BIBLIOGRAPHY OF RELAY LITERATURE, 1990
IEEE COMMITTEE REPORT

Members of the Bibliography and Publicity Working Group of the IEEE Power System Relaying Committee are: M.S. Sachdev, Chairman, C.H. Castro, H. Disante, E.J. Emmerling, A.G. Folkman, J.W. Ingleson, M. Kezunovic, R. Ramaswami, T.S. Sidhu, J.E. Stephens, M.J. Swanson, R.P. Taylor 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:

1927-1939, Vol. 60,	1941;	p 1435-1447
1940-1943, Vol. 63,	1944;	p 705-709
1944-1946, Vol. 67, pt. I,	1948;	p 24-27
1947-1949, Vol. 70, pt. I,	1951;	p 247-250
1950-1952, Vol. 74, pt. III,	1955;	p 45-48
1953-1954, Vol. 76, pt. III,	1957;	p 126-129
1955-1956, Vol. 78, pt. III,	1959;	p 78-81
1957-1958, Vol. 79, Pt. III,	1960;	p 39-42
1959-1960, Vol. 81, pt. III,	1962;	p 109-112
1961-1964, Vol. PAS-85, No. 10;	1966;	p 1044-1053
1965-1966, Vol. PAS-88, No. 3;	1969;	p 244-250
1967-1969, Vol. PAS-90, No. 5;	1971;	p 1982-1988
1970-1971, Vol. PAS-92, No. 3;	1973;	p 1132-1140
1972-1973, Vol. PAS-94, No. 6;	1975;	p 2033-3041
1974-1975, Vol. PAS-97, No. 3;	1978;	p 789-801
1976-1977, Vol. PAS-99, No. 1;	1980;	p 99-107
1978-1979, Vol. PAS-100, No. 5;	1981;	p 2407-2415
1980-1981, Vol. PAS-102, No. 4;	1983;	p 1014-1024
1982-1983, Vol. PAS-104, No. 5;	1985;	p 1189-1197
1984-1985, Vol. PWRD-2, No. 2;	1987;	p 349-358
1986-1987, Vol. PWRD-4, No. 3;	1989;	p 1649-1658
1988-1989, Paper No. 91 WM 280-8 PWRS		

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 COMPUTER RELAYING
3151 DISTRIBUTION AND NETWORK PROTECTION
3152 TRANSMISSION LINE PROTECTION
3153 RELAY INPUT SOURCES
3154 ROTATING MACHINERY PROTECTION
3155 OTHER PROTECTION
3156 FAULT AND SYSTEM CALCULATIONS
3157 TESTING AND ANALYSIS
3158 STABILITY, OUT OF STEP, RESTORATION
3159 SURGE PHENOMENA

91 SM 510-8 PWRD A paper recommended and approved by the IEEE Power System Relaying Committee of the IEEE Power Engineering Society for presentation at the IEEE/PES 1991 Summer Meeting, San Diego, California, July 28 - August 1, 1991. Manuscript submitted April 30, 1991; made available for printing May 29, 1991.

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 various sections. A list of the periodicals which have been cited and their place of publication follows the bibliography.

The abstracts of many of the articles reported in this paper are available in the Science Abstracts - Section B, the Engineering Index, and other digesting 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 all countries are covered.

3150 COMPUTER RELAYING

Design of a Digital Multi-Curve Time-Overcurrent Relay, G. Benmouyal, IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1725-31. The paper presents an algorithm for implementing a digital time-overcurrent relay on a single 8-bit microprocessor, which accommodates multiple time-current curves within the same system. The need for standards to define performance with respect to input waveform parameters (peak, rms, avg.), immunity to harmonics, response to time varying inputs, and accuracy is discussed.

Some Aspects of the Digital Implementation of Protection Time Functions, G. Benmouyal, IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1705-13. Microprocessor technology allows time function implementation characterized by integration and a fully controllable resetting time constant. Care should be exercised in considering solely their static characteristics. However, some microprocessor relays may produce large time errors for a time varying input.

Development of Distributed Relaying Processor with Digital Filtering of Fast Sampled Data, T. Chiba, H. Kudo, M. Kido, T. Kawai and S. Mori, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1292-8. In order to deal with advanced relaying schemes, a multi-microprocessor based digital relay was developed featuring distributed processing among 5 processors to obtain high speed. The paper describes how these technologies are implemented and their performance.

The Protection of Circuit Breakers from Excessive Duty Using Digital Techniques, R.P. Depuy, W.Z. Tyska and D.A. Pritchard, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper describes a breaker operation limiter (BOL) recloser relay developed by AEP to provide breaker protection during conditions of galloping conductors.

Microprocessors Expand Relays, W.A. Elmore, Electric Light & Power, Vol. 68, No. 1, Jan. 1990, p 25. This paper outlines the advantages of microprocessor based relays, their reduced size, and their ability to perform sophisticated functions, handle and display

data and conduct self testing.

A Multi-Processor Aproach to Distance Protection, A.T. Giuliante, J. Gosalia and G.K. Clough, Western Protective Relay Conference, Spokane, WA, Oct. 22-5, 1990. This paper describes how a multi-processor aproach is used to create adaptive characteristics that enhance relay performance according to power-system conditions. Also discussed is the load-compensated quadrilateral ground-fault characteristic and test methods used to test these adaptive characteristics.

Digital Relay Software Quality, C.R. Heising, R.C. Patterson and E.Y. Weintraub, 43rd Annual Conference for Protective Relay Engineers, College Station, TX, Apr. 23-5, 1990. This paper identifies and discusses the various aspects of software quality from the perspective of electric power system protection, and provides pertinent data on several current designs.

