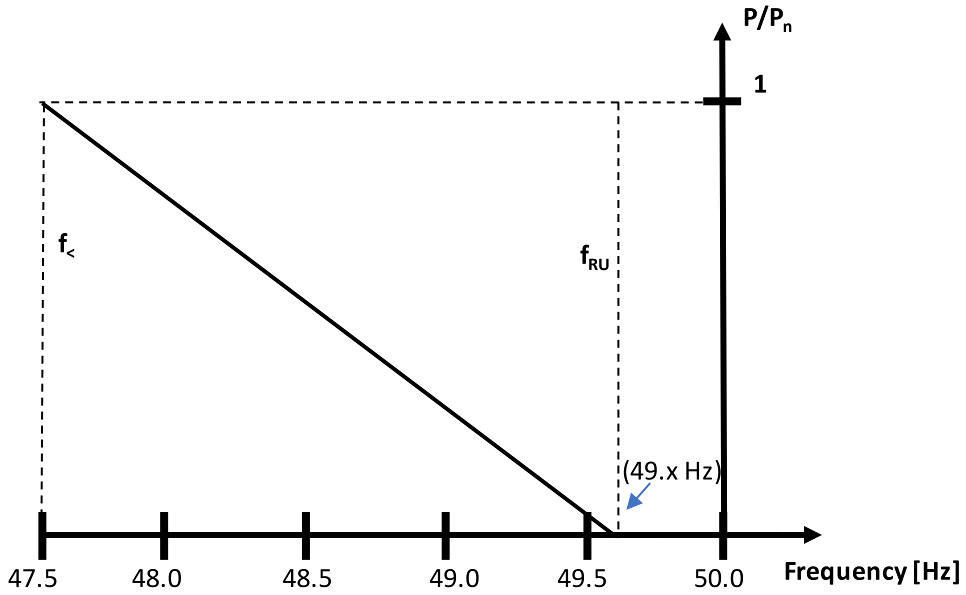

Figure 6.7 – Frequency response droop at underfrequency.

The frequency threshold for commencement of frequency response (f_{RU}) must be set in the 49.5 Hz - 49.8 Hz frequency range, both values inclusive, with a resolution of 10 mHz or better.

The droop of the active power increase must be in the 2-12% range with a resolution of 1% or better.

The settings for frequency response during underfrequency for Western and Eastern Denmark are as follows:

	DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Start frequency f_{RU}	49.8 Hz	49.5 Hz
Droop (of P_n)	5%	4%
Intentional delay for islanding detection	500 ms	500 ms

Table 6.4 – Default settings for frequency response – underfrequency.

When the frequency response is enabled, the active power must follow the droop with an accuracy of 5% of nominal active power or better, measured over a period of one minute.

Frequency must be measured with an accuracy of ±10 mHz or better.

Supply of frequency response in case of underfrequency must take the availability of the primary energy source into consideration as well as the permitted reduction of active power at underfrequency, see section 6.1.2.2.

Consumption which is not part of power-generating plant operation must be disconnected in case of underfrequency. In DK1, consumption must be disconnected at 49.0 Hz, and in DK2 at 48.5 Hz.

6.3.3. Frequency control

A power-generating plant must be capable of supplying frequency control and contributing to stabilising the grid frequency.

Frequency control must be set in the 47.5 Hz - 51.5 Hz frequency range, both values inclusive. This frequency range includes frequency response for both underfrequency and overfrequency as well as frequency control with deadband as shown in figure 6.8.

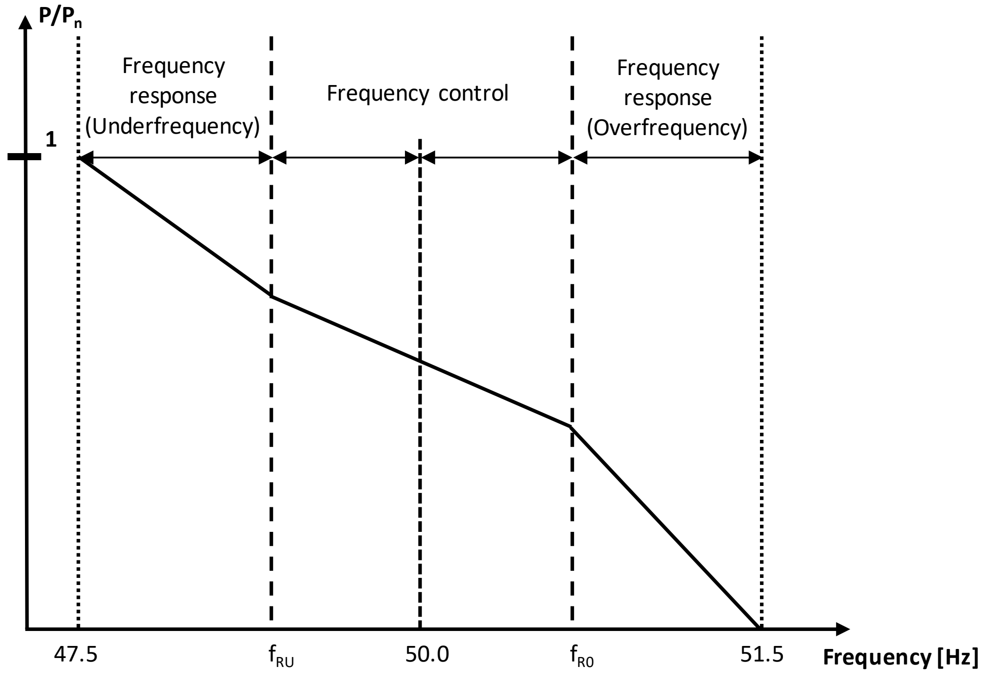

Figure 6.8 – Frequency control and frequency response.

The actual frequency control is between f_{RU} and f_{RO}, which are the activation frequencies for frequency response for underfrequency and overfrequency.

Control of power-generating plant active power with respect to frequency must be initiated within two seconds of a grid frequency change.

The measurement accuracy for the grid frequency must be ±10 mHz or better.

Frequency control must follow a droop as shown in figure 6.8. It must be possible to set a negative slope droop in the 2-12% range with a resolution of 1% or better.

The active power $\Delta P/P_n$, which is used for frequency control, must be set in the 1.5%-10% range of power-generating plant maximum power capacity.

It must be possible to set a deadband around the nominal frequency in the 49.5 - 50.5 Hz frequency range with a width of 0 - 500 mHz.

It must also be possible to set an insensitivity to frequency changes so that frequency changes below the set threshold value do not result in active power changes. The control insensitivity must be set to 10 mHz.

A power-generating plant must be capable of supplying full frequency control for 15 minutes. Full frequency control means that the plant must be capable of delivering the power $\Delta P/P_n$ continuously throughout the required period.

A synchronous power-generating plant must be capable of activating full frequency control within the parameters in table 6.5 within 30 seconds.

Setting intervals for frequency control are stated in table 6.5.

		DK 1 (Western Denmark)	DK 2 (Eastern Denmark)
Frequency control range		49.8 - 50.2 Hz	49.5 - 50.5 Hz
Active power in proportion to the nominal output $\Delta P/P_n$		1.5 - 10%	1.5 - 10%
Control insensitivity	$\lvert\Delta f_i\rvert$	±10 mHz	±10 mHz
Deadband		0 - 200 mHz	0 - 500 mHz
Droop slope		2 - 12%	2 - 12%

Table 6.5 – Setting intervals for frequency control.

6.3.4. Constraint functions

A power-generating plant must be equipped with a number of active power constraint functions. The requirements depend on plant type.

6.3.4.1. Absolute power limit

A power-generating plant must be capable of limiting its maximum active power.

Absolute power limit is used to limit the active power from a power-generating plant to a set point-defined maximum power limit at the Point of Connection (POC).

Absolute power limit is used to protect the public electricity supply grid against overload in critical situations.

Control using a new parameter for the absolute power limit must be completed within five minutes of receiving the parameter change order.

6.3.4.2. Ramp rate limit

A power-generating plant must be capable of limiting the gradient of the active power. Unless another functionality, including ancillary services, requires a higher gradient, e.g. active power recovery after fault, the gradient must be within maximum and minimum gradients in connection with upward and downward regulation.

Upward regulation	Max.	20% of P_n/min; however, max. 60 MW/min.
	Min.	1% of P_n/min.
Downward regulation	Max.	20% of P_n/min; however, max. 60 MW/min.
	Min.	1% of P_n/min.

Table 6.6 – Maximum and minimum gradients in connection with upward and downward regulation.

6.3.4.3. System protection scheme

The requirement for system protection applies to power park modules. For synchronous power-generating plants, the need is assessed when assigning the Point of Connection (POC).

A power-generating plant must be equipped with system protection scheme which is an emergency control function that, following a downward regulation order, is capable of quickly adjusting the active power supplied from a plant to one or more predefined set points. Set points are determined by the DSO during commissioning.

The power-generating plant must have at least five different configurable adjustment positions.

The following default set points are:

1. To 70% of rated power
2. To 50% of rated power
3. To 40% of rated power
4. To 25% of rated power
5. To 0% of rated power, i.e. the power-generating plant is stopped.

Control must be initiated within one second and completed within ten seconds of receipt of a downward regulation order.

If the system protection receives an upward regulation order, e.g. from step 4 (25%) to step 3 (40%), it is acceptable that completion of the order may take additional time due to the design limits of power-generating plant generators or other plant units.

6.3.4.4. (b) Power park modules – additional requirements

Delta power limit

The delta power limit is used to limit the active power from a power-generating plant to a required constant value relative to available active power $P_{possible}$.

Control to a new parameter value for the delta power limit must be initiated within two seconds and completed within five minutes of receipt of a parameter change.

Delta power constraint is typically used to obtain a control reserve for upward regulation in connection with frequency control of plants with varying availability of the primary energy source, e.g. solar and wind power.

Reduction of active power during high winds

For wind power plants, the requirements for ramp rate limit for reduction of active power during high winds.

To ensure system stability, a wind power plant must be capable of gradually reducing active power at high wind speeds to prevent sudden loss of active power when the wind speed exceeds the wind power plant's overspeed limitation.

The active power reduction must be within the shaded blue band as shown in figure 6.9. Reduction can be continuous or in discrete steps. If the reduction is performed in discrete steps, the step size must not exceed 25% of P_n. The settings for reduction of active power at high winds must be agreed with the DSO prior to commissioning the wind power plant.

Automatic downward regulation is specified at minimum three points:

- Wind speed – activation of downward regulation [m/s]
- Wind speed – 10% of P_n [m/s]
- Wind speed – cut-out [m/s]

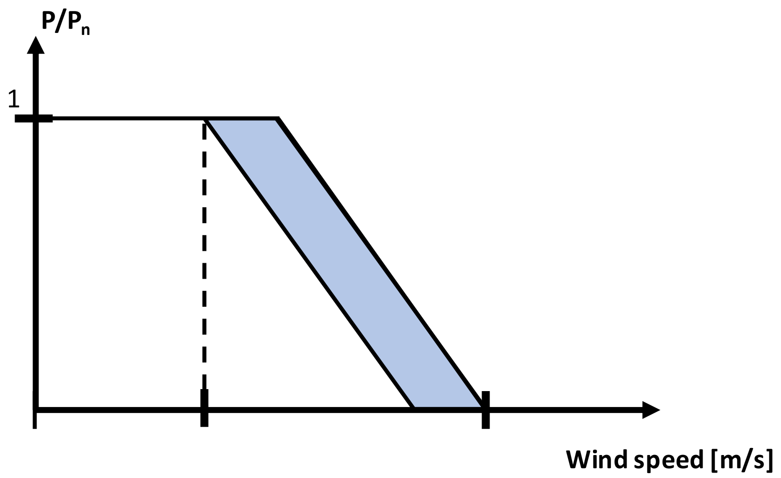

Figure 6.9 – Downward regulation at high winds.

6.4. Reactive power control

A power-generating plant must be capable of delivering reactive power. Only one of the following required control functions can be active at a time.

