

TO TenneT-ONL

DATE
REFERENCE
FROMDecember 1, 2017
PU-AM 17-472
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SUBJECT Impedance loci harmonic impedance at 66 kV connection point, location 'Hollandse Kust Zuid'

REPORT



DECISION



1. Introduction

This memo specifies the root loci of the calculated harmonic impedances, with reference point at the 66 kV offshore grid busbar. These root loci can be used by the wind farm developers to verify their compliance with the harmonic requirements.

2. Starting points

The calculations are performed based on the following starting conditions:

- The calculations are performed for the offshore wind farm connections to the platforms 'Hollandse Kust Zuid'-Alpha (HKZ-Alpha) and 'Hollandse Kust Zuid'-Beta (HKZ-Beta). Both platforms are connected to the 380 kV substation Maasvlakte.
- The modelled 66 kV inter array collection grid is based on the draft layout proposed by Ecofys. This grid is used for both platforms.
- The modelled 380 kV onshore grid for the year 2025 is used.
- The calculations have been performed for two offshore cases:
 - o Case 1: the platform is energised via two 220 kV export cables (normal operating condition), see figure 2;
 - o Case 2: the platform is energised via one 220 kV export cable, and the 66 kV busbars are interconnected (abnormal operating condition), see figure 3;
- The harmonic impedance is calculated seen from 66 kV busbar "Alpha A", with the 66 kV array cables connected to this busbar "Alpha A" out of service.
- The harmonic impedance is calculated up to the 40th harmonic (2000 Hz). The calculated harmonic impedances for both cases, are divided into four harmonic order sets (h = 1-5, 4-7, 6-20, and 19-40). For each set the root locus is defined, including all relevant 'N-0', 'N-1' and 'N-2' onshore grid configurations. The results for case 1 and case 2 are combined in one table.

3. Results

For each onshore grid situation and harmonic order set the outline of the area of the grid impedances is defined. For each area the following general layout of the outline, see figure 1, is valid, specified by the values φ_{\min} , φ_{\max} , R_{\min} , R_{\max} , X_{\min} , and X_{\max} as presented in table 1.

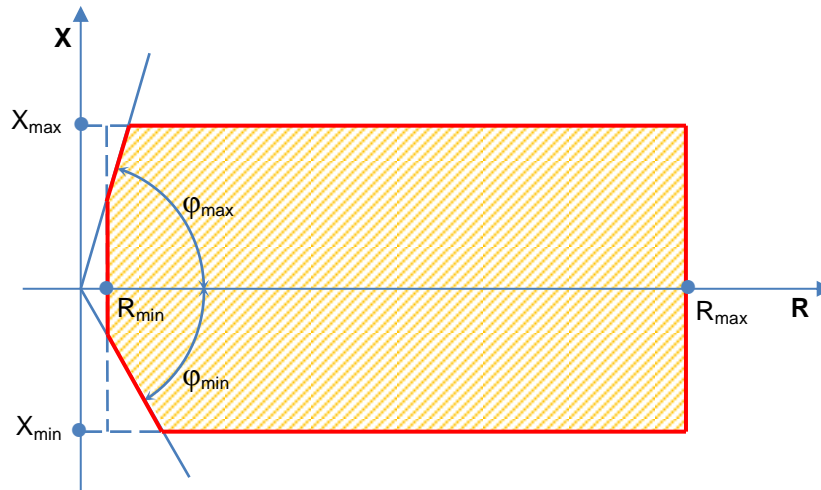


figure 1: General layout outline (in red) of the harmonic impedance profile:

table 1: Defined values for the impedance profiles

	Harmonic order	defined values					
		φ_{\min}	φ_{\max}	R_{\min}	R_{\max}	X_{\min}	X_{\max}
	(-)	(°)	(°)	(Ω)	(Ω)	(Ω)	(Ω)
Case 1 Case 2	1-5	-32	47,6	5,25	27	-11	7
	4-7	-15	86,6	1,43	11	-4	23
	6-20	0	89,9	0,08	33	8	76
	19-40	0	85,0	12,07	22	48	140

Each harmonic order set as presented in table 1 is applicable to the inner numbered harmonics, i.e. the values of the set 1-5 are applicable for harmonic 2, 3 and 4; the values of the set 4-7 are applicable for harmonic 5 and 6; the values of set 6-20 are applicable for harmonic 7, 8 up to 19, and so on.

