

Digital Protective Relays

Problems and Solutions

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Vladimir Gurevich



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Contents

Preface.....	xi
Acknowledgments	xv
About the Author	xvii
1. Basic Components of Digital Protective Relays	1
1.1 Semiconducting Materials and the $p-n$ Junction	1
1.2 The Principle behind Transistors.....	8
1.3 Some Transistor Kinds	9
1.4 General Modes of the Bipolar Transistor.....	17
1.5 Transistor Devices in Switching Mode	25
1.6 Thyristors	32
1.7 Optocouplers.....	36
1.8 Electromagnetic Relays	40
Reference	53
2. Design and Functional Modules of Digital Protective Relays.....	55
2.1 Overall Structure and Design of Digital Protective Relays (DPRs)	55
2.2 Analog Input Modules	58
2.3 Output Relay Modules	63
2.4 Digital (Logic) Input Modules.....	70
2.5 Central Processing Units (CPUs).....	76
2.5.1 Analog-to-Digital Converters (ADCs).....	78
2.5.2 Memory Devices	83
2.5.3 Microprocessors	91
2.6 Internal Power Supplies	97
References	111
3. Problems with the Reliability of Digital Protective Relays	113
3.1 Introduction	113
3.2 Reliability Myth.....	114
3.2.1 One More Class of Problems Which DPR Manufacturers Prefer Not to Mention	121
3.3 The Real State of Affairs with DPR Reliability	122
3.3.1 Myth about the Extreme Importance of Microprocessor-Based Protective Devices	122
3.3.2 Why Have Digital Protective Relays Become So Popular?.....	123
3.3.3 The Actual Problems with the Reliability of Digital Protective Relays	127

- 3.3.4 Criteria for the Estimation of Reliability (Failures) of Microprocessor-Based Protective Devices 131
 - 3.3.5 Summary..... 133
 - 3.3.6 Conclusions..... 134
 - 3.4 What to Do with All These Problems? 134
 - 3.5 “Intellectualization” of Protective Relays: Good Intentions or the Road to Hell? 138
 - References 143
- 4. Logic Inputs in Digital Protective Relays 149**
 - 4.1 Reliability of Logic Inputs in DPRs 149
 - 4.2 Increasing Noise Immunity of the Logical Inputs in DPRs..... 155
 - References 158
- 5. Problems with Output Electromechanical Relays..... 161**
 - 5.1 Introduction 161
 - 5.2 The Analysis of Actual Operating Conditions of the Output Relays in Digital Protective Relays 163
 - 5.3 Analysis of the International Standards and Technical Specifications 169
 - 5.4 Improvement of DPR Output Circuits 172
 - 5.5 Conclusions..... 184
 - References 185
- 6. Problems with External Power Supplies 187**
 - 6.1 Electromagnetic Disturbances in the Power Network 187
 - 6.1.1 Blackout..... 187
 - 6.1.2 Noise 187
 - 6.1.3 Sag 188
 - 6.1.4 Spike..... 188
 - 6.1.5 Surge 188
 - 6.2 Applying Uninterrupted Power Supply 189
 - 6.3 Other Problems in the AC Network..... 190
 - 6.3.1 Voltage Sags in Manufacturing Plants’ 0.4 kV Networks..... 191
 - 6.3.2 Voltage Sags in 0.4 kV Auxiliary AC Network 195
 - 6.3.3 Problematic Action of the Powerful Contactors as a Changeover from the Main to Reserved Auxiliary AC Power Supply on Substations 196
 - 6.3.4 Offered Solution for the Problem 198
 - 6.3.5 Conclusion 200
 - 6.4 Problems in DC Networks..... 200
 - 6.4.1 Problems of Power Supplies of DPRs in Emergency Mode 200

- 6.4.2 System for Supervision Substation Battery Connectivity 209
 - 6.4.2.1 Existing Methods for Supervising Substation Battery Connectivity 210
 - 6.4.2.2 Suggested Methods for Supervising Substation Battery Connectivity 212
 - 6.4.2.3 Device for a Supervision Battery Circuit Based on a Nonlinear Shunt 212
 - 6.4.2.4 Using a Standard Shunt as a Current Sensor ... 214
 - 6.4.2.5 Use of the Hall-Effect Sensor in Systems for Supervision Battery Circuits..... 215
 - 6.4.2.6 The Newest Developments and Prospects for Their Application 217
 - 6.4.2.7 Conclusion 220
- 6.4.3 Measures for Improving the Reliability of DC Battery Chargers 220
- References 225

