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Comparative Analysis of the Specifications on the Power Quality of the European Union and the Russian Federation

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Abstract. Since July 2014 the interstate standard GOST 32144-2013 is the only document that defines standard requirements for the power quality in the territory of the Russian Federation. The new standard preamble specifies that this document considers the requirements of the European regional standard EN 50160-2010. However, GOST authors established the degree of standards conformity as nonequivalent. In connection with Russia's accession to the World Trade Organization (WTO) all requirements for goods including electric energy should correspond the international standard requirements. The article analyzes the above standard requirements and assesses the requirements for the power quality standards used in the European Union and in the Russian Federation.

Key words: power supply system, power quality, unified power quality index, power quality standards

1. Introduction

Membership in the World Trade Organization (WTO) obliges the participating State to implement fully the agreements reached by the organization member countries. For this, first and foremost, methods are to be brought in conformity with the established and approved rules for regulating the external economic activities of the WTO member countries. Regarding the issues of standardization, this requirement is to bring the existing rules and norms (standards) in line with the requirements of the Agreement on Technical Barriers to Trade [1, 2].

The field of meeting the standards (standardization) requirements has the main task to exclude the possibility of a regulatory document to influence the trade turnover between the WTO member countries in a technical barrier form. Countries should ensure that there is no difference in the requirements of national and interstate technical regulations and standards when developing, approving and applying them. So, in most cases, the only option is the international standards application. Thus, when developing any national technical regulation or standard, it is necessary to analyze the availability of a similar international standard (or its project) and to adopt it, in whole or in part, as the basis for the normative document being developed.

If national normative document requirements differ significantly from the international standards and thus can impede trading relations and trade turnover between countries who are WTO participants, the established norms differences from international standards are to be specified in the document.

In connection with Russia's accession to the WTO and necessity to balance Russian legislation with international community approaches, a new GOST 32144-2014 "Norms for the power quality in general-purpose power supply systems" was introduced in relation to the parameters of electric power quality indices [3,4].

This GOST 32144-2014 is developed on the basis of the earlier valid GOST 541149-2010 [5], it considers the provisions of the European Union regulations in the field of electromagnetic compatibility and the conceptual provisions principles of the European Union New and Global



Approach to the quality assurance problem [6]. According to the definition of GOST 32144-2014 authors, it considers the main normative provisions of the European standard EN 50160:2010 "Voltage characteristics of electricity supplied by public distribution networks" (Characteristics of the voltage supplied by public distribution networks) [7,8]. However, a preliminary analysis of the current and previous standards shows that only the structure of these documents is identical, but the norms differ significantly for certain power quality indices [4,5,8,9,10].

2. Statement of the problem

Electric power supply systems are to be designed and operated in various industries considering the implementation of existing norms and rules including power quality standards adopted at the state level.

The authors of this article analyze the regulatory requirements for the power quality indices established by the European standard EN 50160: 2010 and an intergovernmental standard GOST 32144-2013, to establish the degree of their correspondence or nonequivalence.

The findings can be applied in practice to evaluate measures aimed at maintaining the necessary working conditions and increasing the efficiency of the electrical equipment operation, considering the manufacturer country

3. Theory

Considering the current state of issues and tasks to ensure the power quality, the regulatory and methodological base in this direction has been substantially developed over the last ten years. The conditions necessary for providing power management and quality control were created. As a result, the required measuring instruments were developed and put into production; testing laboratories carried out power monitoring and quality control [11].

In 2013 the Eurasian Economic Community countries, due to the transition to the unified technical regulations and interstate standards, focused on the European Union requirements, re-designed and put into effect the relevant interstate standards to ensure the power quality requirements.

Since 01.06.2014 the Russian Federation introduced GOST 32144-2013 "Norms of power quality in general-purpose power supply systems" instead of the previous GOST R 54149-2010 [3, 5]. Nevertheless, the current GOST contains many indices from GOST 13109-97 [12 - 16]. In this regard, the GOST 32144-2013 standards on some indices are being criticized by scientific community and are to be revised [17, 18].

The current regulations are argued to lead to arbitration disputes between grid organizations and electricity consumers. In addition, the difference between Russian and European requirements for the power quality can lead to difficulties with import and export of electrical equipment and electricity [9].

4. Results of the experiments

As a result of the above-mentioned effective standards and their requirements to the power quality standards analysis, the main differences are determined for each standardized index measured during one week time interval.

In accordance with GOST 32144-2013 in synchronized systems, the frequency deviation should not exceed ± 0.2 Hz for 95% of the frequency measurement time interval and ± 0.4 Hz for 100% of the measurement time, see Table I.

