

Vladimir Gurevich

Protecting Electrical Equipment

Good Practices for Preventing High Altitude
Electromagnetic Pulse Impacts

DE GRUYTER

Author

Dr. Vladimir Gurevich
Israel Electric Corporation
POB 10, 31000 Haifa
Israel
vladimir.gurevich@gmx.net

ISBN 978-3-11-063596-6
e-ISBN (PDF) 978-3-11-063928-5
e-ISBN (EPUB) 978-3-11-063606-2

Library of Congress Control Number: 2019934269

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at <http://dnb.dnb.de>.

© 2019 Walter de Gruyter GmbH, Berlin/Munich/Boston
Cover image: dani3315 / iStock / Getty Images

www.degruyter.com

Annotation

V. Gurevich

Protecting Electrical Equipment. Good Practices for Preventing High Altitude Electromagnetic Pulse Impacts. – De Gruyter, Berlin, 2019.

This unusual book recounts the history and development of military nuclear programs in the USSR and USA; the role of intelligence services in the development of nuclear weapons; discovery of electromagnetic pulses (EMP) caused by high-altitude nuclear explosion; and numerous tests of nuclear weapons. The book contains numerous previously secret documents and photos that have been recently declassified and approved for public release.

Using approachable language for the nonspecialist in nuclear physics, the book describes the formation process of EMPs caused by high-altitude nuclear explosions (HEMP) and discusses numerous factors affecting the HEMP strength and other of its parameters. Also discussed is the impact of nuclear EMPs on electronic components and devices and also on electrical power equipment.

The main part of the book describes only practical (and not theoretical, as in hundreds of existing scientific reports) protective methods and protection means, as well as methods for effective evaluation of the protective measures.

Due to its breadth of scope, timeliness, depth of coverage and the practical importance of described protective means, the book may be considered as an encyclopedia of HEMP, having no equal on the book market.

The book is intended for electrical engineers dealing with the development, design and operation of electronic and electrical equipment, and it will also be useful for university lecturers and students. Much interesting material will be found here, also appealing to fans of the history of technology.

Theme of the book corresponds to the “Executive Order on Coordinating National Resilience to Electromagnetic Pulse”, signed by President D. Trump at March 26, 2019.

Introduction

The electromagnetic pulse resulting from a high-altitude (30–400 km) explosion of a nuclear charge (HEMP) is a quite strange and extraneous phenomenon in the context of both physical processes and informational contradictions. Initially, the phenomenon was detected as a side-effect of the first nuclear-test explosion in 1945. That side-effect disrupted the registering and the measuring equipment and prevented obtaining numerous important data about the parameters of a nuclear explosion. For a long time, it has been impossible to gather clear and accurate EMP parameters due to the correlative impact on the equipment.

Numerous misunderstandings and calculation mistakes made by the leading physical scientists of that time hindered the efforts to build HEMP's theoretical models. However, recently, it appears that the theory of the process actually had been developed in 1925, well ahead of the detection of the phenomenon.

The informational contradictions result from the fact that, during the decades since the initial detection of HEMP, the phenomenon has been described in meticulous detail in hundreds of extensive reports, unclassified only 20 or 30 years ago (today the reports are freely available on the internet) many of them describing HEMP impact on electronics. However, over the decades, the phenomenon has not become known or clear to the majority of civil experts in a critical national industry such as the electrical power infrastructure. It seems like they live in a parallel universe: While there exist large groups of military experts working on this problem, the leaders in the electric power industry, as well as

engineers and technicians, in the best case, have only appeared to have heard something about a problem related to the electromagnetic pulse. However, the problem is really severe: HEMP acting on the unprotected microelectronic and microprocessor components of the control, telecommunication and relay protection systems commonly used in the modern power industry, can cause a power disaster over a vast area. Consequently, this will result in the suspension of the water supply, sewerage systems, communication, etc.

