Energinet
Tonne Kjærsvej 65
DK-7000 Fredericia

+45 70 10 22 44
info@energinet.dk
CVR no. 28 98 06 71

Date:
14 October 2019

Author:
JMI /JMI

ANNEX D – REACTIVE CONTROL PROPERTIES CF. ARTICLES 20, 40 AND 48, HVDC – REV. 0

This specification of requirements presents Energinet's requirements for reactive power control properties for the connection of HVDC facilities. The specification of requirements is included as background documentation in connection with the implementation of EU regulation 2016/1447, *High Voltage Direct Current (HVDC)*, and thus concerns requirements for HVDC facilities.

SECTION NO.	TEXT	REV.	DATE
	Original edition for the Danish Facility Regulator	A	28-09-2018
2.1	Changed requirements for DK2	B	03-10-2019
	Requirements approved by the Danish Utility Regulator	0	14-10-2019

Please note that this is a translation of the original Danish text.
In case of inconsistencies, the Danish version applies.

Contents

1. Reading instructions

This specification of requirements includes all general and specific requirements for reactive power control properties for HVDC facilities.

In this specification of requirements, section 2 contains the overall general requirements and obligations.

The specification of requirements is published by the transmission system operator and is available for download on Energinet's website, www.energinet.dk

2. Requirements for reactive power control properties for HVDC facilities

Cf. articles 20, 40 and 48 of the HVDC regulation, the independent system operator must, in collaboration with the TSO, specify requirements for U/Q-Pmax properties for HVDC facilities, DC connected PPMs and HVDC facilities to which DC-connected PPMs are connected. This document lists the requirements as well as the basis for setting these.

Figure 5 and table 6 in the HVDC regulation illustrate the defined voltage and reactive power ranges that the requirements set must stay within.

The following subsections define requirements for HVDC facilities and requirements for DC-connected PPMs and HVDC facilities to which DC-connected PPMs are connected.

2.1 HVDC facilities

The future electricity supply system will be based on renewable energy, and the majority of the central thermal power plants, which have traditionally been used to maintain power system stability, are expected to be phased out. The properties required to maintain power system stability that will be lost with the phase-out of power plant must be replaced by other installations in the electricity supply system. In this context, HVDC units are expected to play an important role in supplying voltage-stabilising properties. The requirements set for U/Q-Pmax properties must attempt to match the properties of the central power plants, taking into account any technological limitations.

The continuous overexcitation property of a central power plant is typically in the 160 – 240 MVAr range. Furthermore, power plants are designed with overload capability, which allow the installation to supply approx. 1.6 times the above value for a short period of time (10 s). Underexcitation properties are more limited due to weakening of the electro-mechanical connection to the grid. These properties are typically in the 100 – 150 MVAr range.

HVDC facilities do not have the same underexcitation issues, and a symmetrical requirement is therefore set. If the same requirements for reactive control properties are used as set for PPMs (tan (phi) = ±0.33), the result is ± 230 MVAr for a HVDC facility with active power transmission capacity of Pmax = 700 MW. This requirement finds a satisfactory correlation between the properties of the power plants and the HVDC facilities. In order to ensure equal treatment, similar requirements are set for both the facilities of external stakeholders and Energinet's own facilities, as the technology used for PPMs and HVDC facilities is the same. The requirement is thus set at tan (phi) = ± 0.33. Fejl! Henvisningskilde ikke fundet.Figure 1 and Figure 2 show requirements for facilities connected in DK1 and DK2, respectively.

