Electrically Driven Wideband Sources for Equipment Vulnerability Tests

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***Abstract*— A collection of high-power wideband (WB) sources for vulnerability testing of electronic equipment is presented.**

Keywords—electromagnetic field, high-voltage techniques

I. Introduction

High-power microwaves have emerged as a new technology allowing novel applications and offering innovative approaches to existing ones [1], [2]. Sources of short high-power electromagnetic pulses are of great interest owing to their ability to disrupt or destroy electrical and electronic systems on which our society is rapidly becoming more and more dependent. The vulnerability of infrastructure (computers, communication systems, car electronic, etc.) to electromagnetic pulse (EMP) is suspected, but is not definitely known. Simulators and test facilities for evaluating the electromagnetic pulse effect on electronics could provide the missing data and enable one to explore the protective measures. A range of microwave sources, from small autonomous systems [3-6] to large microwave test facilities with varied frequency, pulse and burst length, pulse repetition frequency (PRF), and output power [7-11] have been developed. Typical values of the electric field strength at 1 meter distance vary from several to several hundred kilovolts per meter at frequencies from hundreds of MHz to several GHz. A conventional approach to vulnerability tests implies either laboratory testing of separate devices and components inside a shielded room [3] or open-air testing of complex multi-component systems using large microwave test facilities [10,11]. Such measurements give data on the vulnerability threshold rather than on the behavior of the system in real life. That is why testing facilities for in-situ trials are of certain interest.

A collection of sources of short high-power electromagnetic pulses for equipment vulnerability testing is presented. The sources developed are compact and easy-to-use. They allow either laboratory or open-air testing of different systems for EMP effect, simulating diverse cases of interest.

II. The Concept

The development of the collection of WB sources is motivated by numerous tasks for in-situ testing of communication and control systems, computer networks, etc. The developed sources are compact, easy-to-use, and demonstrative to be used in the laboratory for trials and training. They are capable of producing the radiated electric field strengths from 70 to 700 kV/m at a normalized range of 1m and frequencies from 100 MHz to 1.5 GHz. Each source includes a pulsed power high-voltage generator feeding the radiating antenna. Omni-directional antennas are designed for operation voltages from 50 to 250kV. Application of reflectors of different types enables guiding and gaining the radiation in prescribed direction.

A. *Portable repetitive WB source operating at up to 500 MHz frequency*

From time to time, the need for express vulnerability tests arises. A dedicated portable repetitive WB source (Figure1) was developed for such situations.

Fig. 1. Portable repetitive WB source with operation frequency up to 500 MHz

A pulsed power high-voltage generator operates with a pulse repetition frequency up to 60 Hz. It is supplied by 24V accumulators and stores 0.25 J.

An omni-directional dipole antenna produces a "donut shaped" radiation pattern and can be used in both vertical and horizontal polarizations. It operates in the range up to 500 MHz (Figure 2).

The radiated electric field strength at a normalized range of 1m is about 70 kV/m (the detected electric field strength at 21.5m distance is shown in Figure 3).

A corner reflector is also designed for use with this source. The antenna and the pulsed power supply can be packed in a compact storage box (Figure 4).

