BIBLIOGRAPHY OF RELAY LITERATURE, 1988-1989
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 R.W. Hirtler, J.W. Ingleson, M. Kezunovic, J.E. Stephens, 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

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 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.

The listing of the titles is subdivided into 10 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 WM 280-8 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 Winter Meeting, New York, New York, February - 3, 1991. Manuscript submitted November 14, 1990; made available for printing January 3, 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.

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.

Computer Relaying for Power Systems, Arun G. Phadke and James S. Thorp, Research Studies Press Ltd., Taunton, Somerset, England, and John Wiley & Sons Inc., New York, 1988. The book presents the basics of computer relaying principles and their applications for transmission line, transformer, machine, and bus, protection. Aspects of integrated substation protection and control are also included. Newer relaying principles, such as travelling wave relays and adaptive relaying, are also discussed.

Microprocessor Relays and Protection Systems, M.S. Sachdev (Coordinator), Tutorial Text, Pub. No. 88EH0269-1-PWR, New York, 1988. This book was prepared in continuation to the previous tutorial text, "Computer Relaying". The information on the subjects of digital relaying hardware and algorithms is updated. Also discussed are the subjects of protection functions, relaying in an integrated hierarchical system, background tasks, and travelling wave relays. Some commercially available relays are also described.

3150 COMPUTER RELAYING

Utilities Move to Digital Relays - But Cautiously, Electrical World, Vol. 202, No. 2, Dec. 1988. Protection engineers are asking about chips and software and even scrutinizing the manufacturers' acceptance tests to make sure that they know what they are buying.

Application of Specific Integrated Circuits for the Transformation from Three Phase AC to DQZ Coordinates, S.A. Allman, A.M. Gole, A. Neufeld and E. Dirks, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1523-9. The paper describes the design, fabrication, and testing of two special purpose digital integrated circuits for use in sequence relays and control systems. Design requirements are discussed and an application is described.

An Adaptive Sampling-Interval Generator for Digital Relaying, G. Benmouyal, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1602-9. This paper presents the basic principle of an adaptive sampling-interval generator which locks to the fundamental frequency component of the incoming signal. An application of this principle to a Volts-per-Hertz relay is described.

Programmable Controllers Quietly Enter Substations, Martin Best, Electric Power and Light, Vol. 66, No. 12, Dec. 1988, p 31, 34. This paper describes the use of programmable controllers or programmable logic controllers (PLC's) as a reliable and cost effective means of designing and implementing relay and control systems for electric power substations.

Extensive Testing of Algorithms for Travelling-Wave Based Protection, M.H.J. Bollen, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 135-139. This paper compares the performance of travelling wave algorithms using data generated by the EMTP and TWONFIL - Travelling Waves On Non-balanced Frequency-Independent Transmission Lines-programs. Line faults, lightening strokes and line energizing are considered.

Development of Custom LSIs for Protective Relays and Their Evolution to New Static Relays, T. Chiba, H. Kudo, A. Watanabe, M. Goto and K. Seo, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 130-7. This paper describes the features of the LSI circuits and the key technologies used to develop high performance relays. Performance tests of prototype relays are also included. Problems solved include: wide input range, precise analog operation with no manual adjustment, whole electronic circuits on a single chip, standardization, and low power dissipation.

Signal Processing and Discriminating Techniques Incorporated in a Protective Scheme Based on Travelling Waves, C. Christopoulos, D.W.P. Thomas and A. Wright, IEE Proceedings-C, Vol. 136, No. 5, Sep. 1989, p 279-88. The technique presented in this paper uses correlation for extracting important features of signals at a relaying location. A method for detecting close-up faults is also presented.

Digital Station Protection, D. Crameri, K.P. Brand, H. Hager and J. Kopainsky, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1617-24. This paper presents a microprocessor based approach for protecting all units in a substation. The processing units are located at each protection zone boundary. Fault type and direction are evaluated from current and voltage phasors. Trip output is produced by a collective decision of all processing units. The structuring allows flexibility, reliability, and maintainability.

A Simplified Algorithm for Digital Distance Protection Based on Fourier Techniques, D. D'Amore and A. Ferrero, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 157-64. A new approach based on a variable frequency sampling technique is proposed. It is shown that the technique performs like other Fourier-series algorithms under typical fault conditions but the computation burden is reduced.

Digital Impedance Protection of Power Transmission Lines Using a Spectral Observer, P.K. Dash and D.K. Panda, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 102-10. A recursive discrete-time filter generates interpolating function coefficients from input signal samples. The algorithm is computationally efficient and is suitable for microprocessor applications.

A New Algorithm for Digital Protection of Power Transformers, P.K. Dash and M.A. Rahman, Trans. CEA E&O Div., Vol. 26, Part 4, 1987, Paper No. 87-SP-169. The paper presents a spectral observer algorithm for digital differential protection of a 3-phase power transformer. The recursive discrete time filter interpolates the samples to generate the Fourier coefficients either by using spectral observation or the Functional expansion technique.

Developments in Distance Protection, P. Dodds, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 205-9. A method for decreasing the comparator operating time in a distance relay is discussed in this paper.

Off-Nominal Frequency Measurements in Electric Power Systems, M.M. Giray and M.S. Sachdev, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1573-8. The paper presents a technique that estimates frequencies in the 20 to 80 Hz range from sampled values of a voltage. The technique uses the Least Error Squares approach to extract the information from the measured values of the samples.

Implementation of Kalman and Adaptive Kalman Filtering Algorithms for Digital Distance Protection and Vector/Signal Processor, A.A. Girgis and D.G. Hart, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 141-56. Two Kalman Filtering processes for determining the fault type and fault location are presented. Each process includes fault detection, postfault current and voltage estimation, fault classification, zone computation and, fault location. The implementation is on a Zoran ZR 34161 Vector Signal Processor.

A Hybrid Expert System for Faulted Section Identification, Fault Type Classification, and Selection of Fault Location Algorithms, A.A. Girgis and M.B. Johns, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 978-85. This paper describes an expert system to identify faulted sections and interpret relay operations in an interconnected power system. The system measures current and voltage phasors to classify the type of a fault and compute its location.

Adaptive Transmission System Relaying, S.H. Horowitz, A.G. Phadke and J.S. Thorp, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1436-45. The adaptive possibilities studied include transmission system protection philosophy, transmission line and transformer protection, relay settings and auto-reclosing. This paper examines many situations and develops strategies to minimize compromises and optimize system performance.

Microprocessor-Based Auto Synchronizer for the CEGB's Transmission System, J.V. Hughes and B.R. Jakeman, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 281-5. This paper presents the specifications, electrical interference characteristics and technical aspects of a microprocessor-based synchronizer developed for the CEGB's transmission system. The operation of the autosynchronizer is also outlined.

Computer Representation of Overcurrent Relay Characteristics, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1659-67. The representation of inverse time overcurrent relay curves using a minimum number of constants is discussed. This report is a comprehensive review of the work done in the past.

Digital Protective Relaying Through Recursive Least-Squares Identification, A. Isaksson, IEE Proceedings-C, Vol. 135, No. 5, Sept. 1988, p 441-9. The recursive least-squares technique is described in this paper and is applied to the estimation of Fourier coefficients of voltages and currents. The estimates are used to detect the presence of line short circuits. Some results obtained by using data from the EMTP program are presented.

Adaptive Transmission Protection: Concepts and Computational Issues, A.K. Jampala, S.S. Venkata and M.J. Damborg, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 177-85. This paper describes the basis for an adaptive transmission protection, defines the concept, identifies its components, and illustrates it with simple examples. Efficient enhancement to existing off-line algorithms used in relay coordination are presented. Two computing approaches are investigated for developing an on-line tool for computing relay settings in real-time.

New Algorithms for Microprocessor-Based Distance Relaying, G.C. Kakoti and H.K. Verma, Electric Power Systems Research, Vol. 15, 1988, p 233-8. This paper describes two algorithms based on the Hartley transform. Their efficacy is examined using representative voltage and current signals.

Microprocessor Based Generalized Overcurrent Protection Schemes, S.C. Kar and A.K. Mukhopadhyay, Model Simul. Control A, Vol. 18, No. 3, 1988, p 55-63. The authors present a microprocessor based overcurrent protection scheme which is suitable for implementing any type of time current characteristics.

Digital Protective Relaying Algorithm Sensitivity Study and Evaluation, M. Kezunovic, J.T. Cain and B. Perunicic, IEEE Trans. on Power Delivery, Vol. 3, No. 3, July 1988, p 912-22. This paper presents the results of a study which investigates the parameter sensitivity of digital relaying algorithms. It develops a methodology and an adaptive criterion for their evaluation.

Microprocessor Applications To Substation Control And Protection, M. Kezunovic and B. Don Russell, IEEE Computer Applications in Power, Vol. 1, No. 4, Oct. 1988, p 16. Application of microprocessors to distance protection of transmission lines, distribution feeder monitoring and protection, and integrated control and protection systems are discussed.

Modern Practices and Field Experience With MC-Based Relays, G. Koch and G. Ziegler, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 315-20. This paper briefly outlines the protection concepts used in MC-based relays. Three concepts are developed from field experience and recommendations of the Association of German Power Supply Authorities.