The power-generating plant must be capable of controlling its reactive power using the functions and characteristics described in sections 6.4.2 to 6.4.4. It must be possible to indicate set points in steps of 100 kVAr or better for reactive power and 0.01 or better for Power Factor.

Control accuracy must be ±3% of Q_n or better. The control accuracy is measured over a period of one minute.

When one or more units of a power park module are taken out of operation for scheduled maintenance, the plant's supply of reactive power may be reduced proportionate to the number of units taken out of operation.

The power-generating plant owner must compensate for the plant infrastructure's reactive power in situations where the plant is disconnected or not generating active power.

6.4.1. Reactive power range

The requirements concerning the ability to supply reactive power (the operating range) depends on the type of power-generating plant.

6.4.1.1. (a) A synchronous power-generating plant

At maximum production, a synchronous power-generating plant must be capable of supplying reactive power at different voltages at the Point of Connection (POC) as specified in figure 6.10.

Inside the grey hatched region in figure 6.10, the synchronous power-generating plant must supply stable reactive power in accordance with the selected control mode, which may only be limited by the technical performance of the plant, e.g. saturation or under-compensation.

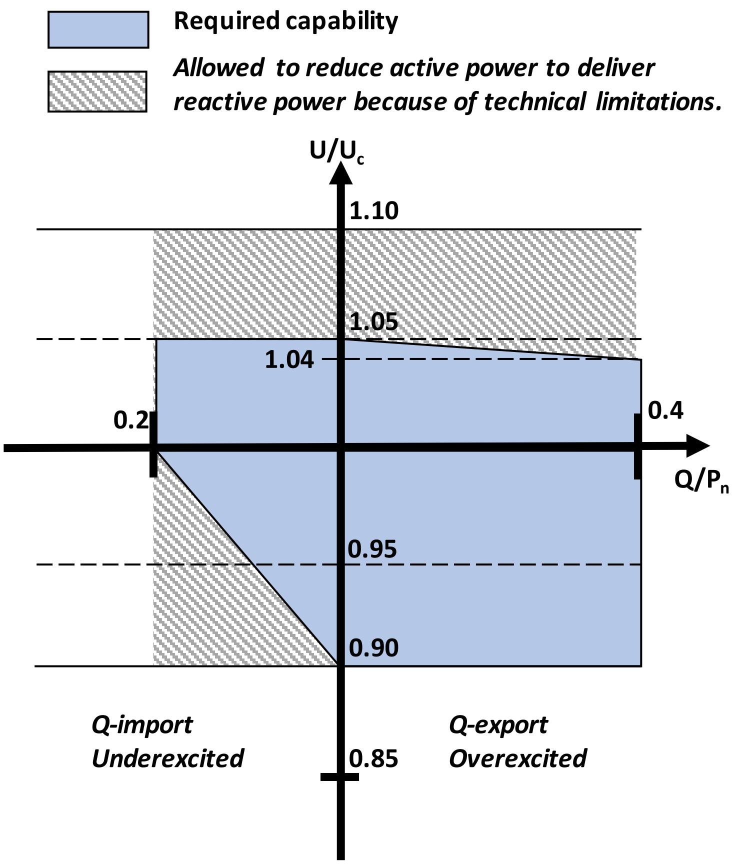

Figure 6.10 – Requirements for supply of reactive power at maximum active power generation.

When generating active power at maximum capacity, a synchronous power-generating plant must be capable of operating at every point inside the plant's P-Q capability curve.

6.4.1.2. (b) A power park module

At maximum production, a power park module must be capable of supplying reactive power at different voltages at the Point of Connection (POC) as specified in figure 6.11.

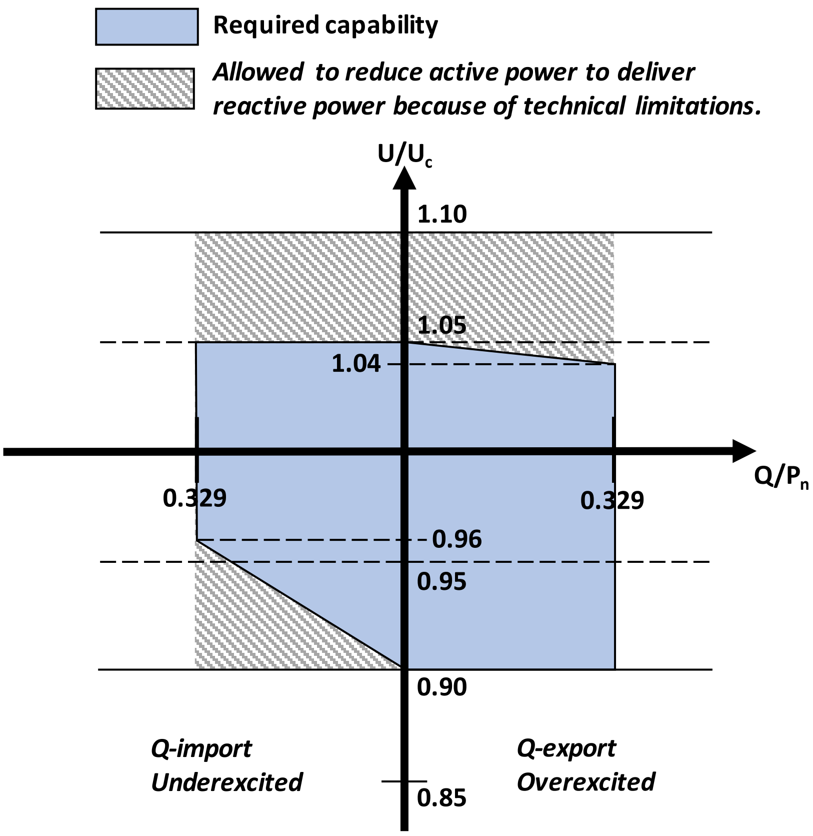

Figure 6.11 – Requirements for supply of reactive power at maximum active power generation.

Inside the hatched grey region in figure 6.11, the power park module must supply stable reactive power in accordance with the selected control mode, which may only be limited by the technical performance of the plant, e.g. saturation or undercompensation.

When active power generation is below the maximum capacity, a power park module must be capable of operating within the area specified in figure 6.12.

In the solid blue area on figure 6.12, it is accepted that the ability to supply reactive power may be limited by a reduced number of units in operation due to start-up and shutdown of power park modules as a result of lacking primary power.

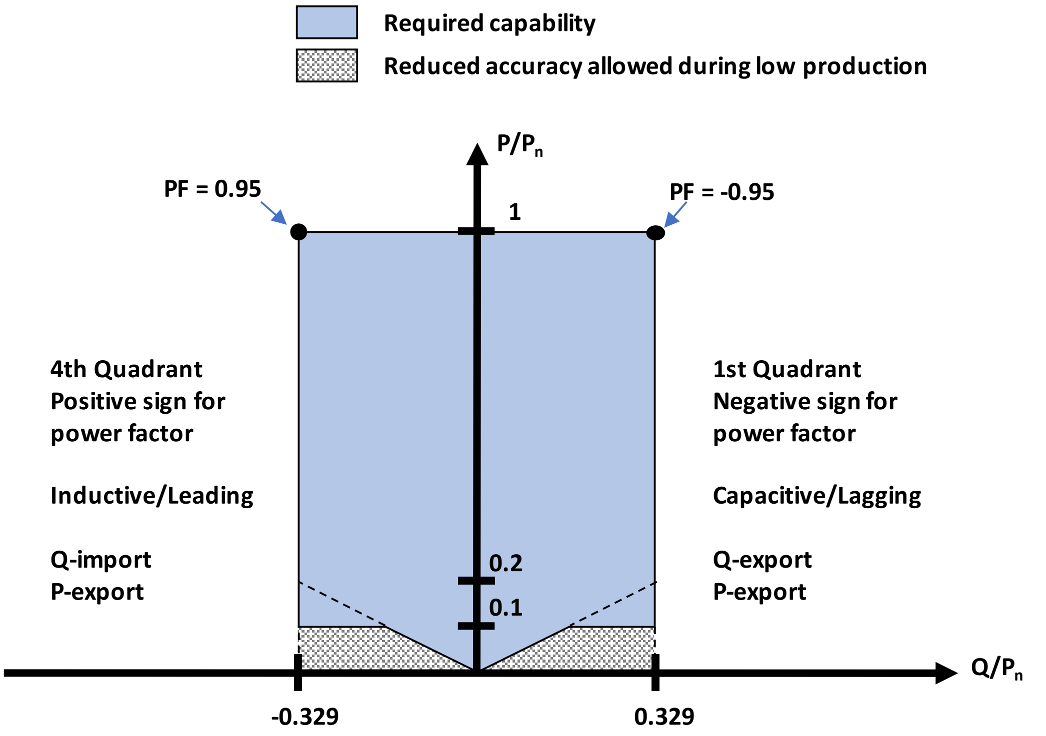

Figure 6.12 – Requirements for supply of reactive power at different active power levels.

6.4.2. Power Factor control

A power-generating plant must be capable of performing Power Factor control allowing the reactive power to be controlled by means of a fixed Power Factor, see figure 6.13.

When a new Power Factor set point is set, the control must be initiated within two seconds and completed within 30 seconds,

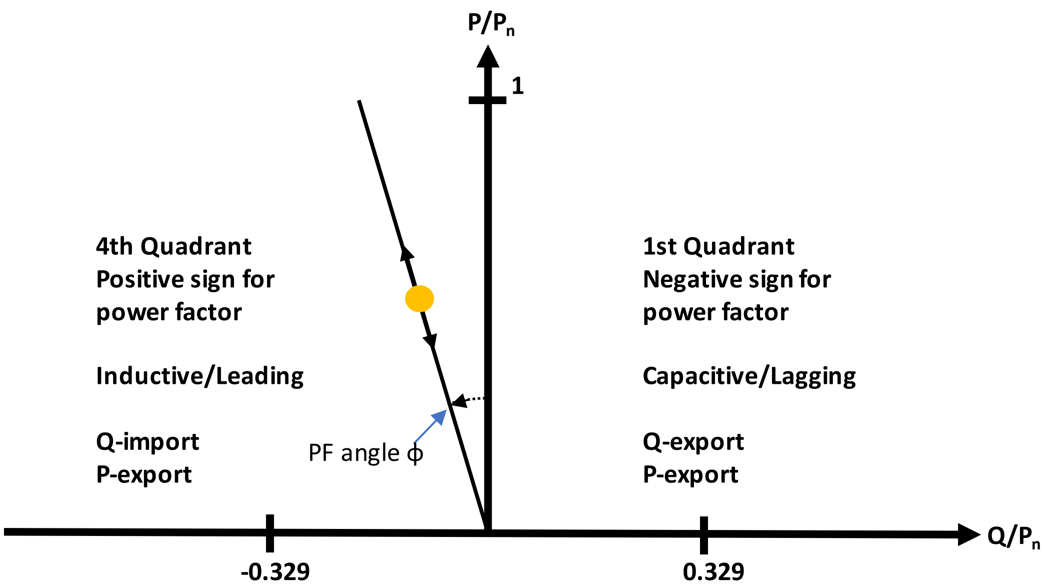

Figure 6.13 – Example of Power Factor control [cos ϕ fixed].

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

6.4.3. Voltage control

A power-generating plant must be capable of performing voltage control with a droop and deadband as shown in figure 6.14.

The voltage control droop slope must be set within the 2% - 7% range in steps no greater than 0.5%.

The deadband must be set within ±5% of U_{ref} with a step size of not more than 0.5% of U_{ref} and must be symmetric around the voltage control set point.

