Digital Protective Relays

Problems and Solutions

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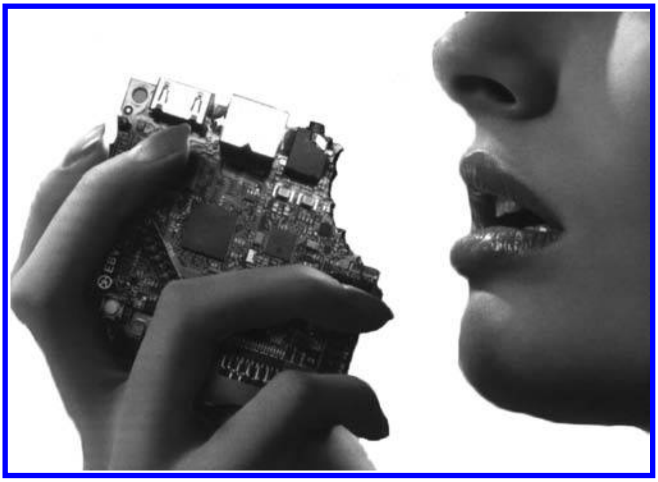
Preface

The Electronic World is reality, the game occurs in the physical world.

—Sidey Myoo



Today it is quite common to say that we are living in the "atomic age," but this is wrong; the fact is that we are, and have been for some time, living in the "electronics age." There is nothing on Earth (and in space) that in one way or another does not depend on electricity. Industry, manufacturing, transportation, communication, banks, health care—whatever the endeavor, it is driven by electricity.

We are so used to electricity that we take it for granted. And we are paying a price for this insouciance. Unfortunately, the electronics age lets us know what happens when electronic systems fail. In the last 20–30 years, we have witnessed several electronic disasters stemming from human error, for example massive power grid failures (blackouts), leading to huge losses and often death (in the United States, 1965, 1977, and 2003; France, 1978; Canada, 1982 and 2003; Italy, 2003; and Sweden, 1983 and 2003), aircraft crashes (the most recent being the crash of flight AF-447, an Airbus A330-200 from Rio de Janeiro to Paris, on June 1, 2009), and so on.

Integral microchips and microprocessors have come into our lives so swiftly and completely that sometimes it seems that modern equipment simply cannot exist without them, which is true. However, the dependence of modern equipment on microelectronics and microprocessors does not mean that there are no problems in this area. The integrity of many functions distributed earlier among separate devices of a complex system in a single microprocessor leads to the reduction of system reliability because damage to the microprocessor or to any number of peripheral elements serving the microprocessor leads to failure of the whole system but not of its separate functions as it was in pre-microprocessor time. Added to this is the extra sensitivity of microelectronic and microprocessor-based equipment to electromagnetic interferences (EMIs) and the possibility of intentional remote actions breaking the normal operation of the microprocessor-based devices (e.g., electromagnetic weapons and electromagnetic terrorism). Intensive investigations into the electromagnetic weapons field are being carried out in Russia, the United States, England, Germany, China, and India. Many world-leading companies work intensively in this sphere creating new devices of these weapon systems functioning at a distance from several dozens of meters to several kilometers, which while specialized in their use are still available to everybody (as they are freely sold on the market).

Relay protection of power units plays an important role in the hierarchy of the electronics age in preventing many disasters.

On the other hand, malfunction protective relays comprise one of the main causes of the heavy failures that periodically occur in power systems all over the world. According to the North American Electric Reliability Council, in 74% of the cases the reason for heavy failures in power systems was the incorrect actions of relay protection in trying to avoid the failure. Thus, the reliability of a power system depends on the reliability of relay protection in many respects.

The possibility of using computers for protecting elements of power systems was first suggested in 1965. George D. Rockefeller was the first to outline the details of using a computer for protecting all the equipment in a high-voltage substation and the lines emanating from the substation.[1]

Digital protective relays (DPRs) started to replace static relays in the beginning of the 1980s. At first these were "hybrid" solutions, where the time-critical filtering was performed with analog electronics. Typical examples are REZ1 (universal phase and ground distance relay for permissive and blocking schemes), RACID (universal phase and ground overcurrent relay for lines and cables), REG 100 (multifunction generator protection relay, with differential, underimpedance, overexcitation, overvoltage, and other protection functions), REB 100 (busbar protection), and others.