Digital Protection of Transmission Lines Using Block Pulse Function, S.R. Kolla, Int. J. Electr. Power Energy Syst. (UK), Vol. 10, No. 4, 1988, p 274-6. An application of block pulse functions for digital protection of transmission lines is presented. A digital relay algorithm is developed to extract fundamental frequency components.

Implementation of a Digital Distance Relay Using an Interpolated Integral Solution of a Differential Equation, H. Kudo, H. Sasaki, M. Takahashi, K. Yoskida and T. Maeda, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1475-84. Low-frequency transient oscillatory voltages and currents have prompted the development of a distance protection scheme for EHV and UHV lines with large capacitance. The relay is based on a differential equation for the line.

Fast (1-Shift) Orthogonal Functions for Extraction of the Fundamental Frequency Component for Computer Relaying, Y.G. Paithankar, Electric Power Systems Research, Vol. 14, 1988, p 233-6. Digital relays extract the fundamental frequency components from distorted post-fault voltages or currents using either Fourier, Walsh, or Harr algorithms. This paper describes a new set of odd/even orthogonal functions and compares its performance with other methods with respect to computational speed and frequency response.

Computer Relaying: Its Impact on Improved Control and Operation of Power Systems, A.G. Phadke, IEEE Computer Applications in Power, Vol. 1, No. 4, Oct. 1988, p 5-10. This paper describes a hierarchical system of computers which can provide relaying, and direct access to relays, control devices, and measuring systems throughout the power system.

Amplitude Comparator Based Algorithm for Directional Comparison Protection of Transmission Lines, K.S. Prakash, O.P. Malik and G.S. Hope, IEEE Trans. on Power Delivery, Vol. 4, No. 4, Oct. 1989, p 2032-41. Fault caused deviations of voltages and phase shifted currents from their prefault values are used to determine the direction of a fault. Fast operation, fault discrimination capability, selective pole tripping, and pickup sensitivity independent of source impedance angle are features of the proposed method.

Ultra High Speed Directional Comparison Relay for EHV/UHV Lines, K.S. Prakash, O.P. Malik and G.S. Hope, Trans. CEA E&O Div., Vol. 26, Part 4, 1987, Paper No. 87-SP-168. This paper describes an ultra high speed directional comparison relay which is based on the quasi steady state components of the locally measured deviations of voltages and currents from their prefault values.

The Protection of Circuit Breakers from Excessive Duty Using Digital Techniques, D.A. Pritchard, R.P. DePuy and W.Z. Tyska, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper discusses the concept of a breaker reclosing relay that limits the number of close operations to avoid excessive circuit breaker duty during repetitive operations.

Adaptive Transmission Relaying Concepts for Improved Performance, G.D. Rockefeller, C.L. Wagner, J.R. Linders, K.L. Hicks and D.T. Rizy, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1446-58. Adaptive concepts include on-line changes in relay settings, relay characteristics, or logic in response to power system or environmental changes. It is shown that adaptive relaying is capable of improving relaying reliability and power system security, and makes better utilization of the facilities.

A Digital Technique for Estimating Frequency from Sampled Values of a Voltage, M.S. Sachdev and B. Chattopadhyay, Trans. CEA E&O Div., Vol. 27, Part 4, 1988, Paper No. 88-SP-158. The technique estimates the angle between voltage phasors at two instants of time and estimates the frequency from the phase measurements. The results presented in the paper show that the technique is suitable for use in microprocessor based relays.

A Non-Linear Modelling Approach for Detecting Winding Faults in Power Transformers, M.S. Sachdev, T.S. Sidhu and H.C. Wood, Trans. CEA E&O Div., Vol. 28, Part 4, 1989, Paper No. 89-SP-142. This paper presents two versions of a digital algorithm that detects winding faults in single and three phase transformers. The algorithm is based on a non-linear model of the protected transformer. A variety of operating conditions simulated on a computer are used to test the algorithms.

A New Digital Technique for Measuring Frequency at a Power System Bus, M.S. Sachdev and J. Shen, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 102-106. A technique for estimating frequency from sampled values of a voltage is described in this paper. Measures for minimizing the effects of system noise are considered and their effectiveness demonstrated.

Feasibility of Adaptive Distribution Protection System Using Computer Overcurrent Relaying Concept, K.R. Shah, E.D. Detjen and A.G. Phadke, IEEE Trans. on Industry Application, Vol. 24, No. 5, Sept./Oct. 1988, p 792-7. Distribution system protection can be improved by adaptive computer relays. Detection of downed conductors, self-testing, improved reclosing, relay performance adjusted to load are some of the benefits that can be realized.

Application of Virtual Digital Relays, T.S. Sidhu, M.S. Sachdev and H.G. Wood, Annual General Meeting of the IEEE Industry Application Society, Pub. No.

87CH2499-2, Part II, 1987, p 1744-9. This paper demonstrates the application of virtual digital relays as computer-aided design tools. Three different designs of a digital overcurrent relay are evaluated and compared.

Distance Digital Algorithm Immune to Saturation of Current Transformers, A. Wiszniewski and J. Szafran, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 196-9. A digital distance relaying algorithm which is not affected by ct saturation is described in this paper. The algorithm avoids the effect of ct saturation by calculating the current phasor only in the intervals when cts are not saturated.

Fault Tolerant Microcomputer Design for Power System Applications, H.C. Wood and A.D. Jalnapurkar, Trans. CEA E&O Div., Vol. 26, Part 4, 1989, Paper No. 89-SP-145. This paper describes a design for a triple modular redundant microcomputer based system. Results are given for a laboratory prototype built to demonstrate the design principles.

Tools for Computer-Aided Development of Microprocessor Based Power System Relays, H.C. Wood, M.S. Sachdev and T.S. Sidhu, Annual General Meeting of the IEEE Industry Application Society, Pub. No. 87CH2499-2, Part II, 1987, p 1733-8. This paper describes the design, development and implementation of virtual digital relays that can be used to examine the feasibility of a relay design. Procedures for modeling A/D converters and simulating the relay software are presented.

3151 DISTRIBUTION AND NETWORK PROTECTION

An Assessment of the Performance of Distance and IDMT Overcurrent Relays for Phase Faults on Interconnected Power System Networks, H.A. Abyaneh and D. Lidgate, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 291-5. An algorithm to assess the performance of distance and IDMT overcurrent relays is presented in this paper. The algorithm is implemented in Fortran V and the test results from its application are presented.

3151.1 INDUSTRIAL AND POWER STATION AUXILIARY SYSTEMS

Improved Microprocessor Based Distribution Feeder Earth Fault Protection Using Pattern Recognition, M. Al-Dabbagh, R. Daoud and R. Coulter, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 172-6. This paper describes a relay that detects earth faults on a three wire ungrounded distribution system. Patterns of voltages and currents during faults are used to identify faults.

Integrated Protection and Control Digital System for Rural Substations, E. Bondia, E. Suarez and F. Cobelo, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 113-5. This paper describes the functions performed by an overcurrent relay which also performs measuring and control functions. The relay can communicate with remote locations through an RS-232 port.

Automatic Earth Fault Isolation and Restoration of Supply in Cable Distribution Networks, K. Brewis, 4th Int. Conf. on Developments in power System Protection, IEE Pub. No. 302, 1989, p 271-5. This paper describes the hardware and application of an automated unit for isolating earth faults and restoring supply in cable distribution networks. The application is discussed in three steps, faulty section identification, sectionalizing and restoration by reconfiguring the system.

Transfer Switching Without Interruption, R. Castenschiold, Electrical Construction and Maintenance, Vol. 87, No. 9, Sept. 1988, p 71-5. Closed-transition transfer eliminates problems caused by momentary loss of power from open-transition transfer to or from a standby or emergency source. Most existing transfer switches are the open-transition type. An economical solution consists of adding two magnetically held contactors to parallel the switch momentarily. Operations with motor loads and power failures are discussed.

Requirements for Cogeneration in Parallel with the Utility, J.M. Daley, Electrical Construction and Maintenance, Vol. 87, No. 4, Apr. 1988, p 63-9. Cogeneration is most energy-efficient when generating in parallel with the utility, but requires proper controls and protection. Typical protective relaying systems for these generators are discussed. Engine and generator operation and system grounding requirements are also outlined.

Microprocessor Based Integrated Feeder Protection RIR 2000, D. Koncnik, J. Rupar, B. Suhel and J. Gorisek, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 286-90. This paper describes the hardware and software of a microprocessor based integrated feeder protection for distribution networks. The system includes three phase-overcurrent and one earth-fault relays.

Development of an Expert System for Power System Protection Coordination, L.L. Lai, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 310-4. The development of a prototype expert system for coordinating the protection of an industrial power system is presented in this paper. The usefulness of the expert system is demonstrated by applying it to a typical industrial power system.

Considerations for Ground Fault Protection: Medium-Voltage Industrial and Cogeneration Systems, D.J. Love and N. Hashemi, IEEE Trans. on Industry Applications, Vol. 24, No. 4, July/Aug. 1988, p 548-53. Typical methods for grounding of industrial medium voltage neutrals - high resistance, low resistance, and ungrounded - as well as methods used to detect the presence of a ground fault are reviewed. The effects of charging currents and the effects of ground fault protection method on conductor ratings are analyzed.