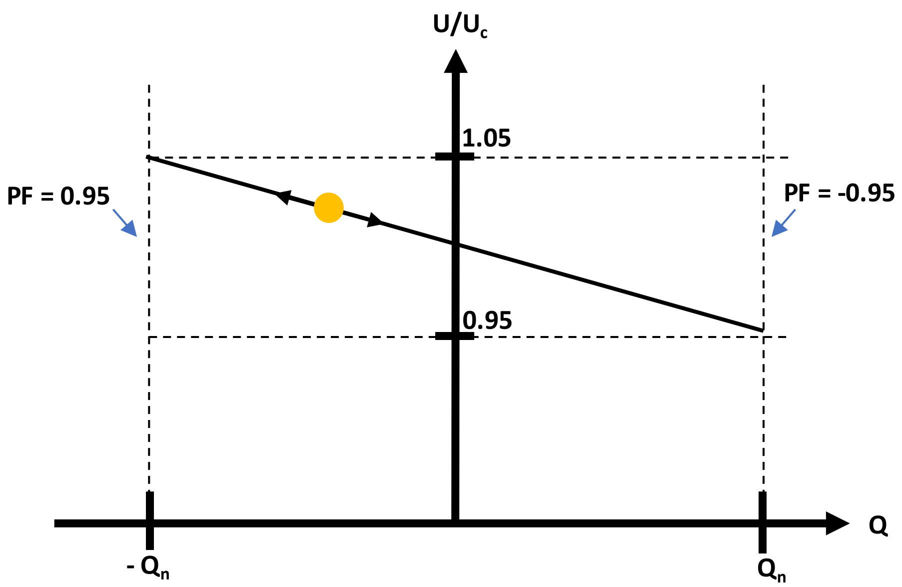

Figure 6.14 – Voltage control droop [Q(U)].

The power-generating plant must be capable of achieving 90% of the reactive power change within one second, and control must be completed within five seconds.

Unless otherwise agreed, this control function must be disabled. If the function is to be enabled, the parameter values for the control function are agreed with the DSO.

6.4.4. Q control

A power-generating plant must be capable of performing Q control as shown in figure 6.15.

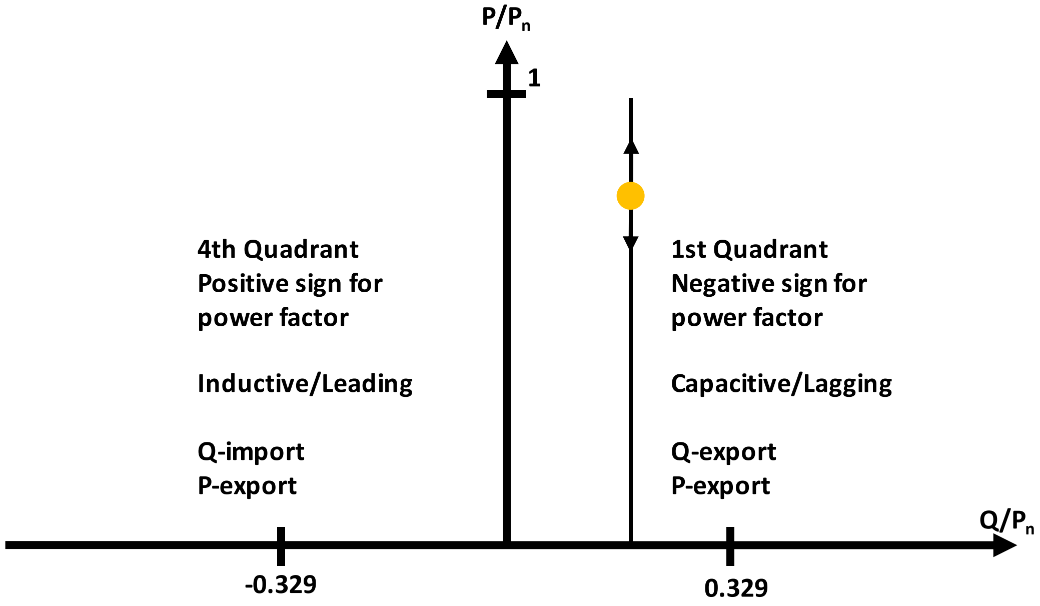

Figure 6.15 – Example of Q control [Q set point].

Control from one set point to another must be initiated within two seconds and completed within 30 seconds.

A power-generating plant may not exchange reactive power with the public electricity supply grid unless otherwise agreed with the DSO. I.e. the plant will as default produce at a Power Factor of 1.

If the function is to be enabled, the current setting values for the control function are agreed with the DSO.

6.4.5. (a) Synchronous generators – additional requirements

6.4.5.1. Generator

For type D power-generating plants, requirements for SCR and transient reactance are defined in cooperation with the DSO and the transmission system operator based on the plant design and stability analyses. The permissible values must appear in the grid connection agreement for the power-generating plant.

6.4.5.2. Generator or plant transformer

For synchronous power-generating plants, the maximum permissible size of the generator transformer or plant transformer short-circuit reactance is defined in cooperation with the DSO and the transmission system operator based on the plant design and stability analyses. The permitted value must appear in the grid connection agreement for the plant.

If an on-load tap changer is installed on the transformer, the on-load tap changer may be used to comply with the requirements for reactive control properties, subject to agreement with the DSO. It must appear in the grid connection agreement for the power-generating plant if such an agreement is made.

If an on-load tap changer is used on the transformer, the power-generating plant owner is responsible for proper coordination between the plant's reactive power control functions and the load tap changer control.

6.4.5.3. Requirements for the excitation system

The specific requirements for functionality and settings of the excitation system and PSS are given by the DSO and the system operator.

Excitation system

A synchronous power-generating plant must be equipped with an automatic excitation system. The purpose is to ensure stable plant operation and to provide the opportunity to contribute to voltage control and/or the reactive power balance in the public electricity supply grid.

The excitation system must be designed in accordance with the European standard DS/EN 60034-16-1:2011 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions' and DS/CLC/TR 60034-16-3:2004 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance'.

In case of system faults resulting in voltage reduction, the generator must be capable of over-excitation for at least ten seconds with 1.6 times excitation current and voltage at nominal power and tan ϕ = 0.4 at the POC and normal operating voltage. If the over-excitation property is dependent on the voltage at the POC, the mentioned property must be available at reduced grid voltage at the POC down to 0.6 pu.

The generator's over-excitation protection and other protection must be designed and adjusted to allow the generator's capacity for temporary overload to be utilised without exceeding the generator's thermal limits.

The excitation system's limit functions must be selective with the power-generating plant's protection functions, enabling short-term utilisation of overload properties without disconnecting the plant.

The excitation system's dynamic response (measured at the generator terminals) during idling (when the generator is disconnected from the grid and operated at nominal rpm) in case of a temporary 10% change of the reference voltage must be non-oscillatory and have a rise time, as defined in DS/EN 60034-16-3, of maximum 0.3 seconds for a static excitation system. For excitation systems with rotating exciters, the maximum allowed time response is 0.5 seconds in case of a positive 10% change of the reference voltage and 0.8 seconds in case of a negative 10% change of the reference voltage.

The excitation system's overshoot measured at the generator terminals, as defined in DS/EN 60034-16-3, in case of a temporary 10% change of the reference voltage, must not exceed 15% of the change.

Power system stabiliser (PSS)

The PSS function must apply input from both the rotor speed/grid frequency and active power (dual input) to derive the stability signal, where a PSS of the IEEE PSS2B type is normative, see IEEE 421.5.

Control of the PSS function must be performed so that significant damping is achieved in the 0.2 - 0.7 Hz frequency range.

In the 0.2 - 2 Hz frequency range, the phase of the added damping signal, produced by the PSS function, must be in phase with the change of the generator rotor speed. Deviations of up to -30 degrees (under-compensated) are acceptable.

At all operating points and during any fault while the PSS function is enabled, damping of plant power oscillations (an exponentially decreasing function) must be performed within one second.

The power-generating plant's natural damping of 'local mode' power oscillations must not be adversely affected by the PSS function.

Control of the PSS function must be performed so that changes to the plant operating point (active power) during normal operation or in case of a fault in for example the turbine controller, boiler plant, feedwater plant or other auxiliary power systems, do not cause voltage changes on the high-voltage side of the plant generator transformer of more than 1%.

The PSS output signal must be limited to prevent that activation of the PSS function results in a change of generator voltage of more than ±5% of nominal generator voltage. It is allowed for the voltage control to reduce the limits automatically and dynamically, e.g. by activating the excitation system's limit functions.

The PSS function must be automatically deactivated when the active power generated is less than 20% of nominal power. It must be possible to connect and disconnect the PSS function. Disconnection of the PSS function must trigger an alarm.

6.5. Protection

6.5.1. General requirements

Power-generating plant protection must both protect the plant and help ensure stability in the public electricity supply grid.

Relay settings cannot prevent specified power-generating plant functions from working properly.

The power-generating plant owner is responsible for ensuring that the plant is dimensioned and equipped with the necessary protection functions so that the plant:

- Is protected against damage due to faults and incidents in the public electricity supply grid
- Protects the public electricity supply grid against unwanted impacts from the power-generating plant
- Is protected against damage as a result of asynchronous connections
- Is protected against disconnection in non-critical situations for the power-generating plant
- Is not damaged and does not switch off during voltage dips as specified in section 6.1.3.

The DSO or the transmission system operator may demand that the setting values for protection functions be changed after commissioning if it is deemed to be of importance to the operation of the public electricity supply grid.

Following disconnection of a power-generating plant due to a fault in the public electricity supply grid, the plant must not reconnect automatically earlier than specified in section 6.2.

A power-generating plant which has been disconnected by an external signal prior to a fault occurring in the public electricity supply grid must not be connected until the external signal has been eliminated and the voltage and frequency are once again within the range specified in section 6.2.

At the power-generating plant owner's request, the DSO must state the highest and lowest short-circuit current that can be expected at the Point of Connection (POC) as well as any other information about the public electricity supply grid as may be necessary to configure the plant's protection functions.

Voltage and frequency must be measured simultaneously for the phases which the power-generating plant is connected to at the Point of Connection (POC).

Furthermore, the power-generating plant owner must ensure that the plant is protected against the mechanical and electrical consequences of a potential reconnection after symmetric as well as asymmetric faults in the transmission system.

Any measures taken in this respect must not compromise any other specified plant properties.

6.5.2. Requirements for protection functions and settings

The power-generating plant's protection functions and associated settings must be as specified in the following subsections. Settings deviating from the default values, e.g. in the event of problems with local overvoltages, may only be used with the DSO's permission.

In connection with internal short circuits in the power-generating plant, the relay protection must be selective with the grid protection. This means that short circuits in the power-generating plant must be disconnected within 100 ms.

All settings are stated as RMS values.

The power-generating plant must be disconnected or shut down if a measuring signal deviates more from its nominal value than the setting.

The trip time stated is the measuring period during which the trip condition must constantly be fulfilled in order for the protection function to release a trip signal.

The accuracy of voltage and frequency measurements must be ±1% of U_c and ±0.05 Hz or better respectively.

The frequency change is calculated according to the following or equivalent principle.

The frequency measurement used to calculate the frequency change is based on a 200 ms measuring period where the mean value is calculated.

Frequency measurements must be made continuously, calculating a new value every 20 ms.

ROCOF [Hz/s] must be calculated as the difference between the currently performed frequency mean value calculation and the calculation performed 20 ms before.

(df/dt = (mean value 2 – mean value 1)/0.020 [Hz/s])

If a power-generating plant is isolated with part of the public electricity supply grid, the plant must not cause temporary overvoltages that can damage the plant or the public electricity supply grid.

The power-generating plant owner must ensure that the plant is protected against the mechanical and electrical consequences of a potential reconnection after symmetric, as well as asymmetric faults, in the transmission system.

Any measures taken in this respect must not compromise any other specified power-generating plant properties

6.5.3. Requirements for grid protection

6.5.3.1. (a) Requirements for grid protection of synchronous power-generating plants

Protection functions and settings of synchronous power-generating plants must be agreed with the DSO and the transmission system operator.

