Cyber and Electromagnetic Threats in Modern Relay Protection

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Preface

Future conflicts will be won in a new arena—
that of the electromagnetic spectrum and cyberspace.
We must merge, then master those realms.

Admiral Jonathan W. Greenert
U.S. Navy

Our power grid is very vulnerable.
It's very much on edge. Our military knows that.

Ex-Congressmen Roscoe Bartlett

The problem is not the technology. We know how to protect against it.
It's not the money, it doesn't cost that much.
The problem is the politics.
It always seems to be the politics that gets in the way.

Peter Vincent Pry, PhD
Executive Director of the Task Force
on National and Homeland Security
President of EMPACT America

It would be "suicidally optimistic" to assume that an EMP attack that inflicted a state-wide blackout would not also cause cascading grid and infrastructure failures at least regionally.

Dr. William Radasky and Dr. Peter Vincent Pry

Relay protection occupies a special place in the system of generation, transmission, and distribution of electric energy. It does not take part in production, transfer, or distribution of electric energy directly. In fact, it does not show itself under normal conditions of operation of a power system. If you disconnect it, nothing will change, that is, generators at power plants will continue producing electric energy and power transmission lines, and distribution networks will continue delivering energy to consumers. But this situation is very deceptive: the smallest technical breakdown of equipment can result in the collapse of the electric power system of an entire country if relay protection fails to interfere into this situation. These facts are well known by specialists and do not require additional clarifications. But it appears that everything is not this simple. Modern protection relays consist of sophisticated electronic complexes, which can also fail like any other type of modern electronic equipment. What happens in case relay protection fails while in an emergency mode in electric power systems? Nothing significant happens, since the protection relay is not operating all by itself, but together with several other relay

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protection devices. If one relay fails to activate, another will step in. After all, all critical power assets have backup protection. But failure to activate is not the only nonoperation of protection relays in the emergency mode. It can be falsely actuated under normal mode of operation as well. This is where the problems begin. The fact is that unnecessary actuation of a relay cannot be *corrected* by backup protection relays. What does unnecessary actuation of protection relay mean? It means the disconnection in power transmitting lines, transformers, and generators by means of switches of thousands of consumers. By no means can the systems of automatic re-closing or automatic takeover always correct the situation. The transient state in electric power circuits and the power system as a whole, which take place during sudden disconnection of high-power units, can result in subsequent disconnections of power transmission lines and generators; in other words, it leads to total outage and collapse of the energy system. The world's majority energy system accidents exhibited this scenario. It appears that protection relays can trigger the collapse of a normally functioning system also.

Recently, people involved in planning potential military campaigns have become aware of this fact. Modern scenarios of power struggles between countries are rarely based on using traditional means of striking lives and weapons of the enemy; they rather rely more and more on means that can affect the enemy's infrastructure but avoid human losses. Damaging the infrastructure of modern postindustrial society proves to be more detrimental than ordinary military actions. Electronification and the dependence of any developed country's infrastructure on computers make destruction of the infrastructure significantly simpler, since the destruction can be virtual rather than physical. Thus, the more developed the infrastructure is, the more vulnerable it will be to virtual impact.

> Some foreign analysts, judging from open source statements and writings, appear to regard EMP attack as a legitimate use of nuclear weapons because EMP would inflict no or few prompt civilian casualties. EMP attack appears to be a unique exception to the general stigma attached to nuclear employment by most of the international community in public statements (Report: "Terrorism and EMP Threat to Homeland Security" – Subcommittee on Terrorism Technology and Homeland Security, S/n J-109-5, March 8, 2005)

What place does relay protection occupy in the infrastructure of a country? An absolutely special place, since through protection relays, which control the position of circuit breakers, one can gain access to change the configuration of a power electric network remotely, which results in the collapse of an ordinary functioning power system. Today, this is clear to organizations strategizing battles. Dozens of large corporations from all over the world are working on orders to create special types of equipment, which can affect very sensitive electronic equipment of the modern power industry. Digital protection relays, due to their special position, are by far not the last target to be hit in the first round. Today, two types of remote

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destructive impacts on digital systems are known: cyber attacks and intentional remote destructive electromagnetic impacts.

Modern trends of relay protection development include, but are not limited to, the overall transition to digital relays, the continuous sophistication of their software and hardware, the increase in the number of functions that they perform (including those that are not directly related to relay protection), the transition from fiber-glass communication channels to less protected channels (Ethernet, Wi-Fi), the continuous miniaturization of electronic equipment, the use of flash-memories based on changing and registration of a very weak electric charge in the insulated area of transistor that is getting wider, and the increase in the number of transistors in microprocessors and the reduction of their operating voltage that make remote destructive impacts significantly easier. On the one hand, we see a continuous increase in relay protection susceptibility; on the other hand, we see a continuous improvement in the methods of remote destructive impact. As a result, these two dangerous vectors of development are rapidly heading toward each other. To recall the famous saying of Winston Churchill, "The Stone Age may return on the gleaming wings of science."

The situation is worsening because both criminals and terrorist organizations are gaining access to modern means of impact on computer and microprocessor systems. This makes the meeting of these two vectors inevitable. This is why it is necessary to understand the existing danger and take preventive measures in advance.

In this book, the author attempts to convince the reader in actuality of this danger and presents solutions to the problem.

Please send your remarks about the book to the author: vladimir.gurevich@gmail.com

Dixi et animam meam salvavi!

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Abstract

The book provides a detailed overview of the vulnerabilities of digital protection relays (DRP) to natural and intentional destructive impacts, which include cyber attacks and electromagnetic impacts. Modern technical tools that realize intentional remote destructive impacts to DPR are also described. The book discusses both traditional passive means of protection, such as screened cabinets, filters, cables, special materials and covers, and advanced tools based on circuit and hardware methods.

The book is intended for engineers dealing with the development, designing, and use of relay protection and can be beneficial for scientists, teachers, postgraduates, and students of specific subjects in vocational schools and higher education establishments.

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Vladimir I. Gurevich received an MS in electrical engineering (1978) at the Kharkov Technical University and a PhD (1986) from the Kharkov National Polytechnic University, Kharkov, Ukraine.

Throughout his employment experience, he has been in the following positions: 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, Haifa.

He is the author of more than 180 professional papers and 11 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.

Other books of the author published by Taylor & Francis Group:

- *Protection Devices and Systems for High Voltage Applications*
- *Electrical Relays: Principles and Applications*
- *Electronic Devices on Discrete Components for Industrial and Power Engineering*
- *Digital Protective Relays: Problems and Solutions*
- *Power Supply Devices and Systems of Relay Protection*

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