Zone Selective Interlocking Reduces Fault Stress, T.A. Michalak, Electrical Construction and Maintenance, Jan. 1989, p 63-5. The operation of circuit breakers of a low voltage distribution system is coordinated by overcurrent magnitude and time delay. Zone Selective Interlocking (ZSI) of electronic trip units permits instantaneous tripping of the upstream breaker when the downstream breaker senses no fault current.

Sensitive Ground-Fault Relaying, T. Novak, L.A. Morley and F.C. Trutt, IEEE Trans. on Industry Applications, Vol. 24, No. 5, Sept/Oct 1988, p 853-61. The importance and requirements for sensitive ground-fault protection are reviewed. Relaying schemes for both ac and dc systems are presented. The work is applicable to portable low-voltage systems that involve manual handling.

An Industrial View of Utility Cogeneration Protection Requirements, L.J. Powell, IEEE Trans. on Industry Applications, Vol. 24, No. 1, Jan/Feb 1988, p 75-81. Typical utility requirements for protection at the interface with a cogenerating industrial system are reviewed. The basis for their formulation is explained and practical ways for the industrial cogenerator to satisfy them are suggested.

Make the Right Interconnection Protection for Cogeneration, William Strand, Electric Power and Light, Vol. 67, No. 2, Feb. 1989, p 26. This paper describes the need for cogeneration/utility interconnection relays and control systems.

3151.2 PRIMARY DISTRIBUTION SYSTEM

Distribution Line Protection Practices - Industry Survey Results, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 512-22. The results of an extensive industry survey on the current practices for overcurrent protection of distribution lines are presented. Appropriate comments and observations are included. The survey questionnaire covered seven protection topics including phase and ground protection, reclosing, cold load pickup, and system operation.

Fault Protection Experience on Radial Distribution Circuits Containing Dispersed Storage and Generation (DSG) Units, J.T. Emery, 42nd Annual GA Tech Protective Relaying Conference, 1988. A comparison of the operating experience of distribution circuits with and without DSG's is presented. The comparison serves as a basis for determining the impact that the installation of DSG's have on radial distribution circuit protection.

Classification of Faults and Switching Events by Inductive Reasoning and Expert System Methodology, C.J. Kim and B.D. Russell, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1631-7. High impedance arcing ground faults do not draw enough current to use for fault detection. Every electrical detection parameter displays characteristics of randomness, making distinction between faults and switching events difficult. Detection methods and threshold settings using induction methods are proposed.

Distribution System Protection - the Application of Modular Electronic Schemes, K.J. Mackay and A.J. van der Walt, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 91-5. The "Phase 2" of the design and development of a protection system for the South Africa's national electical power supply utility is described in this paper. This system is for use on lines rated up to 132 kV.

Coordination Principles for Applying Expulsion and Backup Current-Limiting Fuses for Protecting Distribution Transformers, J.R. Marek and R.F. Gustin, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 610-4. The selection of current and voltage ratings for expulsion and current-limiting fuses is presented.

Relaying Protects Automated Distribution Systems, G.E. Meter and Control, Electric Power and Light, Vol. 67, No. 3, March 1989, p 42. This paper describes the technology which includes relays in control and metering systems for distribution automation.

Development of High Voltage, Self-Healing Current Limiting Element and Verification of its Operating Parameters as a CLD for Distribution Substations, H. Nakayama, T. Fukazu, Y. Wada, Y. Shinozaki and I. Ibuki, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 342-8. The paper discusses the need for a high voltage current limiting device. It then proposes a self-healing current limiting element of metallic sodium which vaporizes when a short circuit occurs and resolidifies after it is cleared.

A Microprocessor Protection Relay for Source Protection of 11-kV Radial Distribution - Its Design and Field Trial Experience, G.V. Roberts, I. Trevor, W. Kwong and H.T. Yipp, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 80-5. A radial distribution protection relay is described in this paper. The relay includes definite time and inverse time overcurrent and ground fault functions. Another function included in this design is the detection of low levels of currents due to faults on the secondary side of a distribution transformer.

The Development of an Integrated Protection and Reclosing Relay for Rural Feeders, P.R. Rosen, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 276-80. Development and features of an integrated protection and reclosing relay for rural feeders are presented in this paper. The relay is developed for use on rural feeders of the South African Electricity Utility.

A Digital Signal Processing Algorithm for Detecting Arcing Faults on Power Distribution Feeders, B.D. Russell and R.P. Chinchali, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 132-40. Several fault sensitive parameters for detecting low magnitude arcing faults are investigated. A detection methodology based on these parameters is described and a partial solution to the problem of directionality is discussed.

Behavior of Low Frequency Spectra During Arcing Fault and Switching Events, B.D. Russell, R.P. Chinchali and C.J. Kim, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1485-92. The variation and behavior of selected low frequency components during faults are presented. They are contrasted to normal events such as feeder and capacitor bank switching. Recorded field data is analyzed and presented. Arc duration, arc repetition rate, and magnitude of low frequency spectra are noted.

An Arcing Fault Detection Technique Using Low Frequency Current Components - Performance Evaluation Using Recorded Field Data, B.D. Russell, K. Mehta and R.P. Chinchali, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1493-1500. 180 Hz and 210 Hz components of fault currents were studied because of strong magnitude variations associated with arcing faults. An algorithm with adaptive characteristics is presented. Results of tests using recorded data are given.

Overall Assessment of Distribution Backup Protection Using Micro-Computer, C.Y. Teo and T.W. Chan, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 107-12. An interactive package for coordinating inverse time overcurrent relays is described in this paper. The software calculates the fault currents after each change in the system configuration and performs the coordination tasks. Breaker failure can be simulated.

A Logic Programming Approach to Fault Diagnosis in Distribution Ring Networks, K.P. Wong and C.P. Tsang, Electric Power Systems Research, Vol. 15, 1988, p 77-87. This paper develops the logic for diagnosing faults in distribution ring networks. It is then implemented by a goal-directed language, Prolog.

Application of Digital Filters in Power Systems, H.C. Wood and M.S. Sachdev, IEEE Pacific Rim Conference on Communications, Computers and Signal Processing, Victoria, B.C. Canada, Pub. No. CH2691-4/89-0000, 1989, p 277-80. This paper describes the application of signal processing techniques to power system protection. Signal processing aspects that are unique to fast and real-time operations in electric power systems are discussed.

3151.4 DISTRIBUTION AND NETWORK PROTECTION

Industrial Feeder Protection, G. Fielding and G.W. Evans, 4th Int. Conf. on Developments in power System Protection, IEE Pub. No. 302, 1989, p 264-70. This paper describes practical arrangements for protecting HV feeders in industrial power systems. The effect of short-circuits on industrial motors is also discussed.

Computer Assessment of IDMT Relay Performance for Phase and Earth Faults on Interconnected Power Systems, D. Lidgate and H. Askarian Abyaneh, IEE Proceedings-C, Vol. 135, No. 2, March 1988, p 157-65. This paper describes two algorithms for coordinating IDMT overcurrent relays. One determines the settings of relays used for detecting phase faults and the other determines the settings of ground fault relays.

Development of New Protection for Interconnected Overhead 33 kV Circuits, J.V.H. Sanderson, M. Kyriakides, W.J.S. Rogers, G.G. Evans and B.W. Swinnerton, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 86-90. This paper describes a microprocessor based relay for use on inter-connected 33 kV over-head lines. The relay includes fault detection, directional overcurrent and voltage restrained overcurrent functions. Communications facilities are included to perform SCADA functions.

3152 LINE PROTECTION

New Approach to Teed Feeder Protection Using Composite Current and Voltage Signal Comparison, R.K. Aggrawal and A.T. Johns, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 125-9. This paper describes a technique for protecting three terminal transmission lines. It uses voltages and currents at the three terminals.

Simplification of Polyphase Line Protection, G.E. Alexander, W.Z. Tyska and S.B. Wilkinson, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 192-5. An "energy comparator" used in GE solid state line protection system (PLS relay system) is described in this paper. Advantages of using the "energy comparator" for solid state directional and distance measuring units are outlined.

Differential Line Protection Application to Multi-Terminal Lines, J. Arbes, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 121-5. This paper describes the functional specifications used in developing a differential line protection system. The relay has been tested using a transient network analyzer and is now undergoing site testing in E.d.F.

The Performance of a Protective Scheme Based on Travelling Waves, C. Christopoulos, D.W.P. Thomas and A. Wright, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 146-50. The travelling waves principle presented in this paper estimates the fault resistance and then the fault location. Sample results are presented.

Experience and Problems With the Protection of Series Compensated Lines, R.G. Coney, G.H. Topham and M.G. Fawkes, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 177-81. The performance of (i) permissive over-reaching and electromechanical impedance relays, (ii) directional comparison relays and (iii) phase and ground impedance protection schemes for series compensated transmission lines over a period of thirteen years is reported in this paper.

