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Technical Requirements for a HEMP Resilient Power Substation on a Project Stage

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Abstract: *This paper describes the technical requirements for a HEMP Resilient Power Substation that can be inserted by the technical staff of the substation as a separate paragraph close to the common technical requirements on a project stage. The technical staff of the substation must determine: critical facilities, critical equipment, partly limited mode or functions for the critical equipment and performance criteria.*

Keywords: *High Altitude Electromagnetic Pulse, HEMP, EMP, resilience, power substation*

1. INTRODUCTION

The problem of Intentional Destructive Electromagnetic Impacts (IDEI) on power systems has recently become more and more realistic in connection with two modern trends: an extending application of microelectronics and microprocessor-based devices and systems in the electric power industry - on the one hand, and intensive designs for special equipment for distance destruction of electronic devices and systems –on the other hand. The most powerful method for such destruction is the High-altitude Electromagnetic Pulse (HEMP) as a result of high-altitude nuclear explosion. The history of experimental high-altitude nuclear explosions is already known for half a century. During this time many tens of detailed scientific reports and standards presenting this phenomenon and measures of protection from it have been published [1]. In view of this fact, it would be possible to assume that for some time the problem of protection against HEMP was solved, and modern power systems are well protected from this phenomenon. The research performed by the author displays that actually this is not true, and for the last several decades, one country of the world has not undertaken any practical measures regarding protection of national infrastructures against HEMP. Why? Obviously, because most such publications are written as scientific reports and scientific articles for the specialist in the HEMP field, or contrariwise, as very popular articles intended for laymen. It is very difficult for the practical specialist of power engineering to use tens of complicated reports and standards in a very specific field and to transform them to practical measures.

2. WHERE TO START?

It is obvious, as usual, from technical requirements to the equipment on the project stage. The technical requirements could start with the selection of the most important power system facilities (critical facilities) – those which require protection from the start. These include nodal substations and the most important power plants. Then, critical kinds and types of equipment should be determined at selected facilities, which are the most susceptible to HEMP on the one hand, and on the other hand, those which are vital for the selected facility of the power industry. For example, relay protection systems, communication systems, fault recorders, SCADA, battery chargers, UPS, controllers, fire protective systems, etc.

Only power object technical staff can determine facilities and equipment as being critical or not critical. It is a very important but not a simple part of all programs to increase resilience of power objects, but without determining this, it is impossible to start practical activities.

After this stage technical requirements for HEMP resilience can be written that will be a separate part of common technical requirements for project of power substation or station.

The technical requirements are introduced below in the form, intended for inserting directly into technical documentation.

3. TECHNICAL REQUIREMENTS FOR HEMP RESILIENT EQUIPMENT

1. The requirements intended for selected critical electronic equipment (SCEE), critical circuits (CC) and also for power transformers, installed on selected critical facilities (SCF).
2. Critical facilities (substation), critical circuits and critical equipment will be determined by the customer.
3. The intention of the requirements – increasing of resilience of equipment on new substations to HEMP on a project stage.
4. All SCEE disposed on SCF must be equipped with HEMP protective elements and technologies. The protective level of SCEE must provide functioning of the substation in a normal mode (or in a partly limited mode, confirmed by the customer) before, during and after HEMP.
5. Protective technologies and elements on SCF must include:

- EMP protected buildings and control rooms;
- special metal cabinets, intended for protection of electronic equipment from EMP;
- screened cables with a multilayer screen intended for protecting against EMP;
- EMP filters on all critical inputs and outputs of SCEE and also on control circuits of critical electromechanical equipment, such as circuit breakers, disconnectors, etc.
- Reserve power supplies based on EMP protected accumulating capacitors for controls of circuit breakers, provided its single operation is minimum without substation batteries, chargers and UPS.
- Special surge protective devices intended for protection against EMP on all critical AC and DC circuits: power, control and signal.
- Grounding methods that provide normal functioning of all kinds of SCEE on the substation before, during, and after HEMP, and also electrical safety of personnel in the normal ordinary regime.
- Spare parts list and storing method for SCEE for fast restoration of SCEE after EMP in emergency cases without using computers, without additional settings and adjustment SCEE by a qualified specialist.
- aggregated protective technologies and elements must provide normal functioning of the substation (or in a partly limited mode, confirmed by customer) during and after HEMP that is characterized by parameters:
- external (out of control room and building) electrical field radiation pulse 2/25 ns with maximal strength up to 50 kV/ m in all axis, according to standards IEC 61000-2-0, IEC 61000-2010, IEC 61000-2-11, Fig. 1.

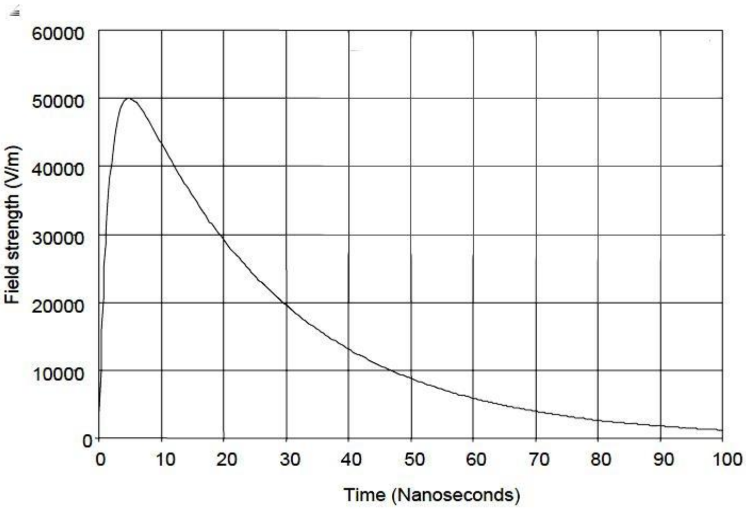

Fig1. *The shape of the E1 component of HEMP according to standards: IEC 61000-2-9, IEC 61000-2-10, IEC 61000-2-11, and MIL-STD-461F.*

- electrical fast transient (EFT) pulses with amplitude 8 kV on all electrical inputs to protected metal cabinets and outputs from protected metal cabinets with internal installed SCEE, according to IEC 61000-4-4 (C1 test level, concept 2b, E8 amplitude level, 50% probability) - Fig. 2.

