

## BIBLIOGRAPHY OF RELAY LITERATURE, 1995

### IEEE COMMITTEE REPORT

Members of the Bibliography and Publicity Working Group of the IEEE Power System Relaying Committee are:

T.S. Sidhu, Chairman, M. Bajpai, A. Darlington, D. Finley, A.G. Folkman, M. Kezunovic,  
W. Marsh, M.S. Sachdev, J.E. Stephens, M.J. Swanson, S.S. Venkata, and P.B. Winston

**ABSTRACT** - The latest of a series of classified lists of power system relaying references, begun in 1927, is presented. This bibliography is in continuation to the bibliographies of relay literature which were published previously and are contained in the following volumes of the IEEE Transactions:

Bibliography for	Particulars of the Transaction				
	Volume	No.	Year	Page# from to	
1927-1939	60		1941	1435	1447
1940-1943	63		1944	705	709
1944-1946	67	pt. I	1948	24	27
1947-1949	70	pt. I	1951	247	250
1950-1952	74	pt. III	1955	45	48
1953-1954	76	pt. III	1957	126	129
1955-1956	78	pt. III	1959	78	81
1957-1958	79	pt. III	1960	39	42
1959-1960	81	pt. III	1962	109	112
1961-1964	PAS-85	10	1966	1044	1053
1965-1966	PAS-88	3	1969	244	250
1967-1969	PAS-90	5	1971	1982	1988
1970-1971	PAS-92	3	1973	1132	1140
1972-1973	PAS-94	6	1975	2033	2041
1974-1975	PAS-97	3	1978	789	801
1976-1977	PAS-99	1	1980	99	107
1978-1979	PAS-100	5	1981	2407	2415
1980-1981	PAS-102	4	1983	1014	1024
1982-1983	PAS-104	5	1985	1189	1197
1984-1985	PWRD-2	2	1987	349	358
1986-1987	PWRD-4	3	1989	1649	1658
1988-1989	PWRD-6	4	1991	1409	1422
1990	PWRD-7	1	1992	173	181
1991	PWRD-8	3	1993	955	961
1992	PWRD-10	1	1995	142	152
1993	PWRD-10	2	1995	684	696
1994 - Paper # 95 SM 436-6					

96 SM 412-7 PWRD A paper recommended and approved by the IEEE Power System Relaying Committee of the IEEE Power Engineering Society for presentation at the 1996 IEEE/PES Summer Meeting, July 28 - August 1, 1996, in Denver, Colorado. Manuscript submitted April 15, 1996; made available for printing April 23, 1996.

The papers listed include references to the subjects of service restoration, testing and methods of calculation, as well as to the field of relaying. Only the more readily available foreign publications are included.

Each reference includes the title, author, publication information, and a very brief summary of the subject matter. The listing of the titles is subdivided into ten sections, depending upon the general substance of each article. The section titles are as follows:

- 3150 RELAYING ALGORITHMS
- 3151 DISTRIBUTION AND NETWORK PROTECTION
  - 3151.1 Industrial and Power Station Auxiliaries
  - 3151.2 Primary Distribution Systems
- 3152 TRANSMISSION LINE PROTECTION
  - 3152.1 Distance and Ground Relaying
  - 3152.2 Relay Communications
  - 3152.3 Relay Systems
- 3153 RELAY INPUT SOURCES
- 3154 ROTATING MACHINERY PROTECTION
- 3155 OTHER PROTECTION
  - 3155.1 Transformer and Reactor Protection
  - 3155.2 Capacitor Bank and Static Var Protection
  - 3155.3 Other Protection
- 3156 FAULT AND SYSTEM CALCULATIONS
- 3157 MAINTENANCE, TESTING, ANALYSIS, AND MODELING
- 3158 STABILITY, OUT OF STEP, RESTORATION
- 3159 SURGE PHENOMENA

The entries in each section are listed in alphabetical order by the name of the first author. Each title is listed in only one section even if it covers material that belongs to several sections. A list of the periodicals which have been cited and the addresses of their publishers follows the bibliography.

The abstracts of many articles reported in this paper are available in the Science Abstracts - Section B, the Engineering Index, and other digesting and/or indexing periodicals.

#### ADDITIONAL REFERENCES

Electrical & Electronics Abstracts, are published monthly by the Institution of Electrical Engineers (U.K.) and the Institute of Electrical and Electronics Engineers, Inc. (USA).

Papers and journals published in several countries are covered.

### 3150 RELAYING ALGORITHMS

Neural Network Approach to Fault Classification for High Speed Protective Relaying, T. Dalstein, B. Kulicke, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 1002-11. A selector module consisting of 4 neural networks can classify a fault or no fault load condition within 8 ms. It also classifies fault as arcing or non-arcing in order to allow reclosing only after an arcing fault.

An Algorithm for Frequency Relaying Based on the Newton-Raphson Method, M. B. Djuric, V. V. Terzija, Electric Power Systems Research, Vol. 31, 1994, p 119-24. This paper presents a new digital algorithm for real-time estimation of the frequency at a power system bus.

High-Speed Fault Detection and Classification with Neural Nets, M. Kezunovic, I. Rikalo, D. J. Sobajic, Electric Power Systems Research, Vol. 34, 1995, p 109-16. This paper introduces a new neural net (NN) approach for automated fault disturbance detection and classification.

