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NEW IEC STANDARDS REQUIREMENTS TO THE PARAMETERS OF POWERFUL ELECTROMAGNETIC PULSED DISTURBANCES

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The European Union Directive on EMC defines a new concept of providing electromagnetic compatibility. The Directive mandates that all electromagnetic phenomena which can influence the operation of technical devices need to be considered. Electromagnetic phenomena which accompany high-altitude nuclear explosions are now on the list of standardized powerful electromagnetic pulsed disturbances which previously included only lightning and electrostatic discharges. The purpose of this paper is to familiarize the developers of the electronic, radio electronic and electrical products with the new EMC requirements set to those products.

The EMC Directive No89/336/ CEE, approved by EU contributed to the development of EMC standardization at a qualitatively new level characterized by the reasonable substantiation and the exact standards development program. As a result within the period of twelve years most Basic IEC 801 standards were revised and as a matter of fact the EMC requirements can practically be laid down for any type of electronic, radio electronic and electrical products, proceeding from the conditions of their operation. These standards have analogous standards that are in force in Ukraine (see Table 1).

The standards that take into consideration the requirements highlighted in MIL SID 461 C /462 D have been developed. These requirements are well-known to the developers.

The standards that are not very well known and have been applied to the civil articles for the first time relate to the most powerful electromagnetic phenomena: Lightning discharge and electromagnetic

Table 1.

Standard IEC	Title	Ukraine Standard
61000-4-2 (1999)	Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.	GOST 29191-91
61000-4-3 (2002)	Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test.	GOST 30375-95
61000-4-4 (1995)	Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test. Basic	GOST 29156-91
61000-4-5 (1995)	Section 5: Surge immunity test.	GOST 30374-95
61000-4-7 (1991)	Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto.	GOST 29280-92
61000-4-8 (2001)	Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test.	DSTU 2465-94
61000-4-9 (2001)	Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test.	DSTU 2626-94
61000-4-10 (2001)	Part 4-10: Testing and measurement techniques - Damped oscillatory field immunity test. Basic EMC Publication.	DSTU 2625-94
61000-4-11 (2001)	Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity test.	GOST 30376-95
61000-4-12 (1995)	Section 12: Oscillatory waves immunity test. Basic EMC Publication.	GOST 30585-98
61000-4-13 (2002)	Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests. .	GOST 29280-92
61000-4-17 (1999)	Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test. Basic EMC Publication.	GOST 30376-95
61000-4-29 (2000)	Part 2-29: Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests.	GOST 30376-95

Table 2.

Standard IEC	Title
61000-1-3 (TR) (2002)	Part 1-3: General – The effects of high-altitude EMP (HEMP) on civil equipment and systems.
61000-2-9 (1996)	Part 2: Environment – Section 9: Description of HEMP environment - Radiated disturbance – Basic EMC publication.
61000-2-10 (1998)	Part 2-10: Environment – Description of HEMP environment – Conducted disturbance.
61000-2-11 (1999)	Part 2-11: Environment – Classification of HEMP environments.
61000-4-23 (2000)	Part 4-23: Testing and measurement techniques – Test methods for protective devices for HEMP and other radiated disturbance. Basic EMC Publication.
61000-4-24 (1997)	Section 24: Test methods for protective devices for HEMP conducted disturbance. Basic EMC Publication.
61000-4-25 (2001)	Part 4-25: Testing and measurement techniques – HEMP immunity test methods for equipment and systems. Basic EMC Publication.
61000-5-3 (TR) (1999)	Part 5-3: Installation and mitigation guidelines-HEMP protection concepts
61000-5-4 (1996)	Section 4: Immunity to HEMP – Specifications for protective devices against HEMP radiated disturbance – Basic EMC Publication.
61000-5-5 (1996)	Section 5: Specification of protective devices for HEMP conducted disturbance – Basic EMC publication.
61312-2 (TS) (1999)	Protection against lightning electromagnetic impulse (LEMP) – Part 2: Shielding of structures, bonding inside structures and earthing.
61312-3 (TS) (2000)	Protection against lightning electromagnetic impulse (LEMP) – Part 3: Requirements of surge protective devices (SPDs).
61312-4 (1999)	Protection against lightning electromagnetic impulse (LEMP) – Part 4: Protection of equipment in existing structures.
61663-1 (1999)	Protection against lightning electromagnetic impulse (LEMP) – Part 1: Fibre optic installations.
61663-2 (2001)	Protection against lightning electromagnetic impulse (LEMP) – Part 2: Lines using metallic conductors.

pulse generated by the high-altitude nuclear burst (HEMP). The list of standards of this kind, which have already been approved by IEC is given in Table 2.

The lightning discharge is quite frequent phenomena and the requirements set to the direct stroke immunity and conductive interference immunity are well known [1]. The new parameters are defined by the requirements set to the immunity of objects that are subjected to the action of electromagnetic fields generated by lightning. The most detailed description of these requirements is given in GOST 30585[2].

The main parameters are as follows:

– electric field voltage pulse
$$\tau_f = 100\ \mu\text{s}, \quad \tau_d = 10\ \mu\text{s},$$
– magnetic field intensity pulse
$$\tau_f = 2\ \mu\text{s}, \quad \tau_d = 50\ \mu\text{s},$$
– electromagnetic field pulse
$$\tau_f = 0{,}1\ \mu\text{s}, \quad \tau_d = 1\ \mu\text{s}.$$

The degrees of strictness are envisaged in compliance with Table 3.

It should be noted that the Ukraine is lack of IEC 61024 and IEC 61312 standards related to the protection of buildings and constructions. The only document that regulates the order of development of the lightning protection systems is the "Instruction on arrangement of the lightning protection for the buildings and constructions" (RD 34 21. 122-87) [3].

