

# EMTP Testing of Selected PST Protec

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**Abstract**— In this paper, testing results of selected procedures for protection of phase shifting transformers are presented. A phase shifting transformer (PST) is usually used for varying the voltage phase angle between the two systems which provides controlling of active power transfer. Some types of PSTs (e.g. dual-core symmetrical PST) allow to control phase shift in a certain defined range which means that phase shift between the two systems can be varied on-line. Therefore this type of phase shifting transformers must be protected by relays which are able to on-line compensate for additional phase shift introduced by PST. The main attention is paid to testing of differential protections for transformer energization and external faults for different phase shift values. It has been observed that for such situations standard differential relays may sometimes maloperate. Therefore, these situations should be analyzed and suggestions for protection improvement proposed. The comparison of two protection arrangements has been realized with the signals generated with use of EMTP program.

**Keywords**— current differential protection, Electromagnetic

series line inductance and compensated line equals  $X_{SL}$  between the two systems (a decreasing) by varying elect. In this method a phase shi. used for varying the voltage phase angle shift  $\theta$  an add subtracted. The PST is se between two systems, thu expressed according to the fi

$$P = \frac{|V_S|}{X_{PST}}$$

where:  $X_{PST}$  is phase shifting angle shift obtained from PS

In Fig. 1 active power

# Electromagnetic Transients Program Reference Manual

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## **Electromagnetic Transients Program Reference Manual:**

**Electromagnetic Transients Program** ,1986 *Electromagnetic Transients Program Reference Manual* Hermann W. Dommel,Bonneville Power Administration,1986 **Power Systems Electromagnetic Transients Simulation** Neville

Watson,Jos Arrillaga,J. Arrillaga,2003 Electromagnetic transients simulation EMTS has become a universal tool for the analysis of power system electromagnetic transients in the range of nanoseconds to seconds This book provides a thorough review of EMTS and many simple examples are included to clarify difficult concepts This book will be of particular value to advanced engineering students and practising power systems engineers *Understanding Electromagnetic Transients in Power Systems* Luiz Cera Zanetta, Jr.,2025-03-26 Understand transients and their roles in linear systems with this essential guide Electromagnetic transients are a fundamental aspect of linear power systems and therefore a key knowledge area for electrical engineers Understanding Electromagnetic Transients in Power Systems provides a comprehensive but accessible overview to transients their underlying theory and mathematics and their impact in electrical power system design Its detailed but clear presentation makes it a must own for students and working engineers alike Readers of Understanding Electromagnetic Transients in Power Systems will also find Deep consideration of the relationship between foundational concepts mathematical calculations and impacts on equipment Detailed discussion of topics including time and frequency domain analysis basic transforms fundamentals of electrical circuit transients and traveling waves overvoltage insulation coordination and many more Dozens of solved simple examples to facilitate understanding Understanding Electromagnetic Transients in Power Systems is ideal for electrical engineers and professionals in utilities and equipment manufacturing as well as for graduate and advanced undergraduate students learning about transients electrical circuits and related subjects

Transient Analysis of Power Systems Juan A. Martinez-Velasco,2020-02-10 A hands on introduction to advanced applications of power system transients with practical examples Transient Analysis of Power Systems A Practical Approach offers an authoritative guide to the traditional capabilities and the new software and hardware approaches that can be used to carry out transient studies and make possible new and more complex research The book explores a wide range of topics from an introduction to the subject to a review of the many advanced applications involving the creation of custom made models and tools and the application of multicore environments for advanced studies The authors cover the general aspects of the transient analysis such as modelling guidelines solution techniques and capabilities of a transient tool The book also explores the usual application of a transient tool including over voltages power quality studies and simulation of power electronics devices In addition it contains an introduction to the transient analysis using the ATP All the studies are supported by practical examples and simulation results This important book Summarises modelling guidelines and solution techniques used in transient analysis of power systems Provides a collection of practical examples with a detailed introduction and a discussion of results Includes a collection of case studies that illustrate how a simulation tool can be used

