Normative framework for harmonics

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Need for harmonic framework (Who will solve the problem)



What are the possible harmonic phenomena?

Nominal frequency Odd non-triplen harmonics Even harmonics Odd triplen harmonics THD Interharmonics Subharmonics Supraharmonics

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Frequency ranges

	Harmonics	L	.F range	Conducted RF range	Conducted RF range	Radiated RF range	Radiated RF range	
	50Hz - 2/2.5kHz 60Hz - 2.4/3kHz	2/2 2.4	2.5Hz - 9kHz /3kHz - 9kHz	9kHz - 150kHz	150kHz - 30MHz	30MHz - 1/2/3GHz *	Above 3GHz	
 Regulated range Unregulated range 			re nge	 Regulated range for some products Upper limit depends on product 				

TU/e

Definition of frequency ranges

Electromagnetic compatibility

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95% and/or 99,9%

Probability distribution Important levels: Emission Immunity Compatibility Planning Emission Immunity Comp. Plan. **Disturbance** level

Slight increase in harmonic distortion LV-network



Slight increase in harmonic distortion MV-network



Slight decrease in harmonic distortion HV-network



High impedance -> high interaction voltage & current





Responsibilities Voltage, Current, Impedance





Limits for harmonic voltages

	Odd ha	irmonics		Even harmonics		
Not multiples of 3 Multiple		es of 3	PQ phenomena	EN 50160	IEC 60092-101	
Order	Relative	Order h	Relativ voltag 5 %	Voltage level	+10% /-15%	+6%/-10%
h	voltage			THD	<8% (95% time)	<5%
5	6 % 5 %	3		HD	Different values	<3%
11	3,5 %	15	0,5 %	Fast voltage variations	3%	+20% -20%
13	3 %	21	0,5 %	Frequency	+1% -1%	+5% -5%
19 23	1,5 % 1,5 %			Transients	-	5.5 Un (1.2/50 us)
25	1,0 /0					
NOTE: No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable due to resonance effects.						



IEC 61000-3-2 Harmonic limits for devices <16A

Reference impedance

5.1.1 Three-phase, four-wire, 230 V supplies

Adoption of the following test reference impedances, Z_{ref}, is recommended:

Phase conductor Neutral conductor $0,24 + j0,15 \Omega$ $0,16 + j0,10 \Omega$ $0.40 + j0,25 \Omega$



Table 1 – Limits for Class A equipment

Harmonic order	Maximum permissible harmonic current					
n	A					
Odd harmonics						
3	2,30					
5	1,14					
7	0,77					
9	0,40					
11	0,33					
13	0,21					
15 ≤ n ≤ 39	0,15 <u>15</u>					
Even harmonics						
2	1,08					
4	0,43					
6	0,30					
8 ≤ n ≤ 40	0,23 <u>8</u>					

Harmonic fingerprint



Impact of the standard!



PQ within the different networks





Allocation of limits to MV-customer



Connection reguirements Harmonics in HV-network



Connection reguirements Harmonics in HV-network Assessment of harmonic voltages





Connection reguirements Harmonics in HV-network Impedance envelope





Connection reguirements Harmonics in HV-network Resonances

 Grid (L) in combination with cable capacitance C results in resonant circuit







Still a lot of questions around harmonic evaluation

Sensible to have a compatibility level for 95, 99, 99,5 or 99,9 or 100%? Sensible to work with 10 minute averages? What is the practical problem with HD-levels, THD a useful index? Is simplified complained process possible for LV- and MV-customers? Is it possible to define min. impedances for POC? What is use of planning levels in time? What to do with positive effect of harmonic currents? What to do with devices reacting strongly on harmonic background? And many others....

IT IS IMPORTANT TO FIND THE ANSWERS, TO SUPPORT THE NORMALIZATION!

Defining this as research topic!

But perhaps there are also questions at this moment?