Over and Undervoltage Protection of Weakly Interconnected HV Long Line Networks, R.G. Coney, G.H. Topham and P.M. Marot, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 162-6. This paper describes the use of overvoltage and undervoltage protection principles on 400 and 765 kV lines of Eskom, Republic of South Africa. Overvoltage relays disconnect the line from the system. Undervoltage relays initiate load shedding in the event of loss of interconnection capacity.

Scheme, Based on Travelling-Waves, for the Protection of Major Transmission Lines, C. Christopoulos, D.W.P. Thomas and A. Wright, IEE Proceedings-C, Vol. 135, No. 1, Jan. 1988, p 63-73. The development of the travelling-wave theory to detect faults on a single phase line is presented in this paper. The identification of the incident and reflected travelling waves is described. The technique is then applied to three phase systems. Some results from simulations are presented.

The Design of a Directional Comparison Protection for EHV Transmission Lines, P.A. Crossley, S.F. Elson, S.J. Rose and A. Williams, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 151-5. A directional comparison relay is described in this paper. The relay can be used in a blocking or permissive inter-tripping scheme.

Limits to Zones of Simultaneous Tripping in Multi-Terminal Lines, M. Mir and M.H. Imam, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 326-30. A technique to quantitatively determine the limits to zones of simultaneous tripping is presented in this paper. The technique models the relay reach as a function of system parameters with their associated uncertainties and uses mathematical programming to determine optimum relay reach. Simulation results from application to a 138 kV three-terminal line are presented.

Adaptive Digital Distance Protection, P.J. Moore and A.T. Johns, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 187-91. This paper describes a digital distance relay which adapts to power system conditions such as power swings and high-resistance earth faults. Simulation studies show the relay operation times, high resistance earth fault coverage and response to power swings.

Series Compensated Line Protection: System Modelling and Relay Testing, A. Newbould and I.A. Taylor, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 182-6. This paper describes the application of distance protection to series compensated lines. The proposed system and tests conducted in a laboratory using computer generated signals are described. Voltage and current inversion phenomena and selection of polarizing voltages are briefly discussed.

A New Approach to High Speed Relaying Based on Transient Phenomena, G. Nimmersjo and M.M. Saha, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 140-5. This paper describes a technique which calculates, from local observations, the voltage expected at the remote terminal of a line if the fault was external. The expected voltage is compared with the observed voltage to decide if the fault is on the protected line.

A Second Generation Microprocessor Line Protection Relay, D.M. Peck, F. Engler and I. De Mesmaeker, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 200-4. This paper describes the hardware and software of a microprocessor-based distance relay for line protection.

Optical Fibre Signalling for Protection Purposes, W.J.S. Rogers, G.F.G. Evans, J.B. Bailey and R.W. Nicholls, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 130-4. A brief description of a fibre optic link for the protection of and communication between two terminals of a short transmission line is given in this paper.

Setting Distance Relays for Multi-Coupled Lines Using Permissive Underreach Schemes, G. Varga and F. Rodrigues, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 306-9. This paper reviews the problems related to setting of distance relays for lines that have multiple couplings. A method using a permissive underreach scheme is suggested.

Design of a Generic Range of Distance Relays, G.C. Weller, B.R.J. Caunce and N. Robinson, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 210-4. This paper describes the design of a generic range of multiprocessor distance relays. Hardware structure, user interface, measuring units and self-monitoring are discussed.

A Microprocessor Based Current Differential Protection, J.M. Wheatley, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 116-20. The functions performed by a current differential relay for line protection are described in this paper. Hardware arrangement for a three terminal application is outlined with the aid of functional block diagrams.

3152.1 DISTANCE AND GROUND RELAYING

Scheme for Accelerated Trip for Faults in the Second Zone of Protection of a Transmission Line, C. Deshu, L. Pei, P. Hua, G.S. Hope and O.P. Malik, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 942-8. An impedance unit with zero sequence current polarization detects a change in local zero sequence current when the remote end breaker trips instantaneously and then initiates sequential tripping of the local breaker. The problems of selectivity and sensitivity are discussed. Test results from a model system are given.

Comprehensive Form for the Protection of Very Short Transmission Lines, A.A. El-Alaily and M.M. Mandour, Electric Power Systems Research, Vol. 14, 1988, p 227-32. The technique described in this paper is based on injecting a precalculated high frequency signal at the relay location and using a pulse type phase comparator to differentiate between leading and lagging circulating currents in the earth fault loop.

Modern Transmission Line Relaying Variations, W.A. Elmore, 43rd Annual GA Tech Protective Relaying Conference, 1989. For many years transmission line relaying varieties were limited to simple non-pilot distance, and directional comparison and phase comparison pilot systems. As reliable and diverse communication channels became available, variation of these fundamental systems began to emerge. This paper describes some of the lesser known systems in their simplest form to amplify their strengths and weaknesses.

The Application of High Speed Grounding Switches for Secondary Arc Extinction on HV/EHV Power Lines Control and Protection, J. Esztergalyos, S.L. Wiese and S.H. Ahmed, 43rd Annual GA Tech Protective Relaying Conference, 1989. The paper covers such areas as: (i) conventional secondary arc extinction methods on HV/EHV lines with single-pole tripping, (ii) the four reactor scheme and the problems that arise from its application on parallel, untransposed HV/EHV lines with single phase trip, and (iii) specific problems arising from lines terminated in Gas Insulated Substations.

Studies of Distance Protection with a Microprocessor for Short Transmission Lines, Z. Li and Z. Zhi-Jing, IEEE Trans. on Power Systems, Vol. 3, No. 1, Feb. 1988, p 330-6. A new type of zero sequence reactance relay for short lines is presented. It uses for polarization line zero sequence current whose phase has been shifted and compares the phases between the polarization and compensated voltage.

A General Method for the Analysis of Distance Relay Elements, R.J. Marttila, Trans. CEA E&O Div., Vol. 27, Part 4, 1988, Paper No. 88-SP-157. A general method for the analysis of the response of distance relay elements is presented. The method calculates the apparent impedance of various types of relay elements from the fault quantities and directly plots on an RX-plane. Computer models of various distance relay elements are presented and examples of their response, as affected by line loading, are highlighted.

Effect of Transmission Line Loading on the Performance Characteristics of Polyphase Distance Relay Elements, R.J. Marttila, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1466-74. The performance characteristics of a polyphase phase fault detection element is reported to show the effect of line loading and reach setting on the detection characteristics. The results are presented in a manner that permits ready assessment of the expected performance in a particular application.

Travelling Wave Relays - An Update, P.G. McLaren, Trans. CEA E&O Div., Vol. 28, Part 4, 1989, Paper No. 89-SP-143. This paper describes the travelling wave and ultra high speed relays which are presently available.

Series Compensated Lines, Issues Relevant to the Application of Distance Protection, A. Newbould, Trans. CEA E&O Div., Vol. 26, Part 4, 1987, Paper No. 87-SP-171. This paper develops a steady state representation of the overall impedance of a capacitor bank and voltage limiting metal oxide varistors connected in parallel. The paper then constructs the 3 phase fault impedance loci seen on three practical examples of series compensated lines as the fault location and fault resistance are varied.

Digital Distance Relay with Improved Characteristics Against Distorted Transient Waveforms, Y. Ohura, T. Matsuda, M. Suzuki, M. Yamaura, Y. Kurosawa and T. Yokoyama, IEEE Trans. on Power Delivery, Vol. 4, No. 4, Oct. 1989, p 2025-31. Future 1100 kV lines and 500 kV cables will have high capacitance which will lower transient frequencies. A differential equation algorithm, which provides measurement performance with less than 3% error when transient low frequency components are present, is described in the paper.

A Polyphase Digital Distance Relay, M.S. Sachdev and S.R. Kolla, Trans. CEA E&O Div., Vol. 26, Part 4, 1987, Paper No. 87-SP-170. This paper describes the modal transformation and lists equalities that define shunt faults. A criterion for distance relaying is derived. The design of a polyphase distance relay is then presented. Some simulated test results are included to demonstrate the performance of the relay.

Traveling Wave Distance Protection-Problem Areas and Solutions, E.H. Shehab-Eldin and P.G. McLaren, IEEE Trans. on Power Delivery, Vol. 3, No. 3, July 1988, p 894-902. This paper examines some problem areas and suggests new techniques to improve distance protection based on traveling waves. A complete correlation output is used to recognize reflections from the fault and distinguish them from reflections from discontinuities behind the relay. Effects of inception angle are compensated; fault resistance effects and external faults are also examined.

Polarizing Sources for Directional Relaying, W.M. Strang, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper is a reference document that describes methods of polarization that are used to accomplish directionality in relays.

Transmission Line Relaying Using Microprocessors, E.A. Udren and Hung Jen Li, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper presents two contrasting approaches to the design of digital line protection - stand-alone digital transmission line relays, and the line protection modules which are an integral part of relaying and control systems for an entire substation.

3152.2 PILOT WIRE, CARRIER AND MICROWAVE

A Differential Line Protection Scheme for Power Systems Based on Composite Voltage and Current Measurements, R.K. Aggarwal and A.T. Johns, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1595-601. This line relaying system derives differential signals from currents and voltages measured at each end of the line. This approach avoids the need for relay bias to compensate for capacitive currents and permits greater sensitivity than that can be achieved with a current only differential scheme.