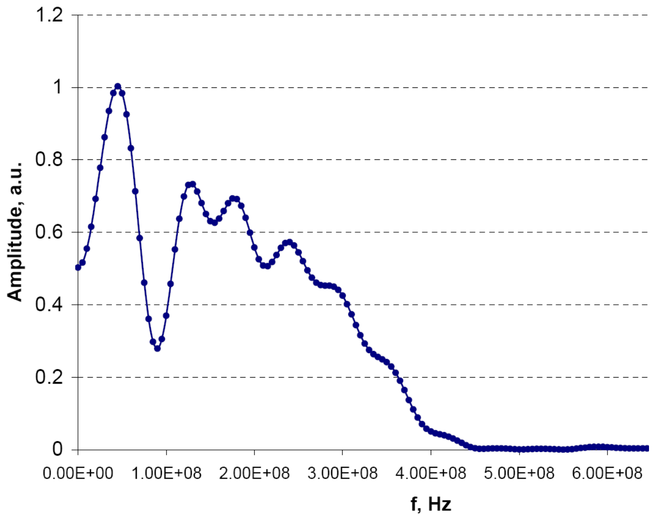

Fig. 2. Signal spectrum

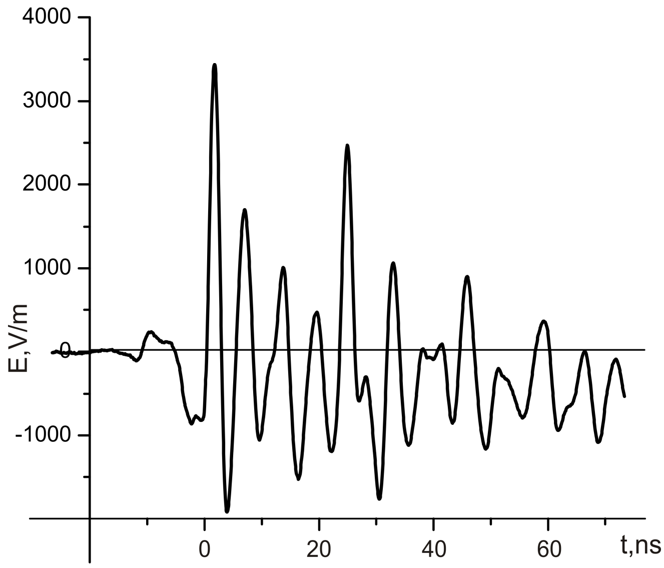

Fig. 3. The detected electric field strength at 21.5m distance

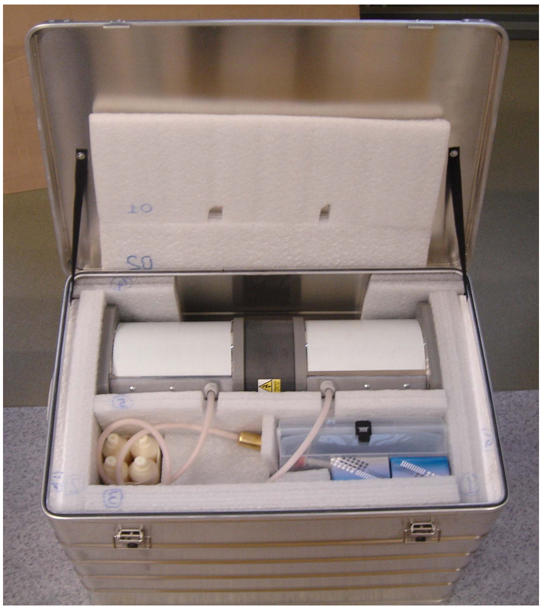

Fig. 4. WB source in storage box

B. Portable repetitive WB source with operation_frequency of about 1GHz

Another WB source is developed for radiating pulses with higher frequency and is used with a parabolic dish reflector. The maximal electric field strength reduced to 1 meter distance that is produced by this source is 700 kV/m, the repetition rate is up to 90 Hz. The pulsed power high-voltage generator is oil insulated.