New Pole Slipping Protection Algorithm for Dispersed Storage and Generation Using Equal Area Criterion, M. A. Redfern, M. J. Checkfield, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 194-202. The algorithm uses real power and its rate of change, and reactive power to detect when the machine is committed to a pole slip, and initiate tripping before the pole slip occurs.

Design, Implementation, and Testing of an Artificial Neural Network-Based Fault Direction Discriminator for Protecting Transmission Lines, T. S. Sidhu, H. Singh, M. S. Sachdev, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 697-706. The paper proposes use of ANNs to solve the problem of fault direction discrimination. Testing by simulated and field recorded data show correct output within 2.4 ms. Direction indication is not affected by the type of fault, power flow, source impedance, and fault resistance.

A New Self-Tuning Algorithm for the Frequency Estimation of Distorted Signals, V. Terzija, M. Djuric, B. Kovacevic, IEEE Trans. on Power Delivery, Vol. 10, No. 4, Oct 1995, p 1779-85. This paper describes an algorithm that uses least error square technique along with the updating procedure for estimating the power system frequency. Some test results are also included in the paper.

### 3151 DISTRIBUTION AND NETWORK PROTECTION

#### 3151.1 Industrial and Power Station Auxiliaries

Critical Considerations for Utility/Cogeneration Inter-Tie Protection Scheme Configuration, R.M. Rifaat, IEEE Trans.

on Industry Applications, Vol. 31, No. 5, 1995, p 973-7. This paper discusses special considerations that must be given to inter-tie protection systems. Typical inter-tie configurations and their protection schemes along with advantages and disadvantages are presented. The importance of examining protection scheme requirements during the conceptual design stage is demonstrated.

#### 3151.2 Primary Distribution Systems

Adaptive Applications for Microprocessor Based Distribution and Transformer Protection Systems, D. Aronson, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. This paper presents a protection, control, metering, monitoring, and communications system utilizing multiple microprocessors for electric power distribution systems. Radial feeder protection, bus protection, and a multifunction transformer relay are part of the system.

Adaptive Application for Microprocessor Based Distribution and Transformer Protective Systems, D.L. Aronson, G. Payne, 48th Annual Texas A&M Conference for Protective Relay Engineers, April 3-5, 1995. This paper presents a protection, control, metering, monitoring, and communications system utilizing multiple microprocessors for electric power distribution systems. A common platform for multifunction distribution relay that provides feeder and bus protection and a multifunction transformer relay that provides transformer and bus protection is discussed.

Overcurrent Protection Alternatives for Underground Distribution Systems, M. T. Bishop, A. G. Jones, W. F. Israel, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 252-7. This paper describes pad mounted vacuum fault interrupter switchgear with electronic trip control to provide fault protection, faster restoration of service, and automatic service restoration for supply system interruptions. Three phase operation may be desirable depending on type of customer load.

Effectiveness of Distribution Backup Ground Protection, J.R. Boyle, 49th Annual Georgia Tech Protective Relaying Conference, May 3-5, 1995. This paper deals with how a varied mix of impedances and loads can greatly influence the magnitude and duration of transients. Also analyzed is the influence that transient harmonics play in the performance of backup ground relays connected in the transformer neutral circuit.

Prony's Method: An Efficient Tool for the Analysis of Earth Fault Currents in Petersen-Coil-Protected Networks, O. Chaari, P. Bastard, M. Meunier, IEEE Trans. on Power Delivery, Vol. 10, No. 3, Jul 1995, p 1234-41. Prony's method is presented for determining location and type of earth faults in Petersen-coil-protected 20 kV networks. The

variation of Prony's parameters for different system and fault conditions is also studied.

Citizens Protected from Downed Lines, B. Cole, Transmission & Distribution, Vol. 47, No. 9, Sep 1995, p 78. City of Norcross, GA uses safety yoke installed on OH distribution line to intercept falling conductor and provide low impedance fault path detectable by circuit relays.

Distribution Line Protection Practices Industry Survey Results, IEEE Committee Report, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 176-86. The results of the recent industry survey are analyzed and discussed. The advantages of indicated changing trends are discussed. Of significance are changes to reduce customer complaints from momentary interruptions and blinking lights.

Protection and Control Design for Distribution Stations, B.W. Jackson, M.K. Boughman, 49th Annual Georgia Tech Protective Relaying Conference, May 3-5, 1995. Discussed in this paper is an effort to take advantage of new technology in order to improve the reliability to the customer by utilizing microprocessor relays and computer controlled equipment in the redesign of distribution stations.

A Novel Approach to Handle the Cold Load Pickup Problem, O.H. Mirza, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper presents a theory that is applicable to all microprocessor based overcurrent protective devices used at the distribution level in order to provide a possible method to handle cold load pickup problems at line reclosers installed on the distribution system.

Signatures and Software Find High-Impedance Faults, R. Patterson, IEEE Computer Applications in Power, Vol. 8, No. 3, Jul 1995, p 12-5. This paper describes how the use of modern digital and software technologies have enabled a practical solution for detecting a high percentage of high-impedance faults.

Performance of High-Impedance Fault Detection Algorithms in Long-Term Field Trials, B. D. Russell, Carl L. Benner, Electric Power Systems Research, Vol. 31, 1994, p 71-7. Researchers at Texas A&M University's Power System Automation Laboratory have tested the long-term performance of high-impedance fault detection algorithms at five utilities. This paper summarizes the test results.