Design and Implementation of a Versatile Digital Directional Overcurrent Relay, Y.V.V.S. Murty and W.J. Smolinski, Electric Power Systems Research, Vol. 18, 1990, p 47-55. This paper presents the design and implementation of a versatile digital directional overcurrent relay. The design of a flexible digital overcurrent relay with features such as adjustable pickup and time-dial setting, time-current curves, directional capability and multiple channels is presented.

Impact of Numerical Relays on Protection Management, D. Peloquin and G. Koch, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-156. This paper describes the impact of digital relays on present protection practices. It emphasizes the need to evaluate oportunities for their use without sacrificing the basic relaying philosophical concepts of redundancy, reliability and speed.

A Fast Microprocessor-Based Computational Algorithm for Transmission Line Fault Impedance, A.A.M. Hassan, Electric Power Systems Research, Vol. 19, 1990, p 57-9. The paper presents a fast microprocessor-based algorithm to calculate impedance. The algorithm is most suitable for microprocessor applications in high speed transmission line protection.

A Shortest Data Window Algorithm for Detecting the Peak Value of Sinusoidal Signals, H. Jou, H. Chu, C. Huang and C. Chen, IEEE Trans. on Industrial Electronics, Vol. 37, No. 5, Oct. 1990, p 424-5. An algorithm for estimating the peak value of steady-state, varying and decaying sinusoidal signals of known frequency is described. Simulation results show the performance of the proposed algorithm.

Multiple Overcurrent Relays Using a Single Microprocessor, M.A. Manzoul, IEEE Trans. on Industrial Electronics, Vol. 37, No. 4, Aug. 1990, p. 307-9. This paper describe the implementation of four overcurrent relays using a single microprocessor. The implementation is based on the concept of multitasking in microprocessors. The time delays are implemented by a combination of a look-up table and a counter.

Interactive Software for Evaluating and Teaching Digital Relaying Algorithms, M.S. Sachdev, M. Nagpal and T. Adu, IEEE Trans. on Power Systems, Vol. 5, No. 1, Feb. 1990, p 346-52. This paper presents an interactive software for evaluating algorithms for digital relay designs. The software includes signal processing and protection modules used in digital relays. Also included are facilities to generate data for testing relay designs.

On the Application of the Least Absolute Value Parameter Estimation Algorithm to Distance Relaying, S.A. Soliman, G.S. Christensen and S.S. Fouda, Electric Power Systems Research, Vol. 19, 1990, p 23-35. An algorithm suitable for distance relaying applications is presented. The algorithm is based on the least absolute value parameter estimation aproximations, and uses digitized voltages and currents to calculate impedances as seen from a relay location.

An Algorithm for Frequency Relaying Based on Least Absolute Value Aproximations, S.A. Soliman, G.S. Christensen, D.H. Kelly and N. Liu. Electric Power Systems Research, Vol. 19, 1990, p 73-84. This paper describes a new algorithm for measuring the frequency and the rate of change of frequency at a power system bus for frequency relaying applications. The new algorithm is based on the least absolute value aproximation.

Algorithm for Harmonic Restraint Differential Relaying Based on the Discrete Hartley Transform, H.K. Verma and G.C. Kakoti, Electric Power Systems Research, Vol. 18, 1990, p 125-9. The paper proposes an algorithm for digital relaying for the differential protection of large transformers. The digital filters, intended to extract the fundamental frequency component and the second and fifth harmonic components to provide operating and restraint signals respectively, are based on the discrete Hartley transform.

Digital High-Speed Calculation of the Distorted Signal Fundamental Component, A. Wiszniewski, IEE Proceedings-C, Vol. 137, Part C, No. 1, Jan. 1990, p 19-24. This paper presents a technique which uses the instant of fault inception to start computations of the voltage and current phasors and increase the size of the data window as the data is sampled.

3151 DISTRIBUTION AND NETWORK PROTECTION

Performance Evaluation of High Impedance Fault Detection Algorithms Based on Staged Fault Tests, M.T. Chen, H.Y. Chu, C.L. Huang and F.R. Wu, Electric Power Systems Research, Vol. 18, 1990, p 75-82. To evaluate relay performances, a staged high impedance fault test was conducted on a heavily loaded feeder. Four algorithms were used to process the fault data. The results of the evaluation are compared with those obtained on a lightly loaded feeder.

High Impedance Fault Tests on the Taipower Primary Distribution System, H.Y. Chu, M.T. Chen, C.L. Huang, S.L. Chen and S.S. Yen, Electric Power Systems Research, Vol. 19, 1990 p 105-14. This paper summarizes results from aplying different detection methods to the data obtained from staged faults on the Taipower primary distribution system. The test results are reported and discussed for the purpose of providing a practical evaluation of high impedance fault detection.

Ground Fault Protection and the Problem of Nuisance Triping of Critical Feeders, H.O. Nash, Jr., IEEE Trans. on Industry Applications, Vol. 26, No. 3, May/Jun. 1990, p 563-79. The NEC requirements for ground fault protection for 480/277 V systems are presented. Troublesome nuisance trips can be reduced with proper system design and application of protective devices. Several case studies are given.

Developing a Standard for Overcurrent Relay Characteristics, S.E. Zocholl, 44th Annual Ga. Tech Protective Relaying Conference, Atlanta, GA, May 1-3, 1990. This paper discusses the background and possibilities for developing a standard that would include an analytic definition for inverse time characteristics. The paper also reviews the existing standards and addresses the issues of their dynamic response and coordination with existing relays.

3151.1 Industrial and Power Station Auxiliaries

Incorrect Pilot Wire Operations Due to False Residual

Current, C. Pounds, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper describes an industrial plant application of pilot wire relaying, along with a problem which occurred due to spurious residual currents.