6.5.3.2. (b) Requirements for grid protection of power park modules

A power park module must have protection functions as specified in table 6.7. Unless otherwise agreed with the DSO, the default values in the table are to be used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Overvoltage (step 3)	$U_{>>>}$	1.0 - 1.3/0.01 Default: 1.20	U_c	0.1 - 5/0.05 Default: 0.1	s
Overvoltage (step 2)	$U_{>>}$	1.0 - 1.3/0.01 Default: 1.15	U_c	0.1 - 5/0.05 Default: 0.2	s
Overvoltage (step 1)	$U_{>}$	1.0 - 1.2/0.01 Default: 1.10	U_c	0.1 - 100/0.1 Default: 60	s
Undervoltage (step 1)	$U_{<}$	0.2 - 1.0/0.01 Default: 0.90	U_c	0.1 - 100/0.1 Default: 60	s
Overfrequency	$f_{>}$	50.0 - 52.0/0.1 Default: 51.5	Hz	0.1 - 5/0.05 Default: 0.2	s

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Underfrequency	$f_<$	47.0 - 50.0/0.1 Default: 47.5	Hz	0.1 - 5/0.05 Default: 0.2	s

Table 6.7 – Protection settings for power park modules in type D.

6.5.4. Requirements for islanding detection

A power-generating plant must be capable of detecting unintentional islanding and must disconnect from the public electricity supply grid if unintentional islanding is detected.

In Denmark, only passive islanding detection methods are used. The use of vector jump relays (ANSI 78) or active islanding detection is not allowed on power-generating plants connected to the Danish public electricity supply grid.

A power-generating plant must have the functions for islanding detection specified in table 6.8. Unless otherwise agreed with the DSO, the default value in the table is used. The ranges and resolutions are indicative, not required.

Protection function	Symbol	Setting (Range/Resolution)		Trip time (Range/Resolution)	
Frequency change	df/dt	2 - 3.5/0.1 Default: ±2.5	Hz/s	0.02 - 5/0.01 Default: 0.08	s

Table 6.8 – Requirements for islanding detection.

6.5.5. Earthing

Conditions related to earthing of the power-generating plant must be agreed with the DSO.

6.6. Power quality

A power-generating plant must not cause unacceptable power quality in the grid. To avoid this, the plant must comply with the requirements specified in the following sections.

In cases when a power-generating plant may have a significant impact on the public electricity supply grid (the distribution system and/or the transmission system), additional requirements may apply, see section 6.6.2.

A three-step procedure for power quality assessment is applied, which in brief comprises:

4. *Checking if the Short-Circuit Ratio (SCR) ≥500.*
5. *Assessing power quality by calculation.*
6. *Measuring noise in the grid before and after connection of the plant and agreeing on a solution to the problem.*

6.6.1. Emission limits

A power-generating plant must comply with the requirements described in the following sections.

6.6.1.1. DC content

A power-generating plant must not inject DC currents into the grid. This requirement is met if the DC content of the current injected by the plant into the grid is below 0.5% of the nominal current of the plant.

If the power-generating plant is connected to the grid by means of a plant transformer, it is assumed that this requirement is met.

The reason for having a limit value for DC content is that DC currents are undesirable in the public electricity supply grid and may have an adverse effect on grid operation and protection. The limit value is set based on IEC/TR 61000-3-15, which provides recommendations for requirements for local production connected to the public electricity supply grid at low-voltage level.

6.6.1.2. Voltage unbalance

A power-generating plant must have balanced three-phase load so as not to cause voltage unbalance.

Requirements for unbalance are made because unbalance in phase voltages between phases is undesirable in the public electricity supply grid as it may have an adverse effect on grid operation and the units connected to the public electricity supply grid.

According to the international standard DS/EN 50160, the limit for the total voltage unbalance in the public electricity supply grid is 2%. Voltage unbalance can be distributed in accordance with the method described in IEC/TR 61000-3-13, but this will yield impractically low limit values for the individual plant, which are lower than the measurement uncertainty for measurement of unbalance.

When the plant has a balanced three-phase load, it will generally not add to the voltage unbalance already present in the public electricity supply grid. Documentation showing that the plant has balanced three-phase production will often be sufficient to establish that the plant will not give rise to voltage unbalance in the public electricity supply grid.

To ascertain that the plant does not give rise to voltage unbalance, the voltage unbalance can be measured at the Point of Connection (POC) before and after commissioning of the plant. If there is no significantly increased voltage unbalance after commissioning of the plant compared to the measurements made before commissioning, the voltage unbalance requirement is met.

Voltage unbalance is measured according to DS/EN 61000-4-30 as the negative sequence component divided by the positive sequence component.

6.6.1.3. Rapid voltage changes

A power-generating plant must not cause rapid voltage changes exceeding the limit values specified in Table 6.9.

Voltage level	Limit value
Medium voltage	d(%) = 4%
High voltage	d(%) = 3%

Table 6.9 – Limit value for rapid voltage changes.

Requirements for rapid voltage changes are based on DS/EN 61000-3-11 and the Research Association of the Danish Electric Utilities (DEFU) report RA 557 as well as the methods for determining limit values described in IEC/TR 61000-3-7.

6.6.1.4. Flicker

The power-generating plant must comply with the flicker limit defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-7.

6.6.1.5. Harmonics

The power-generating plant must comply with the voltage limit values for harmonics emissions defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

6.6.1.6. Interharmonic overtones

The power-generating plant must comply with the voltage limit values for interharmonic overtones defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

6.6.1.7. Distortions in the 2-9 kHz frequency range

The power-generating plant must comply with the voltage limit values for distortions in the 2-9 kHz frequency range defined by the DSO.

When defining the requirements, the DSO uses the method described in IEC/TR 61000-3-6.

6.6.2. Division of responsibilities

6.6.2.1. The power-generating plant owner's obligations

As a rule, the power-generating plant owner must ensure that the plant is designed, constructed and configured to comply with all emission limits.

The power-generating plant owner must verify that emission limits at the Point of Connection (POC) are complied with.

For calculation of power quality, the power-generating plant owner uses the typical three-phase short-circuit power, $S_{k,powerquality}$ at the Point of Connection (POC).

The DSO and the transmission system operator will perform a joint assessment of whether or not a power-generating plant may have significant impact on the public electricity supply grid.

For power-generating plants with a significant impact on the public electricity supply grid, the plant owner must also:

- Use frequency-dependent impedance loci to calculate power quality
- Verify that emission limits are also complied with towards the transmission system

- Be capable of supplying an impedance model for the power-generating plant, see section 6.8.

Compliance with emission limits for plants with a significant impact on the electricity supply grid is typically verified by performing calculations on a model model given by the DSO, where one or two points in the model will contain emission limits to be complied with.

Subject to agreement, the plant owner can buy additional services (higher short-circuit power or subscribed capacity) from the DSO in order to comply with the specified limit values.

6.6.2.2. The DSO's obligations

The DSO is responsible for setting emission limits at the Point of Connection (POC).

The DSO must specify the short-circuit level $S_{k,powerquality}$ with associated short-circuit angle ψ_k at the Point of Connection (POC).

When it is impossible to calculate $S_{k,powerquality}$ for a connection point, $S_{k,powerquality}$ is estimated as $(S_{k,min} + S_{k,max})/2$.

The DSO must also state the frequency-dependent grid impedance at the Point of Connection (POC) $Z_{net,h}$. The DSO may choose to state the grid impedance as a measured value or as an approximate model. Using impedance loci, the grid company passes on the impedance loci from the transmission system operation, adjusted to account for any intermediate systems.

$Z_{net,h}$ is generally stated as an approximate model using the approximation method described below. When it is deemed necessary with respect to the impact on the public electricity supply grid, frequency-dependent impedance loci are stated instead.

For frequencies up to and including 2 kHz:

$$|Z_{net,h}| = \sqrt{R_{50}^2 + (h \cdot X_{50})^2}\ , for\ h = [1; 40]$$

For frequencies above 2 kHz:

$$|Z_{net,h}| = \sqrt{R_{50}^2 + (40 \cdot X_{50})^2}\ , for\ h > 40$$

R_{50} and X_{50} are resistance and reactance at 50 Hz. They are calculated from $S_{k,powerquality}$ and the matching short-circuit angle ψ_k.

6.6.3. Measuring method

Measurements of various power quality parameters must be carried out in accordance with the European standard DS/EN 61000-4-30 (class A).

Measurement of harmonic distortion of voltage and current must be carried out as defined in IEC 61000-4-7 in accordance with the principles (harmonic subgroup) and with the accuracies specified for class I.

Measurement of interharmonic distortion up to 2 kHz must be carried out as defined in IEC 61000-4-7 Annex A and must be measured as interharmonic subgroups.

Alternatively, it is allowed to measure harmonic distortion up to 2 kHz with grouping enabled (harmonic groups) as specified in IEC 61000-4-7 and with the accuracies specified for class I. If harmonic distortion up to 2 kHz is measured with grouping enabled, it is not required to measure interharmonic distortion up to 2 kHz separately.

Measurement of distortions in the 2-9 kHz frequency range must be carried out as defined in IEC 61000-4-7 Annex B and must be measured in 200 Hz windows with centre frequencies from 2100 Hz to 8900 Hz.

6.7. Exchange of information

A power-generating plant must be equipped with a PCOM enabling real-time exchange of signals.

If a power-generating plant consists of more than one unit, a plant controller must be installed to allow control of the whole plant at the PCOM, see figure 3.3 and figure 3.4.

6.7.1. Requirements for time stamping and update speed

The information must have time stamps. The time stamps shall have the following update times:

- Maximum time to update functional status (enabled/disabled) is 10 ms.
- Maximum time to update parameter value is one second.
- Maximum time to update measured values is one second.

6.7.2. Requirements for data exchange

A plant shall at a minimum be able to exchange the following information in real-time.

Signal description	Signal type
Absolute power limit	Set point
Absolute power limit	Enabled/disabled
Possible active power output	Value in proportion to P_n
Possible reactive power output	Value in proportion to Q_n
Circuit breaker status at the POC	Status
Circuit breaker status at the PGC	Status
Active power	Measurement
Reactive power	Measurement
Current	Measurement
Voltage	Measurement
Scheduled active power	Set point
Power Factor (PF)	Measurement (may also be computed values)
Q control	Set point
Q control	Enabled/disabled
Power Factor control	Set point
Power Factor control	Enabled/disabled
Voltage control	Enabled/disabled
Voltage control – requested voltage	Set point
Voltage control – droop	Set point
Downward regulation during high winds*	Enabled/disabled
System protection scheme**	Enabled/disabled
System protection scheme**	Set points for steps

* Only applicable to wind power plants
** Only applicable if the plant is required to have system protection scheme when connecting.

Table 6.1 – Requirements for information which a power-generating plant must be capable of exchanging in real time in the PCOM interface.

6.7.3. Fault recording

For a type D power-generating plant, logging must be performed by means of electronic equipment capable, as a minimum, of logging relevant events for the signals mentioned below at the Point of Connection (POC) in case of faults in the public electricity supply grid.

The power-generating plant owner must install logging equipment (a digital fault recorder) at the Point of Connection (POC), which at least records:

- Voltage for each phase of the plant
- Current for each phase of the plant
- Active power for the plant (may be computed values)
- Reactive power for the plant (may be computed values)
- Frequency for the plant
- Frequency deviations
- Speed deviations (only applies to synchronous power-generating plants)
- Activation of internal protection functions

Specific requirements for measurements are described in the grid connection agreement.

Logging must be performed as correlated time series of measuring values from ten seconds before an event until 60 seconds after the event.

The minimum sampling frequency of all fault logs must be 1 kHz.

The specific settings for event-based logging must be agreed with the DSO and the transmission system operator during plant commissioning.

All measurements and data exchanged at the PCOM must be logged with a time stamp and an accuracy ensuring that they can be correlated with each other and with similar records in the public electricity supply grid.

Logs must be kept on file for a minimum of three months after a fault event; up to a maximum 100 event logs.

The DSO and the transmission system operator must, upon request, be given access to log data and other relevant information.

6.8. Simulation model

For power-generating plants with a nominal active power above 10 MW, the plant owner must deliver a simulation model. The requirements for the simulation model have been coordinated with Energinet, therefore reference is made to Energinet's memorandum on requirements for simulation models: [Requirements for Generators (RfG) – krav til simuleringsmodel].

For power-generating plants with a capacity under 10 MW, the DSO can, in exceptional circumstances, require that the plant owner delivers a simulation model. In this case, the requirements are the same as for plants above 10 MW.