Arcing Fault Detection for Distribution Feeders: Security Assessment in Long Term Field Trials, B. D. Russell, C. L. Benner, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 676-83. This paper is an update of the Texas A & M University work on high impedance fault detection. The paper gives the results of five relays installed on feeders of five utilities, and 62 staged downed conductor tests.

Adaptive Relaying for Ground Fault Protection of a Distribution Network, M.S. Sachdev, T.S. Sidhu, B.K. Talukdar, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. This paper reports developments in the second phase of a project for designing an adaptive protection system for the City of Saskatoon's distribution network. Software modules for achieving adaptive capabilities for ground fault protection are described. Results from system studies are also included.

Design and Evaluation of an Adaptive Protection System for a Distribution Network, M. S. Sachdev, T. S. Sidhu, B. Chattopadhyay, B. Talukdar, G. McDonald, R. Chan, CIGRE, Jun 11-17, 1995, Paper No. 34-202. This paper describes an adaptive protection system designed for the "City of Saskatoon" distribution network.

System Considerations in the Application of Reclosers, D.A. Walder, L. Kojovic, 49th Annual Georgia Tech Protective Relaying Conference, May 3-5, 1995. Technology improvements in the design of automatic circuit reclosers allow for coordination flexibility in the application of the devices in series. This paper describes how the use of this technology may improve system performance.

## 3152 TRANSMISSION LINE PROTECTION

### 3152.1 Distance and Ground Relaying

Application of Phase and Ground Distance Relays to Three Terminal Lines, G.E. Alexander, J.G. Andrichak, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper discusses many of the issues related to the application of distance relays to the protection of three terminal lines. Although such an application is more complex, in certain configurations adequate protection is possible.

Evolution of Distance Relaying Principles, W. Elmore, F. Calero, L. Yang, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper describes the evolution and principles of one lineage of distance relaying concepts that build up to a new concept for transmission line distance protection. The numerical comparator is discussed along with several advantages over present techniques.

Useful Applications for Negative-Sequence Overcurrent Relaying, A.F. Elneweihi, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper presents some practical applications on the B.C. Hydro system where negative-sequence overcurrent elements offer a much better sensitivity than zero-sequence elements in detecting some single-line-to-ground faults.

Consideration for the Design and Application of Ground Distance Relays, A.T. Giuliante, J. E. McConnell, S.P.

Turner, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. How ground distance relays are designed and applied is discussed. The limitations of the classic R-X diagram introduces an alternative technique using fault record data available in most microprocessor relays.

New Technique for the Accurate Location of Earth Faults on Transmission Systems, A.T. Johns, P.J. Moore, R. Whittard, IEE Proceedings-C, Vol. 142, No. 2, 1995, p 119-27. An algorithm for protecting transmission lines for resistive ground faults is proposed. The algorithm is insensitive to variations in source impedances. Some results from the application of the proposed algorithm to a 400 kV transmission line are given.

New Directional Element for Numerical Distance Relays, P. G. McLaren, G. W. Swift, Z. Zhang, E. Dirks, R. P. Jayasinghe, I. Fernando, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 666-75. The paper discusses a new directional element based on positive sequence voltage and current changes caused by the fault. Successful operation has been demonstrated in relays installed on the Manitoba Hydro network.

A New Blocking Principle with Phase and Earth Fault Detection During Fast Power Swings for Distance Protection, A. Mechraoui, D.W.P. Thomas, IEEE Trans. on Power Delivery, Vol. 10, No. 3, Jul 1995, p 1242-8. This paper presents a power swing blocking principle that has ability to immediately clear the block when a fault occurs within the relay trip zone. Simulation results are included.

Limits to the Sensitivity of Ground Directional and Distance Protection, J. Roberts, E.O. Schweitzer, III, R. Arora, E. Poggi, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. Relay designers have used analog and digital electronic technology to advance the sensitivity of protective relays while simultaneously decreasing the instrument transformer burden. The fact is that with today's technology, the sensitivity of the settings is not generally limited by the relays. This paper addresses some of the issues related to this problem.

Real-Time Assessment of a Symmetrical Component and Microcontroller Based Distance Relay, D. L. Waikar, S. Elangovan, A. C. Liew, S.H. Sng, Electric Power Systems Research, Vol. 32, 1995, p 107-12. This paper presents the design, implementation and real-time assessment of a microcontroller based digital distance relay that can be used for the protection of power transmission lines.

Second- and Third-Zone Performance Assessment of a Symmetrical Component Based Improved Fault Impedance Estimation Method, D. L. Waikar, A. C. Liew, S. Elangovan, Electric Power Systems Research, Vol. 32, 1995, p 113-20. A brief review of the symmetrical component

based fault impedance estimation method that has previously been proposed by the authors is discussed in this paper.

### 3152.2 Relay Communications

Power Line Carrier Practices and Experiences, IEEE Committee Report, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 639-46. The paper describes the results of a 1990 survey of utility PLC experiences and application practices. Equipment selection, maintenance, and problems are discussed.

Survey of Optical Channels for Protective Relaying Practices and Experiences, IEEE Committee Report, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 647-58. The results of a 1991 survey of utility optical channel users are discussed. Information on existing and planned installations is given.

JEA's Application of Protective Relaying on Digital Communication Systems, V.A. Monfort, V.M. Kamath, L.E. Jones, 49th Annual Georgia Tech Protective Relaying Conference, May 3-5, 1995. This paper addresses the concerns, problems, and solutions JEA implemented to construct a communications network that would serve the critical operational needs of protective relaying, and at the same time provide the large capacity required by corporate communications needs.