Protective Relaying for Multi-Source Generator Buses, R.H. Simpson, IEEE Trans. on Industry Applications, Vol. 26, No. 2, Mar./Apr. 1990, p 330-41. An overview of the issues encountered in protecting a medium voltage industrial power system is presented and a relaying philosophy is developed, to address those issues using instantaneous, summation & directional overcurrent relays.

3151.2 Primary Distribution Systems

Fault and Operating Data Collection Features of a New Microprocessor Recloser Control, T.G. Dolnik and J.A. Kischefsky, IEEE Trans. on Power Delivery, Vol. 5, No. 1, Jan. 1990, p 456-9. The monitoring features of a new digital control for a distribution circuit automatic circuit recloser are described. The control is able to tabulate load currents for the previous 24 hours, calculate recloser fault interruption duty, and record data for 50 events or status changes.

Relaying Changes Improve Distribution Power Quality; N.G. Engleman; Transmission and Distribution, May 1990, p 72-6. An increasing concern for better power quality on distribution circuits, prompted one utility to rethink its practice of instantaneous circuit breaker triping for fuse savings. By adding time delay to the instantaneous trip, fuses that would not have been saved because of high fault currents, were allowed to blow without triping the circuit breaker.

A Parameter-Based Process for Selecting High Impedance Fault Detection Techniques Using Decision Making Under Incomplete Knowledge, C.J. Kim, B.D. Russell and K. Watson, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1314-20. The behavior of high impedance faults is affected by four environmental factors. This study considers five detection techniques. Technique selection depends on the most indicative electrical parameter. This generic selection method provides a head start when attempting to optimize detection given the wide variety of affecting factors.

Detecting High-Resistance Earth Faults, A. Otto, R. Schafer, S. Reinhard and F. Frey; ABB Review, Jan. 1990, p 19-26. A relay is described for use in detecting high-resistance earth faults on high voltage transmission lines. The relay uses either zero-sequence or negative-sequence currents to detect the fault and includes a directional element for comparison at each end of the line. The relay is designed as an add-on module for use with existing or new directional-comparison relay schemes.

3152 TRANSMISSION LINE PROTECTION

Distance Protection of Double-Circuit Lines With Different Rated Voltages During Intersystem Faults, H. Becker, J. Nilges and H. Dittrich, CIGRE General Session, 1990 Paper No. 34-206. This paper presents a procedure that detects intersystem faults on double-circuit lines with different voltage levels and different line parameters. Distance protection principle including the zero-sequence mutual coupling of the double-circuit line and fault resistances are used.

CLECO'S Hybrid Line Panel, E. Chastant and G. Coco, 43rd Annual Conference for Protective Relay Engineers, College Station, TX, Apr. 23-5, 1990. This paper describes Central Louisiana Electric Company's newly developed transmission line panel and its performance statistics. The panel combines a modular static relay system and a two-zone stepped distance protection scheme.

Protection of a Two-Circuit Three Terminal Line By Means of Equipment Employing Digital Microwave Links as Communication Carrier, J. Hoffelman, P. Lienart, F. Wellens and M. Delgado, CIGRE General Session, 1990, Paper No. 34-203. The report describes the means employed to protect a two-circuit, three-terminal line. Two different types of protective systems are discussed. The results of simulations and field tests are then presented.

Swivelling Characteristic for the Protection of Series Compensated Lines, M.E. Mandour and A.A. El-Alaily, Electric Power Systems Research, Vol. 18, 1990, p 31-5. This paper presents a layout of hardware with a swivelling quadrilateral characteristic to cater for the switching of series capacitor spark gaps. A check for accommodating the instantaneous fault impedance during the post-fault conditions is also included.

The State of the Art of Multi-Circuit and Multi-Terminal Overhead Transmission Line Protection Systems Associated with Telecommunication Systems, J. Kobayashi, Y. Ohura, M. Yuki, K. Hashisako, K. Seo, K. Suzuki, A. Tsuboi and F. Andow, CIGRE General Session, 1990 Paper No. 34-201. This paper describes pilot protection systems for multi-circuit and multi-terminal transmission lines. The systems use phase comparison or differential protection in accordance with the types of telecommunication systems used. (PLC, microwave and fiber-optics).

Walsh Transform Realization for Microprocessor Implementation of Distance Protection, P. Sharma, J. Henry and S.I. Ahson, Electric Power Systems Research, Vol. 19, 1990, p 157-66. This paper describes simple computational procedures, based on the fast Walsh-Hadarard transform (FWHT), for real-time calculation of the impedance of faulted transmission lines. The paper also presents test results carried out on the relay using simulated fault data.

3152.1 Distance and Ground Relaying

Investigation of Alternative Residual Current Compensation for Improving Series Compensated Line Distance Protection, F. Ghassemi and A.T. Johns, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 567-74. If the series capacitor does not flash-over during a ground fault, the relay reach measurement is affected by the residual current compensation. Therefore, the residual compensation factor should be set at a fixed value corresponding to a fault at the zone 1 balance point.

A Digital Distance Relay Using Negative Sequence Current, Y. Ohura, T. Matsuda, M. Suzuki, F. Andow, Y. Kurosawa and A. Takeuchi, IEEE Trans. on Power Delivery, Vol. 5, No. 1, Jan. 1990, p 79-84. A distance relay for remote backup protection, where fault current input might be small, that minimizes the effect of load current has been realized by using the negative-sequence current for fault detection and directional sensing.

Analysis of an Accelerated Trip Scheme for Faults in the Second Zone of Protection of a Transmission Line, L. Pei, C. Deshu, P. Hua, O.P. Malik and G.S. Hope, IEEE Trans. on Power Delivery, Vol. 5, No. 1, Jan. 1990, p 72-8. This paper proposes a scheme to identify the remote end breaker triping by a second change in the zero and negative sequence currents to sequentially trip the local breaker for a zone 2 fault. The scheme differentiates from a fault in the next line section.