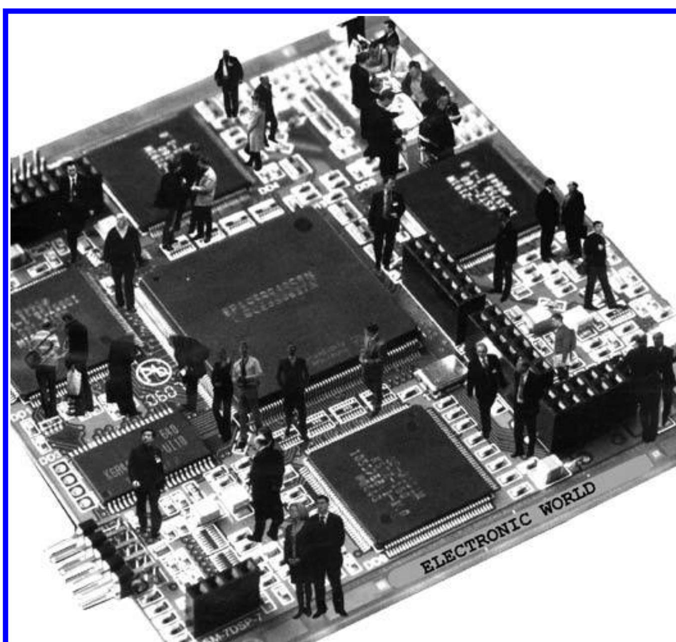
Today protective-relay usage patterns in the world's electric power business continue to grow, with the annual market exceeding $1.5 billion (all figures this volume given in U.S. dollars unless otherwise indicated), according to a recent study by the Newton-Evans Research Co.[2] In total, global demand for protective relays will approach $2 billion by 2009, estimates Newton-Evans. The percentage of digital relays in the mix of the millions of protective relays used by the world's utilities continues to increase. Nearly 60% of the installed generator relays and more than 50% of transmission line relays in North America are now digital units.

There are currently at least ten large suppliers of protective relays: ABB, Areva, GE, SEL, Siemens, NARI-Relays, Basler, Beckwith, Cooper Power, and Schneider.

On a global basis, electric utilities currently purchase only about $850 million in protective relays directly from manufacturers each year. As much as $120 million of this amount is electromechanical, which is still prevalent in Russia, Eastern Europe, and Central Asia and continues to account for another 10 to 20% or so of demand in most other world regions. North American utilities continue to account for about $35 million in annual purchases of electromechanical relays.

Despite some clear and very well-known advantages of digital relays (which are much discussed in technical journals), digital relays also have serious problems, about which researchers usually prefer to not mention. Why? But are the DPR ideal devices? If one is to trust numerous publications in the technical literature, yes! Then it is possible to explain the full absence of critical publications considering problems and disadvantages of the DPR. However, it seems rather strange that such complex technical systems as DPRs should not have disadvantages, like any other complex engineering systems. Alas, in a real world, as we well know, ideal devices do not exist.

This is the first book on the market that is not devoted to the well-known advantages of DPRs, as all other books on the subject are, but to its poorly known problems and disadvantages. It is thus unique in this sense.



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2. Newton-Evans Research Co. The World Market for Protective Relays in Electric Utilities: 2006–2008. Ellicott City, MD: Newton-Evans Research Co.

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About the Author

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

He has held the positions of assistant and associate professor at Kharkov Technical University and chief engineer and director of Inventor, Ltd.

He arrived in Israel in 1994 and works today at the Israel Electric Corporation as an engineer specialist and head of a section of the Central Electric Laboratory.

He is the author of more than 130 professional papers and 5 books and the holder of nearly 120 patents in the fields of electrical engineering and power electronics. In 2006, he became an honored professor with the Kharkov Technical University. Since 2007, he has served as an expert with the TC-94 Committee of the International Electrotechnical Commission (IEC) and in 2010, he became a member of the Israel National Committee of the International Council on Large Electric Systems (CIGRE).

Gurevich's books, which have been published by Taylor & Francis, include the following:

- *Protection Devices and Systems for High-Voltage Applications*
- *Electrical Relays: Principles and Applications*
- *Electronic Devices on Discrete Components for Industrial and Power Engineering*

His personal website is www.gurevich-publications.com