### 3152.3 Relay Systems

Laboratory Investigation of a Digital Protection Technique for Parallel Transmission Lines, M. I. Gilany, O. P. Malik, G. S. Hope, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 187-93. The proposed relay uses a fast data acquisition system to obtain data from each terminal of parallel lines. The technique avoids mutual coupling and current/voltage reversal problems. The relay has been studied for all types of faults, reclosing, and line charging on a physical laboratory system model.

High Speed Phase Segregated Line Differential Relay, H. Patterson, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. This paper describes a complete line terminal for protecting lines. The performance of the terminal is maximized by evaluation of the whole information in the opposite terminal currents and its reliability is enhanced by an integral distance protection independent of communication.

A New Approach to a Line Protection Terminal With Adaptive Features, K. Wikstrom, K. Kuras, C. Ohlen, J. Zakonjsek, CIGRE, Jun 11-17, 1995, Paper No. 34-208. This paper describes the evolution of microprocessor based line distance protections into "intelligent transmission line terminals" using a modularized standard multiprocessor

hardware platform to custom design a terminal to a certain application.

### 3153 RELAY INPUT SOURCES

Ferroresonant Oscillations in Capacitor Voltage Transformers, S.K. Chakravathy, C.V. Nayar, IEE Proceedings-C, Vol. 142, No. 1, 1995, p 30-6. This paper proposes the use of integral form of system equations to determine different types of ferroresonant oscillations. The periodicity of these oscillations can be determined by plotting the temporal evolution of the state variables.

Integrated Optics Pockels Cell High-Voltage Sensor, N.A.F. Jaeger, F. Rahmatianr, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 127-34. An integrated optics version of the Pockels cell is very small, immune to electromagnetic interference, and does not need earthquake proofing. Samples with a 1 MHz bandwidth have been fabricated, capable of measuring lightning impulses. They show promise in replacing conventional VTs.

A Prototype Clamp-on Magneto-Optical Current Transducer for Power System Metering and Relaying, J. Song, P.G. McLaren, D.J. Thomson, R.L. Middleton, IEEE Trans. on Power Delivery, Vol. 10, No. 4, Oct 1995, p 1764-70. This paper presents the theoretical background, design, and testing of a new type of Faraday effect based magneto-optical current transducer.

Experience with Optical PT's and CT's at 500kV for Relaying and Metering, J. Tillett, J. Pease, J. Hall, D. Bradley, J. Nordstrom, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper discusses the evaluation of 500kV optical voltage and current transducers that are part of the Advanced Substation Project. The equipment from two manufacturers were purchased for evaluation.

Bus Differential Protection with a Combination of Ct's and Magneto-Optic Current Transducers, E.A. Udren, T.W. Cease, P.M. Johnston, K. Faber, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper describes the design and testing of a microprocessor-controlled bus-differential relaying system which permits using mixed input sources. All of the dependability and security of the original scheme is retained as the ct's are replaced.

### 3154 ROTATING MACHINERY PROTECTION

Novel Approach to Alternator Field Winding Interturn Fault Detection, D.W. Auckland, I.E.D. Pickup, R. Shuttleworth, Y.-T. Wu, C. Zhou, IEE Proceedings-C, Vol. 142, No. 2, 1995, p 97-102. A neural network is employed to predict the field current from measurements at the stator terminals. The predictions can be used to identify operation with a faulted

rotor. Test results from a laboratory micromachine are given.

A Microprocessor Relay Used for a Cogenerator, J.A. Brogan, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper presents one utility's solution to a unique cogeneration request by a customer. Also discussed are some of the problems identified during testing and installation. The application solution emphasizes the flexibility of microprocessor relays.

Neural Networks Aided On-Line Diagnostics of Induction Motor Rotor Faults, F. Filippetti, G. Franceschini, C. Tassoni, IEEE Trans. on Industry Applications, Vol. 31, No. 4, 1995, p 892-9. Induction machine rotor fault diagnosis based on a neural network approach is presented. Training of the network is achieved by data obtained through experimental tests on healthy machines and through simulations of faulted machines.

Upgrading Generator Protection Using Digital Technology, C.J. Mozina, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. This paper presents the reasons and areas in which utilities as well as non-utility generator owners should consider upgrading the electrical protection of their generators to meet today's standards. The advantages of digital versus conventional technology for such an upgrade program are given.

### 3155 OTHER PROTECTION

#### 3155.1 Transformer and Reactor Protection

Neural Network-Based Algorithm for Power Transformer Differential Relays, P. Bastard, M. Meunier, H. Regal, IEE Proceedings-C, Vol. 142, No. 4, 1995, p 386-92. A neural network-based algorithm for protecting a single-phase transformer is proposed. Training cases are generated using empty simulations. The proposed algorithm is compared with a conventional differential algorithm.

A Multi-Criteria Differential Transformer Relay Based on Fuzzy Logic, A. Wiszniewski, B. Kasztenny, IEEE Trans. on Power Delivery, Vol. 10, No. 4, Oct 1995, p 1786-92. This paper presents a digital relay scheme for protecting power transformers. Decision making is done by using a multi-criteria algorithm based on fuzzy sets. Test examples showing performance of the relay are also included in the paper.

Artificial Neural Network Based Protection of Transformers, M.R. Zaman, M.A. Hoque, M.A. Rahman, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. This paper describes the use of artificial neural networks to distinguish between magnetizing inrush and internal fault currents of a power transformer. Results from a laboratory prototype are included in the paper.