3152.2 Relay Communications

Fiber Optics is Chalking Up a Good Record, C.E. Biggers, Transmission and Distribution, Apr. 1990, p 60-3. A survey was performed to determine how fiber optic communication systems were being used by electric utilities, and what types of problems had been encountered with installation, operations, or maintenance of the systems. The results of the survey are summarized in this article.

Data Collection and Control Techniques for Protective Relays, J.P. Garrity, 43rd Annual Conference for Protective Relay Engineers, College Station, TX, Apr. 23-5, 1990. The introduction of remotely accessible relays of varying design has raised the question, "How do you communicate efficiently with multiple devices at a single location?" This paper describes a means by which microprocessor and electromechanical relays can be addressed using a substation computer on a local area network.

Laboratory Investigation of an Amplitude Comparator Based Directional Comparison Digital Protection Scheme, K.S. Prakash, O.P. Malik, G.S. Hope, G.C. Hancock and K.K. Wong. IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1689-94. This paper describes the implementation and on-line testing of the directional comparison protection scheme reported in PWRD Oct. 1989. Different types of tests are conducted in the physical model of a double circuit transmission line, simulating the performance of a 500 kV, 300 km long line connected to a 1000 MVA generator.

Application Considerations of Fiber Optic Channels, R. Ray, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper provides a discussion of the fundamentals of optical communications, including examples of loss calculations.

3152.3 Relay Systems

Digital Differential Relaying Scheme for Teed Circuits Based on Voltage and Current Signal Comparison, R.K. Aggarwal and A.T. Johns, IEE Proceedings-C, Vol.137, Part C, No. 6, p 414-23. This paper presents a scheme for protecting three terminal transmission line. The voltages and currents sampled at each terminal are processed and transmitted to one of the three terminals where decisions concerning the protection of the line are taken.

Overview of Series-Compensated Line Protection Philosophies, F. Anderson and W.A. Elmore, Western Protective Relay Conference, Oct. 22-5, 1990. This paper describes several types of relaying systems that have been designed with series compensation in mind. The paper also describes many of the pitfalls that exist in aplying conventional relays to series compensated lines and describes the extremes to which manufacturers have gone to circumvent these problems.

Series Compensated Line Protection: Practical Solutions, J.G. Andrichak, G.E. Alexander and W.Z. Tyska, Western Protective Relay Conference, Oct. 22-5, 1990. Series compensated lines offer unique problems to protection engineers. The problems are not insurmountable; relays and schemes are available to address them. Some solutions to these problems are presented in this paper.

Performance Analysis of Microcomputer Based Differential Protection of UHV Lines Under Selective Phase Switching, A.A. Bhatti, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 556-66. Disconnecting only the faulted phases for single or double circuit lines results in inductive and capacitive current flow from the healthy phases to the faulted phases, causing differential currents and voltages on the healthy phases. This may cause unwanted triping of healthy phases. This paper discusses analysis, compensation and calculation of threshold settings.

New Aproach to Power Line Protection Based upon the Detection of Fault Induced High Frequency Signals, A.T. Johns and P. Agrawal, IEE Proceedings-C, Vol. 137, Part C, No. 4, Jul. 1990, p 307-14. This paper presents a transmission line protection scheme which uses non-power-frequency components of voltages. The non-power- frequency components are obtained from stack tuner circuits connected to the coupling capacitors of the capacitor voltage transformers.

Experiences with the Application and Setting of Ground Distance Relaying, E.R. Terlau II, Western Protective Relay Conference, Spokane, WA, Oct. 22-5, 1990. As with all relaying methods, ground distance protection has both desirable and undesirable aspects. This paper discusses the measures a utility has taken in specifying, applying and setting ground distance relays.

Transmission Line Relaying with Microprocessors, E.A. Udren and H.J. Li, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper discusses two aproaches to the application of microprocessors to the protection of transmission lines; the stand alone line protection relay and a line protection module as part of an integrated station system.

3153 RELAY INPUT SOURCES

A Magneto-Optic Current Transducer, T.W. Cease and P. Johnston, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 548-55. A current measuring technique using the rotation of the plane of polarization by a magnetic field in glass (Faraday effect) has been developed and tested. This paper deals with the comparison of test data with design qualification data.

Gaped Core Current Transformer Characteristics and Performance, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1732-40. It was concluded that in some cases, the use of gaped core ct's can offer a significant size reduction and economic advantage. Gaped ct's can offer improved transient performance which may contribute to greater reliability and consistent high speed operation of the protection. The method of specifying gaped core ct's is presented.

CT Performance in Critical Relay Applications, S.E. Zocholl and W.C. Kotheimer, Western Protective Relay Conference, Oct. 22-5, 1990. This paper analyzes the interaction of current transformers with high speed machine and bus differential relays. The non-linear behavior of the cts and relay burden is analyzed with the aid of a simulation on a personal computer.

3154 ROTATING MACHINERY PROTECTION

A Survey of Generator Back-Up Protection Practices, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 575-84. The paper reports on and analyzes a survey of practices and experiences with time-delayed back-up protections for unit-connected generators. Application and setting considerations are discussed. The survey includes phase back-up, negative-sequence overcurrent, and high side neutral overcurrent protection.

Plant Jack Watson Unit #4 Generator Field Ground, Apr.-May 1989, W.J. Riley and P.D. Smith, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This is a practical experience paper relating history, problem identification, and potential

solution to a generator field ground problem on a 250 MW unit.

Adaptive Ground Fault Protection Schemes for Turbo-Generators Based on Third Harmonic Voltages, X.G. Yin, D.S. Chin, O.P. Malik and G.S. Hope, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 595-603. Available 3rd harmonic schemes have limited sensitivity due to the change in ratio of 3rd harmonic voltages at the terminals and neutral with excitation and load. This paper proposed two schemes which automatically track changes of terminal and neutral 3rd harmonic voltages before a ground fault occurs and only operate during a big enough sudden change.

