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Technical Note - TN23

Shielding of NEMP test installations

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1. Introduction

The NEMP test installations are working with high radiated electromagnetic field (EMF) pulses which could interfere with sensitive electronic systems located in the vicinity. The influence on the health of personnel working or living close to the test installation has also to be considered. This technical note will establish the needed shielding around the NEMP test installations and will try to compare the residual field to standards or guidelines. This document relates to GTEM simulators.

2. Limitation concerning the health protection

There are no standard specifying extensive limits for single electromagnetic pulse. The ICNIRP[1] defines limits for electric, magnetic and electromagnetic field but for continuous waves only, in the frequency domain. The ICNIRP document is essentially based on the exposure limitation based on the absorption of energy from electromagnetic fields, in the high frequency domain. With continuous wave, the situation is quite clear and the limits are well defined (610 V/m from 800 Hz to 1 MHz, decreasing from 610 V/m to 61 V/m from 1 MHz to 10 MHz, 61 V/m from 10 MHz to 400 MHz).

These ICNIRP guidelines for limiting exposure have been developed following a thorough review of all published scientific literature. Only proven effects were used as the basis for the proposed exposure restrictions. Induction of illnesses such as cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and tissue temperatures increases resulting from absorption of energy during exposure to EMF.

In pulse mode, very few studies are available. It is harder to evaluate the risk due to the multiplication of various factors characterising the pulse: duration, rise time, repetition rate, nature of the pulse (unipolar, bipolar), etc. A short and unique pulse has obviously not the same influence on a biological organism as long and repetitive pulses.

Therefore the only value which can be given is based on the note 5 of the table 6 (reference levels for occupational exposure) of the ICNIRP guideline. This note says: "*For frequencies exceeding 10 MHz it is suggested that … the field strength does not exceed 32 times the field strength exposure levels given in the table*". Because the limit for continuous wave (from 10 MHz to 400 MHz) is 61 V/m, the result of the calculation for pulsed fields is roughly 2 kV/m.

Remarks: The ICNIRP guideline is only dealing with pulses of sine wave, for instance radar pulses. Pure pulses like double exponential pulses are not discussed in these guidelines. In addition, no mention of the repetition rate is given.

A very common phenomenon can produce electromagnetic fields which are similar to NEMP pulses: the electrostatic discharge (ESD). When a charged person touches a metallic object, a high current pulse flows in its body and an electric field is produced around it. The rise time is lower than 1 ns and the duration could be some tens of ns. The charging voltage before the pulse can reach 10 kV. Therefore, the electric field around the body due to its discharge can reach some kV/m, even some tens of kV/m, locally. See figure D.1 of the standard IEC 61000-4-2 giving an example of the measured field. This type of pulse does not induce any known illnesses.

Conclusion: compared to ESD, we estimate that the value of 2 kV/m is very severe for single pulses but it is the only value which can be found in the standards or guidelines concerning health protection.

[1] *ICNIRP: International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).*

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3. Limitation concerning the electronic equipment

Electronic equipment placed in the vicinity of the test installation can be disturbed or destroyed by the radiated pulse. Additionally to the field strength (which depends on the distance to the line) the level of disturbance depends on the susceptibility of the electronic device.

Very few studies are dealing with immunity of common electronic equipment to NEMP pulses. In addition, no common civilian standard documents are referring to pulsed radiated field tests. For instance domestic appliances and computers are not tested to pulsed fields. It is then almost impossible to establish a limit of immunity to this type of disturbances. Some electronic equipment can be disturbed with low pulsed fields due to bad internal design even if other similar devices can be very robust.

The only civilian standard which indirectly mentions an immunity test to pulsed radiated fields is the standard IEC 61000-4-2 (ESD). The indirect discharge test described for instance in the paragraph 7.2.2 can produce local electric fields of 10 – 40 kV/m.

The deep experience which is the result of many tests of various electronic systems in our EMC test labs shows that very few devices are disturbed by these pulsed electric fields.

Conclusion: we estimate that below 10 kV/m, only few modern pieces of electronic equipment will be disturbed or destroyed. Exception: sensitive measurement equipment like spectrum analysers, oscilloscopes, receivers which must be protected against this type of disturbances.

4. Estimation of the shielding

The GTEM test installations produce electric field in vertical polarisation. This test is described in the standard MIL-std-461/RS105, for instance. The minimum peak electrical field is of 50 kV/m at the EUT location.

The maximum frequency range of the standard RS105 pulse goes up to 400 MHz.

To reduce the field outside the GTEM-cell to not more than 2 kV/m, following shielding effectiveness is expected:

Frequency range	Required shielding	Remark
10 kHz - 1 MHz	20 dB	The continuous wave limit (ICNIRP) in this frequency range is 10 times higher than in the 10 MHz to 400 MHz range. Thus a shielding of 20 dB is adequate.
1 MHz - 400 MHz	40 dB	This is the important frequency range for the shielding.
400 MHz - 18 GHz	0 dB	There is no requirement here as the energy of the RS105 pulse in this frequency range is very low.

5. Conclusions

No standard specifies any limitation of the peak pulsed electric field neither for personnel nor for equipment placed in the vicinity. Simple extrapolations with the ICNIRP guidelines give a quite severe value of 2 kV/m, as an indication. But the ICNIRP guidelines actually concern only the frequency domain and not pure pulses.

The situation is even more complicated with the susceptibility of electronic equipment placed in the vicinity of the test installation. Tests made according to IEC 61000-4-2 (indirect ESD) have shown that few devices are disturbed (or destroyed) under an equivalent peak electric field of 10 kV/m. Therefore a field limit of 10 kV/m can be taken into account for the estimation of minimum safety distance to electronic equipment. It is important to note that even so, some sensitive devices could be disturbed. The number of devices which can be disturbed is statistically decreasing with the distance.

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