### 3155.2 Capacitor Bank and Static Var Protection

Static Var Compensator Protection, IEEE Committee Report, IEEE Trans. on Power Delivery, Vol. 10, No. 3, Jul 1995, p 1224-33. This paper presents Static Var Compensator (SVC) protection practices, describes different protection functions applicable to SVCs and outlines testing of SVC protection systems. Interaction of SVCs with the power system and its impact on protection is discussed.

### 3155.3 Other Protection

Bus Differential Protection, J.G. Andrichak, J. Cardenas, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. A variety of methods have been used to implement bus differential relaying schemes. The introduction of digital technology has led to further improvements in bus differential protection. This paper reviews the various methods that have been used and discusses improvements that can be provided via digital technology.

Applied Adaptive Protection Practices Based on Data Transmission Between Relays, J. Eisman, G. Gomez, J. Torres, CIGRE, Jun 11-17, 1995, Paper No. 34-207. This paper describes adaptive relay settings based on information available from other digital relays in the substation, and adaptive practices that provide improved backup relay settings in case of a relay failure.

The DC System: Heart of a Protective Relaying Scheme, C.D. Fate, D.F. Coerber, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. The purpose of this paper is to review the design and application of a DC system, including battery and charger sizing, dc distribution system protection and dc design criteria for reliability.

Protection and Control Design for Distribution Stations, B.W. Jackson, M.K. Boughman, 49th Annual Georgia Tech Protective Relaying Conference, May 3-5, 1995. Discussed in this paper is an effort to take advantage of new technology in order to improve the reliability to the customer by utilizing microprocessor relays and computer controlled equipment in the redesign of distribution stations.

Adaptive Relaying - An Application View, G. Koch, CIGRE, Jun 11-17, 1995, Paper No. 34-203. This paper discusses the impact of adaptive relaying on today's relay practice and some practical applications for performance enhancement and simplification of traditional adaptive schemes.

Adaptive Protection and Control, A. G. Phadke, CIGRE, Jun 11-17, 1995, Paper No. 34-212. This paper is a study of adaptive protection and control, and is based on the report of Working Group 34.02 of CIGRE.

Gas Evolving Materials for Improved Low Current Interruption in High Voltage Current Limiting Fuses, J. J. Shea, W. R. Crooks, J. D. B. Smith, IEEE Trans. on Power

Delivery, Vol. 10, No. 1, Jan 1995, p 258-65. New compounds lower the interrupting current limit by a combination of gas species evolved, increased local pressure, and by not forming any carbon residues. Compounds, test methods, evaluation, and short circuit tests are described.

Adaptive Protection - Potential and Limitations, W. Winkler, A. Wiszniewski, CIGRE, Jun 11-17, 1995, Paper No. 34-206. This paper discusses the scope of adaptive protection, what are conditions needed to apply adaptivity, and to what extent adaptive relaying is needed in contemporary power systems.

### 3156 FAULT AND SYSTEM CALCULATIONS

Inter and Intra Substation Communications: Requirements and Solutions, M.G. Adamiak, R.C. Patterson, J. Melcher, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper presents an outline of the communication requirements of the myriad of IED's in existence in the substation today as well as the expectations of what the second generation microprocessor based devices might be able to do.

Evaluation of a Phasor-Based Fault Location Algorithm, G.E. Alexander, J.M. Kennedy, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. Fault location calculations based on quantities from a single line terminal are subject to errors that can not be completely eliminated by settings in the algorithm. This paper discusses how a much better estimate can be obtained when currents from other lines and/or from other terminals are used.

Removal of DC-Offset in Current Waveforms Using Digital Mimic Filtering, G. Benmouyal, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 621-30. Some line relays have a tendency to overreach in the presence of dc offset components in the fault current. This paper shows that by using the exact digital replica of a mimic circuit, the exponentially decaying component of a current can be removed. An analysis of the performance of some popular relaying digital filters is included.

Fuzzy-Set Approach to Fault-Type Identification in Digital Relaying, A. Ferrero, S. Sangiovanni, E. Zappitelli, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 169-75. Digital relays may have difficulty in determining whether a ground fault involves one conductor or two. A simple fuzzy procedure involving the ratios of symmetrical component currents is described.

Fault Analysis of Multi-Phase Unbalanced Nonradial Power Distribution Systems, S.M. Halpin, L.L. Grisby, IEEE Trans. on Industry Applications, Vol. 31, No. 3, 1995, p 528-34. Algorithms are presented for the accurate determination of voltages, currents, and power flows in faulted three-phase unbalanced non-radial power distribution systems. Results

obtained using the proposed algorithms are compared with those obtained from an existing conventional three-phase fault analysis algorithm.

Synchronised Sampling Improves Fault Location, M. Kezunovic, B. Perunicic, IEEE Computer Applications in Power, Vol. 8, No. 2, Apr 1995, p 30-3. This paper describes a fault location technique that uses synchronised voltage and current samples. The technique can be implemented either as a simple add-on to DFRs or as a stand-alone relaying function.

Fault Location Using Digital Relay Data, D. Novosel, D.G. Hart, E. Udren, M.M. Saha, IEEE Computer Applications in Power, Vol. 8, No. 3, Jul 1995, p 45-50. This article discusses one-terminal and two-terminal data algorithms for locating transmission line faults. Some results from evaluation of these algorithms are also included.