Motor Analysis and Thermal Protection, S.E. Zocholl, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1275-80. The paper discusses a PC program to calculate and plot motor voltage, current, speed, torque, and rotor temperature from readily available name plate rating, torque, and thermal limit data. The paper reviews the method of analysis and identifies the required source data.

3155 OTHER PROTECTION

Dissolved Gas-In-Oil Analysis, K. Barrett, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper discusses the benefits of dissolved gas-in-oil analysis and describes a diagnostics test for power transformers.

An Overview of Utility/Customer-Owned Generation Interconnections, E.C. Carlsen, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. Over the past several years, there has been a marked increase in the number of customer-owned sources of generation. Of special interest is the increased number of small installations. This paper addresses Georgia Power Company's attempt to adequately deal with these changes from a procedural and protection standpoint.

Breaker Failure Protection; Review and Experience, G. Dalke, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper reviews the fundamentals of local back-up breaker failure relaying and describes some experiences with this type of protection on the OG&E system.

Digital Protection, Control, Monitoring and Integration of Functions at PSE&G Deans 500 kV Switching Station, J.W. Dean, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-TC-204. This paper describes briefly the field experience with the protection and control system developed and installed under the EPRI Project RP-1359.

Advances in the Design of Differential Protection for Power Transformers, A. Guiliante and G. Clough, Western Protective Relay Conference, Oct. 22-5, 1990. Modern advances in electronics have allowed techniques to be used in new relays that overcome the disadvantages of conventional differential relays, such as high inrush currents and ct saturation. This paper discusses one such relay.

An Overview of Transmission Station Protection at Nashville Electric Service, R.M. Hale and L.E. Leech, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper deals with the transition of a 69KV system to a 161KV and some of the problems and improvements that were encountered in this conversion.

A Multifunction Protective Relay for the Cogeneration Industry, J.H. Harlow, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. Modern technology and techniques of high speed digital processing has made it possible to combine all of the commonly specified protection functions into a single package. This paper concentrates on the technical aspects of a newly developed relay which accomplishes this goal.

Operating Experience with a Delta Var LTC Control on the Florida Power Corporation System, D.L. Hornak and M. Young, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. The combination of three autotransformers which have no common high side and low side presents a special LTC control problem. This paper addresses one utility's solution to the problems of circulating currents, transformer loss of life, and additional workload on system dispatchers.

Protection Relaying Aspects of the Sound Cable Project, M. Ibrahim and F. Stacom, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper deals with the protection aspects of a 26.3 mile underground-underwater 345KV transmission line; such as, phase angle regulating transformer protection, breaker failure schemes, shunt reactor protection, autotransformer protection, overvoltage protection, and direct transfer trip systems.

Summary of IEEE Guide for the Protection of Network Transformers, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1288-91. This paper publicizes the Guide C37.108-1989 and discusses some of the protection requirements presented in the guide. It describes equipment used in a typical system, its performance, and limitations. The application of high side interrupting devices are discussed with ecial conditions stated.

Overvoltage Protection Scheme for Series Capacitor Banks on High Voltage Distribution Systems, M.V. Lat and D. Kundu, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1459-65. This paper provides an analysis of the overvoltage protection requirements for a series capacitor bank on a 16/27.6 kV system. A special rotating-arc spark-gap provides protection for fault currents exceeding about 3 times the rated load. Below that value, an overcurrent relay activated vacuum switch bypasses the capacitor bank in 6 cycles.

Generation Rejection for Area Mode Stability (GRAMS) Protection System - Design Aspects and Field Experience, R.J. Malewicz and P. Prabhakara, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-160. A scheme for rejecting generation following critical transmission contingencies is described in this paper. The scheme operates under control of the System Control Center via bi- directional serial data links to two generating stations.

An Improved Busbar Protection Scheme Using a MCS-8096 Single Chip Microcomputer, O.P. Malik and G.S. Hope, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-159. This paper describes a bus differential relay hardware which uses three MCS-8096 micro-computers; one performs the protection and control functions and other two perform sampling and data processing functions.

A Kalman Filter Based Digital Percentage Differential and Ground Fault Relay of a 3-Phase Power Transformer, Y.V.V.S. Murty and W.J. Smolinski, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 1299-313. The relay combines the fundamental and harmonics of all 3 phases for restraint, uses 2nd and 4th harmonics for magnetizing inrush restraint and 5th harmonics for over-excitation restraint. Separate primary & secondary ground fault protection are provided. The relay is economical and fast.

Nelway Substation Phase Shifting Transformer Protection, F.P. Plumtre, Western Protective Relay Conference, Oct. 22-5, 1990. This paper discusses a utility's experience in the application of a phase

shifting transformer. Not only the protection and control schemes are discussed, but a remedial scheme which offers some unique features which provides an automatic means to control overloads is discussed.

Design and Testing of Microprocessor-Based Protective Relay for Power Transformer, M.A. Rahman and I. Hermanto, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-161. Design and testing of a microprocessor based transformer differential protection relay are described in this paper. The relay uses differential currents for triping, and through currents and harmonic currents for restraining.

Differential Relay Concepts and Applications, J.B. Royle, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-157. The paper describes techniques which are used in recently developed differential relays for bus, line and transformer differential protection to overcome some of the traditional problems and improve their performance.

A Least Squares Technique and Differential Protection of Three- Phase Transformers, M.S. Sachdev and M. Nagpal, Trans. CEA E&O Div., Vol. 29, 1990, Paper No. 90-SP-158. A recursive least squares technique is described in this paper with reference to protection of three-phase transformers. The implementation of the technique on a micro-processor based relay is outlined. Also described briefly are the hardware and software of the relay.