- 7. Testing Digital Protective Relays 229**
 - 7.1 Problems with DPR Testing 229
 - 7.2 New View of the Problem 231
 - 7.3 Modern Test Systems for Digital Protective Relays 233
 - 7.4 Modern RPTS Problems 234
 - 7.5 Offered Solutions 235
 - 7.6 Digital Rate of Change of Frequency Relays and Problems in Testing It 236
 - 7.6.1 What Is the Rate of Change of Frequency Relays? 236
 - 7.6.2 The Algorithm of Frequency and ROCOF Measurements 238
 - 7.6.3 A Suggested Method for Precise ROCOF Measurement and Calibration 240
 - References 242

- 8. Electromagnetic Intrusions on Digital Protective Relays 243**
 - 8.1 Electromagnetic Vulnerability of DPRs 243
 - 8.2 Lightning Strikes..... 246
 - 8.3 Switching Processes and Electromagnetic Fields Generated by Operating Equipment 248
 - 8.4 Issues with Control Cable Shielding 252
 - 8.5 Distortion of Signals in the Current Transformer Circuits..... 257
 - 8.6 Optical-Electronic Currents and Voltage Transformers 264
 - 8.7 The Harmonics Impact on the Measured Current and Voltage on DPRs 271
 - 8.8 The Quality of Voltage in the Supply Mains..... 272

- 8.9 Intentional Destructive Electromagnetic Impacts..... 273
 - 8.9.1 Background..... 273
- References 282
- 9. Alternative (Nondigital) Protective Relays 287**
 - 9.1 Universal Overcurrent Protective Relays 287
 - 9.2 Reed Switches Are New Perspective Elements for Protective Relays 288
 - 9.3 Polarized and Memory Reed Switches 294
 - 9.4 Power Reed Switches 301
 - 9.5 Overcurrent Protective Relays with Reed Switches..... 303
 - 9.6 Simple, Very-High-Speed Overcurrent Protection Relays 308
 - 9.7 Reed-Based Devices for Overcurrent Protection of HV DC Equipment 325
 - 9.8 The New-Generation Universal-Purpose Hybrid Reed: Solid-State Protective Relays 335
 - 9.8.1 Instantaneous Current Relay 337
 - 9.8.2 Instantaneous Current Relay with a High Release Ratio 338
 - 9.8.3 Current Relays with Independent and Dependent Time Delays 340
 - 9.8.4 Relay of a Power Direction 341
 - 9.8.5 Relay of Differential Protection 342
 - 9.8.6 Current Relay with Restraint 342
 - References 346
- 10. Problems with International Standards 347**
 - 10.1 Introduction 347
 - 10.2 The Basic International Standard on Electromechanical Relays (IEC 61810-1)..... 347
 - 10.2.1 Terms and Definitions..... 347
 - 10.2.2 Rated Values of Currents and Voltages 348
 - 10.2.3 The Documentation and Marking..... 350
 - 10.2.4 Test Procedure 352
 - 10.3 The International Standard on Solid-State Relays (IEC 62314-1) 353
 - 10.3.1 Subject and Scope 353
 - 10.3.2 Terms and Definitions..... 357
 - 10.3.2.1 Solid-State Relays 357
 - 10.3.2.2 Rated Insulating Voltage 358
 - 10.3.2.3 Rated Impulse Withstand Voltage 358
 - 10.3.2.4 Rated Operational Current 359
 - 10.3.2.5 Rated Uninterrupted Current..... 359
 - 10.3.2.6 Rated Conditional Short-Circuit Current 360
 - 10.3.2.7 Leakage Current..... 360