The carelessness of government agencies, and primarily the leaders of the electrical power industry, endangers the strategic national interests and provokes potential enemy countries to develop specialized nuclear weapons with intensified HEMP (so-called Super-EMP).

More than ten years ago, in 2005, I raised for the first time the question of electromagnetic security in the electrical power industry in an article published in the journal *Public Utilities Fortnightly* and, later that year, in articles published in Russian-language technical publications. In Russia, after my first publications, I was confronted with total misunderstanding and furious antagonism by electrical power engineering experts. They were unaware of the problem and perceived it as something outrageous and contradictory to their conventional perception of the world.

The Western world, including the US, perceives it somewhat differently. Today, there are dozens of governmental and non-governmental entities in the US working on the protection of the national infrastructure against HEMP. There are scores of booklets alarming about the consequences of HEMP impact on the housewife's level. A lot of such populist scary stores can be found on Internet sites and in on-line book shops. Unfortunately, numerous of those entities produced publications by academics

about the damage resulting from the global collapse that inevitably results from HEMP impact. Fundamentally, the only difference between those reports and the above booklets is that the reports are written with addition small amount of technical and economical details for frighten the Congress and the Senate, not the housewives.

It may seem strange, but in parallel and completely independently of the above, there is a pattern of complete disregard and concealment of the problem in some of the professional journals in the field of the electric power industry. However, this is not a harmless pattern of behavior because the absence of appropriate knowledge about the existence of the HEMP problem by specialists in the field of the industry leads to hazardous decisions, sharply increasing its vulnerability. This is a very dangerous trend, but the people who have a certain commercial interest in all respects support it, limiting the transmittal of knowledge about the dangerous effect of the HEMP on digital microelectronic devices for protection, automation and control. Very often the apologists of digitalizing everything, including everything in the electric power industry, simply manipulate public opinion.

“Digitalization – Yes or No?”—appears very popular international journal “Protection, Automation & Control World” (PAC World) in September 2018 issue (in the section “Last word”, p. 98), and continue: *“This is a question that many people in the electric power industry are asking themselves”*. Furthermore, the journal editor invented his own interpretation of the term “digitization” and asked the reader to accept it and say “Yes”: *“Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; if we just think about this definition, it is clear that the answer should be Yes”*.

“Many other questions cross our minds” – writes the editor next – *“but they don’t stop us from moving forward and taking advantage of*

the digital technology... And it is the time to get to the office, bring your team together and say – Let's go digital!"

Paraphrasing the author of these lines:

“the dangers to HEMP are off interest to us and they will not stop us on our way forward”.

Such continued expanding uncontrolled use of digital microelectronic technologies in the electric power industry that are **unprotected against HEMP** is a tragedy of a national scale that must be prevented.

This is the main mission of the book.

Also, there are numerous companies thriving on specialized expensive training materials only developed to scare the staff of power-generating companies. Are such publications and trainings helpful when it comes to the protection of the national infrastructure? The answer is obvious. This answer motivated me to write a code of practice actually helpful to a power-system staff willing to protect their facilities against HEMP, instead of just being afraid of HEMP's consequences.

Certainly, to understand the nature of all the recommendations made in the book and to apply them appropriately under a specific electric equipment operation, the elementary theory of HEMP must be explained. That is why it is included in the book.

Finally, to make the book both interesting and inspiring, I included recondite historical facts about the creation and testing of nuclear weapons the USSR and the US, as well as photocopies of the previously classified documents of the USSR Committee for State Security (KGB) and the CIA.

Finally, I hope my readers will find much new, interesting and useful information in this book.

Important document “Executive Order on Coordinating National

Resilience to Electromagnetic Pulse”, recently signed by the President D. Trump gives hope that the book will be in demand by many specialists responsible for protecting the infrastructure against HEMP.