Fig. 5. Repetitive WB source with operation frequency of about 1GHz

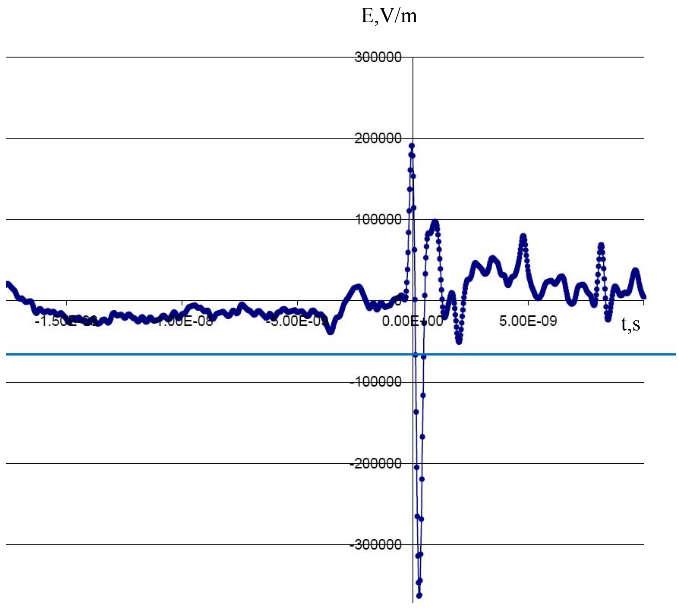

Fig. 6. The detected electric field strength reduced to 1 distance (typical signal)

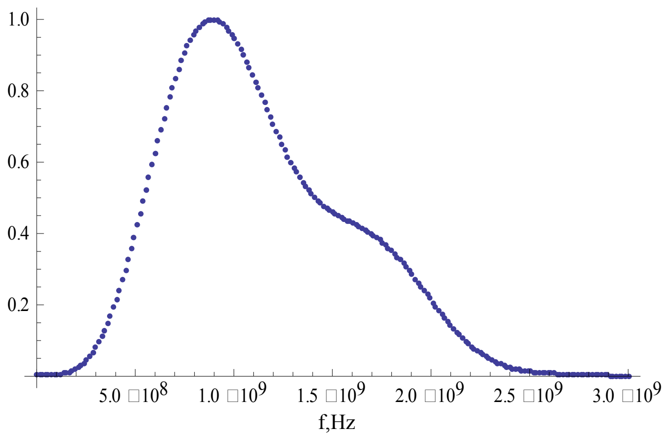

Fig. 7. Signal spectrum

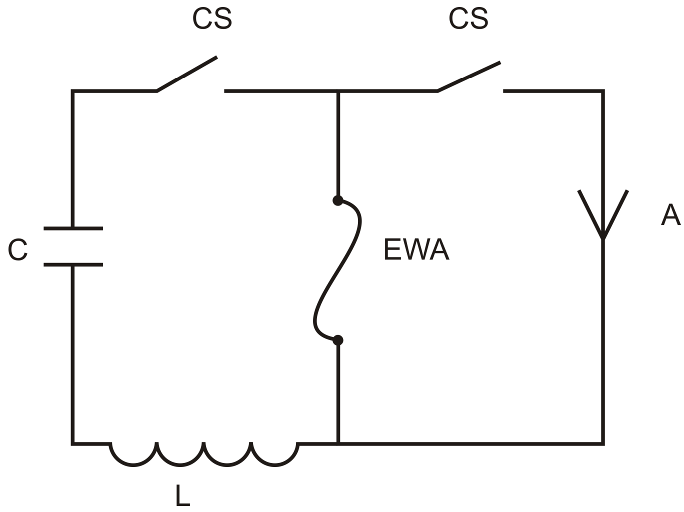

Fig. 8. The circuit includes capacitor C, inductance L, exploding wire array (EWA), two closing switches (CS), and radiating antenna A

Fig. 9. A compact single-shot radiation source

C. Compact single-shot radiation source

Further increase of voltage and frequency in the systems of types A and B imply some advanced approaches to both pulsed power source and antenna design. The output parameters of systems A and B are restricted by the breakdown voltage and the gap in the discharge gap of the antenna, as well as by the features of the voltage pulse provided by the pulsed power source. An attempt to increase the frequency and voltage simultaneously makes them conflict in the discharge gap, unless the voltage pulse risetime becomes very short. An exploding wire array is a reasonable component providing a high-voltage pulse with a fast risetime.