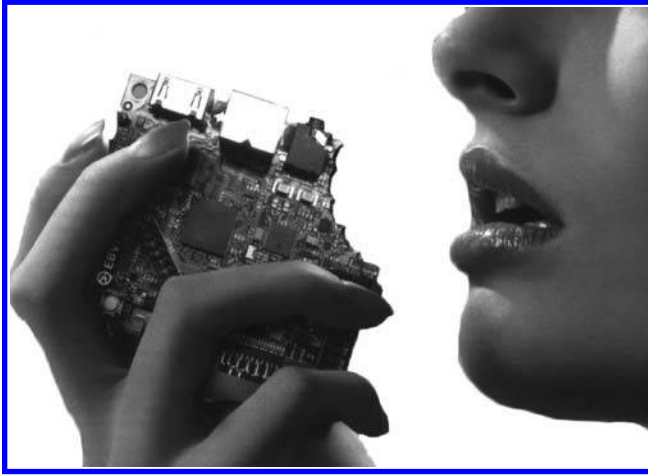
- 10.3.2.8 ON-State Voltage Drop 360
- 10.3.2.9 Functional Insulation and Basic Insulation..... 361
- 10.3.2.10 Solid Insulation..... 361
- 10.3.2.11 Conclusions 362
- 10.3.3 Characteristics of the Solid-State Relay 362
 - 10.3.3.1 Introduction 362
 - 10.3.3.2 Overload Current Profile..... 363
 - 10.3.3.3 Rated Control Circuit Voltage and Rated Control Supply Voltage..... 363
 - 10.3.3.4 Switch-ON Voltage and Switch-OFF Voltage... 364
- 10.3.4 Marking and Documentation 364
- 10.3.5 Construction Requirements 364
- 10.3.6 Tests..... 365
- 10.4 The International Standard on Reed Switches (IEC 62246-1) 365
 - 10.4.1 Scope 365
 - 10.4.2 Terms and Definitions..... 366
 - 10.4.2.1 Introduction 366
 - 10.4.2.2 Reed Switch..... 367
 - 10.4.2.3 Heavy-Duty Reed Switch..... 367
 - 10.4.2.4 Contact Blade 368
 - 10.4.2.5 Wetted Reed Switches 368
 - 10.4.2.6 A Precise Definition of Reed Switches 370
 - 10.4.2.7 Maximum Cycling Frequency..... 370
 - 10.4.2.8 Maximum Contact Current 370
 - 10.4.3 Rated Values 371
 - 10.4.3.1 Section 4.2..... 371
 - 10.4.3.2 Section 4.4..... 371
 - 10.4.3.3 Section 4.5..... 372
 - 10.4.3.4 Section 4.6..... 372
 - 10.4.3.5 Section 4.10 372
 - 10.4.3.6 Section 4.11 373
 - 10.4.3.7 Section 4.12 373
 - 10.4.3.8 Section 4.13 373
 - 10.4.3.9 Section 4.14 373
 - 10.4.3.10 Section 4.16 374
 - 10.4.4 Tests and Measurement Procedures 374
- 10.5 Conclusion..... 380
- References 381
- 11. New Concepts for DPR Design..... 383**
 - References 391

- Index 393**

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.

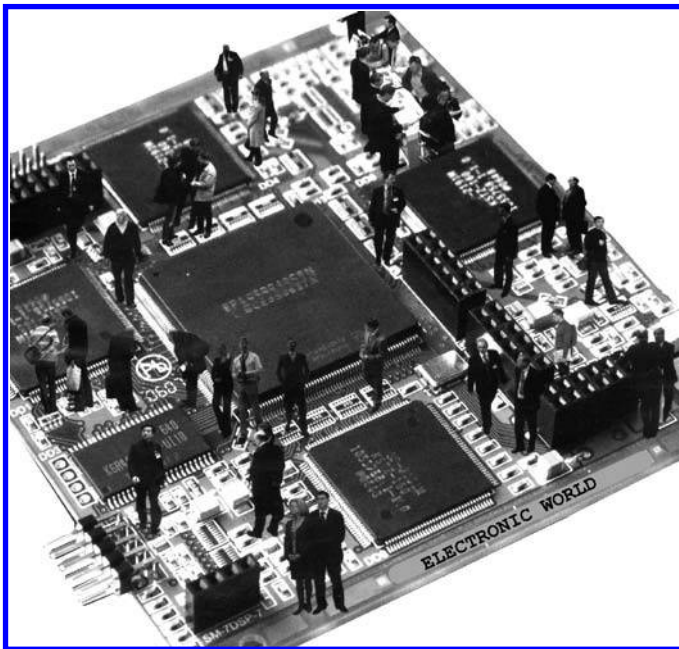
Today protective-relay usage patterns in the world's electric power business continue to grow, with the annual market exceeding \$1.5 billion (all figures this volume given in U.S. dollars unless otherwise indicated), according to a recent study by the Newton-Evans Research Co.² In total, global demand 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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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.

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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*

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