Author

Contents

About the Author

Annotation

Introduction

1 Electromagnetic pulse—a parcel from the past

1.1 Introduction

1.2 History of HEMP

1.3 The issues of theoretical physics

1.4 People's Commissariat for Internal Affairs (NKVD) as the primary “designer” of the first Soviet nuclear explosive

1.5 Thermonuclear bombs

1.6 Nuclear test explosions

1.7 The status of HEMP protection

Bibliography

2 A contemporary view of HEMP for electrical engineers

2.1 Is the contemporary view up to date?

2.2 The basic physical processes

Bibliography

3 HEMP simulators

3.1 HEMP simulators: principle of operation

3.2 Classification of HEMP simulators

3.3 Foreign HEMP simulators

3.4 HEMP simulators available in Russia and Ukraine

3.5 Portable HEMP simulators

4 The vulnerability of electronic equipment to HEMP

4.1 Electronic equipment is the most important component of the modern infrastructure

4.2 The vulnerability of discrete electronic components to HEMP

4.3 Vulnerability of integral circuits (microchips) to HEMP

4.4 Vulnerability of microprocessors to HEMP

4.5 Vulnerability of computers to HEMP

4.6 Conclusions

Bibliography

5 Electronic components for HEMP protection system

5.1 Testing of low-power protective components under the low pulse voltages

5.2 Testing of low-power protective components under the high pulse voltages

5.3 Testing of powerful protective components under conditions close to reality

5.4 Conclusions

Bibliography

6 External protection of power systems' electronic equipment from HEMP

6.1 Introduction

6.2 Analysis of capability of conventional building materials to weaken electromagnetic emission

6.3 Composite construction materials with improved electrical conductivity

6.4 Materials absorbing electromagnetic emission

6.5 Another method for depression of HEMP electromagnetic field strength inside the power industry facilities containing the electronics