Table 1. Requirements to frequency deviations in synchronized systems.

Measuring interval	GOST 32144-2013			EN 50160:2010		
	%	Δf , Hz	Range of change, Hz	%	Δf , Hz	Range of change, Hz
95%	± 0.4	± 0.2	49.8 – 50.2	–	–	–
99.5 %	–	–	–	± 1	± 0.5	49.5 – 50.5
100%	± 0.8	± 0.4	49.6 – 50.4	- 6 / +4	-3; +2	47.0 – 52.0

The standard EN 50160: 2010 determines that the frequency deviations should not exceed ± 0.5 Hz for 99.5% of time and should be in the range from + 2 Hz to - 3 Hz for 100% of time in synchronized systems.

GOST 32144-2013 is established for slow voltage changes, caused, as a rule, by changing the value of the network load, the interval within $\pm 10\%$ of the nominal voltage level or the matched voltage within 100% of the measurement time. It should be noted that GOST 32144-2013 for four-wire three-phase systems takes the value of the rated voltage equal to 220 V [4].

At the same time, EN 50160: 2010 for analogous three-phase networks sets the nominal voltage between the phase conductor and the neutral at 230 V [8], and the limit of variation of the voltage deviation $\pm 10\%$ of the nominal voltage level establishes at 95%, see table 2.

Table 2. Requirements to voltage deviations in synchronized systems.

Measuring interval	GOST 32144-2013			EN 50160:2010		
	%	$\delta U(\pm)$, B	Range of change, B	%	$\delta U(\pm)$, B	Range of change, B
95%	—	—	—	± 10	± 23	207 – 253
100%	± 10	± 22	198 – 242	—	—	—

For an indicator characterizing fluctuations in the voltage of the power supply lasting less than 1 minute - the dose of the flicker, the regulatory documents requirements of the European Union and Russia are also not the same.

GOST 32144-2013 specifies the norms of short-term PST and long-term dose of PLT flicker, which should not exceed the established limits for 100% of one week time interval. EN 50160: 2010 sets only the long-term dose rate of the PLT flicker, but at 95% of one week measurement time, see table 3.

Table 3. Requirements to flicker dose in synchronized systems.

Measuring interval	GOST 32144-2013		EN 50160:2010	
	P_{ST}	P_{LT}	P_{ST}	P_{LT}
95%	—	—	—	1.0
100%	1.38	1.0	—	—

For power energy quality indices that characterize the voltage non-sinusoidal - values of some coefficients of the harmonic components $K_{U(n)}$ and the total harmonic components K_U , the standards established by GOST 32144-2013 must be met within 95% of one week measurement time interval. During 100% of the measurement period, the same standards should not exceed the normative value of 95% of the observation period increased by 1.5 times. Document EN 50160: 2010 for non-sinusoidal voltage defines only requirements for values for 95% of one week measurements see eable 4.

Table 4. Requirements to the total coefficients of harmonic components.

Measuring interval	GOST 32144-2013			EN 50160:2010	
		U_n , kV		U_n , kV	
	0.38	6-25	35	110-220	0.4-220
95%	8.0	5.0	4.0	2.0	8.0
100%	12.0	8.0	6.0	3.0	-

It should be noted that in the European Union where EN 50160: 2010 operates, unlike countries participating in the Interstate Council for Standardization, Metrology and Certification, which approved GOST 32144-2013, they are Armenia, Belarus, Kyrgyzstan, the Russian Federation,

Tajikistan and Uzbekistan, the norms for indicators $K_U(n)$ and K_U are the same regardless of the voltage class (low, medium or high).

GOST 32144-2013 normalizes the requirements of the coefficients $K_{U(n)}$ and K_U for the harmonic components of the voltage up to the 40th order, determining the deviation in percent from the fundamental harmonic component of the direct sequence voltage U_1 , see table 5 and table 6.

Table 5. Requirements to the coefficients of odd harmonic components.

Harmonic component number	GOST 32144-2013				EN 50160:2010
	0.38	U _n , kV			U _n , kV
		6-25	35	110-220	0.4-220
n	Values of the coefficients K_U , %				
5	6.0	4.0	3.0	1.5	6.0
7	5.0	3.0	2.5	1.0	5.0
11	3.5	2.0	2.0	1.0	3.5
13	3.0	2.0	1.5	0.7	3.0
17	2.0	1.5	1.0	0.5	2.0
19	1.5	1.0	1.0	0.4	1.5
23	1.5	1.0	1.0	0.4	1.5
25	1.5	1.0	1.0	0.4	1.5
>25	1.5	1.0	1.0	0.4	1.5

Table 6. Requirements to the coefficients of odd harmonic components 3-fold.

