ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2004, Tome II, Fascicole 1

TECHNICAL REGULATION IN POWER QUALITY FIELD

Vladimir KATIĆ

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNICAL SCIENCES
TRG D. OBRADOVIĆA 6, 21000 NOVI SAD
SERBIA & MONTENEGRO, E-mail: katav@uns.ns.ac.yu

ABSTRACT:
Electric power quality parameters and their border values are treated in the paper. Special attention is dedicated to standards and recommendations issued by International Electrotechnical Commission (IEC), which are usually used as a base for European Norms (EN). Experience from power quality research in Serbia will be also presented.

KEY WORDS:
Power quality, Harmonics, Voltage sags, Standards

1. INTRODUCTION

In the last few years, a high increase of electric energy consumption was noticed, together with wide introduction of power electronic converters in controlled electric drives and the other areas of industry. This resulted in deterioration of power quality and appearance of voltage sags and harmonic “pollution”. At the same time, sophisticated, microprocessor controlled equipment, computers and tele-communication devices, sensitive to both voltage sags and harmonics type of disturbances, flooded all aspects of people every day life, business, commercial, industry, banking, government etc. The negative effects started to cause problems, mainly in industry, which lead to consumer complaints [1].

One of the methods for decreasing negative effects is establishing appropriate technical regulation – guidelines, recommendations, standards etc. The first documents were issued on national level in United Kingdom and former USSR back in 1967 and treated harmonics. After that many national and international organizations have discussed power quality parameters and issued different documents in order to explain the nature and effects of disturbances and to propose limits or border values. At the present moment, power quality issues are treated within much broader field of Electromagnetic Compatibility (EMC), which covers all kind of disturbances both of conducted and radiated nature.

The paper will present the present structure of international organizations, which deals with EMC and power quality in particular. Some of the experience from power quality research in Serbia and proposed technical regulative will be also presented.

2. ELECTROMAGNETIC DISTURBANCE PHENOMENA

EMC is defined as "the ability of an equipment or system to function satisfactory in its electromagnetic environment without introducing intolerable electromagnetic (EM) disturbances to anything in that environment" [2]. All disturbances are divided into four main categories:

- Conducted: Low frequency phenomena, High-frequency phenomena
- Radiated: Low frequency field phenomena, High-frequency field phenomena
- Electrostatic discharge (ESD)
- Electromagnetic pulses – High-altitude nuclear electromagnetic pulse (HEMP)

The parameters, which influence the quality of supply i.e. the electric power quality parameters, are treated as conducted EM disturbances.

3. CLASSIFICATION OF CONDUCTED EM DISTURBANCES PHENOMENA

Operation of a power system is always followed with large number of disturbances of different nature, duration, amplitude and spectral characteristics. A classification is presented in Table 1, where three main groups and 12 types of disturbances are distinguished [3]. Harmonics, flicker, voltage sags and interruptions have the most significant effects on operation of industry.

Table 1 – Classification of power quality parameters

Group	Type	Duration	Spectra	Amplitude
Deformation of transient nature	1. Impulses	< 200 μs	> 5 kHz	< 15 U
	2. Oscillations	< 50 ms	< 5 kHz	< 10 U
		< 20 μs	0.05-0.5 MHz	< 15 U
		< 5 μs	0.5-5MHz	< 15 U
Transient states deformation	3. Sag	0.01 - 0.6s 0.6 - 3 s 3 s - 1 min	50 Hz	0.1-0.9U
	4. Swell	0.01 - 0.6s	50 Hz	1.1-1.8U
	5. Outage	0.02-0.2s	/	0
	6. Under voltage	> 1 min	50 Hz	0.8-0.9U
	7. Over voltage	> 1 min	50 Hz	1.2-1.4U
	8. Interruptions	< 3 min	/	0
Steady state deformation	9. Harmonics	0.3 ms	0.15-5kHz	< 0.05 U
	10. Flicker		< 25 Hz	0.3-2.5U
	11. Dips & notches		0.2-0.3 kHz	0.1-0.9U
	12. Noise		> 5 kHz	0.9-1.1U

4. INTERNATIONAL REGULATIVE

Several international organizations deals with issuing technical regulative documentation in order to reach standard approach to EMC phenomena. Power quality parameters are treated by (in alphabetic order): CENELEC (Comite Europeen de Normalisation Electrotechnique), CIGRE (Conseil International des Grands Reseaux Electriques), CIRED (Congres International des Reseaux Electriques de

Distribution), IEC (International Electrotechnical Commission), IEEEE (Institute of Electrical and Electronics Engineers) and UNIPEDE (Union Internationale des Producteurs et Distributeurs d'Energie Electrique),

CIGRE, CIRED and UNIPEDE are professional organizations, which issued technical regulative documents relative to member countries electric power systems [4,5,6]. These documents usually serve as basic references for preparation of CENELEC and IEC standards.