A simple circuit (Figures 8, 9) with 100 kV, 0.4 μF capacitors discharging through an array of 100 μm copper wires enables one to obtain a single voltage pulse up to 700 kV, whereas the use of the additional discharge gap provides a reduction in the risetime of the voltage pulse at the antenna gap.

The oil insulated antenna, supplied by such pulsed power source, can produce at a normalized range of 1m the electric field strength as high as 110 kV/m at a frequency of about 1.5GHz. A further increase in frequency is possible, but is accompanied by the reduction in the radiated field strength.

The presence of the essentially single-shot component is the sole disadvantage of this system. By varying the circuit inductance, the number and length of exploding wires, and the parameters of the discharger switching the voltage pulse to the antenna, one can gain an incredible assortment of pulse features.

III. Conclusion

A collection of WB sources dedicated for equipment vulnerability tests is presented. The sources are compact, easy-to-use, and demonstrative to be used in the laboratory for trials and training.

REFERENCES

[1] J. Benford, J. A. Swegle, E. Schamiloglu "High Power Microwaves", Taylor& Francis, (2007).

[2] D.V. Giri, "High-Power Electromagnetic Radiators, Non-Lethal Weapons and Applications", Harvard University Press, (2004).

[3] F. Sonnemann, J. Bohl "Susceptibility and Vulnerability of Semiconductor Components and Circuits against HPM" in Proc. XXVIIth General Assembly of the International Union of Radio Science, 2002, Available: http://www.ursi.org Directory: Proceedings/ProcGA02/papers File: p1352.pdf

[4] S.M. Hwang, J.I. Hong, and C.S. Huh "Characterization of the susceptibility of integrated circuits with induction caused by high power microwaves", *Progress In Electromagnetics Research*, PIER 81, pp.61-72, (2008).

[5] M. Camp, H. Garbe, D. Nitsch, "UWB and EMP Susceptibility of Modern Electronics", IEEE EMC, Montreal, August 13-17, 2001, ISBN: 0-78036569-0, pp. 1015-1020, (2001).

[6] D. Nitsch, M. Camp, "UWB and EMP Susceptibility of Modern Microprocessorboards", presented at EMC Europe, Brugge, Sept., (2000).

[7] Benot Martin, Philippe Delmote "The GIMLI: a compact High-power UWB radiation source" presented at EUROEM’2008, Lausanne, Switzerland, (2008).

[8] Robert L. Gardner "Methods to Determine the Effect of Pulse Width on Susceptibility Threshold Levels" presented at EUROEM’2008, Lausanne, Switzerland, (2008).

[9] V.B. Carboni, H.J. Kishi,T.M. DaSilva, T.W. Tatman, I.D. Smith, C.C.R. Jones, N.R.M. Ritchie, S.I. Richmond "Full Threat Level Transportable Lightning Simulation System" presented at EUROEM’2008, Lausanne, Switzerland, (2008).

[10] Frank E. Peterkin, James L. Hebert, David C. Stoudt, and John Latess "Modification of an EMP facility to support threshold testing of electronic systems" in Proc. *PPC-2005*, 2005, p. 759, Available: ftp://ftp.pppl.gov Directory: pub/neumeyer/Pulsed_Power_Conf/data/papers/2005/ File: 2005_187.pdf

[11] Odd Harry Arnesen, Ernst Krogager, Mats Bäckström, Sigbjørn Bø-Sande, Jostein Godø, Seppo Härkönen, Karl G. Lövstrand, Mikko Moisio, Barbro Nordström, Jouni Peltonen, Ole Øystad "High power microwave effects on civilian equipment", Proc. URSI 2005 , 2005, p. Available: http://rp.iszf.irk.ru Directory: hawk/URSI2005/pdf File: E03.2(0528).pdf

[12] V.G. Baryshevsky, A.E. Borisevich, A.A. Gurinovich, G.Yu. Drobyshev, P.V. Molchanov, A.V. Senko "A compact high power microwave (HPM) source" presented at EPPC 2009, Geneva, Switzerland, (2009).