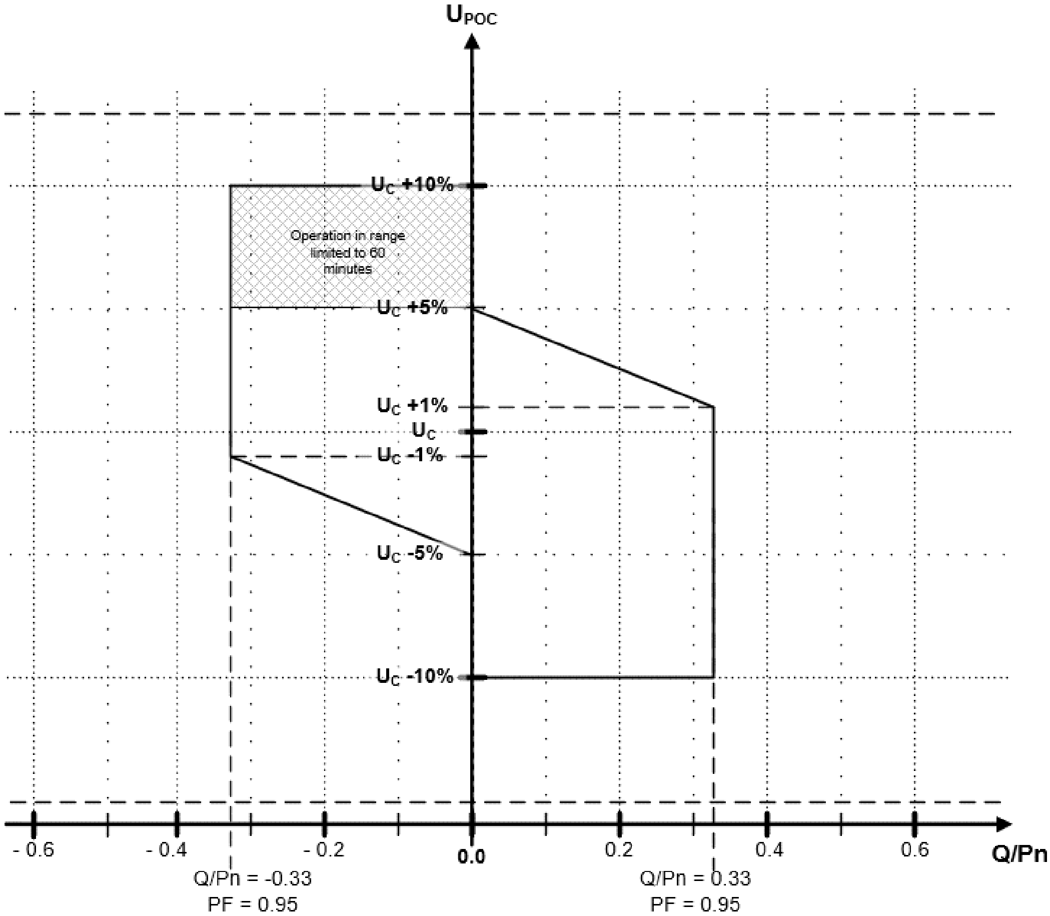

Figure 1 - U/Q-Pmax requirements for HVDC facilities, DK1.