Adaptive Features in Line Fault Location Processes, L. Philippot, J. C. Maun, CIGRE, Jun 11-17, 1995, Paper No. 34-201. The paper discusses the different fault locator algorithms, development trends in fault location, and advantages of adaptive features in the automated process leading to fault diagnosis.

Digital Simulation of Fault Location on EHV Lines Using Wideband Spread Spectrum Techniques, V. Taylor, M. Faulkner, A. Kalam, J. Haydon, IEE Proceedings-C, Vol. 142, No. 1, 1995, p 73-80. This paper proposes to transmit a direct sequence signal down a faulted EHV line by using the existing PLC equipment. The fault position may then be estimated by correlation analysis of the reflected waveforms. The proposed fault location process has been simulated on a digital computer and result indicate the fault locations are within 0.5 km.

A Distribution Short Circuit Analysis Approach Using Hybrid Compensation Method, X. Zhang, F. Soudi, D. Shirmohammadi, C. Cheng, IEEE Trans. on Power Systems, Vol. 10, No. 4, 1995, p 2053-9. This paper describes a short circuit analysis method that uses a hybrid compensation method to account for loops, PV nodes, and fault currents simultaneously. The approach is suitable for radial and weakly meshed distribution networks.

Three-Phase Circuit Analysis and the Mysterious Ko Factor, S.E. Zocholl, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper is a tutorial on the three-phase analysis of the transmission line circuit and is of the scale that can be easily implemented on a PC using a readily available math program.

### 3157 MAINTENANCE, TESTING, ANALYSIS, AND MODELING

Development of a New Fault Location System for Multi-Terminal Single Transmission Lines, M. Abe, N. Otsuzuki, T. Emura, M. Takeuchi, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan 1995, p 159-68. An algorithm synchronizes asynchronously sampled data from each terminal. Another algorithm converts the multi-terminal system to a 2-terminal system containing the fault. EMTP simulation results are presented.

Field Experience with Advanced Protective Relay Testing, J. Amantegui, J. M. Gallastegui, J. L. Martinez, M. Agrasar, F. Uriondo, J. R. Hernandez, CIGRE, Jun 11-17, 1995, Paper No. 34-109. This paper describes the extent and experience in the use of automatic protection equipment testing procedures.

Interfacing a Relay Settings Database with an Automated Relay Testing Program, D. Angell, C. Harris, D. Porter, M. Enns, D. Loudermilk, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper presents Idaho Power's automated protective relay testing history, test routine development, data base additions, data handling between the data base and the test program, technician access to the data, and experience with the system.

DTNA: A Digital Transient Network Analyzer for Testing Protection and Control Devices, L. Barretta, E. Panzeri, N. Scarabottolo, CIGRE, Jun 11-17, 1995, Paper No. 34-106. Requirements for implementing a real-time digital simulator of power networks for the closed-loop testing of protection and control systems are described.

Substation Relay Data and Communication, K.C. Behrendt, M.J. Dood, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper discusses the importance of digital relay data, the evaluation in communication interface development to meet user information needs, and some practical applications for integrated substation relay data using various communication media.

Met Ed Relaying System Uses PLCs, J.J. Deane, T.H. Groscup, Transmission & Distribution, Vol. 47, No. 4, Apr 1995, p 33-4. A training program for people involved in designing and installing PLC-based substation control schemes is described.

A Team Evaluation of a Digital Feeder Monitor, M.D. Diehl, R.F. Hoad, R.H. Jones, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper presents a utility perspective as to their involvement in the design and evaluation of the GE Digital Feeder Monitor. Described are the test procedures used, experience gained to

date, and the rationale for requesting some of the unique features.

The Use of Software Tools for Investigating the Performance of Power System Protection, J. A. Downes, J. L. H. Goody, B. J. Gwyn, CIGRE, Jun 11-17, 1995, Paper No. 34-111. The paper describes experience with software tools for relay application studies and investigations of faults, and also describes work done on automating the analysis of digital fault records.

GPS Satellite Synchronized Test System Simulates Faults on Transmission Lines, S.B. Francis, Jr., N. Farrar, S.I. Thompson, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. The testing and calibration of protective relaying has historically been performed during cut-in and periodic testing. Using GPS synchronized test systems actual simulated faults can be imposed on the relays to determine functionality.

Distribution and Transmission Fault Analysis Using Digital Fault Recorders and the National Lightning Detection Network, M.M. Gonzalez, D.R. Sevcik, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. This paper presents one utility's experience in using the National Lightning Detection System to identify and locate problems on their electric system. A description of the LDS system is included in the paper.

Power System Monitoring and Control Facilities on Protective Relays, S.M. Haden, 48th Annual Texas A&M Conference for Protective Relay Engineers, Apr 3-5, 1995. As newer protective relays increase in power and therefore their ability to do more than the traditional function of protection, the question arises as to integration of these devices into the control functions of the substation. This paper addresses some of these issues and proposes some advantages of this approach.

Overcurrent Protection Co-ordination: A Modern Approach for Modern Devices, P.J. Hindle, J.V.H. Sanderson, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. An approach to overcurrent relay coordination is proposed which is able to take advantage of improved performance of modern protective devices. The method can deal with mixture of new and old equipment and justifies reduced time margins in many difficult applications.