for building environments that can be applied to both analysis and design of power systems Offers guidelines for building custom made models and libraries of modules supported by some practical examples Facilitates application of a transients tool to fields hardly covered with other time domain simulation tools Includes a companion website with data input files of examples presented case studies and power point presentations used to support cases studies Written for EMTD users electrical engineers Transient Analysis of Power Systems is a hands on and practical guide to advanced applications of power system transients that includes a range of practical examples Power System Transient Analysis Eiichi Haginomori, Tadashi Koshiduka, Junichi Arai, Hisatochi Ikeda, 2016-05-02 Understanding transient phenomena in electric power systems and the harmful impact of resulting disturbances is an important aspect of power system operation and resilience Bridging the gap from theory to practice this guide introduces the fundamentals of transient phenomena affecting electric power systems using the numerical analysis tools Alternative Transients Program Electromagnetic Transients Program ATP EMTD and ATP DRAW This technology is widely applied to recognize and solve transient problems in power networks and components giving readers a highly practical and relevant perspective and the skills to analyse new transient phenomena encountered in the field Key features Introduces novice engineers to transient phenomena using commonplace tools and models as well as background theory to link theory to practice Develops analysis skills using the ATP EMTD program which is widely used in the electric power industry Comprehensive coverage of recent developments such as HVDC power electronics with several case studies and their practical results Provides extensive practical examples with over 150 data files for analysing transient phenomena and real life practical examples via a companion website Written by experts with deep experience in research teaching and industry this text defines transient phenomena in an electric power system and introduces a professional transient analysis tool with real examples to novice engineers in the electric power system industry It also offers instruction for graduates studying all aspects of power systems **Electromagnetic Transients in Transformer and Rotating Machine Windings** Su, Charles Q., 2012-07-31 This book explores relevant theoretical frameworks the latest empirical research findings and industry approved techniques in this field of electromagnetic transient phenomena Provided by publisher Power System Dynamics Ramanujam, R., 2010 This comprehensive text offers a detailed treatment of modelling of components and sub systems for studying the transient and dynamic stability of large scale power systems Beginning with an overview of basic concepts of stability of simple systems the book is devoted to in depth coverage of modelling of synchronous machine and its excitation systems and speed governing controllers Apart from covering the modelling aspects methods of interfacing component models for the analysis of small signal stability of power systems are presented in an easy to understand manner The book also offers a study of simulation of transient stability of power systems as well as electromagnetic transients involving synchronous machines Practical data pertaining to power systems numerical examples and derivations are interspersed throughout the text to give students practice in applying key

concepts This text serves as a well knit introduction to Power System Dynamics and is suitable for a one semester course for the senior level undergraduate students of electrical engineering and postgraduate students specializing in Power Systems Contents contents Preface 1 ONCE OVER LIGHTLY 2 POWER SYSTEM STABILITY ELEMENTARY ANALYSIS 3 SYNCHRONOUS MACHINE MODELLING FOR POWER SYSTEM DYNAMICS 4 MODELLING OF OTHER COMPONENTS FOR DYNAMIC ANALYSIS 5 OVERVIEW OF NUMERICAL METHODS 6 SMALL SIGNAL STABILITY ANALYSIS OF POWER SYSTEMS 7 TRANSIENT STABILITY ANALYSIS OF POWER SYSTEMS 8 SUBSYNCHRONOUS AND TORSIONAL OSCILLATIONS 9 ENHANCEMENT AND COUNTERMEASURES Index

**Electric Power Distribution Equipment and Systems** Thomas Allen Short, 2018-10-03 Power distribution and quality remain the key challenges facing the electric utilities industry Choosing the right equipment and architecture for a given application means the difference between success and failure Comprising chapters carefully selected from the best selling Electric Power Distribution Handbook Electric Power Distribution Equipment and Systems provides an economical sharply focused reference on the technologies and infrastructures that enable reliable efficient distribution of power from traversing vast distances to local power delivery The book works inward from broad coverage of overall power systems all the way down to specific equipment application It begins by laying a foundation in the fundamentals of distribution systems explaining configurations substations loads and differences between European and US systems It also includes a look at the development of the field as well as future problems and challenges to overcome Building on this groundwork the author elaborates on both overhead and underground distribution networks including the underlying concepts and practical issues associated with each Probing deeper into the system individual chapters explore transformers voltage regulation and capacitor application in detail from basic principles to operational considerations With clear explanations and detailed information Electric Power Distribution Equipment and Systems gathers critical concepts technologies and applications into a single source that is ideally suited for immediate implementation

**Emerging Developments in the Power and Energy Industry** Rodolfo Dufo-López, Jaroslaw Krzywanski, Jai Singh, 2019-10-31 Power and Energy Engineering are important and pressing topics globally covering issues such as shifting paradigms of energy generation and consumption intelligent grids green energy and environmental protection The 11th Asia Pacific Power and Energy Engineering Conference APPEEC 2019 was held in Xiamen China from April 19 to 21 2019 APPEEC has been an annual conference since 2009 and has been successfully held in Wuhan 2009 2011 Chengdu 2010 2017 Shanghai 2012 2014 Beijing 2013 2015 Suzhou 2016 and Guilin 2018 China The objective of APPEEC 2019 was to provide scientific and professional interactions for the advancement of the fields of power and energy engineering APPEEC 2019 facilitated the exchange of insights and innovations between industry and academia A group of excellent speakers have delivered keynote speeches on emerging technologies in the field of power and energy engineering Attendees were given the opportunity to give oral and poster presentations and to interface with invited experts