Fiber Optic Channels for Protective Relaying, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 165-76. This paper provides relay engineers with a general description of fiber optic hardware, methods of modulation, splicing considerations, and testing. The economics of a multi-use fiber optic system is discussed. Available relaying equipment, including equipment which interfaces existing pilot wire relays to optic fibers, is described.

LFCB Current Differential Relay for Use with Digital Communication Systems, B. Ling and W.S. Kwong, Trans. CEA E&O Div., Vol. 27, Part 4, 1988, Paper No. 88-SP-156. The paper describes a microprocessor based current-differential transmission line relay designed for use with digital communication systems. The advantages of the relay are discussed. The requirements of digital communication systems, with emphasis on optical fibre systems, both multiplexed and dedicated, are addressed.

Relay Setting Considerations & Operational Experience of a Long Transmission Line, K.K. Mustaphi and R. Zimering, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 111-20. The relaying of a 500 kV line requiring enhanced reliability and security is described. Single pole tripping and reclosing is used for single phase faults. Primary relaying is negative sequence current directional comparison unblock system and secondary relaying is an individual phase, phase comparison system with audio tones on microwave.

Application Consideration of Fiber-Optic Channels for Protective Relaying, R.E. Ray, 42nd Annual GA Tech Protective Relaying Conference, 1988. The groundwork required for the reader to further study the topic of fiber-optics is presented. Some of the topics covered include: why fiber-optics in protective relaying, main components of fiber-optic systems, system performance calculations, and application notes.

Disturbance Monitoring/Fault Test Evaluation of a Directional Comparison Protection on the UK 400 kV Transmission System, S.J. Rose, P.A. Crossley, E.P. Walker, A.T. Johns, M.A. Martin and D. Peck, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1410-8. Monitoring of the UK 400 kV system and the salient features of the response of a directional comparison relay in a noisy substation environment are discussed. The use of the disturbance monitored data in the design and evaluation of the prototype relay system is described.

3152.3 RELAY SYSTEMS

Line Protection Design Trends in the USA and Canada, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1530-5. The line protection practices of 116 electric power utilities are analyzed and presented for reference of current design practices.

Development of a Substation Digital Protection and Control System Using Fiber-Optic Local Area Network, M. Suzuki, T. Matsuda, N. Ohashi and Y. Sano, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1668-75. The paper describes a new system that has been developed and is in trial use at a 500 kV substation. Digital protection and control equipment are located close to the outdoor power apparatus and are linked by a fiber optic network. The equipment configuration and networking system are discussed.

Integrated Metering and Protective Relay Systems, S.E. Zocholl, IEEE Trans. on Industry applications, Vol. 25, No. 5, Sept/Oct 1989, p 889-93. Digital filtering and real-time computation of voltage and current phasors by low cost microprocessors make metering, event recording, and fault locating an integral part of a protective relay system. These systems perform a range of functions in maintainable software, such as, self diagnostics. They use unified hardware, and provide a significant reduction in cost per function.

3153 RELAY INPUT SOURCES

Current Transformers with Secondary Current Rating Lower than 5 A, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 501-6. The report examines the conditions that favor a lower ct rating to allow smaller lead size, smaller ct core, or improved ct response. The paper puts the pertinent parameters into perspective for an engineering evaluation of specific applications.

Summary of the Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases ANSI/IEEE C57.13.3, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1459-65. The guide provides information for achieving consistency in grounding practices that impact personnel safety and proper performance of relays at power line frequencies. This paper promotes an awareness in the industry of the guide and the concerns which prompted its preparation.

Optical Fibre Current Sensor for Circuit Protection, A.P. Steer, S.J. Turner, P.R.B. Farrie, A.N. Tobin, R.P. Tatam, J.D.C. Jones and D.A. Jackson, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 296-300. This paper describes the design of an optical fibre current sensor for application in protection systems. The results of ac and dc current measurements are presented and are compared with those from a current transformer.

3154 ROTATING MACHINERY PROTECTION

Factors Influencing the Protection of Small-to-Medium Size Induction Generators, J.D. Bailey, IEEE Trans. on Industry Applications, Vol. 24, No. 5, Sept/Oct 1988, p 955-64. The performance and unique characteristics of induction generators, as they relate to the protection of the units of several kW to 1500 kW, are discussed. The differences in protection suggested for synchronous and induction units are provided. The concern of overvoltage due to self-excitation of induction generators under load rejection is also addressed. Minimum protection recommendations are given.

Microprocessor Motor Protection Relay, D. Clegg and B. Lacroix, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 235-8. This paper describes a microprocessor-based relay for protecting high voltage motors.

Large Induction Motors - Field Test on Locked Rotor Protection, H.G. Farley and L.G. Hajos, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 488-93. Large motors with high inertia loads often require longer starting times than locked rotor protection permits. The paper describes the authors' experience in solving the problems of nuisance trips during start up. The test results are provided to assist in proper setting of supervising distance relay.

Summary of the Guide for Abnormal Frequency Protection for Power Generating Plants ANSI/IEEE C37.106-1988, Power System Relaying Committee Working Group, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 153-8. The paper is an introduction to the guide. It discusses the hazards of operating generating equipment at abnormal frequencies and describes acceptable protective schemes.

Survey of Experience with Generator Protection and Prospects for Improvements Using Digital Computers, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1511-22. Results of an industry survey are presented. The survey identifies problems for which adequate protective devices are not available and examines the extent of those problems. The feasibility of using digital processors for alleviating those problems is examined.

Summary of the "Guide for AC Generator Protection" ANSI/IEEE C37.102-1987, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 957-64. This paper serves as an introduction to the guide. It briefly describes the material contained in the guide and presents some examples.

Inadvertent Energizing Protection of Synchronous Generators, IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 965-74. A significant number of large machines have been damaged on being accidently energized when off-line. This report describes the problem, the hazard to the generator and turbine, and the major dedicated protection schemes employed within the industry to detect this condition.

Design Aspects of Torness Main Generator Protection, R.A. Mather, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 45-50. This paper describes the protection provided for a 685 MW generator at the Torness advanced gas cooled nuclear station of the South of Scotland Electricity Board.

Determining Relay Setting for Motor Protection Using Published and Empirical Data, P.W. Powell and S.E. Zocholl, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper describes the relation between the thermal limit curves and the published parameters of an induction motor and shows how to use this data to determine relay settings for the thermal and fault protection of the stator and rotor.

Analysis of Ground Protection of Unit Connected Generators Using Third Harmonics, S. Shiwen and S. Binhua, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 254-8. Description and analysis of a scheme for ground fault protection of unit connected generators is presented in this paper.

Relay Performance in DSG Islands, C.L. Wagner, W.E. Feero, W.B. Gish and R.H. Jones, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 122-31. Field tests were made with isolated DSGs to confirm the existence of self excitation, ferroresonant, and high voltage conditions. A number of voltage and frequency relays were installed and their performance monitored. Problem areas which became apparent are discussed.

Research and Application of Protection Relay Schemes for Internal Faults in Stator Windings of a Large Hydro-Generator with Multi-Branch and Distributed Arrangement, X.H. Wang, L.Z. Zhang, W.J. Wang and Z.H. Yu, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 51-5. A technique described in this paper protects a large generator with multiple stator windings. A method for calculating currents due to faults in one of the loops is also described.

New Developments of Third Harmonic Ground Fault Protection Schemes for Turbine-Generator Stator Windings, W. Weijian, X. Xiaoping and Z. Xiling, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 250-3. This paper introduces a third harmonic equivalent circuit of turbine-generator stator windings and uses the equivalent circuit to analyze stator ground fault protection schemes.

3155 TRANSFORMER, BUS, CAPACITOR, AND REACTOR PROTECTION

Load Shedding Scheme of Jordanian National Power System, M.F. Abusharkh and A.A. Hiyasat, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 96-101. This paper describes the load shedding scheme used by the Jordan Electricity Authority. The decisions are made using four parameters, voltage, frequency, rate of change of frequency and time.

An Automatic Transfer Scheme Using a Programmable Controller, M.F. Best, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper explains the basic operating characteristics of a station transfer scheme and describes the evolution from a component relay scheme to a programmable controller scheme.

Monitoring and Fault Protection of High Voltage Switchayards by the Remmit Method, D.W.E. Blatt, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 167-71. Current measurements by remote magnetic field monitoring instrument transformers is described in this paper. Sensing coils are located at each segment but at a safe distance from the high voltage conductors. Field measurements are converted to currents in the conductors using a matrix that describes the couplings between the conductors and the sensing coils.

Advanced Control Relaying for Switching Substation Capacitor Banks, T.L. Branch, D.L. Hornak and R.D. Pettigrew, 42nd Annual GA Tech Protective Relaying Conference, 1988. The application of an advanced multi-function control relay for automatically controlling switched capacitor banks is presented.

System Back-up Protection - A New Approach, F.C. Chan, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 331-5. The basic requirements of system back-up protection are outlined in this paper. A new approach, that used earth fault relay with current dependent time-lag characteristic, provides system back-up protection. The application of the proposed technique is demonstrated by using a 400 kV model system.