6.9. Verification and documentation

This section describes the documentation to be provided by the power-generating plant owner, or a third party, to the DSO in order to obtain operational notification.

The power-generating plant owner is responsible for complying with the requirements described in this document and for documenting such compliance.

The DSO may at any time request verification and documentation showing that the power-generating plant meets the requirements described in this document.

The documentation must be submitted to the DSO as part of the process for obtaining operational notification. During the process, several types of permits must be obtained before the final operational notification is issued. The permit stages are as follows:

1. Energisation operational notification (EON)
2. Interim operational notification (ION)
3. Final operational notification (FON)

To obtain an energization operational notification, the power-generating plant owner must submit Annex B2.1 or B3.1 for respectively power park module or synchronous power-generating plants. The annex must be accompanied by technical documentation in support of the answers given.

To obtain an interim operational notification, the power-generating plant owner must submit Annex 02 or B3.2 for respectively power park module or synchronous power-generating plants. The annex must be accompanied by technical documentation in support of the answers given. Once the documentation is approved, the interim operational notification is issued.

To obtain final operational notification, the plant owner must submit Annex B2.33 or B3.3 for respectively power park module or synchronous power-generating plants. Once the DSO approves the documentation, the final operational notification is issued.

If the DSO does not receive Annex B2.33 or B3.3 before expiry of the interim operational notification, the DSO is entitled to electrically disconnect the plant, as a valid operational notification no longer exists after expiry of the interim operational notification.

If, based on Annex B2.33 or B3.3, the DSO deems that the plant does not comply with the requirements of these instructions, a plan must be prepared for remedying the outstanding items identified. The plan can be used to apply for an extension of the interim operational notification.

Product certificates may be used as part of the documentation for compliance with the requirements of this document.

6.9.1. Requirements for documentation

- CE Declaration of Conformity
- Protection functions
- Single-line diagram
- Power quality
- Tolerance of voltage dips
- P-Q capability curve
- Signal list
- Simulation model
- Conformance testing plan
- Verification report
- Annex 0 or B3.1 complete with technical documentation in support of the answers given.
- Annex B2.32 or B3.2 complete with technical documentation in support of the answers given.
- Annex B2.3 or B3.3 complete with technical documentation in support of the answers given.

Product certificates issued by an approved certification body may also be used. The product certificates may cover some of the documentation requirements.

In connection with documentation of the power-generating plant's technical properties, testing and simulations must be performed as described in sections 6.9.2 to 6.9.5.

6.9.2. Tests

As part of the documentation of the power-generating plant's technical properties, testing must be performed to demonstrate compliance with the requirements of this document. The tests to be carried out include:

- Power response to overfrequency
- Power response to underfrequency
- Frequency control
- Frequency recovery check (only synchronous power-generating plants)
- Reactive power operating range
- Voltage control (only power park modules)
- Power Factor control (only power park modules)
- Q control (only power park modules)

Results must be presented in a report.

6.9.3. Simulations

As part of the documentation of the power-generating plant's technical properties, simulations must be performed to demonstrate compliance with the requirements of this document. The simulations to be carried out include:

- Power response to overfrequency (LFSM-O)
    - Must be carried out for frequency changes in both steps and ramps.
    - Must show how the plant reacts when reaching the lower active power limit.
- Tolerance to voltage dips
- Active power recovery
- Supply of fast fault current (only power park modules)
- Power response to underfrequency (LFSM-U)
    - Must be carried out for frequency changes in both steps and ramps.
    - Must show how the plant reacts when reaching the upper active power limit.
- Frequency control (FSM)
- Islanding (same characteristics with a weaker grid)
- Reactive power operating range
- Damping of oscillations (PSS)

Simulation results and the simulation model must be validated against the tests carried out to demonstrate that model and simulations are accurate.

Product certificates issued by an approved certification body may be used instead of simulations.

6.9.4. Excitation system verification requirements

Documentation verifying compliance with the above functional requirements for excitation equipment must be enclosed. Simulations performed, relevant measurements from commissioning test, functional descriptions and 'as-built' setting values must be enclosed as part of the complete plant documentation.

Coordination between limit functions and protection functions must be documented in a PQ diagram for static and dynamic characteristics, respectively, containing trip times and activation levels.

Simulation, analysis and commissioning test must be used to document the satisfactory dynamic characteristics of the excitation system.

Simulations performed must comprise the following test scenarios:

1. RMS simulation of voltage dips according to the function below, where the machine operating point before the fault is defined as U_{POC} = 1 pu, P = 1 pu, Q_{POC} = 0.4 pu:
    a. Upoc(t) = {1 pu $where$ t < 0s; 0.6 pu where t > 0s
2. RMS simulation of step response test during a temporary ±10% change of the reference voltage, where the machine is operated at idling speed and at nominal rpm.

The commissioning test must include the following tests:

1. Step response test during a temporary ±10% change of the reference voltage, where the machine is operated at idling speed and at nominal rpm.
2. Test of selectivity between under-excitation protection and under-excitation limiter. This is done by means of:
    a. A step response test where it is attempted to force the machine into an under-excited operating point outside the allowable operating range for the under-excitation limiter.
    b. Ramp-up of active power, from P_{min} to P_n, where the machine, before start of the test, is configured to a fully under-excited operating point.
3. Test of selectivity between over-excitation protection and over-excitation limiter. This is done by means of:
    a. A step response test where it is attempted to force the machine into an over-excited operating point outside the allowable operating range for the over-excitation limiter.
    b. Ramp-up of active power, from P_{min} to P_n, where the machine, before start of the test, is configured to a fully over-excited operating point.
4. Stator current limiter performance test. This is done by means of:
    a. A step response test where it is attempted to force the machine into an operating point outside the permissible current value of the stator current limiter. The test is performed at reduced settings.
5. V/Hz limiter performance test. This is done by means of:

   a. A step response test where it is attempted to force the machine into an operating point outside the permissible voltage-to-frequency ratio of the V/Hz limiter. The test is performed using reduced settings and with the machine at idling speed and at nominal rpm.
   b. Change of rpm where it is attempted to force the machine into an operating point outside the permissible voltage-to-frequency ratio of the V/Hz-limiter. The test is performed using reduced settings and with the machine at idling speed and at nominal rpm before change of rpm.

6.9.5. PSS function verification requirements

Documentation verifying compliance with the above functional requirements for the PSS function must be enclosed. Simulations performed, relevant measurements from commissioning test, functional descriptions and 'as-built' setting values must be enclosed as part of the complete plant documentation.

Simulation, analysis and commissioning tests must be used to document that the setting values applied result in the PSS function and the overall excitation system having satisfactory dynamic characteristics.

The simulations performed must include the test scenarios below. With the exception of Test 5, they must all be performed with the PSS function activated and deactivated, respectively:

1. Verification of frequency characteristics, including correct phase compensation of the overall excitation system, in the form of bode plots for gain and phase.
2. Step response at a temporary ±5% change of the reference voltage. Simulations are performed at various operating points, e.g. 25%, 50%, 75% and 100% of nominal plant capacity.
3. Near-to-generator short circuit, see sect. 6.1.3.36.1.3.
4. Disconnection of a line, where the change in the impedance of the public electricity supply grid goes from strongest to weakest grid configuration (short-circuit power). Simulations are performed at various operating points, e.g. 25%, 50%, 75% and 100% of nominal plant capacity.
5. Change of the mechanical power supplied from the drive machine to the generator in accordance with the functions below (PSS function must be active):
   a. Sine function, p(t) = $A \cdot Sin(\omega \cdot t)$, A= 0.1 pu, ω= 2 π 1/60rad
   b. Ramp function, p(t) = {0 pu where t < 0s; 0.25 t pu where 0s < t ≤4s; 1 pu where t > 4s
   c. Step function, p(t) = {1 pu where t < 0s; 0.6 pu where t > 0s

The commissioning test must include the following tests:

1. Measuring phase and gain (bode plot) for the transfer function Vt(s)/Vref(s) with the PSS function deactivated and the plant operated 'off grid' at nominal rpm and terminal voltage.

2. Measuring phase and gain (bode plot) for the transfer function Vt(s)/Vref(s) with the PSS function deactivated and the plant operated ‘on grid’ at an operating point as close to P = 0 and Q = 0 as possible.
3. Measurement of transfer function for the PSS function.
4. Step response test at a temporary ±5% change of the reference voltage. The test is performed at various operating points, e.g., 25%, 50%, 75% and 100% of nominal plant capacity with the PSS function activated and deactivated, respectively.
5. Increase PSS gain by a factor 3 of the proposed value.

Energisation operational notification (EON)
The energisation operational notification entitles the plant owner to energise the plant's internal network and auxiliaries. The plant may, however, not be put into operation or generate electricity for the grid.

Interim operational notification (ION)
The interim operational notification gives the right to operate the plant to the extent necessary to perform conformance testing in accordance with the conformance testing plan submitted.

The maximum period of validity of an interim operational notification is 24 months.

Final operational notification (FON)
The final operational notification entitles the plant owner to operate the plant with a grid connection.

CE Declaration of Conformity
CE Declarations of Conformity must be submitted for each of the main components. The CE Declaration of Conformity must contain a list of relevant standards, codes of practice and directives which the component or plant complies with.

Protection functions
Documentation of protection settings is a list of all current relay configurations at the time of commissioning.

Single-line diagram
A single-line diagram is a drawing that shows the plant main components and how they are electrically interconnected. In addition, the location of the protection and measuring points are included in the representation.

Power quality
Power quality is a collection of parameters characterising the electricity supplied. A certificate or report demonstrating that the requirements are complied with must be presented.

Tolerance of voltage dips
Tolerance of voltage dips is the plant's ability to stay connected to the public electricity supply grid during a voltage dip as well as power park modules' ability to supply fast fault current. The plant's ability to stay connected to the grid and supply fast fault current may be documented in two ways: simulation or testing.

P-Q capability curve
A diagram showing the plant's operating range for active and reactive power.

Signal list
A list of signals which the plant can exchange with the DSO in accordance with section 6.7.

Simulation model
A simulation model complying with the requirements in section 6.8.

Conformance testing plan
A detailed plan for performance of conformance testing to demonstrate that the plant complies with the requirements of this document.

Verification report
A report which uses the conformance testing to demonstrate that the plant complies with the requirements of this document.

Completion of annexes
Completed annexes 0 and B2.3 means that the annexes in these instructions must be completed, and that technical documentation verifying the correctness of the answers given in the annexes must be attached. Technical documentation may include a test report, product certificate, user manual, simulations, etc.

ANNEX 1 DOCUMENTATION FOR TYPE B POWER-GENERATING PLANTS

B1.1. Documentation for type B power-generating plants (part 1)

Please complete the documentation with power-generating plant data before commissioning and send it to the DSO.

B1.1.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Plant owner name and address:	
Plant owner telephone number:	
Plant owner email address:	

B1.1.2. Description of the power-generating plant

Type:	Synchronous power-generating plant ☐ Power park module ☐
Primary energy source: *Describe type:	Wind ☐ Solar ☐ Fuel ☐ Other* ☐
Energy conversion technology:	Steam turbine ☐ Gas turbine ☐ Combined cycle plant ☐ Internal combustion engine ☐ Inverter-based ☐
Fuel type, if applicable:	
Manufacturer/model:	
Voltage at the POC (U_c):	

Nominal power (P_n):	
Minimum power (P_{min}):	
Rated mechanical shaft power for drive system (P_{mech}) (only synchronous power-generating plants):	
Is a process diagram available for the plant? (only synchronous power-generating plants) Document reference:	Yes ☐ No ☐
Is a single-line diagram available showing settlement metering, online metering, ownership boundaries and operation manager boundaries? Document reference:	Yes ☐ No ☐

B1.1.2.1. Generator information

Please only complete this section for **synchronous power-generating** plants.

Manufacturer:	
Type/Model:	
Does the generator comply with relevant sections of the following European standards?: - DS/EN 60034-1, 'Rotating electrical machines – Part 1: Rating and performance', 2004 - DS/EN 60034-3 'Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines', 1995	Yes ☐ No ☐
Is detailed generator documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.2.2. Generator data

Please only complete this section for **synchronous** power-generating plants.