6.6 Reducing electronic equipment vulnerability to HEMP with architectural solutions

6.7 Conclusions

Bibliography

7 The issues of electronic equipment grounding at the power facilities

7.1 Types of electromagnetic interference at power facilities

7.2 Challenges of the conventional grounding systems

7.3 Differences between lightning and HEMP

7.4 Grounding of electrical equipment as the main protective means for HEMP

7.5 Protection devices for HEMP

7.6 New method for grounding electronic equipment mounted inside the cabinets

Bibliography

8 The issue of control cables selection for HEMP-protected electric facilities

8.1 Introduction

8.2 Designs and features of shielded control cables

8.3 Evaluation of control-cable shielding effectiveness

8.4 Choosing control cables

8.5 Conclusion

Bibliography

9 Grounding of control-cable shields

9.1 Introduction

9.2 Shielding principles

9.3 Interference types and grounding options for cable shields

9.4 Problems and contradictions

9.5 Factors impacting the effectiveness of shield groundings

9.6 The suggested method of shield grounding

Bibliography

10 HEMP filters

10.1 Introduction

10.2 Do the filters really protect from an electromagnetic pulse?

10.3 The frequency range of filters

10.4 Feasibility of HEMP equipment protection with filters

10.5 Protection of equipment from HEMP high-frequency noise

10.6 Protection of the equipment from the HEMP-generated pulse overvoltage

10.7 Ferrite filters

10.8 Conclusions

Bibliography

11 High-voltage insulation interfaces

11.1 Introduction

11.2 High-voltage link for transmitting discrete commands in relay protection, automation and control systems

11.3 Usage reed-switch-based high-voltage interfaces in HEMP susceptibility tests

11.4 Design features of high-voltage isolation interfaces

Bibliography

12 Improvement of the resilience of industrial cabinet-installed electronic equipment to HEMP Impact

12.1 Introduction

12.2 New cabinets for electronic equipment

12.3 Retrofitting existing cabinets equipped with glass doors

12.4 Enhancement of the cabinet cable entries

12.5 Voltage pulse suppression

12.6 Retrofitting grounding systems of electric cabinets

12.7 Conclusion

Bibliography

13 Basic principles of direct-current auxiliary-power system (DCA

PS) protection

13.1 Introduction

13.2 Protection of DCAPS operating equipment from HEMP

13.3 Backup-power supplies for DCAPS systems

13.4 Mobile substations and features to protect their DCAPS from HEMP

13.5 Direct-current auxiliary-power systems of power plants

Bibliography

14 Protection of telecommunication systems in electric power facilities from HEMP

14.1 Introduction

14.2 Ways to solve the problem

14.3 The use of fiber-optic communication lines

14.4 Protection telecommunication equipment with galvanic couplings

14.5 New devices for protecting existing telecommunication equipment

14.6 Protection of the communication cabinets

14.7 The general concept for communication-equipment protection

14.8 Retrofitting grounding systems of cabinets containing the electronic equipment

14.9 Retrofitting open-patch panels

14.10 Protection of the power supply system

14.11 Retrofitting the facility (room) containing the critical kinds of communication equipment

14.12 Conclusion

Bibliography

15 Improvement of HEMP resilience of automatic fire-suppression systems

15.1 Introduction

15.2 Firefighting systems for power facilities

15.3 Improvement of automatic firefighting system's resilience to HEMP

15.4 Conclusion

Bibliography

16 Protection of diesel generators from HEMP

16.1 Introduction

16.2 Increasing resilience of medium- and high-capacity DGs

16.3 Protection of DGs stored and de-energized outdoors

16.4 Protection of DGs connected to consumer network

16.5 Active protection method for diesel-generator controller

16.6 Conclusion

Bibliography

17 Features of HEMP resilience-test methods for power system electronics

17.1 Introduction

17.2 Features of testing equipment on a HEMP simulator

17.3 Test objectives

17.4 Features of the test procedure

17.5 Test modes and test-pulse parameters

17.6 Performance criteria

17.7 Conclusion

Bibliography

18 Methods and means of evaluation of the effectiveness of HEMP protection of the installed power-system

18.1 Introduction

18.2 Testing of equipment resilience to direct impact of the HEMP electrical field (E1-component)

18.3 Equipment for HEMP filter testing

18.4 Equipment designed for evaluation of the effectiveness of building

ng, room and cabinet shielding

18.5 Pulse voltage generators

18.6 Conclusion

Bibliography

19 Features of testing digital protective relays resilience to HEMP

19.1 Use of performance criterion during the electromagnetic compatibility (EMC) test of electronic equipment

19.2 Features of using performance criterion during the HEMP resilience test of digital protective relays (DPR)

19.3 Criticism of the DPR testing method used

19.4 Analysis of the result of the second independent trial of the same type of DPR

19.5 Analysis of the result of the third independent trial of the same type of DPR

19.6 Conclusions

Bibliography

20 Establishment of inventory of electronic equipment's replacement modules as a way to improve survivability of the power system

20.1 Optimization of inventory of electronic equipment replacement modules

20.2 The problem of the traditional mode of SPTA storage

20.3 Requirements for protective containers

20.4 Protective containers available on the market

20.5 Conclusion

Bibliography

21 The problem of impact of geomagnetically induced currents on power transformers and its solution

21.1 Geomagnetically induced currents generated by solar storms

- 21.2 Geomagnetically induced currents generated by HEMP
- 21.3 The effect of the E3 component of HEMP on electric power equipment
- 21.4 Protection of power equipment from geomagnetically induced currents
- 21.5 Conclusions
- Bibliography

A Standards on HEMP

- A.1 Standards of International Electrotechnical Commission (IEC)
- A.2 Standards of Institute of Electrical and Electronics Engineers (IEEE)
- A.3 Standards of European Commission
- A.4 Standards of International Telecommunication Union (ITU)
- A.5 Military Standards (USA)
- A.6 NATO Standards

B EMP and its Impact on Power System (List of Reports)

- B.1 EMP Theory
- B.2 Geomagnetically Induced Currents and its Impact on Power System
- B.3 EMP Impact on Power System

C European Projects related to Protection against HEMP

Index