Unified Shunt Capacitor Bank Control and Protection, E.O. Schweitzer III, J. Schafman, Western Protective Relay Conference, Oct. 22-5, 1990. This paper describes a new relay for the protection and control of grounded capacitor banks and discusses factors which are important in achieving the required sensitivity.

Microprocessor-Based Relay for Protecting Power Transformers, T.S. Sidhu, M.S. Sachdev and H.C. Wood, IEE Proceedings-C, Vol. 137, Part C, No. 6, p. 436-44. The paper describes the design, implementation and testing of a relay for protecting single phase, and three phase wye-wye and delta-wye transformers. Non-linear models of the protected transformer are used in the algorithm to verify the operating conditions of the transformer.

Microprocessor-based Comprehensive Relaying Scheme for Power Transformer Protection, H.K. Verma and A.M. Basha, Electric Power Systems Research, Vol 19, 1990, p 115-27. The paper reports the development of a comprehensive relaying scheme for power transformer protection. A prototype of the relay has been tested in the laboratory on simulated signals for various normal and abnormal conditions of the power transformer.

3156 FAULT AND SYSTEM CALCULATIONS

CPL's Experience with a PC-based Relay Coordination Program, T.D. Cook and S. Chan, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. In recent years, several PC-Based short-circuit and relay-coordination programs have been developed. This paper presents the experience that Central Power and Light Company has had with one of these programs including the improvements it has provided in the areas of accuracy and productivity.

LCRA Fault Recorder System, L.D. Glass and D. Penney, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper describes the application and experience of fault recorder systems to the LCRA power system.

Accurate Fault Location Technique for Power Transmission Lines, A.T. Johns and S. Jamali, IEE Proceedings-C, Vol. 137, Part C, No. 6, p. 395-402. The paper describes a fault location technique based on distributed parameters of a line, fault and pre-fault load currents and voltages observed at the two terminals of a line. Some simulation results are presented to show the effectiveness of the technique.

Compression of Voltage and Current Waveforms, R.J. Murphy and P.S. Sterlina, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper describes the use of compression techniques aplied to utility recorders from a historical perspective, presents a review of presently available aproaches, and introduces the harmonic predictor algorithm.

The Truth About Standby Generator Excitation Suport Systems, H.O. Nash, Jr., IEEE Trans. on Industry Applications, Vol. 26, No. 4, Jul./Aug. 1990, p 726-34. This article explains how types of excitation suport systems and types of faults can affect the ability of the self-excited generator to deliver fault current.

Ferroresonance: Then and Now, A.M. Oskoui, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. This paper describes the ferroresonance phenomenon on low voltage and EHV power systems and suggests ways to protect the substation equipment from being damaged due to stresses caused by ferroresonance.

Coordination of Directional Overcurrent Relays in Transmission Systems - A Subsystem Approach, R. Ramaswami, M.J. Damborg and S.S. Venkata, IEEE Trans. on Power Delivery, Vol. 5, No. 1, Jan. 1990, p 64-71. This paper proposes a "subsystem" coordination approach to efficiently compute proper relay settings in response to system structure or load changes. The program accounts for constraints imposed by relays outside the subsystem and requires about one-fourth as much computer time as for a "full system".

A Comparison of Static & Dynamic Short Circuit Analysis Procedures, O.E. Roennspiess and A. E. Efthymiadis, IEEE Trans. on Industry Applications, Vol. 26, No. 3, May/Jun. 1990, p 463-75. Fault current calculating programs now available can calculate system dynamic responses taking into consideration inertia constants, controllers, prefault voltages and load flows. A comparison of results from a dynamic fault current program and an ANSI-based (static) program is made for a sample industrial type power system.

Sample System for Three Phase Short Circuit Calculations, C.R. St. Pierre, IEEE Trans. on Industry Applications, Vol. 26, No. 2, Mar./Apr. 1990, p 204-11. Solutions from various short circuit programs are compared for correlation. Also, short circuit solutions from the same program run on 8 bit and 32 bit microcomputers are compared.

3157 TESTING AND ANALYSIS

Analog vs. Digital Modeling of Power Systems, G.E. Alexander, J.G. Andrichak and S.B. Wilkinson, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. Discussed are the differences between modeling a power system using a high power analog model and a digital model. The current and voltage waveforms produced by the two simulations are compared, and the models and test methods reviewed.

Comparative Testing Using Digital Simulation and an Analog Model Power system, G.E. Alexander, P.J. Lerley and R. Ryan, Western Protective Relay Conference, Oct. 22-5, 1990. This paper discusses the differences between testing the dynamic response of protective

relays using conventional test equipment versus a model power system. The current and voltage waveforms produced by the two methods are compared, and the results and test methods are discussed.

Operating Characteristics of Protective Relays in Positions Other Than Vertical, B. Bridger, Jr. and R.J. Walker, IEEE Trans. on Industry Applications, Vol. 26, No. 1, Jan./Feb. 1990, p 50-5. This paper examines the behavior of induction disk, induction cup, hinged armature and solid state relays under oscillary motion and while tilted left, right, forward and backward.

Application of Digital Fault Recorders on the Tampa Electric Company System, D.M. Denison, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. One utility's experiences with digital fault recorders is presented. Some of the decisions which led to their application, as well as several interesting system conditions that were observed are included.

State Space Relay Modelling and Simulation Using the ElectroMagnetic Transients Program and Its Transient Analysis of Control Systems Capability, A. Domijan and M.V. Emami, IEEE Trans. on Energy Conversion, Vol. 5, No. 4, Dec. 1990, p 697-702. A simulation of a MHO distance relay is developed to study the effect of system conditions on its operation. State space approach and Electro-Magnetic Transients program are used. Simulation results are validated by comparing them with those obtained from an independent study.