At the present time the financial losses caused by the lightning destroying the equipment considerably exceeds those caused by the concurrent fires. Therefore, the Ukrainian standards should be based on the appropriate IEC standards in addition to the available Instruction [3]. The HEMP standards have no equivalents in Ukraine, therefore exactly these standards present the greatest difficulties for the developers of new articles. HEMP is characterized by the ability to affect large territories (within the range of thousands of kilometers) and to generate overcurrents and overvoltages in the extended lines. The high altitude (above 30 km) nuclear burst produces electromagnetic pulses of three types [4]. These pulses are observed on the earth surface.

– early-time HEMP (fast);
– intermediate-time HEMP (medium);
– late-time HEMP (slow).

The early-time HEMP which can propagate for

Table 3.

Degree of the requirements strictness.	E-field kV/m	H-field A/m	E-component LEMP, kV/m	H-component LEMP, A/m
1	50	50	15	40
2	150	150	50	120
3	300	300	100	250

thousands of kilometers from epicenter has persistently been evoking the great interest. The HEMP amplitude – time parameters depend on many factors including the nuclear burst power and its altitude above the earth level. However, for the purpose of standardization the following option has been chosen. The electric field early-time behavior in free space is described by [4]:

$$E_1(t) = E_0 k_1 (\exp(-\alpha t) - \exp(-\beta t)),$$

where: $t \geq 0$; $E_0 = 50$ kV/m; $\alpha = 4 \cdot 10^7$ s^{-1}; $\beta = 6 \cdot 10^8$ s^{-1}; $k_1 = 1,3$.

The pulse has a peak amplitude of 50 kV/m, rise time of 2,5 ns, time-to-peak of 4,8 ns, and a pulse width at half maximum of 23 ns. The energy influence of the early-time waveform is 0,114 J/m^2.

The corresponding magnetic field has similar waveform and peak, determined as

$$H_{01} = E_0 / (120\pi) = 132,6 \text{ A/m}$$

As far as the origin is concerned the lightning and HEMP are quite different phenomena, however the radiated and conducted environments produced by them are similar to some extent [5]. Therefore, it should be noted that the concepts of protection from aftereffects produced by HEMP and lightning are also the same but differ by their technical realization. The high frequency component of the electric field created by HEMP reaches at least 100 MHz, but the field spectrum of the first and subsequent lightning strokes has no significant values for frequencies exceeding 1 MHz in case of the first stroke and 5 MHz in case of the subsequent strokes. The high amplitude of the magnetic field created by lightning can be of importance at low frequencies because the shielding properties practically of all materials with regard to the low frequency magnetic fields are very poor.

The energy content of the HEMP and lightning electric fields does not differ significantly. HEMP has $N = 0,114$ J/m^2. The first lightning return stroke $W = 0,15$ J/m^2, and for the subsequent stroke $W = 0,04$ J/m^2 (at a distance of 600 m). At a distance of 100 m, the values are 5 J/m^2 and 1,5 J/m^2, accordingly. Despite the available differences between these factors, the methods and devices used for the protection from lightning stroke can serve as a basis for protection from HEMP action.

The test equipment owned by the R&D Institute "Molniya" satisfies most of the new electromagnetic disturbance requirements and can be used without major modifications.

The comparison of the parameters of these factors with parameters of some other EMP phenomena leads to the assumption that if the immunity of articles subjected to the lightning and HEMP action has been assured the ESD immunity tests, surge immunity tests, radio-frequency tests ($f < 100$ MHz), etc. may not be conducted.

References

1. IEC 61024-1-1-1993. Protection of structures against lightning – Part 1: General principles. Sect. 1: Guide A– Selection of protection levels for lightning protection systems.
2. GOST 30585-98. EMC of Technical Equipment. Stability to action of lightning Discharges. Technical requirements and method of tests.
3. RD 34 21. 122-87. Instruction on arrangement of the lightning protection for the buildings and constructions.
4. IEC 61000-2-9-1996. Part 2: Environment – Section 9: Description of HEMP environment – Radiated disturbance – Basic EMC publication.
5. IEC 61000-5-3- Part 5-3: Installation and mitigation guidelines – HEMP protection concepts.

НОВЫЕ ТРЕБОВАНИЯ СТАНДАРТОВ IEC К ПАРАМЕТРАМ МОЩНЫХ ЭЛЕКТРОМАГНИТНЫХ ИМПУЛЬСНЫХ ВОЗМУЩЕНИЙ

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Директива Европейского Совета по ЕМС определяет новую концепцию обеспечения электромагнитной совместимости. Директива предписывает рассматривать все электромагнитные явления, которые влияют на работу технических устройств. Электромагнитные явления, которые сопровождают ядерные взрывы на большой высоте, включены в перечень стандартных мощных электромагнитных импульсных возмущений, который ранее включал в себя только молниевые и электростатические разряды. Целью настоящей работы является ознакомление разработчиков электронной, радиоэлектронной техники и электрических устройств с новыми требованиями к электромагнитной совместимости.

НОВІ ВИМОГИ СТАНДАРТІВ IEC ДО ПАРАМЕТРІВ ЕЛЕКТРОМАГНІТНИХ ІМПУЛЬСНИХ ЗБУРЕНЬ

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Директива Європейської Ради з ЕМС визначає нову концепцію забезпечення електромагнітної сумісності. Директива наказує розглядати усі електромагнітні явища, що впливають на роботу технічних пристроїв. Електромагнітні явища, що супроводжують ядерні вибухи на великій висоті, включені до переліку стандартних потужних електромагнітних імпульсних збурень, до якого раніше входили тільки блискавкові та електростатичні розряди. Метою цієї роботи є ознайомлення розробників електронної, радіоелектронної техніки та електричних приладів з новими вимогами до електромагнітної сумісності.