Future HPEM Protection Measures

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Abstract— Several Standards describe HPEM environments. Others suggest protection measures or list mitigation methods. All of them are based on maximum threats and protection measures. Until recently, no standard considered a natural shell such as an above-ground brick structure or an earth-covered facility made of reinforced concrete as an enclosure with a certain shielding effectiveness.
Computing speed and operating frequencies are continuously rising. Short conductors on PCB's are starting to transmit. Internal EMC becomes increasingly important. Component and subsystem shielding has become inevitable. Actual commercial of the shelf (COTS) devices and systems have therefore a higher immunity than a few years ago. Future HPEM protection at reasonable costs needs to be adapted to the new conditions.

Keywords – HPEM threats; device immunity; appropriate protection measures

I. HPEM PROTECTION IN THE PAST

In Switzerland, most existing command and control facilities with HEMP protection requirements are well protected according to the recommendations of standards like [1]. Faraday cages with 80 to 100 dB shielding effectiveness are installed in underground facilities. The total shielding effectiveness may be up to 160 dB when we take into account the earth covering the facility and the reinforced concrete structure.
Many threat-level HEMP tests and HPEM experiments have shown that the known threats don't require such high shielding levels. Because such an amount of protection is obviously oversized, solutions for appropriate and more cost effective protection methods are required.

II. ADAPTED PROTECTION MEASURES

In 2017 an International Technical Specification [2] containing a list of natural construction materials providing certain shielding effectiveness was published. Redundant and training systems do not require the same amount of protection as mission critical equipment. The amount of protection required is determined by the expected system availability, which is depending on an appropriate selection of protection level and protection criterion shown in Figure 1. In Switzerland the protection level and protection criterion are determined following [3]. As an example the necessary protection can be defined as II B. According to Figure 1 II B stands for HEMP protection, interference allowed, functional integrity without data loss.

Protection Level	Environment	Definition
0	-	System withstands Common Electromagnetic Environment defined in civil Standards
I	Lightning	Lightning Protection for Systems MIL-STD-461G
II	HEMP	HEMP Protection according to VG 95 371-10 or IEC 61000-2-9, -10 and -11, Lightning Protection is included
III	HPEM	Non nuclear IEMI Environments like UWB, HPM, DS according to IEC 61000-2-13 Lightning and HEMP is included

Protection Criterion	Functional Integrity
A	Intended system function during test. No Impairment or functional Failure below System Availability
B	Intended system function after test Impairment allowed during HPEM attack but no change of operation mode nor data loss
C	Temporary malfunction allowed with systems self-recovery or operational reboot measures
D	Destruction possible, elimination acceptable due to redundancy

Figure 1 Determination of protection requirement.

Experiments with equipment conform to European EMC requirements (CE-mark) have shown that for permanent damage by radiated pulses minimum field strengths on the order of 10 kV/m are required. Most mission critical systems tolerate short-time interrupts (nanoseconds) thanks retransmitted information. Consequent application of surge protection devices (SPD) on all lines maintains system interconnections and function. Buried reinforced cable traces slow down the rise time of pulses in long wires to values >1 ns where SPD's start to work. Therefore, natural shields considerably reduce the required shielding levels, but fast and reliable SPD's, which work for different HPEM sources, are still required.
However, it remains a great challenge to protect a system against in-band front door coupling. As there is no off-the-shelf protection available, the system manufacturer must solve this during the procurement phase of a system.
Non-nuclear IEMI threats appear locally and can be attenuated by measures such as redundant systems, electrically conducting fences and large "keep-out" zones.

III. CONCLUSION

The inherent system immunity of modern electronic equipment has increased. In future, the shielding effectiveness may be lower, but the line filters are becoming increasingly important and should be able to work under various HPEM threats. Special attention is required to protect against in-band front door coupling. Selection of an appropriate protection level and protection criterion will allow full protection of systems in C4I facilities at reasonable costs. In addition, other measures such as redundancy, "keep-out" zones and HPEM detectors are useful for future HPEM protection.

REFERENCES

[1] MIL-STD-188-125-1:2005-04-07
[2] IEC TS 61000-5-10:2017
[3] IEC 61000-6-1:2016