Description	**Symbol**	**Unit**	**Value**
Rated apparent power :	S_n	MVA	
Rated voltage:	U_n	kV	
Rated frequency:	f_n	Hz	
Rated Power Factor (cosϕ):	$\cos\phi_n$	-	
Rated minimum reactive power generation from PQ diagram:	$Q_{min,n}$	Mvar	
Rated maximum reactive power generation from PQ diagram:	$Q_{max,n}$	Mvar	
Synchronous speed:	n_n	Rpm	
Total moment of inertia for rotating mass (generator, drive system, etc.):	J_{tot}	$kg \cdot m^2$	
Total moment of inertia for generator:	J_G	$kg \cdot m^2$	
Total moment of inertia for drive system:	J_D	$kg \cdot m^2$	
Rotor type:	-	-	Salient poles ☐ Distinct poles ☐
Stator resistance per phase:	R_a	p.u.	
Temperature for resistance:	T_R	ºC	

Stator dispersion reactance per phase:	X_{ad}	p.u.	
Positive-sequence reactance, d axis:	X_d	p.u.	
Transient reactance, d axis:	X'_d	p.u.	
Subtransient reactance, d axis:	X''_d	p.u.	
Saturated positive-sequence reactance, d axis:	$X_{d,sat}$	p.u.	
Saturated subtransient positive-sequence reactance, d axis:	$X''_{d,sat}$	p.u.	
Positive-sequence reactance, q axis:	X_q	p.u.	
Transient reactance, q axis:	X'_q	p.u.	
Subtransient reactance, q axis:	X''_q	p.u.	
Transient open circuit time constant, d axis:	T'_{d0}	s	
Subtransient open circuit time constant, d axis:	T'_{d0}	s	
Transient open circuit time constant, q axis:	T'_{q0}	s	
Subtransient open circuit time constant, q axis:	T''_{q0}	s	
Potier reactance:	X_p	p.u.	
Saturation point at 1.0 p.u. voltage:	$SG_{1.0}$	p.u.	
Saturation point at 1.2 p.u. voltage:	$SG_{1.2}$	p.u.	
Reactance, inverse-component:	X_2	p.u.	
Resistance, inverse-component:	R_2	p.u.	
Reactance, zero-component:	X_0	p.u.	
Resistance, zero-component:	R_0	p.u.	
Is the generator star point earthed?	-	-	Yes ☐ No ☐
If yes, ground reactance:	X_e	Ohm	
If yes, ground resistance:	R_e	Ohm	
Generator's short-circuit ratio (Rated):	K_c	p.u.	

B1.1.2.3. Excitation system

Please only complete this section for **synchronous power-generating** plants.

Manufacturer:	
Type/Model:	
Does the excitation system comply with relevant parts of the following European standards?: - DS/EN 60034-16-1:2011 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions' - DS/CLC/TR 60034-16-3:2004 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance'.	Yes ☐ No ☐
Is the power-generating plant equipped with excitation system as specified in section 4.4.5?	Yes ☐ No ☐
Is detailed excitation system documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.2.4. Generator or plant transformer

Is the plant connected through a generator or plant transformer? If yes, fill in the remaining fields:	Yes ☐ No ☐
Manufacturer:	
Type/Model:	
Is detailed transformer documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.3. Tolerance of frequency and voltage deviations

B1.1.3.1. Phase jump

Does the power-generating plant remain connected during voltage phase jumps of 20 degrees at the POC as specified in section 4.1.1? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.3.2. Operating area for voltage and frequency

Is the power-generating plant capable of remain connected to the public electricity supply grid within the voltage and frequency range specified in section 4.1.1 and 4.1.2 and on figure 4.1 and generating continuously within the normal operating range. If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.3.3. Frequency change

Will the power-generating plant remain connected in case of frequency changes of 2.0 Hz/s at the POC? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.3.4. Permitted reduction of active power during underfrequency

Is the active power reduction at underfrequency less than the limit specified in section 4.1.2.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.4. Tolerance of voltage deviations

Does the power-generating plant stay connected to the public electricity supply grid during voltage dips as specified in section 4.1.3.3? If yes, please provide reference to documentation:	Yes ☐ No ☐
Does the power-generating plant stay connected to the public electricity supply grid during voltage swells as specified in section 4.1.3.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.4.1. Fast fault current

Please only complete this section for **power park modules**.

Does the power park module supply fast fault current as specified in section 4.1.3.3 (b)? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.5. Start-up and reconnection of a power-generating plant

Is connection and synchronisation performed as specified in section 4.2? If yes, please provide reference to documentation:	Yes ☐ No ☐
Is it possible to bypass automatic synchronisation? If no, please provide reference to documentation:	Yes ☐ No ☐

B1.1.6. Active power control

B1.1.6.1. Power response to overfrequency

Is the power-generating plant equipped with a frequency response function for overfrequency as specified in section 4.3.1? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.6.2. Absolute power limit function

Is the power-generating plant equipped with an absolute power limit function as specified in section 4.3.2.1? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.6.3. Ramp rate limit

Is the power-generating plant equipped with ramp rate limit as specified in section 4.3.2.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.7. Reactive power control

B1.1.7.1. Operating range

Is the power-generating plant capable of supplying reactive power at P_n and varying operating voltages as specified in section 4.4.1? Where can documentation showing that this requirement has been met be found?	Yes ☐ No ☐
Is the power-generating plant capable of supplying reactive power when active power varies as specified in section 4.4.1? Where can documentation showing that this requirement has been met be found?	Yes ☐ No ☐

B1.1.7.2. Power Factor control

Is the power-generating plant equipped with a Power Factor control function as specified in section 4.4.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.7.3. Automatic Power Factor control

Is the power-generating plant equipped with an automatic Power Factor control function as specified in section 4.4.3? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.7.4. Q control

Is the power-generating plant equipped with Q control function as specified in section 4.4.4? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8. Power quality

Are the values in the provided documentation computed values?	Yes ☐ No ☐
Are the values in the provided documentation measured values?	Yes ☐ No ☐
Is a report documenting that the calculations or measurements comply with the emission requirements included? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.1. Rapid voltage changes

Does the power-generating plant comply with the limit value for rapid voltage changes specified in section 4.6.1.3? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.2. DC content

Please only complete this section for **power park modules**.

Does the DC content during normal operation exceed 0.5% of nominal current, as specified in section 4.6.1.1? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.3. Voltage unbalance

Please only complete this section for **power park modules**.

Does the plant have balanced three-phase load, as specified in section 4.6.1.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.4. Flicker

Please only complete this section for **power park modules**.

Is the flicker contribution for the entire plant below the limit value specified in section 4.6.1.4? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.5. Harmonic overtones

Please only complete this section for **power park modules**.

Are all the harmonic overtones for the entire plant below the limit values specified in 4.6.1.5? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.6. Interharmonic overtones

Please only complete this section for **power park modules**.

Are all the interharmonic overtones for the entire plant below the limit values specified in section 4.6.1.6? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.8.7. Distortions in the 2-9 kHz frequency range

Please only complete this section for **power park modules**.

Are emissions of distortions in the 2-9 kHz frequency range less than 0.2% of I_n as required in section 4.6.1.7? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.9. Protection

Is the power-generating plant equipped with the protection functions required in section 4.5.3? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.9.1. Islanding detection

Is the power-generating plant equipped with the protection functions required in section 4.5.4? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.9.2. Additional requirements for grid protection of synchronous power-generating plants

Please complete this section for **synchronous** power-generating plants.

Is a synchronous undervoltage relay used? If yes, please provide reference to documentation:	Yes ☐ No ☐
Is an overcurrent relay used? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.10. Requirements for information exchange

Is the power-generating plant capable of exchanging information as required in section 4.7? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.1.11. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

B1.2. Documentation for type B power-generating plants (part 2)

Please complete the documentation with *power-generating plant* data after commissioning and send it to the *DSO*.

B1.2.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B1.2.2. Active power control

B1.2.2.1. Power reponse to overfrequency

Is the frequency response function for overfrequency enabled?	Yes ☐ No ☐
If yes, what are the set point values? Frequency threshold (f_{RO}): Droop: Intentional delay for islanding detection:	_________Hz _________% _________ms

B1.2.2.2. Absolute power limit function

Is the absolute power limit function enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point value is used?	_________kW

B1.2.2.3. Ramp rate limit

Is the power-generating plant ramp rate limit enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point value is used?	_____% P_n/min

B1.2.3. Reactive power control

B1.2.3.1. Q control

Is the Q control function enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point is used? (Values different from 0 kVAr must be agreed with the DSO)	________kVAr

B1.2.3.2. Power Factor control

Is the Power Factor control function enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point is used? (Values different from cosϕ 1.0 must be agreed with the DSO)	________ cosϕ Inductive ☐ Capacitive ☐

B1.2.3.3. Automatic Power Factor control

Is the automatic Power Factor control function enabled? (Must only be enabled subject to prior agreement with the DSO)	Yes ☐ No ☐
If yes, which set points are used?	
Set point 1 – P/P_n	________%
Set point 1 – Power Factor (inductive)	______ cosϕ
Set point 2 – P/P_n	________%
Set point 2 – Power Factor (inductive)	______ cosϕ
Set point 3 – P/P_n	________%
Set point 3 – Power Factor (inductive)	______ cosϕ

B1.2.4. Protection

B1.2.4.1. Relay settings

Please state the actual values at the time of commissioning in the table below.

Protection function	Symbol	Setting		Trip time	
Overvoltage (step 2)	$U_{>>}$		V		ms
Overvoltage (step 1)	$U_{>}$		V		s
Undervoltage (step 1)	$U_{<}$		V		s
Overfrequency	$f_{>}$		Hz		ms
Underfrequency	$f_{<}$		Hz		ms
Frequency change	*df/dt*		Hz/s		ms

B1.2.4.2. Islanding detection

Are vector jump relays or active islanding detection used?	Yes ☐ No ☐

B1.2.4.3. Additional relay settings for synchronous power-generating plants

Please complete this section for **synchronous** power-generating plants.

Please state the actual relay setting values at the time of commissioning in the table below.

Protection function	Symbol	Setting		Trip time	
Overcurrent	$I_{>}$		A		ms
Synchronous undervoltage*			V		ms

*If synchronous undervoltage relay is used.

B1.2.5. Conformance testing

Is a plan for conformance testing available as specified in sections 4.8.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B1.2.6. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

ANNEX 2 DOCUMENTATION FOR TYPE C AND D POWER-GENERATING PLANTS

B2.1. Documentation for type C and D power park module (part 1)

Please complete the documentation with power park module data to obtain **energisation operational notification (EON),** that allows to energise the plant's internal network and auxiliaries.

B2.1.1. Identification

Power-generating plant name:	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B2.1.2. Description of the power-generating plant

Primary energy source: *Describe type:	Wind ☐ Solar ☐ Other* ☐
Manufacturer/model:	
Voltage at the POC (U_c):	
Nominal power (P_n):	
Minimum power (P_{min}):	

B2.1.2.1. Plant transformer

Is the plant connected through a generator or plant transformer? If yes, fill in the remaining fields:	Yes ☐ No ☐
Manufacturer:	
Type/Model:	
Is detailed transformer documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3. Power quality

Are the values in the provided documentation computed values?	Yes ☐ No ☐
Are the values in the provided documentation measured values?	Yes ☐ No ☐
Is a report documenting that the calculations or measurements comply with the emission requirements included? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.1. Rapid voltage changes

Does the power-generating plant comply with the limit value for rapid voltage changes specified in sections 5.6.1.3 and 6.6.1.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.2. DC content

Does the DC content during normal operation exceed the limit values specified in sections 5.6.1.1 and 6.6.1.1 for type C and D plants, respectively? If no, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.3. Voltage unbalance

Does the plant have balanced three-phase load, as specified in sections 5.6.1.2 and 6.6.1.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.4. Flicker

Does the power-generating plant comply with the emission limits for flicker, provided by the DSO according to sections 5.6.1.4 and 6.6.1.4 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.5. Harmonic overtones

Does the power-generating plant comply with the voltage distortion limits for harmonic emissions, provided by the DSO according to sections 5.6.1.5 and 6.6.1.5 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.6. Interharmonic overtones

Does the power-generating plant comply with the voltage distortion limits for interharmonic emissions, provided by the DSO according to sections 5.6.1.6 and 6.6.1.6 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.3.7. Distortions in the 2-9 kHz frequency range

Does the power-generating plant comply with the voltage distortion limits for emission of distortions in the 2-9 kHz frequency range specified by the DSO according to 5.6.1.7 and 6.6.1.7 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.1.4. Protection

B2.1.4.1. Relay settings

Please state the actual values at the time of commissioning in the table below.