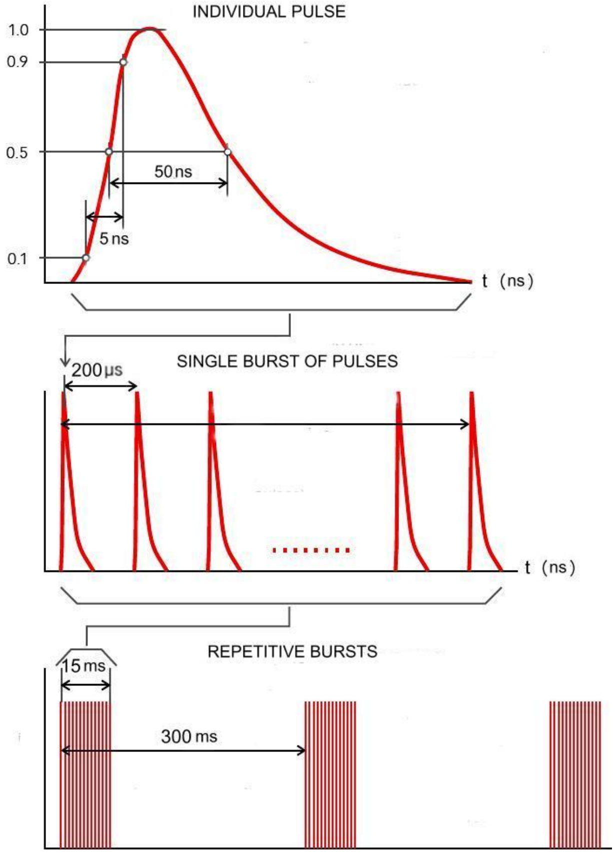

Fig2. *Electrical Fast Transient (EFT) – fast pulse (IEC 61000-4-4)*

6. Power transformers protection method must be based on disconnection of transformers at dangerous DC component registration (more than 10 A) in the grounded zero point. The controller for this operation will determine the SCEE which must be protected against the EMP.

Additional determination needs for “the partly limited mode” definition. This definition is correlated with “performance criteria” in testing procedures for EMP immunity. The acceptable type of certain equipment response to electromagnetic interferences during and after the certain test type is known as the “performance criteria”. There are many kinds of acceptable responses, listed in relevant standards, but for SCEE two acceptable performance criteria can only be used [2]:

A) Normal performance within specified limits.

B) Temporary degradation or loss of functions or performance, which is self-recoverable.

For “the partly limited mode” (i. e., for some unimportant functions in the specified SCEE) can be used in addition to the performance criteria, such as:

C) Temporary degradation or loss of functions or performance, which requires operator intervention or system reset.

Therefore, for such unimportant functions in the specified SCEE, the aggregated protective technologies and elements can provide partial protection (for performance criteria C only). The technical staff of the power object must determine the partly limited mode or functions (if it exists) for all specified SCEE. The information about such partial protection can be described in the attachment to technical requirements.

The described requirements are requirements of the technical staff of a power object to a project implementer. The implementer problem is to find appropriate technologies and elements for successful performance of the project. At this stage the book [3] can very helpful to the implementer.

4. Conclusion

It is very difficult for a practical specialist of power engineering to use tens of existing complicated reports and standards in the field of EMP protection and to transform them to practical measures, that is one of the reasons for the absence of practical measurements regarding protection of national infrastructures against HEMP.

Described in this paper the technical requirements for an EMP resilient substation can be helpful to the technical staff by inserting these requirements as separate paragraphs directly into common technical requirements of the substation on the project stage. The technical staff of the power object must determine:

- critical facilities;
- critical equipment;
- partly limited mode or functions for critical equipment and performance criteria

The implementer of the project must be to find appropriate solutions for technologies and elements for successful performance of the project. Such solutions can be based on the information described in [3].

References

[1] Gurevich V. I. EMP and Its Impact on Electrical Power System: Standards and Reports. – International Journal of Research and Innovation in Applied Science (IJRIAS), 2016, v. I, issue VI, pp. 5-10.

[2] Gurevich V. I. Main Principles of Electromagnetic Pulse Immunity Test Methods for Power System Electronics. - – International Journal of Research Studies in Electrical and Electronics Engineering (IJRSEEE), 2016, v. 2, Issue 2, pp. 1-8.

[3] Gurevich V. I. Protection of Substation Critical Equipment against Intentional Electromagnetic Threats. – Wiley, London, 2017, 240 pp.

Author's Biography

Vladimir I. Gurevich, was born in Kharkov, Ukraine, in 1956. He received an M.S.E.E. degree (1978) at the Kharkov Technical University, named after P.Vasilenko, and a Ph.D. degree (1986) at Kharkov National Polytechnic University.

His employment experience includes: teacher, assistant professor and associate professor at Kharkov Technical University, and chief engineer and director of Inventor, Ltd.

In 1994, he arrived in Israel and works today at Israel Electric Corp. as a Senior specialist and Head of section of the Central Electric Laboratory.

He is the author of more than 200 professional papers and 13 books and holder of nearly 120 patents in the field of electrical engineering and power electronics. In 2006 he was Honorable Professor with the Kharkov Technical University.