IEEE is also a professional organization, which issued guidelines, recommendations and standards targeted especially to North and South American countries [7].

CENELEC is founded in 1973. In line with the policy of the European Commission and with support from the EFTA (European Free Trade Association) Secretariat, CENELEC aims to prepare a single set of voluntary electrotechnical standards for Europe in order to support the achievement of the free market for goods and services inside Europe. European Standards are also prepared in response to specific requests from the European Commission and EFTA. A large number of co-operating partners give active support to the work of CENELEC by indicating priorities and by preparing draft specifications [8].

IEC is founded in 1906. It is the world organization that prepares and publishes international standards for all electrical, electronic and related technologies. The IEC's mission is to promote, through its members, international cooperation on all questions of electrotechnical standardization and related matters, such as the assessment of conformity to standards in the fields of electricity, electronics and related technologies. The IEC charter embraces all electrotechnologies including electronics, magnetics and electromagnetics, electroacoustics, telecommunication, and energy production and distribution, as well as associated general disciplines such as terminology and symbols, measurement and performance, dependability, design and development, safety and the environment. To further its mission, the Commission's objectives are to: meet the requirements of the global market efficiently; ensure primacy and maximum world-wide use of its standards and conformity assessment schemes; assess and improve the quality of products and services covered by its standards; establish the conditions for the interoperability of complex systems; increase the efficiency of industrial processes; contribute to the improvement of human health and safety; contribute to the protection of the environment [9].

5. IEC DOCUMENTS IN EMC FIELD

The first work in the EMC field can be traced back to when the International Special Committee on Radio Interference (CISPR, now part of the IEC) was established in 1934. But today the scope of EMC work has expanded to such an extent that the IEC organizes it among several committees. Many of these have working relationships or official liaisons with outside groups ranging from professional associations to national, regional and international organizations. The diagram on Fig. 1 outlines from an IEC perspective how these groups cooperate.

EMC-related standardization work is not limited to the IEC – indeed, numerous other organizations take part. Such groups usually deal with a large variety of technical problems, of, which EMC is only one. But clearly the greatest benefits to industry would derive if all the parties involved – worldwide – at least had access to identical Basic EMC standards.