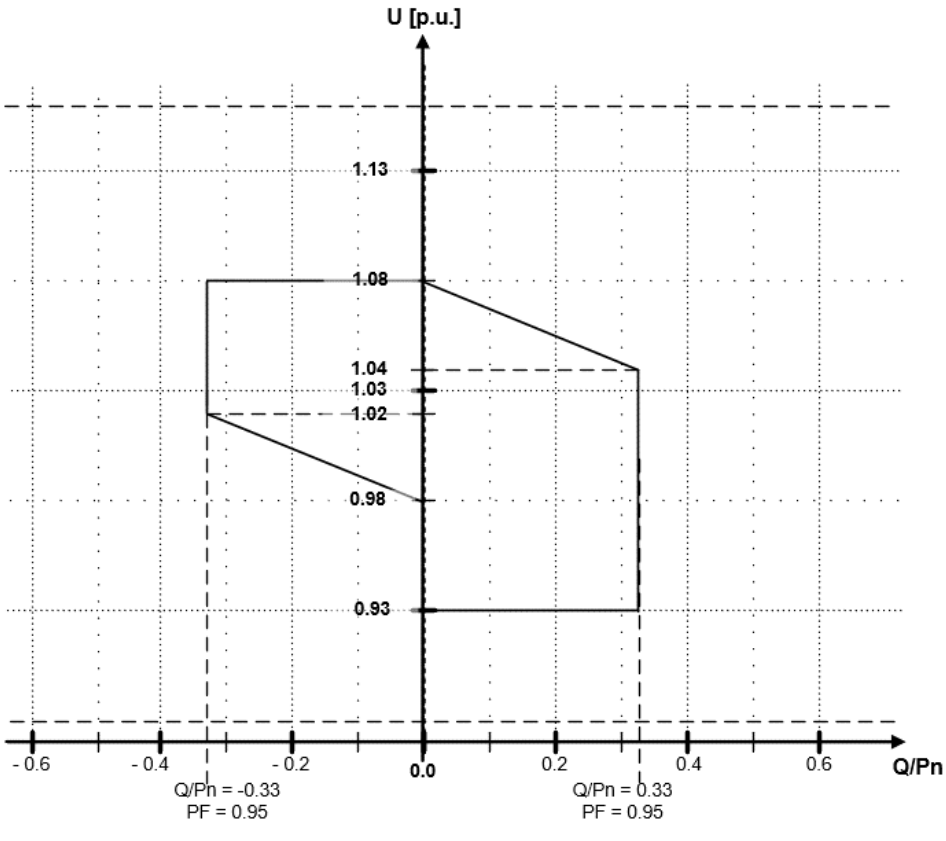

Figure 2 - U/Q-Pmax requirements for HVDC facilities, DK2.

Future HVDC facilities are expected to be connected at strong nodes in the 400 kV transmission grid. Thus, these facilities must always be operated in voltage control mode. Consequently, reduced requirements are set for the overvoltage/overexcitation and undervoltage/underexcitation voltage ranges, as the facility will never have an operating point within these ranges. It must be possible to set the voltage reference of the voltage control in the 0.95-1.05 pu range, cf. Article 22 in NC HVDC. In practice, voltage reference will be set for a typical operating voltage in the 1.02-1.04 pu (408 – 416 kV) range. Therefore, the DK1 voltage range has been set to enable operation with voltage control with a voltage reference in the 0.96 – 1.04 pu range with the possibility of setting a droop in the 3%-6% range with 4% as the typical setting. As the DK2 voltage range is narrower, it has been decided that the starting point for control properties is based on Uc + 3%, corresponding to 1.03 pu. From this starting point, it is possible to set a droop in the 3%-6% range with 4% as the typical setting.

The DK1 voltage range of 1.05-1.1 pu is limited in time in reference to the robustness requirements. Therefore, it is accepted that the reactive properties in this range are available only for the periods when the facility is required to be in operation.

The maximum current rating for the inverter is defined by the operating point, where the inverter must be able to deliver Pmax and Qmax during undervoltage continuously. The current rating determines the performance of voltage support during faults as the HVDC facility injects a reactive current of a size that, as a minimum, corresponds to the nominal current. As can be seen, undervoltage has been set at 0.9 pu, meaning that inverter size (Mva rating) must be designed as 10% larger with reference to 1 pu.

At operating points from 0.0-1.0 pu active power, it must be possible to utilise the inherent reactive properties of the HVDC facility. In other words, it must be possible to use any increased reactive properties that the facility may have at operating points below 1.0 pu active power.

It must be possible to operate the facility in statcom mode, which enables the use of the reactive properties of the HVDC facility in situations with no active power transmission.

2.2 DC-connected PPM

As for requirements set, reference is made to requirements defined in EU Regulation 2016/631, Article 21. No other requirement is made as this would be discriminating against the facility type.

As the reactive properties from PPMs cannot be transferred via the HVDC facility to the public electricity supply grid, it must be possible to obtain an exemption from U/Q Pmax requirements. The facility owner likely owns both PPMs and related HVDC facilities, and therefore has control of both facilities as regards voltage control of offshore AC island. Thus, the facility owner can decide which of the facilities is to perform voltage control.

2.3 Remote-end HVDC converter stations

In the requirements, reference is made to requirements defined for HVDC facilities (see Figure 1 and Figure 2).

As the reactive properties from the HVDC facility cannot be transferred to the public electricity supply grid, it must be possible to obtain an exemption from U/Q Pmax requirements. The facility owner likely owns both PPMs and related HVDC facilities, and therefore has control of both facilities as regards voltage control of offshore AC island. Thus, the facility owner can decide which of the facilities is to perform voltage control.