Harmonic component number	Electrical network voltage, kV			Electrical network voltage, kV	
	GOST 32144-2013	EN 50160:2010	110-220	0.4-220	
n	Values of the coefficients K_U , %				
3	5.0	3.0	3.0	1.5	5.0
9	1.5	1	1	0.4	1.5
15	0.3	0.3	0.3	0.2	0.5
21	0.2	0.2	0.2	0.2	0.5
>21	0.2	0.2	0.2	0.2	0.5

Document EN 50160: 2010 in this case is limited to the 24th harmonic component, motivating it by the fact that harmonics with higher order are much smaller in comparison with the fundamental harmonic component and may be less predictable due to the resonance effect.

Both standards for the power quality differentiate the limit values of the harmonic components coefficients for even (see Table 7) and odd harmonics, dividing the latter by multiples and not multiples of three, respectively.

One of the main differences between GOST 32144-2013 and the European standard EN 50160: 2010 is the absence of the maximum permissible value for an important index in the operated Russian networks as the coefficient of voltages unbalance in the zero sequence K_{0U} . EN 50160: 2010 rationing the values of the unbalance factor of the voltage by the negative sequence K_{2U} , but only by 95% time interval, see Table 8.

Table 7. Requirements to the coefficients of even harmonic components.

Harmonic component number	GOST 32144-2013				EN 50160:2010
	Electrical network voltage, kV				Electrical network voltage, kV
n	0.38	6-25	35	110-220	0.4-220
	Значения коэффициентов K_U , %				
2	2.0	1.5	1	0.5	2.0
4	1.0	0.7	0.5	0.3	1.0
6	0.5	0.3	0.3	0.2	0.5
8	0.5	0.3	0.3	0.2	0.5
10	0.5	0.3	0.3	0.2	0.5
12	0.2	0.2	0.2	0.2	0.5
>12	0.2	0.2	0.2	0.2	0.5

Table 8. Requirements for non-symmetry voltages.

Measuring interval	GOST 32144-2013		EN 50160:2010	
	K_{2U}	K_{0U}	K_{2U}	K_{0U}
95%	2.0	2.0	2.0	-
100%	4.0	4.0	—	—

5. Discussion of the results

The narrower scope of the requirements for the frequency deviation in GOST 32144-2013 compared to EN 50160: 2010 may lead to difficulties in connecting to synchronized power systems of cogeneration plants and distributed generation facilities, their development is indicated as a priority task of the Energy Strategy of Russia till 2030 [19].

At the same time, the methods adopted in EN 50106: 2010 and applied to the establishment of the norms of the total coefficients of harmonic components K_U and the harmonic components $K_{U(n)}$, are justified. This assumption is due to higher harmonics having the greatest negative impact on low voltage network consumers [9].

The current interstate standard GOST 32144-2013, the norms for medium and high voltage networks define a more stringent framework for changing quality indicators compared to EN 50160: 2010. For low voltage networks, GOST 32144-2013, by introducing the zero-sequence unbalance coefficient, considers the presence of consumers in the networks and its load is distributed unevenly.

At the same time, the need to separate the norms of the power quality in terms of voltage classes in GOST 32144-2013 is primarily related to the need to meet the requirement of sharing responsibility for ensuring the voltage quality between electric energy suppliers (backbone networks) and consumers (territorial network organizations) [4].

The fulfillment of GOST 32144-2013 requirements obliges not only the network organizations to maintain individually the required power quality in the distribution networks of consumers. The requirements of this GOST stimulate the manufacturers of electrical equipment and end-users, who buy it, to be responsible for the absence in the networks of inadmissible conductive electromagnetic interference generated during the operation of this equipment and installations.

6. Conclusion

Thus, in all key parameters GOST 32144-2013 does not comply with the European standard EN 50106: 2010. Therefore, the indication, at present, of information on the non-equivalent degree of correspondence on it must be considered a necessary condition.

It is worth noting that the structure of GOST 32144-2013 is formed in the established international practice of testing the power quality. In this connection, GOST 32144-2013 is more similar in its

structure to EN 50160: 2010 than the previous regulatory framework [5, 12]. To this end, the requirements for the power quality indicators [4], the methods of their measurement [20], as well as the requirements for measuring instruments [21] have been singled out into separate standards.

The requirements of the European standard EN 50160: 2010 are primarily designed for distribution networks of countries that have different requirements for both the design of electrical networks and different, in comparison with the level of the countries of the Eurasian Union, including the Russian, technical condition of the networks

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