Capacitive Voltage Transformers: Transient Overreach Concerns and Solutions for Distance Relaying, D. Hou, J. Roberts, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper discusses CVT models whose purpose is to identify which major CVT components contribute to the CVT transient which can be a concern with high speed microprocessor relays. The paper also reviews how the Source Impedance Ratio (SIR) affects CVT transient response and discusses improvements in relay logic.

A Real Time Digital Transient Network Analyser for Testing Equipment on a General Purpose Computer, M. Jerosolimski, D. Descause, O. Devaux, O. Huet, L. Levacher, B. Meyer, CIGRE, Jun 11-17, 1995, Paper No. 34-104. The Digital Transient Network Analyzer (DTNA), a fully digital real-time transients simulator that runs on a standard, multi-purpose parallel computer is presented.

Results of GPS Satellite Synchronized End to End Transient Simulation and Dynamic State Tests on 500kV and 750kV Circuits, J. A. Jodice, K. Carr, Y. Knobel, A. Molkov, E. Savchenko, V. Sokolov, CIGRE, Jun 11-17, 1995, Paper No. 34-112. The paper describes new methods for analyzing overall protection and communications system performance, and their application on transmission circuits.

Simulation and Test of Protection in FACTS Environment, R. Krebs, D. Retzman, G. Ziegler, CIGRE, Jun 11-17, 1995, Paper No. 34-105. This paper discusses protection issues related to FACTS (Flexible AC Transmission Systems).

Predicting the Optimum Routine Test Interval for Protective Relays, J. J. Kumm, M. S. Weber, D. Hou, E. O. Schweitzer, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995, p 659-65. The paper introduces a new statistical model that is applicable to protective relays with and without automatic self-test functions. Abnormal unavailability for a power system protected by traditional relays and one protected by digital relays is compared.

Relay Performance Considerations with Low-Ratio CT's and High-Fault Currents, J.R. Linders, C.W. Barnett, J.W. Chadwick, Jr., P.R. Drum, K.J. Khunkhun, W.C. Kotheimer, P.A. Kotos, D.W. Smaha, J.W. Walton, P.B. Winston, S.E. Zocholl, IEEE Trans. on Industry Applications, Vol. 31, No. 2, 1995, p 392-404. The significance and consequences of using low-ratio CT's and the accompanying saturation during high-fault currents are discussed. Considerations when testing low-ratio CT applications for saturation, alternate CT connections and corrective alternatives are presented along with conclusions to aid in resolving low-ratio/high-fault current situations.

Modern Facilities for Laboratory Testing of Modern Protective Relays, R. J. Marttila, CIGRE, Jun 11-17, 1995, Paper No. 34-103. This paper examines experiences in testing relays to demonstrate new approaches to relay testing, desired capabilities of test equipment, philosophy of testing, importance of testing, and real-time digital simulation.

Relay Database Design, J. McClain, S.M. Chan, D. Choe, IEEE Computer Applications in Power, Vol. 8, No. 3, Jul 1995, p 16-20. This article describes several existing relay database designs and their advantages and disadvantages. A new database model is proposed which is easy to use and can accommodate a wide variety of relays.



EMTP Used in Testing of a Protection Scheme for Series Compensated Network, C. Ohlen, J. Esztergalyos, G. Nimmesjo, M. Saba, CIGRE, Jun 11-17, 1995, Paper No. 34-110. This paper describes the development and evaluation of micro-computer based transmission line protection on the Bonneville Power Administration's 500kVAC Pacific Northwest - Southwest Intertie using EMTP simulations.

Computer Based Harmonic Simulation and Testing for Directional-Overcurrent Relays, R. A. Rob, W. T. Jewell, A. Teshome, Electric Power Systems Research, Vol. 31, 1994, p 125-35. This paper discusses a unique simulation method to study harmonics using a computer based three-phase harmonic source, programmable three-phase voltage and current amplifiers, a digital-to-analog interface board, and a computer program.

Synchronised End-to-End Tests on Protective Relay Schemes, B. Ryan, J. Littaman, IEEE Computer Applications in Power, Vol. 8, No. 4, Oct 1995, p 20-5. This paper describes simultaneous secondary injection tests for evaluating the performance of communication-based protection schemes. Synchronisation is achieved using public domain satellite time signals.

Adapted Philosophy for Maintenance Testing on Digital Protection, L. Simoens, Z. Kaminski, F. Wellens, CIGRE, Jun 11-17, 1995, Paper No. 34-102. This paper analyzes the current maintenance policy for protection in Belgium as well as the evolution for digital protection in the near future.

Modelling and Simulation for Protection, D. Simpson, W. D. Humpage, CIGRE, Jun 11-17, 1995, Paper No. 34-101. A software system for electromagnetic transient analysis based on the z-plane transform sequence is described.

A Developmental Package of Interactive Software for Illustrating Power System Protection Principles in Educational and Industry Training Programs, H.A. Smolleck, H. Chen, S. Badruzzaman, R. Bravo, D. Pardave, IEEE Trans. on Power Systems, Vol. 10, No. 1, 1995, p 34-43. This paper describes the philosophy, development and use of a series of microcomputer-based interactive software packages which assist in the analysis and demonstration of some fundamental concepts associated with power system protection and related areas. The modules are applicable to both academic power programs and industry training efforts.

Protection and Control Testing Opportunities for Modularised Bay Secondary Equipment Located in Transportable Bay Kiosks, J. M. Theunissen, R. Niemack, G. C. Oosthuysen, B. Young, CIGRE, Jun 11-17, 1995, Paper No. 34-108. The paper describes the approaches taken in establishing testing requirements and procedures, and developing simulation equipment for modular architecture relay equipment.