The Application of System Control Centre Computer Assisted Special Protection Systems in Ontario Hydro, D.R. Cowbourne and P.M. Murphy, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 156-61. A transmission line fault on the Ontario Hydro system could result in disconnecting critical lines, limiting the ability of the system to transport power generated at the Bruce Nuclear Power Station. This paper describes a control scheme for rejecting nuclear generation on the inception of faults on selected lines.

New One-Cycle Static Blocking Scheme for Inrush in Differential Relay, B.T. Desai, H.O. Gupta and M.K. Vasantha, IEE Proceedings-C, Vol. 136, No. 1, Jan. 1989, p 48-54. A technique for detecting magnetizing inrush in transformers is presented in this paper. The technique is based on the shape of the waveforms of currents. Electronic circuits for identifying magnetizing inrush are also included. Some results from laboratory tests are presented.

Adaptive Control of Load Shedding Relays Under Generation Loss Conditions, B. Fox, J.G. Thomson and C.E. Tindall, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 259-63. This paper describes an adaptive load shedding scheme that uses the continuously up-dated information regarding generator loadings.

Practical Considerations in Protecting Gas-Insulated Substation to Cable Interfaces, N. Fujimoto, Trans. CEA E&O Div., Vol. 26, part 1, 1987, Paper No. 87-A-60. Insulated flanges are commonly used at the interface between gas-insulated substations and high pressure oil filled ("pipe type") cables. This practice provides galvanic corrosion protection of the cable pipe. The practical considerations of techniques for protecting the insulating flange are discussed for both new designs and retrofits for existing installations.

System Analysis of Digital Differential Power Transformer Protection, B. Grcar, D. Dolinar, J. Ritonja and J. Pihler, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 220-4. A model of a three-phase core type power transformer and models of cts are presented in this paper. The data generated by using the proposed models is then used to study the performance of a digital algorithm for differential protection of transformers.

Study of the Non-Operation for Internal Faults of Second Harmonic Restraint Differential Protection of Power Transformers, G.S. Hope, O.P. Malik, D. Chen and P. Liu, Trans. CEA E&O Div., Vol. 28, Part 4, 1989, Paper No. 89-SP-141. This paper studies the non-operation of second harmonic restraint differential protection for faults in transformers. To prove the existence of this problem, three algorithms are analyzed for a large number of faults and energization of a transformer. The sample data used is based on on-line tests of a laboratory transformer. Modified schemes to solve this problem are presented.

Digital Protection Method for Power Transformers Based on an Equivalent Circuit Composed of Inverse Inductance, K. Inagaki, M. Higaki, Y. Matsui, M. Suzuki, K. Yoshida and T. Maeda, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1501-10. The paper presents an algorithm for the protection of power transformers without reference to the shapes of current waveforms. The algorithm readily discriminates between internal faults and magnetizing inrush.

A Rationalised Policy for Application and Setting of Back-up Protection on the CEGB Supergrid System, R. Inglesfield, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 301-5. This paper reviews the need for back-up protection on the CEGB supergrid. A back-up protection scheme for feeders, bus sections and couplers, and transformers is proposed. The performance objectives and a relay setting policy for back-up protection are outlined.

Computer Algorithm for Selection of Frequency Relays for Load Shedding, J.R. Jones and W.D. Kirkland, IEEE Computer Applications in Power, Vol. 1, No. 1, Jan. 1988, p 21-5. This paper describes a method of setting under-frequency load shedding relays. The method iteratively calculates the relay setting in software while changing parameters, thereby optimizing the design.

Primary Protection for Network Transformers, J.A. Kischefsky, Trans. CEA E&O Div., Montreal, Vol. 26, Part 1, 1987, Paper No. 87-D-47. This paper reviews the requirements for distribution transformer protection and describes the equipment developed to meet the physical and electrical requirements for interrupting devices installed in transformer vaults.

A Microprocessor Based Protective System for Generator-Transformer Units, I. Korbasiewicz, M. Korbasiewicz and W. Winkler, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 56-60. A general concept of protecting a generator-transformer unit is described in this paper. The proposed relays are divided in three groups. It is proposed that each group of relays be implemented on a 16-bit microprocessor.

A New Detection Scheme for Realization of Magnetizing Inrush Current in Transformers, P.C.Y. Ling and A. Basak, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 239-44. This paper describes a model used to determine the second harmonic components of the magnetizing inrush currents in single-phase and three-phase transformers. An algorithm for detecting the magnetizing inrush conditions is then proposed.

A New Look at Trip Circuit Design - The Lifeline of Protective Relaying, L.C. Lunsford, R.B. Bliss, 42nd Annual GA Tech Protective Relaying Conference, 1988. This paper discusses the relationship of the various components in the trip circuits and their impact on each other. Older schemes are not always compatible with newer equipment. The problems encountered by one utility are discussed.

Performance of Differential Protection for Three-Winding Power Transformers During Transient ct's Saturation, M. Mikrut, W. Winkler and B. Witek, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 66-9. This paper presents digital simulation studies on the performance of differential relays protecting three winding transformers under transient saturation of conventional ct's. Both internal and external faults are considered.

Developments in Transformer Protection, P. Mudditt and R. Niven, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 61-5. This paper describes a digital transformer protection system which includes differential and overcurrent functions. Ratio balance, phase angle correction and zero sequence current removal are achieved in the software. Magnetizing inrush and overfluxing are detected by the presence of second and fifth harmonics respectively.

Design of a Digital Protection Scheme for Power Transformers using Optimal State Observers, Y.V.V.S. Murty, W.J. Smolinski and S. Sivakumar, IEE Proceedings-C, Vol. 135, No. 3, May 1988, p 224-30. The design of the software for a transformer protection relay is described in this paper. The state observer approach is used for estimating the fundamental and harmonic components in the currents. Results from the application of this approach to the data obtained from laboratory tests are presented.

Design and Implementation of a Digital Differential Relay for a 3-Phase Power Transformer Based on Kalman Filtering Theory, Y.V.V.S. Murty and W.J. Smolinski, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 523-30. The paper describes a five state Kalman filter and its implementation in a differential relay. The fundamental and second harmonic components of the differential currents are estimated using Kalman filters. Test results are included.

Protection and Design of Shunt Capacitor Banks With Internally Fused Capacitors, G.C. Parr, 42nd Annual GA Tech Protective Relaying Conference, 1988. This paper discusses the differences in the protection required when capacitor banks are built using internally fused capacitors instead of the traditional external fuses.

A State-of-the-Art Review of Transformer Protection Algorithms, M.A. Rahman and B. Jeyasurya, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 531-41. The mathematical bases for six algorithms are briefly described. The algorithms are compared as to their speed of response, computational burden, and capability to distinguish between an inrush and transformer internal fault.

Low Impedance Biased Differential Busbar Protection for Application to Busbars of Widely Differing Configuration, J.B. Royle and A. Hill, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 40-4. High impedance and low impedance biased differential techniques for busbar protection are briefly described. A technique described in the paper detects ct saturation and ensures operation for internal faults and stability during external faults.

A Digital Relaying Algorithm for Detecting Transformer Winding Faults, M.S. Sachdev, T.S. Sidhu and H.C. Wood, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1638-48. This paper describes a new digital algorithm for detecting winding faults in single-phase and three-phase transformers. The algorithm, based on the electromagnetic equations of a transformer, is suitable if it is or it is not possible to measure winding currents. The results of the tests show that the algorithm performs well.

Detecting Transformer Winding Faults Using Non-Linear Models of Transformers, T.S. Sidhu, M.S. Sachdev and H.C. Wood, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 70-4. This paper describes an algorithm for detecting faults in three phase delta-wye transformers. The technique models the transformer as a non-linear device and compares the operating parameters observed at the primary and secondary terminals.

Novel Ways of Protection and Control Equipment Accommodation, J.E. Starke, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 336-40. This paper describes techniques for accommodating protection and control equipment at new and existing substations. The techniques provide reductions in lifetime costs and overall engineering time without sacrificing availability and reliability.

New Approaches to Differential Relaying/Solid State Power Transformer Protection, W.M. Strang, 42nd Annual GA Tech Protective Relaying Conference, 1988. This paper presents a general overview of transformer differential protection including specific considerations to factors such as, magnetizing inrush and harmonic restraint. The paper reviews two new relay designs and outlines the advantages of their application for transformer protection.

Expert System Application in Substation Monitoring, Back-up Protection and Control, J. Trecat and W. Jianping, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 75-9. The implementation of an expert system for protection and control of a substation is considered in this paper. The organization of the system and the functions performed by each module are outlined.

3156 FAULT AND SYSTEM CALCULATION METHODS

A Method For the Computation of Fault Transients in Transmission Lines, A.S. Al-Fuhaid, M.M. Saied, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 288-97. Digital computational techniques for calculating line transients are reviewed. A method for determining the line parameters is given. The effect of frequency is considered.

Analysis of Simultaneous Ground and Phase Faults on a Six Phase Power System, B.K. Bhat and R.D. Sharma, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1610-6. A single algebraic equation is presented for calculating the sequence currents following a simultaneous ground and phase fault at the terminals of a six phase generator. The connection of the sequence networks is indicated.