Protection function	**Symbol**	**Setting**		**Trip time**	
Overvoltage (step 3)	$U_{>>>}$		V		ms
Overvoltage (step 2)	$U_{>>}$		V		ms
Overvoltage (step 1)	$U_{>}$		V		s
Undervoltage (step 1)	$U_{<}$		V		s
Overfrequency	$f_{>}$		Hz		ms
Underfrequency	$f_{<}$		Hz		ms
Frequency change	df/dt		Hz/s		ms

please provide reference to documentation of the protection functions:

B2.1.5. Simulation model requirements

Is a simulation model as specified in sections 5.8 and 6.8 for type C and D plants, respectively, sent to Energinet?	Yes ☐ No ☐

B2.1.6. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

B2.2. Documentation for type C and D power park module (part 2)

Please complete the documentation with power park module data to obtain **interim operational notification (ION)** and send it to the DSO.

B2.2.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B2.2.2. Description of the power-generating plant

Primary energy source: *Describe type:	Wind ☐ Solar ☐ Other* ☐
Manufacturer/model:	
Voltage at the POC (U_c):	
Nominal power (P_n):	
Minimum power (P_{min}):	
Is a single-line diagram available showing settlement metering, online metering, voltage reference point, ownership boundaries and operation manager boundaries? If yes, please provide reference to document:	Yes ☐ No ☐

B2.2.3. Tolerance of frequency and voltage deviations

B2.2.3.1. Phase jump

Does the power-generating plant remain connected during voltage phase jumps of 20 degrees at the POC as specified in section 5.1.1 and 6.1.1? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.3.2. Operating area for voltage and frequency

Is the power-generating plant capable of remain connected to the public electricity supply grid within the voltage and frequency range specified in section 5.1.1 and 5.1.2 or 6.1.1 and 6.1.2 and on figure 5.1 or 6.1 and generating continuously within the normal operating range. If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.3.3. Frequency change

Will the power-generating plant remain connected in case of frequency changes of 2.0 Hz/s at the POC? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.3.4. Permitted reduction of active power during underfrequency

Is the active power reduction at underfrequency less than the limit specified in section 4.1.2.2 and 6.1.2.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.4. Tolerance of voltage deviations

Will the power-generating plant remain connected to the public electricity supply grid in case of voltage dips as specified in sections 5.1.3.3 and 6.1.3.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Will the power-generating plant remain connected to the public electricity supply grid in case of voltage swells as specified in sections 5.1.3.2 and 6.1.3.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.4.1. Fast fault current

Does the **power park modules** supply fast fault current as specified in section 5.1.3.3 or 6.1.3.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.5. Connection and synchronisation

Is connection and synchronisation performed as specified in sections 5.2 and 6.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
It is possible to bypass the automatic synchronisation? Reference to documentation:	Yes ☐ No ☐

B2.2.6. Active power control

B2.2.6.1. Power response to overfrequency

Is the power-generating plant equipped with a frequency response function for overfrequency as specified in sections 5.3.1 and 6.3.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.2. Power response to underfrequency

Is the power-generating plant equipped with a frequency response function for underfrequency as specified in sections 5.3.2 and 6.3.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.3. Frequency control

Is the power-generating plant equipped with a frequency control function as specified in sections 5.3.3 and 6.3.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.4. System protection scheme

Is the power-generating plant equipped with a system protection scheme function as specified in section 5.3.4.3 and 6.3.4.3 for type C and D, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.5. Absolute power limit function

Is the power-generating plant equipped with an absolute power limit function as specified in sections 5.3.4.1 and 6.3.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.6. Delta power limit function

Is the plant equipped with a delta power limit function as specified in sections 5.3.4.3 and 6.3.4.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.6.7. Ramp rate limit function

Is the power-generating plant equipped with a ramp rate limit function as specified in sections 5.3.4.2 and 6.3.4.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.7. Reactive power control functions

Is it possible to use the resolution specified in sections 5.4 and 6.4 for type C and D plants, respectively, for the set point values? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.7.1. Requirements for reactive power control range

Is the power-generating plant capable of supplying reactive power at P_n and varying operating voltages as specified in sections 5.4.1 and 6.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Is the power-generating plant capable of supplying reactive power when active power varies as specified in sections 5.4.1 and 6.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.7.2. Q control

Is the power-generating plant equipped with a Q control function as specified in sections 5.4.4 and 6.4.4 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.7.3. Power Factor control

Is the power-generating plant equipped with a Power Factor control function as specified in sections 5.4.2 and 6.4.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.7.4. Voltage control

Is the power-generating plant equipped with a voltage control function as specified in sections 5.4.3 and 6.4.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Where is the voltage reference point located?	

B2.2.8. Power quality

Have changes been made to the system that have an impact on the power quality since the EON? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.9. Information exchange

B2.2.9.1. Data communication

Have data communication protocols and data security requirements been established and configured as specified in section 5.7 and 5.7 for type C and D plants, respectively?	Yes ☐ No ☐
Are the signals specified in section 5.7 and 5.7 for type C and D plants, respectively, available in the PCOM interface?	Yes ☐ No ☐

B2.2.9.2. Fault recording

Is logging equipment installed at the POC as specified in sections 5.7.3 and 6.7.3 for type C and D plants, respectively?	Yes ☐ No ☐
Has an agreement been made with the DSO and the transmission system operator defining which incidents to log? If yes, which incidents are to be logged?	Yes ☐ No ☐

B2.2.10. Simulation model requirements

Is the simulation model approved by Energinet? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.11. Conformance testing

Is a plan for conformance testing available as specified in sections 5.9 and 6.9 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.12. Conformance simulation

Is a plan for conformance simulation available as specified in sections 5.9.3 and 6.9.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.2.13. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

B2.3. Documentation for type C and D power park module (part 3)

Please complete the documentation with power park module data to obtain **final operational notification (FON)** and send it to the DSO.

B2.3.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B2.3.2. Active power control

B2.3.2.1. Power respnonse to overfrequency

Is the frequency response function for overfrequency as specified in sections 5.3.1 and 6.3.1 for type C and D plants, respectively, enabled?	Yes ☐ No ☐
If yes, what are the set point values? Frequency threshold: Droop: Time for islanding detection (minimum response time):	 _________Hz _________% _________ms

B2.3.2.2. Power response to underfrequency

Is the frequency response function for underfrequency as specified in sections 5.3.2 and 6.3.2 for type C and D plants, respectively, enabled?	Yes ☐ No ☐
If yes, what are the set point values? Frequency threshold: Droop: Intentional delay for islanding detection (minimum response time):	 _________Hz _________% _________ms

B2.3.2.3. Frequency control

Is the frequency control function as specified in sections 5.3.3 and 6.3.3 for type C and D plants, respectively, enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, what are the set point values? Frequency threshold – Low (f_{RU}): Frequency threshold – High (f_{RO}): Droop: Desired frequency: ΔP:	_________Hz _________Hz _________% _________Hz _________kW

B2.3.2.4. Absolute power limit function

Is the absolute power limit function as specified in sections 5.3.4.1 and 6.3.4.1 for type C and D plants, respectively, enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point value is used?	_________kW

B2.3.2.5. Ramp rate limit function

Is the power-generating plant ramp rate limit function as specified in sections 5.3.4.2 and 6.3.4.2 for type C and D plants, respectively, enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point value is used?	______% P_n/min

B2.3.3. Reactive power control

B2.3.3.1. Q control

Is the Q control function as specified in sections 5.4.4 and 6.4.4 for type C and D plants, respectively, enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point is used? (Values different from 0 kVAr must be agreed with the DSO).	_________kVAr

B2.3.3.2. Power Factor control

Is the Power Factor control function as specified in sections 5.4.2 and 6.4.2 for type C and D plants, respectively, enabled?	Yes ☐ No ☐ Controlled online ☐
If yes, which set point is used? (Values different from cosφ 1.0 must be agreed with the DSO).	_________ cosφ Inductive ☐ Capacitive ☐

B2.3.3.3. Voltage control

Is the voltage control function as specified in sections 5.4.3 and 6.4.3 for type C and D plants, respectively, enabled? (Must only be enabled subject to prior agreement with the DSO) If yes, which set point is used?	Yes ☐ No ☐ Controlled online ☐ _________kV

B2.3.3.4. Conformance testing

Is documentation of conformance testing enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.3.3.5. Conformance simulation

Is documentation of conformance simulation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.3.4. Verification of simulation model

Is a simulation model verified with the conformance test with Energinet? If yes, please provide reference to documentation:	Yes ☐ No ☐

B2.3.5. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

ANNEX 3 DOCUMENTATION FOR TYPE C AND D SYNCHRONOUS POWER-GENERATING PLANTS

B3.1. Documentation for type C and D synchronous power-generating plant (part 1)

Please complete the documentation with synchronous power-generating plant data to obtain **energisation operational notification (EON),** that allows to energise the plant's internal network and auxiliaries.

B3.1.1. Identification

Power-generating plant name:	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B3.1.2. Description of the power-generating plant

Primary energy source: *Describe type:	Fuel ☐ Other* ☐
Energy conversion technology	Steam turbine ☐ Gas turbine ☐ Combined cycle plant ☐ Internal combustion engine ☐
Fuel type, if applicable:	
Manufacturer/model:	
Voltage at the POC (U_c):	
Nominal power (P_n):	
Minimum power (P_{min}):	

B3.1.2.1. Generator transformer

Is the plant connected through a generator transformer? If yes, fill in the remaining fields:	Yes ☐ No ☐
Manufacturer:	
Type/Model:	
Is detailed transformer documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.1.3. Power quality

Are the values in the provided documentation computed values?	Yes ☐ No ☐
Are the values in the provided documentation measured values?	Yes ☐ No ☐
Is a report documenting that the calculations or measurements comply with the emission requirements included? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.1.3.1. Rapid voltage changes

Does the power-generating plant comply with the limit value for rapid voltage changes specified in sections 5.6.1.3 and 6.6.1.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.1.4. Protection

B3.1.4.1. Relay settings

Please state the actual values at the time of commissioning in the table below.

Protection function	**Symbol**	**Setting**		**Trip time**	
Overvoltage (step 3)	$U_{>>>}$		V		ms
Overvoltage (step 2)	$U_{>>}$		V		ms
Overvoltage (step 1)	$U_{>}$		V		s
Undervoltage (step 1)	$U_{<}$		V		s
Overfrequency	$f_{>}$		Hz		ms
Underfrequency	$f_{<}$		Hz		ms
Frequency change	df/dt		Hz/s		ms

please provide reference to documentation of the protection functions:

B3.1.4.2. Additional requirements for grid protection of synchronous power-generating plants

Is a synchronous undervoltage relay used?	Yes ☐ No ☐
Is an overcurrent relay used?	Yes ☐ No ☐
Is a study of the type and parameter values of protection functions available? If yes, please provide reference to the study:	Yes ☐ No ☐

B3.1.5. Simulation model requirements

Is a simulation model as specified in sections 5.8 and 6.8 for type C and D plants, respectively, sent to Energinet?	Yes ☐ No ☐

B3.1.6. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

B3.2. Documentation for type C and D synchronous power-generating plant (part 2)

Please complete the documentation with synchronous power-generating plant data to obtain **interim operational notification (ION)** and send it to the DSO.