Simulation of Protective Relay Performance Under Short-Circuit and Transient Swing Conditions, A.E. Efthymiadis, O.E. Roennspiess and J.A. Guerra, IEEE Trans. on Industry Applications. Vol. 26, No. 6, Nov./Dec. 1990, p 1108-15. In industrial power systems, fault current levels depend on customer generation and motor loads. The paper describes a technique for transient calculations to identify the sensitivity of relay coordination to the decay of current with time.

Phasors Revisited, W.A. Elmore, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. This paper is a tutorial on the practical application of phasors. The basics of phasors is discussed as well as the concepts of polarity and symmetrical components. How some of these basics are incorporated into the latest technology and the importance of relay engineers and software engineers sharing knowledge and experiences in future relay development is discussed.

Effect of Waveform Distortion on Protective Relays, W.A. Elmore, S.E. Zocholl and C.A. Kramer, Western Protective Relay Conference, Oct. 22-5, 1990. This paper examines the effect of waveform distortion on protective relays. The paper examines several electromechanical, solid state and microprocessor measuring concepts; describes the theoretical expectations of harmonic influence; and presents laboratory confirmation of these results.

Analysis of High-Impedance Fault Generated Signals Using a Kalman Filtering Approach, A.A. Girgis, W. Chang and E.B. Makram, IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1714-24. High impedance faults are accompanied by erratic variations in the 60 Hz and harmonic components. Kalman filtering algorithms were developed to obtain optimal estimates of time varying low-order harmonics of high impedance faults. The change in low-order odd harmonics and their rate of change were found to be valuable indicators of such faults.

Distribution Fault Recorder Analysis, M.M. Gonzalez, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. This paper discusses one utility's use of digital fault recorders to collect data from the distribution system that would verify the effectiveness of relaying practices and of the protection equipment, and to point to areas where changes are needed.

Harmonics on Transmission and Distribution; Causes, Effects and Remedies, W.M. Grady, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper provides definitions, causes and effects of power system harmonics. It also discusses some preventive and remedial measures.

PC-Based Maintenance Scheduling Program, E. Himel and L. Frye, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper describes the development and use of a pc-based program to plan and document a preventive maintenance program.

Pilot Relay Performance Analysis, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 5, No. 1, Jan. 1990, p 85-102. This paper concentrates on the evaluation of pilot relay performance by analyzing data from fault recorders and sequence-of-event recorders. System and equipment phenomena and limitations that may effect pilot relay performance are described. Typical oscillograms are shown and discussed.

Computer Simulation of Current Transformers for Relay Performance Analysis, W.C. Kotheimer, S.E. Zocholl and R. Garrett, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper discusses performance of low ratio cts and their effects on overcurrent relay operation. The impact of the use of anti-aliasing filters is also examined.

Power System Phase Rotation and Polarized Protective Relays, W.H. Nichols and C.A. Castro, IEEE Trans. on Industry Applications, Vol. 26, No. 6, Nov./Dec. 1990, p 1075-80. This paper demonstrates the use of voltage and current phasors and calculation of maximum torque lines for protective relays.

New Software Techniques for Coordinating Phase and Ground Protection for Ground Faults, T.S. Ning, H.M. Ham, P.R. Leblanc and R.W. Johnson, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper describes the requirements for coordinating phase and ground devices for ground faults, the analytical tools used, and the results obtained by one utility using a version of presently available protection coordination software.

Utilizing Reliability Analysis in Applying and Maintaining Relays, R.C. Patterson, 42nd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 17-9, 1989. The paper compares reliability levels of electromechanical versus solid state relays by functions performed. It also describes the advantages to be gained by solid state systems as the number of functions performed increases.

SEPIDE - An Expert System to Interpret Network Events, S.d. Pozo; Transmission and Distribution, Feb. 1990, p 96-102. An expert system is used at Hydro Quebec to interpret transmission system events. Information received by a sequence-of-events reporting system is presented to SEPIDE (Systeme Expert Pour L'interpretation des Envenements) to produce a diagnosis every time there is a change in status of the Hydro Quebec EHV network.

Analysis of Event Reports, J. Roberts and E.O. Schweitzer, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. One of the routine duties of protection engineers is analyzing event reports that have been preserved by microprocessor

relays in order to more clearly understand these faults and disturbances on the transmission system. This paper reviews the manual and automated techniques used to analyze ten such reports.

Steep Front Impulse Test on a Solid-State Relay, T.M. Salas, C.M. Wiggins and P.R. Barnes, IEEE Trans. on Power Delivery, Vol. 5, No. 3, Jul. 1990, p 281-7. Limited laboratory tests were made on a solid-state transformer differential relay to investigate the response to a fast rise transient pulse. The purpose was to determine voltage levels and locations where arcing occurs. The addition of an Sp raised the pulse withstand level substantially.

The Significance of Relay Self Test and Monitoring, W.Z. Tyska and W.A. Massey, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper describes two types of self test; automatic period testing and continuous monitoring. The pros and cons of each method are examined.

Novel Applications of a Digital Relay with Multiple Setting Groups, D.A. Tziouvaras and W.D. Hawbaker, Western Protective Relay Conference, Oct. 22-5, 1990. This paper presents a novel approach in maintaining protection during circuit breaker maintenance and concentrates on applications where breaker and a half or ring bus arrangements cannot be economically justified.

Design and Application of a Table-Top EMTP Test System, R. Wall and T. Tibbals, Western Protective Relay Conference, Oct. 22-5, 1990. Conventional relay testing offered by manufacturers of past relays consisted of observing relay responses to standard test signals which differ significantly from actual field installed values. This paper describes a PC-based EMTP testing system currently in use by one relay manufacturer.