A Personal Computer Approach to Overcurrent Protective Device Coordination, K.A. Brown and J.M. Parker, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 507-11. The paper discusses a computerized approach for overcurrent device coordination. The program is designed to minimize the tedious mechanics of checking coordination, to improve accuracy of comparing time-current curves, and to increase the ease with which the coordination of two devices may be checked.

ASPEN One Liner: A Computer-Aided Relay Coordination Program, S. Chan, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper describes a computer-aided relay coordination program which combines in one program the elements of a CAD (computer-aided design) package, a short circuit program, and a relay coordination program.

Fault Locators Reduce Outage Time, D.H. Deverell and D.E. Shields, Transmission and Distribution, Aug. 1988, p 58-62. This paper describes the application of fault locating relays on subtransmission and distribution lines to minimize customer outage time. One relay which uses the current on the load side of a power transformer is used to locate faults on several distribution circuits.

Utility Solves Problem of Communications Protection at High Voltage Sites, L.L. Duda, Transmission and Distribution, Jan. 1988, p 34-6. This paper describes techniques for calculating the ground-potential-rise due to a nearby power line faults. It also outlines the guidelines used to safely terminate a communication entrance cable, and shows the benefits of having protective safeguards in place.

New Algorithm for Distance Protection of High Voltage Transmission Lines, M. Fikri and M.A.H. El-Sayed, IEE Proceedings-C, Vol. 135, No. 5, Sep. 1988, p 436-40. The technique described in this paper estimates the location of a transmission line fault from instantaneous data sampled at the line terminals. It is essential that the sampling of data at the two line terminals be synchronized. The simulation results presented in the paper show the accuracy of the expected results.

Benefits of Performing Unbalanced Voltage Calculations, M.E. Galey, IEEE Trans. on Industry Applications, Vol. 24, No. 1, Jan./Feb. 1988, p 15-24. An accurate load flow of a distribution system requires complicated equations to calculate voltages when the loads are unbalanced. Digital computers and appropriate software can take into account unbalanced loads, ground resistance, temperature, etc. Worked examples show how software is used to reduce the time an engineer needs to study the problem.

Application of Adaptive Kalman Filtering in Fault Classification, Distance Protection, and Fault Location using Microprocessors, A.A. Girgis, E.B. Markram, IEEE Trans. on Power Systems, Vol. 3, No. 1, Feb. 1988, p 301-9. The current and voltage data of each phase is processed in two Kalman filter models simultaneously. One model assumes that the phase is not faulted and the other assumes that the phase is faulted. Convergence of estimates and observations determines the apparent resistance and reactance to the fault.

Power System Disturbance Recorder, T.A. Gough and G.R. Berube, Trans. CEA E&O Div., Vol. 28, Part 4, 1989, Paper No. 89-SP-155. A microprocessor-based Power System Disturbance Recorder is described in this paper. The recorder is for use at major generating, transformer and switching stations within the Ontario Hydro system.

Use of Data Compression Techniques in Digital Fault Recorder, I. Heller and P. Lucas, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 18-22. This paper briefly describes a digital fault recorder which can store in its local mass memory data of thirty events over a five seconds duration. This is achieved partly by using a data compression technique.

Generator Representation and Characteristics for Three Phase Faults, T. Higgins, H. Holley and L. Wall, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper provides some guidance in the selection of generator parameters for incorporating initial conditions and accounting for generator voltage regulator/exciter action during three phase faults.

State of the Art Developments in Master Station Fault Analysis, A.T. Howard, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper describes some presently available software tools for analyzing of digital fault recorder data.

Accurate Fault Location of Transmission Lines using Microprocessors, B. Jeyasurya and M.A. Rahman, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 13-7. A technique for estimating the location of a transmission line fault is described in this paper. The technique uses the information recorded by digital relays.

Analysis and Review of Transmission Line Fault Locating Algorithms, B. Jeyasurya and M.A. Rahman, Trans. CEA E&O Div., Vol. 27, Part 4, 1988, Paper No. 88-SP-159. This paper reviews the algorithms for transmission line fault location. The mathematical basis for each algorithm is briefly described.

New Accurate Transmission Line Fault Location Equipment, A.T. Johns, S. Jamali and S.M. Haden, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 1-5. This paper describes a technique for estimating the distance of a transmission line fault from the relay locations. A distributed parameter model of the line is used in this technique.

Harmonic Behavior During Arcing Faults on Power Distribution Feeders, C.J. Kim and B.D. Russell, Electric Power Systems Research, Vol. 14, 1988, p 219-25. The waveforms of normal and arcing fault currents on power distribution feeders are investigated. The amplitude of the waveform is compared with the amplitude of the normally observed fundamental frequency component. The purpose of the study is to find parameters that indicate arcing faults.

A Step Forward: Automatic SER Data Acquisition and Analyzation, D.S. Kolbenschlag, 42nd Annual GA Tech Protective Relaying Conference, 1988. This paper describes one utility's system for remote acquisition of data from sequence of events recorders. The method of retrieving data and separating from it data that is pertinent to a specific disturbance is discussed.

Transmission Line Fault Location Using Digital Fault Recorders, D.J. Lawrence and D.L. Waser, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 494-500. A fault location algorithm, which uses the Z- transform technique to model system response to a fault, is described. A relationship between the measured phase voltages and currents and the system network impedances is developed.

Transmission Line Modeling for Short Circuit Calculations, A.P. Meliopoulos and A.H. Ayoub, 42nd Annual GA Tech Protective Relaying Conference, 1988. Error analysis of power line parameters and cases in which this error may be unacceptable are discussed. Also presented is a new algorithm for computing the sequence parameters of power lines.

Graphics Relay Coordination Analysis Using an Integrated Short Circuit Module, R. Ramaswami, A. Poznansky, P.F. McGuire and D.M. MacGregor, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper concentrates on two modules (Coordination Graphics and Short Circuits) of a computer-aided protection engineering program. Actual examples are given using a portion of the Georgia Power Company system.

Computer Aided Coordination of Directional Relays: Determination of Break Points, V.V.B. Rao and K.S. Rao, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 542-5. Break points are the network locations where directional overcurrent relays have minimum settings. A technique for determining the break points is described. This technique could be incorporated in a computer-aided relay setting package.

A Technique for Estimating Transmission Line Fault Locations from Digital Impedance Relay Measurements, M.S. Sachdev and R. Agarwal, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 121-9. Recorded fault data from both ends of a line plus the known line impedance are used to calculate the apparent fault impedance from each terminal, the fault resistance, and the location of the fault. The technique does not require synchronized data or source impedances. The procedures for all common fault types and test results are described.

A Review of Impedance-Based Fault-Locating Techniques, E.O. Schweitzer, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper reviews the fundamental fault-locating principles and field experience. It also discusses and analyzes special cases, and points out how fault locating has benefited protection as well as operation of power systems.

A New Fault Location Algorithm for Radial Transmission Lines with Loads, K. Srinivasan and A. St. Jacques, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1676-82. Conventional fault location schemes applied to radial lines have errors if loads are neglected. A new method, which takes loads into consideration, is proposed in this paper. Single phase to ground, phase to phase, and three phase to ground faults are considered.

Optimal Coordination of Directional Overcurrent Relays in Interconnected Power Systems, A.J. Urdaneta, R. Nadira and L.G.P. Jimenez, IEEE Trans. on Power

Delivery, Vol. 3, No. 3, July 1988, p 903-11. The paper presents a methodology, based on the optimization theory, for solving a large scale coordination problem. The results of sample power systems up to 30 buses are presented.

3157 TESTING AND ANALYSIS

Reliability Expectations for Protective Relays, J.G. Andrichak, C.R. Heising and R.C. Patterson, 42nd Annual GA Tech Protective Relaying Conference, 1988. Discussed are various aspects of performance and reliability of electromechanical and solid-state relays. Also presented are some guidelines for the application of different types of relays based on their expected performance and functions.

"Morgat": A Data Processing Program for Testing Transmission Line Protective Relays, P. Bornard, P. Erhard and P. Fauquembergue, IEEE Trans. on Power Delivery, Vol. 3, No. 4, Oct. 1988, p 1419-26. This paper describes a digital simulator of electrical transient phenomena in the 0-3kHz bandwidth for studying and testing of protective systems. The requirements and methods for simulating the transients are described. The hardware configurations and ease of use by the operator are described. Also see MORGAT: Digital Simulator Used for Industrial Qualification of Protective Relays, J-Y. Boussion, P. Erhard, P. Lasbleiz and Y. Fratti, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 230-4.

The CAPE System: Computer-Aided Protection Engineering, R.H. Cauthen and W.P. McCannon, IEEE Computer Applications in Power, Vol. 1, No. 2. Apr. 1988. The paper describes a computer-aided protection engineering system which integrates interactive short-circuit studies, calculates relay settings, coordinates protective zones, and calculates transmission line parameters into a process that is uniform and effective.

Performance Assessment and Control of Power System Relaying, F.C. Chan, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 986-94. In this paper, the basic protection system design is examined, the method of measuring protection performance is presented, and control measures on various protection activities are discussed. Several approaches to evaluating equipment reliability are discussed and a method of developing a performance index is presented.