B3.2.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B3.2.2. Description of the power-generating plant

Primary energy source: *Describe type:	Fuel ☐ Other* ☐
Energy conversion technology	Steam turbine ☐ Gas turbine ☐ Combined cycle plant ☐ Internal combustion engine ☐
Fuel type, if applicable:	
Manufacturer/model:	
Voltage at the POC (U_c):	
Nominal power (P_n):	
Minimum power (P_{min}):	
Rated mechanical shaft power for drive system (P_{mech}):	
Is a process diagram available for the plant? Document reference:	Yes ☐ No ☐
Is a single-line diagram available showing settlement metering, online metering, voltage reference point, ownership boundaries and operation manager boundaries? If yes, please provide reference to document:	Yes ☐ No ☐

B3.2.3. Generator

Manufacturer:	
Type/Model:	
Does the generator comply with relevant sections of the following European standards?: - DS/EN 60034-1, 'Rotating electrical machines – Part 1: Rating and performance', 2004 - DS/EN 60034-3 'Rotating electrical machines – Part 3: Specific requirements for turbine-type synchronous machines', 1995	Yes ☐ No ☐
Is detailed generator documentation enclosed?	Yes ☐ No ☐
If yes, please provide reference to documentation:	

B3.2.4. Generator data

Please only complete this section for **synchronous** power-generating plants.

Description	Symbol	Unit	Value
Rated apparent power:	S_n	MVA	
Rated voltage:	U_n	kV	
Rated frequency:	f_n	Hz	
Rated Power Factor (cosϕ):	$\cos\phi_n$	-	
Rated minimum reactive power generation from PQ diagram:	$Q_{min,n}$	Mvar	
Rated maximum reactive power generation from PQ diagram:	$Q_{max,n}$	Mvar	
Synchronous speed:	n_n	Rpm	
Total moment of inertia for rotating mass (generator, drive system, etc.):	J_{tot}	$kg{\cdot}m^2$	
Total moment of inertia for generator:	J_G	$kg{\cdot}m^2$	
Total moment of inertia for drive system:	J_D	$kg{\cdot}m^2$	
Rotor type:	-	-	Salient poles ☐ Distinct poles ☐
Stator resistance per phase:	R_a	p.u.	
Temperature for resistance:	T_R	ºC	
Stator dispersion reactance per phase:	X_{ad}	p.u.	
Positive-sequence reactance, d axis:	X_d	p.u.	
Transient reactance, d axis:	X'_d	p.u.	
Subtransient reactance, d axis:	X''_d	p.u.	
Saturated positive-sequence reactance, d axis:	$X_{d,sat}$	p.u.	
Saturated subtransient positive-sequence reactance, d axis:	$X''_{d,sat}$	p.u.	
Positive-sequence reactance, q axis:	X_q	p.u.	
Transient reactance, q axis:	X'_q	p.u.	
Subtransient reactance, q axis:	X''_q	p.u.	
Transient open circuit time constant, d axis:	T'_{d0}	s	
Subtransient open circuit time constant, d axis:	T'_{d0}	s	
Transient open circuit time constant, q axis:	T'_{q0}	s	
Subtransient open circuit time constant, q axis:	T''_{q0}	s	
Potier reactance:	X_p	p.u.	
Saturation point at 1.0 p.u. voltage:	$SG_{1.0}$	p.u.	
Saturation point at 1.2 p.u. voltage:	$SG_{1.2}$	p.u.	

Reactance, inverse-component:	X_2	p.u.	
Resistance, inverse-component:	R_2	p.u.	
Reactance, zero-component:	X_0	p.u.	
Resistance, zero-component:	R_0	p.u.	
Is the generator star point earthed?	-	-	Yes ☐ No ☐
If yes, ground reactance:	X_e	Ohm	
If yes, ground resistance:	R_e	Ohm	
Generator's short-circuit ratio (Rated):	K_c	p.u.	

B3.2.5. Excitation system

Manufacturer	
Type/Model	
Does the excitation system comply with relevant parts of the following European standards?: - DS/EN 60034-16-1:2011 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions' - DS/CLC/TR 60034-16-3:2004 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance'.	Yes ☐ No ☐
Is the plant equipped with an excitation system as specified in sections 5.4.5 and 6.4.5.3 for type C and D plants, respectively?	Yes ☐ No ☐
Is detailed excitation system documentation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.6. PSS function

Is the plant equipped with a PSS function as specified in section 6.4.5.3? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.7. Tolerance of frequency and voltage deviations

B3.2.7.1. Phase jump

Does the power-generating plant remain connected during voltage phase jumps of 20 degrees at the POC? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.7.2. Operating area for voltage and frequency

Is the power-generating plant capable of remain connected to the public electricity supply grid within the voltage and frequency range specified in section 5.1.1 and 5.1.2 or 6.1.1 and 6.1.2 and on figure 5.1 or 6.1 and generating continuously within the normal operating range. If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.7.3. Frequency change

Will the power-generating plant remain connected in case of frequency changes of 2.0 Hz/s at the POC? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.7.4. Permitted reduction of active power during underfrequency

Is the active power reduction at underfrequency less than the limit specified in section 4.1.2.2 and 6.1.2.2? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.8. Tolerance of voltage deviations

Will the power-generating plant remain connected to the public electricity supply grid in case of voltage dips as specified in sections 5.1.3.3 and 6.1.3.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Will the power-generating plant remain connected to the public electricity supply grid in case of voltage swells as specified in sections 5.1.3.2 and 6.1.3.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.9. Connection and synchronisation

Is connection and synchronisation performed as specified in sections 5.2 and 6.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
It is possible to bypass automatic synchronisation? Reference to documentation:	Yes ☐ No ☐

B3.2.10. Active power control

B3.2.10.1. Power response to overfrequency

Is the power-generating plant equipped with a frequency response function for overfrequency as specified in sections 5.3.1 and 6.3.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.10.2. Power response to underfrequency

Is the power-generating plant equipped with a frequency response function for underfrequency as specified in sections 5.3.2 and 6.3.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.10.3. Frequency control

Is the power-generating plant equipped with a frequency control function as specified in sections 5.3.3 and 6.3.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.10.4. System protection scheme

Is the power-generating plant equipped with a system protection scheme function as specified in section 5.3.4.3 and 6.3.4.3 for type C and D, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.10.5. Absolute power limit function

Is the power-generating plant equipped with an absolute power limit function as specified in sections 5.3.4.1 and 6.3.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.10.6. Ramp rate limit function

Is the power-generating plant equipped with a ramp rate limit function as specified in sections 5.3.4.2 and 6.3.4.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.11. Reactive power control functions

Is it possible to use the resolution specified in sections 5.4 and 6.4 for type C and D plants, respectively, for the set point values? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.11.1. Requirements for reactive power control range

Is the power-generating plant capable of supplying reactive power at P_n and varying operating voltages as specified in sections 5.4.1 and 6.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Is the power-generating plant capable of supplying reactive power when active power varies as specified in sections 5.4.1 and 6.4.1 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.11.2. Q control

Is the power-generating plant equipped with a Q control function as specified in sections 5.4.4 and 6.4.4 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.11.3. Power Factor control

Is the power-generating plant equipped with a Power Factor control function as specified in sections 5.4.2 and 6.4.2 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.11.4. Voltage control

Is the power-generating plant equipped with a voltage control function as specified in sections 5.4.3 and 6.4.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐
Where is the voltage reference point located?	

B3.2.12. Power quality

Have changes been made to the system that have an impact on the power quality since the EON? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.13. Information exchange

B3.2.13.1. Data communication

Have data communication protocols and data security requirements been established and configured as specified in section 5.7 and 6.7 for type C and D plants, respectively?	Yes ☐ No ☐
Are the signals specified in section 5.7 and 6.7 available in the PCOM interface?	Yes ☐ No ☐

B3.2.13.2. Fault recording

Is logging equipment installed at the POC as specified in sections 5.7.3 and 6.7.3 for type C and D plants, respectively?	Yes ☐ No ☐
Has an agreement been made with the DSO and the transmission system operator defining which incidents to log? If yes, which incidents are to be logged?	Yes ☐ No ☐

B3.2.14. Simulation model requirements

Is the simulation model approved by Energinet? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.15. Conformance testing

Is a plan for conformance testing available as specified in sections 5.9 and 6.9 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.16. Conformance simulation

Is a plan for conformance simulation available as specified in sections 5.9.3 and 6.9.3 for type C and D plants, respectively? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.2.17. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	

B3.3. Documentation for type C and D synchronous power-generating plant (part 3)

Please complete the documentation with synchronous power-generating plant data to obtain **final operational notification (FON)** and send it to the DSO.

B3.3.1. Identification

Power-generating plant name:	
Global Service Relation Number (GSRN number):	
Power-generating plant owner name and address:	
Power-generating plant owner telephone number:	
Power-generating plant owner email address:	

B3.3.2. Active power control

B3.3.2.1. Power response to overfrequency

Is the frequency response function for overfrequency as specified in sections 5.3.1 and 6.3.1 for type C and D plants, respectively, enabled?	Yes ☐ No ☐
If yes, what are the set point values? Frequency threshold: Droop: Time for islanding detection (minimum response time):	 _________Hz _________% _________ms

B3.3.2.2. Power response to underfrequency

Is the frequency response function for underfrequency as specified in sections 5.3.2 and 6.3.2 for type C and D plants, respectively, enabled?	Yes ☐ No ☐
If yes, what are the set point values? Frequency threshold: Droop: Intentional delay for islanding detection (minimum response time):	_________Hz _________% _________ms

B3.3.2.3. Frequency control

Is the frequency control function as specified in sections 5.3.3 and 6.3.3 for type C and D plants, respectively, enabled? If yes, what are the set point values?	Yes ☐ No ☐ Controlled online ☐
Frequency threshold – Low (f_{RU}): Frequency threshold – High (f_{RO}): Droop: Desired frequency: ΔP:	_________Hz _________Hz _________% _________Hz _________kW

B3.3.2.4. Absolute power limit function

Is the absolute power limit function as specified in sections 5.3.4.1 and 6.3.4.1 for type C and D plants, respectively, enabled? If yes, which set point value is used?	Yes ☐ No ☐ Controlled online ☐ _________kW

B3.3.2.5. Ramp rate limit function

Is the power-generating plant ramp rate limit function as specified in sections 5.3.4.2 and 6.3.4.2 for type C and D plants, respectively, enabled? If yes, which set point value is used?	Yes ☐ No ☐ Controlled online ☐ ______% P_n/min

B3.3.3. Reactive power control

B3.3.3.1. Q control

Is the Q control function as specified in sections 5.4.4 and 6.4.4 for type C and D plants, respectively, enabled? If yes, which set point is used? (Values different from 0 kVAr must be agreed with the DSO).	Yes ☐ No ☐ Controlled online ☐ _________kVAr

B3.3.3.2. Power Factor control

Is the Power Factor control function as specified in sections 5.4.2 and 6.4.2 for type C and D plants, respectively, enabled? If yes, which set point is used? (Values different from cosϕ 1.0 must be agreed with the DSO).	Yes ☐ No ☐ Controlled online ☐ _________ cosϕ Inductive ☐ Capacitive ☐

B3.3.3.3. Voltage control

Is the voltage control function as specified in sections 5.4.3 and 6.4.3 for type C and D plants, respectively, enabled? (Must only be enabled subject to prior agreement with the DSO) If yes, which set point is used?	Yes ☐ No ☐ Controlled online ☐ ________kV

B3.3.4. PSS-function

Er the PSS-function activated?	Yes ☐ No ☐ Controlled online ☐

B3.3.5. Conformance testing

Is documentation of conformance testing enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.3.6. Conformance simulation

Is documentation of conformance simulation enclosed? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.3.7. Verification of simulation model

Is a simulation model verified with the conformance test with Energinet? If yes, please provide reference to documentation:	Yes ☐ No ☐

B3.3.8. Signature

Date:	
Contractor:	
Manager:	
Signature (manager):	
Plant owner:	
Signature (plant owner):	