Remark: the indicated area in figure 1 shall normally be defined by all parameters (φ_{\min} , φ_{\max} , R_{\min} , R_{\max} , X_{\min} and X_{\max}), but in some cases the angle φ_{\max} or φ_{\min} does not cross the outline of the underlying R-X rectangle and may be ignored.

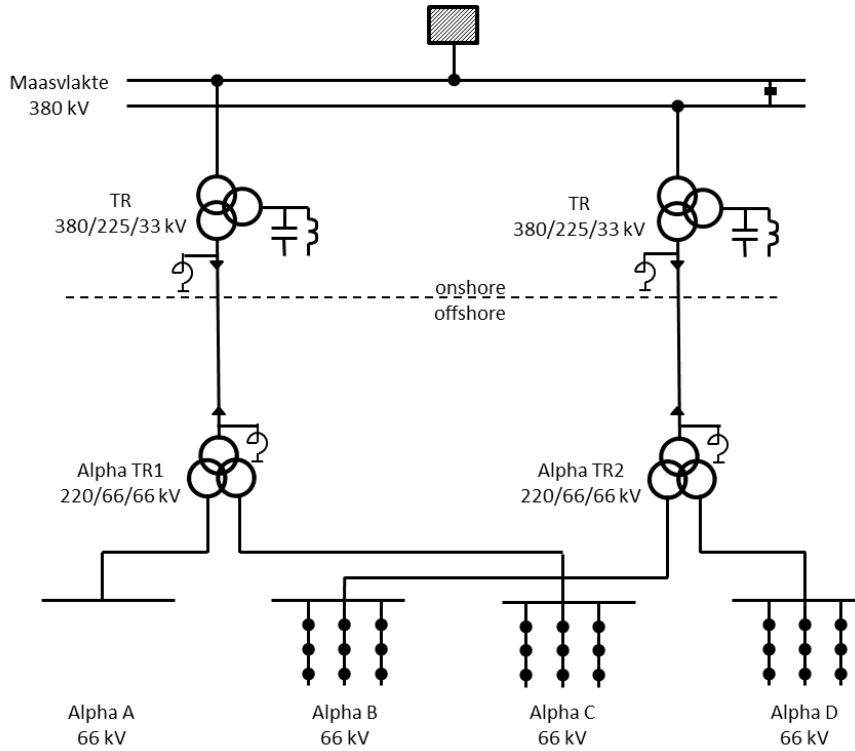


figure 2: grid layout platform HKZ-Alpha (normal operating condition)

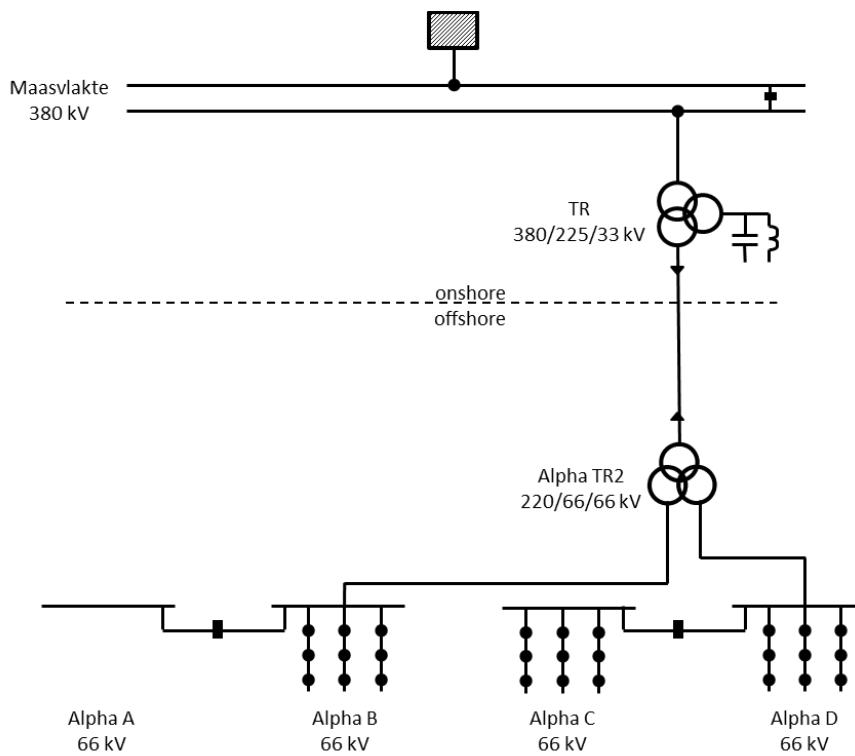


figure 3: grid layout platform HKZ-Alpha (abnormal operating condition)