Aspects of Modern Secondary Relay Testing Equipment, J. Cremer and M. Dohmann, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 225-9. A system for testing relays of different manufacturers is described in this paper.

Development of Relaying Problem Reporting and Evaluation Programs, P.R. Drum and M.F. Best, 42nd Annual GA Tech Protective Relaying Conference, 1988. Presented is one utility's method of documenting and identifying relay problems and potential solutions. The paper describes two different programs: Equipment Condition Reports and Problem Relay Evaluation.

Influence of Harmonics on Power System Distribution System Protection, J.F. Fuller, E.F. Fuchs and D.J. Roesler, IEEE Trans. on Power Delivery, Vol. 3, No. 2, Apr. 1988, p 546-54. Tests were made on a static underfrequency relay, two static overcurrent relays, and an electromechanical overcurrent relay (pickup only). A single harmonic was added to the fundamental frequency with magnitude and phase controlled. The results and commentary are given.

Computer Simulation of Current Transformers and Relays for Performance Analysis, R.M. Garrett, W.C. Kotheimer and S.E. Zocholl, 42nd Annual GA Tech Protective Relaying Conference, 1988. The use of low ratio, low accuracy class current transformers in switchgear applications exposes many relays to grossly distorted currents. This paper describes a computer simulation of these waveforms and shows how the results can be used as an economical means to verify relay operation.

Time Synchronous End-to-End Relay Testing, S.W. Harpham and J.A. Jodice, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 244-9. A method for synchronizing and controlling protection test instruments at remote locations using Geo-Stationary or Global Positioning satellite receivers is presented in this paper. Test methods suitable for end-to-end testing of protection systems are also suggested.

Reliability Expectations for Protective Relays, C.R. Heising and R.C. Patterson, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 23-6. The failure rates of electromechanical and electronic relays are reviewed in this paper. The effects of self testing, reliability prediction, and performance test procedures are then considered.

Summary of the Special Publication "Application of Fault and Disturbance Recording Devices for Protective System Analysis", IEEE Power System Relaying Committee Report, IEEE Trans. on Power Delivery, Vol. 4, No. 3, July 1989, p 1625-30. Special Publication No. 87THO 195-8-PWR is summarized. The report is intended to update and supplement previous papers to provide additional guidance in justifying, utilizing, and specifying fault recording equipment.

Ground Resistance - Revisited, D.I. Jeerings and J.R. Linders, IEEE Trans. on Power Delivery, Vol. 4, No. 2, Apr. 1989, p 949-56. The nature of ground resistance is examined to explain the high impedance of faults directly to ground as contrasted to low impedance faults to the ground wire or grounded structures. The harmonics of the resulting current may be used to distinguish high impedance faults from load conditions.

Five Years' Experience with a New Method of Field Testing Cross and Quadrature Polarized Mho Distance Relays; Part 1; Results and Observations; Part 2: Three Case Studies, W.O. Kennedy, B.J. Gruel, C.H. Shih and L. Yee, IEEE Trans. on Power Delivery, Vol. 3, No. 3, July 1988, Pt. 1, p 880-6; Pt. 2, p 887-93. A new method has been used to test relays from different manufacturers, to successfully predict and improve distance relay discrimination and to solve unexplained relay operations. Problems that arise from using the new method are discussed. Part 2 describes two case studies that show what the elements of the relay connected to the unfaulted phases do. A 3rd case study determines the boundary of a relay with a complex characteristic.

Dyna-Test Simulator: Protective Relaying Teaching Tool, M. Kezunovic, IEEE Trans. on Power Systems, Vol. 4, No. 3, Aug. 1989, p 1300-5. A Dynamic Testing Simulator concept, to be used as a teaching tool, is proposed. Instead of fault analysis and protection methods based on the steady-state concept, fault transients may be analyzed. The examples discussed focus on teaching different approaches to the design of measurement algorithms.

A Digitally-Controlled, Real-Time, Analog Power System Simulator for Closed-Loop Protective Relaying Testing, G. Nimmersjo, B. Hillstrom, O. Werner-Erichsen and G.D. Rockefeller, IEEE Trans. on Power Delivery, Vol. 3, No. 1, Jan. 1988, p 138-52. A computer controls the configuration and parameters of a real time analog model of a power system. Models of instrument transformers produce precision outputs to drive the relays under test. Use of a 3kHz band width signals provides proper signals for testing travelling wave relays. Field recorded fault data can also be used.

Experience With a Modern Real-Time Power System Simulator, G. Nimmersjo, M.M. Saha and B. Hillstrom, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 6-12. An analog power system simulator controlled by a digital computer is described in this paper. The operational experience with the simulator is briefly outlined.

Interactive Power System Simulation for the Laboratory Testing of Power System Protection Relays, M.A. Redfern, R.K. Aggrawal and G.C. Masey, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 215-9. This paper describes the hardware and software of a desk-top microcomputer based system for evaluating the performance of relays in the laboratory.

Preventive Maintenance can Reduce Outages, P. Todd, Electric Power and Light, Vol. 66, No. 2, Feb. 1988, p 20. This paper describes the benefits of maintenance of transformers, breakers, relays, and control and communication equipment.

Computer Controlled Protection Testing - a Western Australian Experience, A. Tunnicliffe, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 35-9. This paper describes the digital relay testing equipment jointly developed by the State Energy Commission of Western Australia, ACET - a private company - and the University of Western Australia. One design is for the equipment to be used in the field and the other for laboratory equipment.

Automated Testing of Power System Protection Relays, A.C. Webb, Power Eng. J., (UK), Vol. 2, No. 6, 1988, p 291-6. The author describes the requirements for automatic test facilities and then goes on to discuss hardware, software, and test routines. Test results and field experience are described.

Computer Generation of Test Quantities for Testing Protection Relays, A.C. Webb, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989 p 30-4. An automatic relay testing set which can use data generated by its own software or digital data provided by the user in an appropriate format, is described. The software applies test quantities including the polarizing voltages to the relays being tested.

The Management of the Commissioning of the Protection of Torness Power Station and Substations, A. Young, 4th Int. Conf. on Developments in Power System Protection, IEE Pub. No. 302, 1989, p 321-5. This paper describes various aspects of commissioning protection system of the Torness power station and substations. Commissioning tests performed on the power station equipment and systems are briefly described.

An Analytical Approach to the Application of Current Transformers for Protective Relaying, S.E. Zocholl, W.C. Kotheimer and F.Y. Tajaddodi, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper analyzes the effects of saturation on the performance of transformer differential and overcurrent relays in actual case histories.

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Experience with Voltage Feed-Through on TRV/Gradient Capacitor on High voltage Circuit Breakers, P.R. Drum, 43rd Annual GA Tech Protective Relaying Conference, 1989. This paper recounts the experience one utility has had with buses and transformers energized by transient recovery voltage (TRV)/gradient capacitors across open circuit breaker contacts.

A Programmable Controller for Protective Relay Logic, F. Karam, Trans. CEA E&O Div., Vol. 26, part 3, 1987, Paper No. 87-SR-146. A microprocessor-based programmable controller provides the auxiliary logic in protective relaying. It offers advantages of continual self-monitoring, and a sequence of events recording feature for testing and post-fault analysis. It allows field programmability of settings for software timers, counters and switches, and local or remote retrieval of sequence of events information.

A Microcomputer-Based Intelligent Load Shedding Relay, W.J. Lee and J.C. Gu, IEEE Trans. on Power Delivery, Vol. 4, No. 4, Oct. 1989, p 2018-24. Load shedding relay settings should be adjusted often to satisfy changing system conditions. The paper describes a relay which can readjust to a higher setting after a partial recovery occurs. The time delay is also adjusted if an unbalanced fault causes sustained low frequency.

A Microprocessor Based Special Protection System, R.J. Malewicz and J.A. Whatley, Trans. CEA E&O Div., Vol. 28, Part 4, 1989, Paper No. 89-SP-144. This paper describes the need for the design of a microprocessor based Special Protection System for monitoring abnormal operating conditions in the Ontario Hydro's 500 kV system in the vicinity of the Bruce Nuclear Power Development and for performing control actions in the form of generation rejection/ runback, tertiary reactor tripping, and load shedding.

Determination of Load Block Compositions in Load-Shedding Schemes: Logic Programming Approach, C.P. Tsang, K.P. Wong, IEEE Computer Applications in Power, Vol. 1, No. 4, Oct. 1988, p 39-43. Based on logic programming, a method for representing load circuits and construction of masks for selecting circuits in a network is described. The method can determine initial load block compositions, and can also find new load block compositions of stages activated previously in a load-shedding operation.

Prediction Methods for Preventing Single-Phase Reclosing on Permanent Fault, G. Yaozhong, S. Fonghai and X. Yuan, IEEE Trans. on Power Delivery, Vol. 4, No. 1, Jan. 1989, p 114-21. The blocking of reclosing after a single phase trip is proposed if the phase remains faulted. Three criteria applied to the measured open-phase voltage determine if reclosing be allowed.

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
Institute of Electrical Eng.	London
Power	New York, NY
Transmission and Distribution	Cos Cob, CT