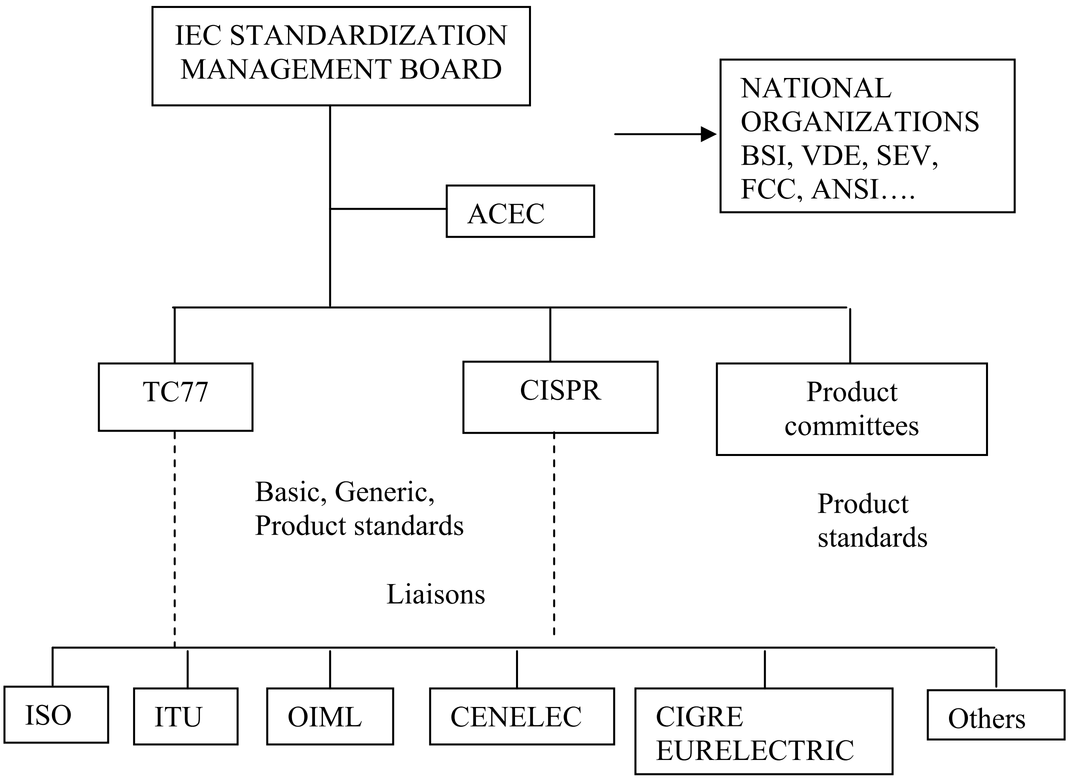

Fig. 1 - IEC and relation with other

The EMC area is covered by standards of 61000 series and this group of standards will be further discussed. Most of the IEC's EMC standards (IEC 61000) are in fact harmonized as European standards under the European Union's EMC Directive (EN 61000). They have the same numbers and titles.

6. STRUCTURE OF IEC 61000

All standards related to EMC field are divided into 3 categories:

a) **Basic standards** (gives description and definition of the phenomenon, detailed test and measurement methods, test instrumentation, basic test set up, specialized terminology, description and classification of the environment, etc.)
b) **Generic standards** (defines a set of precise EMC requirements, including limits, and indicate which standardized tests are applicable to those products intended to be used in a given environment)
c) **Product standards**, including product family standards and dedicated product standards (define specific EMC requirements, immunity and emission, and precise tests for the products within their scope).

The structure of the IEC 61000 series, large and considerably subdivided series of standards and technical reports, will consist of nine parts. Since the titles of Parts 7 and 8 are still open, the present structure is as follows:

Part 1: General: General considerations (introduction, fundamental principles, safety), Definitions, terminology

Part 2: Environment: Description of the environment, Classification of the environment, Compatibility levels

Part 3: Limits: Emission limits, Immunity limits (insofar as they do not fall under the responsibility of product committees)

Part 4: Testing and measurement techniques: Measurement techniques, Testing techniques
Part 5: Installation and mitigation guidelines: Installation guidelines Mitigation methods and devices
Part 6: Generic standards
Part 9: Miscellaneous

7. COMPATIBILITY LEVELS

The compatibility level is clearly a key quantity when it comes to setting limits. The IEC defines it as "the specified electromagnetic disturbance level used as a reference level for co-ordination in the setting of emission and immunity limits." By convention, the compatibility level is chosen so that there is only a small probability that it will be exceeded by the actual disturbance level. The probability distribution depends entirely on the method used for evaluating the levels (samples of time, location, intervals, etc.), but frequently the 95% probability level is defined as compatibility level. Table 2 shows compatibility levels of basic quantities, while harmonic levels are defined in Fig.2 for three distinguished classes of consumers.

Table 2 – Recommended compatibility voltage levels according to IEC 61000-2-4.

Disturbances	Class 1	Class 2	Class 3
Voltage variation *ΔUeff/Unom*	± 8%	± 10%	+10% do – 15%
Voltage sag *Ueff/Unom 100 [%]* *Δt (half periodes)*	10% do 100% 1	10% do 100% 1 - 300	10% do 100% 1 - 300
Interuptions [s]	None	Not applicable	≤ 60
Voltage unbalance Uneg/Upos	2%	2%	3%
Frequency tolerance *Δf/fnom*	± 1%	± 1%	± 2%