Proceedings of the Tenth Power Systems Computation Conference Graz Austria,2016-06-06 Proceedings of the Tenth Power Systems Computation Conference Power Quality in Power Systems, Electrical Machines, and Power-Electronic Drives Ewald F. Fuchs,Mohammad A. S. Masoum,2023-02-13 Power Quality in Power Systems Electrical Machines and Power Electronic Drives uses current research and engineering practices guidelines standards and regulations for engineering professionals and students interested in solving power quality problems in a cost effective reliable and safe manner within the context of renewable energy systems The book contains chapters that address power quality across diverse facets of electric energy engineering including AC and DC transmission and distribution lines end user applications such as electric machines transformers inductors capacitors wind power and photovoltaic power plants and variable speed variable torque power electronic drives The book covers nonsinusoidal waveshapes voltage disturbances harmonic losses aging and lifetime reductions single time events such as voltage dips and the effects of variable speed drives controlled by PWM converters The book also reviews a corpus of techniques to mitigate power quality problems such as the optimal design of renewable energy storage devices including lithium ion batteries and fuel cells for automobiles serving as energy storage and the optimal design of nonlinear loads for simultaneous efficiency and power quality Provides theoretical and practical insights into power quality problems related to future smart grid renewable hybrid electric power systems electric machines and variable speed variable torque power electronic drives Contains a highly varied corpus of practical applications drawn from current international practice Designed as a self study tool with end of chapter problems and solutions designed to build understanding Includes very highly referenced chapters that enable readers to save time and money in the research discovery process for critical research articles regulatory standards and guidelines

**High Voltage Test Techniques** Dieter Kind,Kurt Feser,2001-01-24 The second edition of High Voltage Test Techniques has been completely revised The present revision takes into account the latest international developments in High Voltage and Measurement technology making it an essential reference for engineers in the testing field High Voltage Technology belongs to the traditional area of Electrical Engineering However this is not to say that the area has stood still New insulating materials computing methods and voltage levels repeatedly pose new problems or open up methods of solution electromagnetic compatibility EMC or components and systems also demand increased attention The authors hope that their experience will be of use to students of Electrical Engineering confronted with High Voltage problems in their studies in research and development and also in the testing field Benefit from a completely revised edition Brings you up to date with th latest international developments in High Voltage and Measurement technology An essential reference for engineers in the testing field

**Modeling and Analysis of Electrical Machine** R. Ramanujam,2018-08-10 This book will serve as a stepping stone for the undergraduate students in Electrical Electronics Engineering for further specialization It is a core subject in the curriculum for post graduate Power Electronics and Power Systems Engineering disciplines offered by most of the universities and educational institutions The

book starts with the fundamental concepts such as phasors and reference frames which are not usually elaborated at the undergraduate level thereby providing smooth transition to more advanced topics as specified in the various syllabi The book is also suitable for final semester undergraduate students and practising engineers     Electric Power Distribution Handbook Thomas Allen Short,2018-09-03 Of the big three components of electrical infrastructure distribution typically gets the least attention In fact a thorough up to date treatment of the subject hasn t been published in years yet deregulation and technical changes have increased the need for better information Filling this void the Electric Power Distribution Handbook delivers comprehensive cutting edge coverage of the electrical aspects of power distribution systems The first few chapters of this pragmatic guidebook focus on equipment oriented information and applications such as choosing transformer connections sizing and placing capacitors and setting regulators The middle portion discusses reliability and power quality while the end tackles lightning protection grounding and safety The Second Edition of this CHOICE Award winner features 1 new chapter on overhead line performance and 14 fully revised chapters incorporating updates from several EPRI projects New sections on voltage optimization arc flash and contact voltage Full color illustrations throughout plus fresh bibliographic references tables graphs methods and statistics Updates on conductor burndown fault location reliability programs tree contacts automation and grounding and personnel protection Access to an author maintained support website [distributionhandbook.com](http://distributionhandbook.com) with problems sets resources and online apps An unparalleled source of tips and solutions for improving performance the Electric Power Distribution Handbook Second Edition provides power and utility engineers with the technical information and practical tools they need to understand the applied science of distribution     Computer-Aided Power System Analysis Ramasamy Natarajan,2002-04-03 This title evaluates the performance safety efficiency reliability and economics of a power delivery system It emphasizes the use and interpretation of computational data to assess system operating limits load level increases equipment failure and mitigating procedures through computer aided analysis to maximize cost effectiveness