Simulation and Testing Methods for Power System Stabilizing Protection, K. Yanagihashi, T. Furuta, K. Kawata, I. Mitani, S. Azuma, R. Takeuchi, F. Iwatani, CIGRE, Jun 11-17, 1995, Paper No. 34-107. This paper reviews digital and analog simulation methods used for developing and testing of stabilizing protection.

Transformer Modeling as Applied to Differential Protection, S.E. Zocholl, 22nd Annual Western Protective Relay Conference, Oct 24-26, 1995. This paper presents a power transformer model to evaluate differential element performance. The paper analyzes transformer energization, overexcitation, external fault, and internal fault conditions with this model.

### 3158 STABILITY, OUT OF STEP, RESTORATION

Out-of-Step Prediction Based on Artificial Neural Networks, A. Y. Abdelaziz, M. R. Irving, A. M. El-Arabaty, M. M. Mansour, Electric Power Systems Research, Vol. 34, 1995, p 135-42. This paper presents a new approach to the prediction (detection) of out-of-step synchronous generators based on artificial neural networks (ANNs).

Intelligent Reclosing for Overdutied Breakers, A. P. Apostolov, J. D. Bronfeld, M. W. Feltis, IEEE Trans. on Power Delivery, Vol. 10, No. 1, Jan. 1995, p 153-8. Breaker trip with fault current control and sequential tripping, combined with reclosing control based on fault current magnitude, may be an economical solution to the overdutied breaker problem. A microprocessor relay with programmable logic is described.

Adaptive Load Shedding for Industrial Power Networks, K. P. Brand, D. Weissgerber, CIGRE, Jun 11-17, 1995, Paper No. 34-209. This paper discusses load shedding selectively adapted to the real load and supply situation to preserve maximum availability of the power system.

A New Approach to the Arcing Faults Detection for Fast Autoreclosure in Transmission Systems, M.B. Djuric, V.V. Terzija, IEEE Trans. on Power Delivery, Vol. 10, No. 4, Oct 1995, p 1793-8. Features of a long arc in the air are used as the basis in the algorithm design to avoid automatic reclosing on permanent faults. Simulation studies show that the algorithm can be used for arcing fault detection.

Experience of Adaptive Auto-reclosure Relay using Data Recorded from EHV Line Faults by ESKOM, D. S. Fitton, R. K. Aggarwal, M. Kockott, I. P. Gardiner, A. Bartylak, CIGRE, Jun 11-17, 1995, Paper No. 34-210. This paper describes provisional verification of an adaptive single pole auto-reclosure procedure derived from training an Artificial Neural Network with simulations of line conditions.

The Role of Adaptive System Protection in Mitigating System Blackouts, S. H. Horowitz, A. G. Phadke, J. S.

Thorp, CIGRE, Jun 11-17, 1995, Paper No. 34-211. This paper reports on research conducted related to hidden failures, and introduces the concepts of regions of vulnerability and vulnerability index to investigate how adaptive relays might be used to eliminate blackouts due to relay failure.

System Protection and Voltage Stability, IEEE Committee Report, IEEE Trans. on Power Delivery, Vol. 10, No. 2, Apr 1995 p 631-8. This is a summary paper of a Special Publication. Protective relay operations often play a significant part in voltage collapse incidents. The effects of low system voltages on relay performance are discussed. Much of the publication deals with load shedding schemes.

Station Based Semi-Adaptive Auto-Reclose Design and Operating Experience, K. Kuras, CEA Engineering and Operating Div. Meetings, Mar 26-31, 1995. A concept for application of Programmable Logic Controllers (PLCs) and their role in the substation control and automation is discussed. Application of and operating experience from the use of PLCs for substation control and protection within the TransAlta Utilities are presented.

A New Microprocessor Based Islanding Protection Algorithm for Dispersed Storage and Generation Units, M.A. Redfern, J.I. Barrett, O. Usta, IEEE Trans. on Power Delivery, Vol. 10, No. 3, Jul 1995, p 1249-54. The islanding protection algorithm has been developed to be a part of an integrated protection package for dispersed storage and generation units. Results from laboratory and field tests are included to demonstrate the performance of the algorithm.

New Stabilizing Protection Systems With an Adaptive Control Approach, M. Tsukada, I. Kouda, I. Mitani, H. Hayashi, H. Kokai, CIGRE, Jun 11-17, 1995, Paper No. 34-204. This paper discusses two new stabilizing systems that employ an adaptive approach to enable automatic optimum control in cases where power system conditions undergo a drastic change.

An Investigation into Breaker Reclosure Strategy for Adaptive Single Pole Autoreclosing, S.P. Websper, A.T. Johns, R.K. Aggarwal, R.W. Dunn, IEE Proceedings-C, Vol. 142, No. 6, Nov 1995, p 601-7. This paper deals with determining the optimal recloser time by inclusion of the additional delay period needed after secondary arc extinction

### 3159 SURGE PHENOMENA

Lightning and Surge Protection of Substations, R.B. Carpenter, R.L. Auer, IEEE Trans. on Industry Applications, Vol. 31, No. 1, 1995, p 162-74. This paper discusses the problem of protecting any substation component including the protection system against lightning strikes and to limit incoming transient voltages. A review of conventional protection systems is given. Two new protective systems,

dissipation array system and series hybrid surge protection system, are described.

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