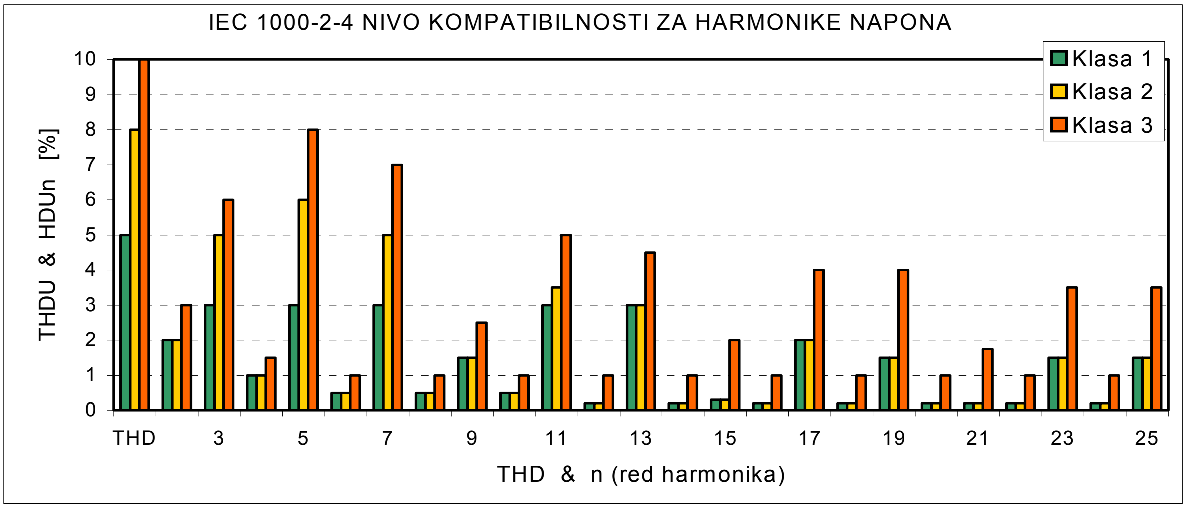

Fig. 2 – Voltage harmonics limits according to IEC 61000-2-4 [10].

8. EMC REGULATIVE IN SERBIA

At the moment, there are no power quality standards in Serbia, but for the basic quantities (voltage level, frequency and unbalance). After a long network harmonics survey, two sets of harmonics limits are proposed: lower limit (warning level) and upper limit (danger level), but they are not approved yed [11]. These levels are in accordance with IEC limits. Fig. 3 shows proposed harmonic border values for public distribution network (class 2).

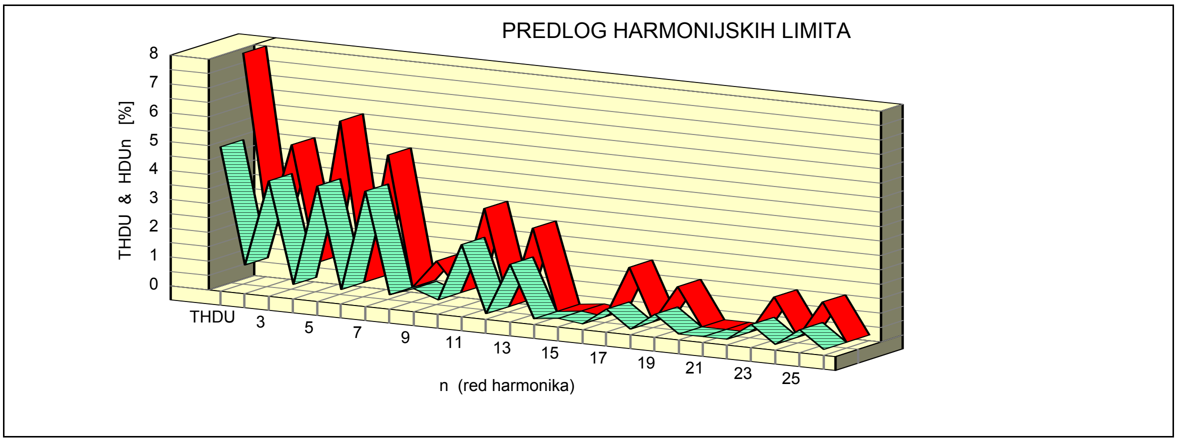

Fig. 3 – Proposed voltage harmonics levels in distribution network of Serbia [11].

9. CONCLUSION

Power quality and its compatibility levels are in focus of interest. The technical regulative is in constant development expanding globally (IEC standards). Electrical network in Serbia has to adapt it structure to the proposed limiting levels in order to be able to join to the common European grid.

10. REFERENCES

1. R.C. Dugan, M.F. McGranaghan, H.W. Beauty, *“Electric Power System Quality”*, McGraw-Hill, New York, 1996.
2. IEC 61000-1-1 (1992-05): *“Electromagnetic compatibility (EMC), Part 1: General - Section 1: Application and interpretation of fundamental definitions and terms”*, IEC Press, Geneve, 1992.
3. A.Robert, J.Marquet, "Assessing Voltage Quality With Relation to Harmonics, Flicker and Unbalance", CIGRE - 1992 Session, Paris, paper no. 36-203.
4. http://www.cigre.org
5. http://www.cired.be
6. http://www.unesco.org/uati/associations/associationseng/unipedeng.htm
7. http://www.ieee.org
8. http://www.cenelec.be; http://www.cenelec.org
9. http://www.iec.ch
10. IEC 61000-2-4 (1994-02): *“Electromagnetic Compatibility (EMC), Part 2: Environment - Section 4: Compatibility levels in industrial plants for low frequency conducted disturbances”*, International Standard, IEC Press, Geneve, 1994.
11. V.Katić, “Distribution network harmonics – research survey and experiences”, *Elektroprivreda*, Vol.54, No 3, Jul-Sep.2001, pp.72-79, *(in Serbian).*