**Passive Macromodeling** Stefano Grivet-Talocia,Bjorn Gustavsen,2015-10-30 Offers an overview of state of the art passive macromodeling techniques with an emphasis on black box approaches This book offers coverage of developments in linear macromodeling with a focus on effective proven methods After starting with a definition of the fundamental properties that must characterize models of physical systems the authors discuss several prominent passive macromodeling algorithms for lumped and distributed systems and compare them under accuracy efficiency and robustness standpoints The book includes chapters with standard background material such as linear time invariant circuits and systems basic discretization of field equations state space systems as well as appendices collecting basic facts from linear algebra optimization templates and signals and transforms The text also covers more technical and advanced topics intended for the specialist which may be skipped at first reading Provides coverage of black box passive macromodeling an approach developed by the authors Elaborates on main concepts and results in a mathematically precise way using easy to understand language Illustrates

macromodeling concepts through dedicated examples Includes a comprehensive set of end of chapter problems and exercises

**Passive Macromodeling Theory and Applications** serves as a reference for senior or graduate level courses in electrical engineering programs and to engineers in the fields of numerical modeling simulation design and optimization of electrical electronic systems Stefano Grivet Talocia PhD is an Associate Professor of Circuit Theory at the Politecnico di Torino in Turin Italy and President of IdemWorks Dr Grivet Talocia is author of over 150 technical papers published in international journals and conference proceedings He invented several algorithms in the area of passive macromodeling making them available through IdemWorks Bj rn Gustavsen PhD is a Chief Research Scientist in Energy Systems at SINTEF Energy Research in Trondheim Norway More than ten years ago Dr Gustavsen developed the original version of the vector fitting method with Prof Semlyen at the University of Toronto The vector fitting method is one of the most widespread approaches for model extraction Dr Gustavsen is also an IEEE fellow

*Electrical Power System Protection* C. Christopoulos,A. Wright,2013-04-18

The death of Professor Arthur Wright in the summer of 1996 deprived me of a friend and a colleague whose judgement and experience shaped this book I pay tribute to his contributions to protection and electrical engineering education In the five years since the first edition appeared many developments have taken place and it is now necessary to update the book The use of digital communications and advanced signal processing techniques is now widespread and several fully numeric relays are available from manu facturers Two new Chapters 13 and 14 have been added to introduce readers to these concepts and associated techniques Artificial intelligence is making its impact in all engineering applications and power system protection is no exception Expert systems fuzzy logic artificial neural networks adaptive and integrated protection synchronized measurements using the global positioning system genetic algorithms flexible a c transmission systems are some of the techniques considered in connection with protection Although many of these techniques have not yet found major application in protection it is nevertheless essential for the educated protection engineer to have a basic understanding of the underlying principles and methodology so that he or she can evaluate their suitability for new relaying problems and applications Chapter 15 was therefore added to guide readers through this developing area I have also added some new material in other chapters to reflect changes over the past years

**Power Quality** R. Sastry Vedam,Mulukutla S. Sarma,2017-12-19 Both deregulation in the electrical supply industry and the creation of new electricity markets present electric utility companies with the challenge of becoming more efficient without compromising quality of service Providing new solutions for this newly deregulated paradigm Power Quality VAR Compensation in Power Systems presents comprehensive coverage of power quality harmonics and static var compensators in one single volume The book explains how to ensure that power quality is not affected by the harmonics generated by power electronic equipment and explains how to reduce labor costs and increase reliability of supply by employing a single pole autoreclosing scheme It also addresses how to analyze frequency response of current transformers and voltage transformers while measuring harmonics Based on the authors extensive experience in the



electric supply industry Power Quality enables engineers to meet the demands of increased loads strengthen their transmission systems and ensure reliable electric supply **Power System Transients** Juan A.

Martinez-Velasco, 2017-12-19 Despite the powerful numerical techniques and graphical user interfaces available in present software tools for power system transients a lack of reliable tests and conversion procedures generally makes determination of parameters the most challenging part of creating a model Illustrates Parameter Determination for Real World Applications Geared toward both students and professionals with at least some basic knowledge of electromagnetic transient analysis Power System Transients Parameter Determination summarizes current procedures and techniques for the determination of transient parameters for six basic power components overhead line insulated cable transformer synchronous machine surge arrester and circuit breaker An expansion on papers published in the IEEE Transactions on Power Delivery this text helps those using transient simulation tools e g EMTP like tools to select the optimal determination method for their particular model and it addresses commonly encountered problems including Lack of information Testing setups and measurements that are not recognized in international standards Insufficient studies to validate models mainly those used in high frequency transients Current built in models that do not cover all requirements Illustrated with case studies this book provides modeling guidelines for the selection of adequate representations for main components It discusses how to collect the information needed to obtain model parameters and also reviews procedures for deriving them Appendices summarize updated techniques for identifying linear systems from frequency responses and review capabilities and limitations of simulation tools Emphasizing standards this book is a clear and concise presentation of key aspects in creating an adequate and reliable transient model

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