3158 STABILITY, OUT OF STEP AND RESTORATION

Application of Single-Phase Autoreclosing in a Complex EHV Network Containing 1200 kV Transmission Lines, N.N. Belyakov, V.L. Volchek, V.V. Ilynichin, S.B. Losev, Yu I. Lyskov, V.N. Novella, V.A. Rashkes, V.M. Strelkov, G.G. Fokin and M.I. Khoroshev, CIGRE General Session, 1990 Paper No. 34-207. This paper presents the field experience on the effectiveness of single-phase autoreclosing (SPAR) on EHV lines. It also examines the dependency of the arc extinction time on current infeed.

Cascading Voltage Collapse in West Tennessee, August 22, 1987, G.C. Bullock, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper presents the facts surrounding a major system disturbance in Western Tennessee. It discusses the chronological events leading up to the disturbance, the subsequent difficulties of restoration, and the planned corrective action .

Dynamic Oscillations Controlled by a Unit Triping Scheme, M.M. Butts and H.S. Smith, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. With the aid of stability studies, the authors identified a potential dynamic stability problem at a large coal fired generating station on the Southern Electric system. This paper discusses these studies, the control scheme installed to control the dynamic oscillation, and the ultimate solution.

Autoreclosing Practices and Experience in Eskom, R.G. Coney, CIGRE General Session, 1990, Paper No. 34-202. Autoreclose relay technology in Eskom has evolved from hinged armature relays with electromechanical timers, to static equipment and more recently to microprocessor based systems. This paper describes Eskom's reclosing philosophies and the experience gained over the past 20 years.

Transmission Reclosing Practices of Northern States Power Company Using a Microprocessor-Based Reclosing Relay, K.C. Dickey and K. Zimmerman, 43rd Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 23-5, 1990. The introduction of microprocessor based technology has allowed utilities to address a wide variety of system considerations with one reclosing relay. This paper summarizes one utility's experience in this area.

Adaptive Estimation of Power System Frequency Deviation and its Rate of Change for Calculating Sudden Power System Overloads, A.A. Girgis and W.L. Peterson, IEEE Trans. on Power Delivery, Vol. 5, No. 2, Apr. 1990, p 585-94. A new Kalman filtering technique is presented for estimating frequency conditions that may require load shedding. The input may be noisy voltage samples.

Maddox Station Transmission Line Recloser Control System, H. Melson and R. West, 41st Annual Conference for Protective Relay Engineers, Texas A&M University, College Station, TX, Apr. 18-20, 1988. The paper describes a controller designed to improve reclosing decisions for a ring bus.

Ring Bus Reclosing Via Programmable Logic Controller, C.A. Miller and A.E. Williamson, 44th Annual Ga. Tech Protective Relaying Conference, May 1-3, 1990. This paper discusses ring bus reclosing considerations and describes the hardware and ladder logic arrangement used to develop a reclosing relay with features not previously available. Also included is the installation and operation experiences.

A Predictive Out-of-Step Protection System Based on Observation of the Phase Difference Between Substations, Y. Ohura, M. Suzuki, K. Yanagihashi, M. Yamaura, K. Omata, T. Nakamura, S. Mitamura and H. Watanabe, IEEE Trans. on Power Delivery, Vol. 5, No. 4, Oct. 1990, p 1695-704. The paper describes a new out-of-step protection system of the Tokyo Electric Power Co. The phase difference between voltages at generating stations is determined. From this data, the phase difference at 200 ms in the future is predicted. If the predicted phase difference exceeds the stability limit, system separation is initiated.

Adaptive Automatic Reclosing, A.G. Phadke, S.H. Horowitz and A.G. McCabe, CIGRE General Session, 1990, Paper No. 34-204. The paper examines the concept of adaptive reclosing of circuit breakers, defined as controlling the circuit breaker reclose sequence and timing based upon the prevailing conditions on transmission lines. Simulation results are included, along with the proposed circuit breaker control scheme.

Discrete Suplementary Control For the Stability of Electronorte's Power System - A R, Rdot Relay Application for Generation Trip on N-NE Intertie, J.G. Tannuri, L.C. Zanetta Jr., J. Da C. Patrao Neto, J. Oliveira, C. Simoes, M.C. Bertolucci, E. Montalvao, D. Mirandella and J.A. de Almeida, CIGRE General Session, 1990, Paper No. 34-105. The use of digital technology in power systems cannot be considered anymore as a new subject. The reasons for using this technology and how it solves the stability problems of the North North-east Brazilian Intertie is described.

Undervoltage Load Shedding for Puget Sound Voltage Stability Challenges, C.W. Taylor, Western Protective Relay Conference, Oct. 22-5, 1990. Undervoltage load shedding is an economical solution (or partial solution) to the voltage stability challenges facing electric utilities. This paper discusses a utility's evaluation of this option on their system.

3159 SURGE PHENOMENA

Lightning Protection for Microprocessor-Based Electronic Systems, O. Melville Clark and Ronald E. Gavender, IEEE Trans. on Industry Applications, Vol. 26, No. 5, Sep./Oct. 1990, p 947-53. Guidelines are given for protecting sophisticated micro-circuits from lightning-caused transient voltage spikes.

Publication	Location
IEEE Transactions & Conf. Papers	New York, NY
ASEA Journal	Stockholm
Brown Bovery Review	Zurich
Canadian Electrical Association-Trans. of Engr. & Operating Div.	Montreal, Can.
Electric Light and Power	Chicago, IL
Electric Construction and Maint.	New York, NY
Electric Forum (GE)	Schenectady, NY
Electric Power System Research	Lausanne
Electrical Review	London
Electrical World	New York, NY
GA Tech	Atlanta, GA
IEE Proceedings, Institute of Electrical Engineers	London
Power	New York, NY
Texas A&M University	College Station, TX
Transmission and Distribution	Cos Cob, CT
Western Protective Relaying Conference, Washington State University	Spokane, WA