Read Book Dynamic State Estimation Using Phasor Measurements Pdf For Free

Optimal Allocation of Phasor Measurement Units Using Practical Constraints in Power Systems Jul 29 2020

Power System Observability Mar 17 2022 Phasor measurement units (PMUs) are considered as a promising tool for future monitoring, protection and control of power systems. One of the applications of phasor measurements is state estimation. The first step in state estimation is to gather measured data from different substations in a power network. These measurements must be sufficient to make the system observable. This book adopts three algorithms for minimizing the size of the PMU configuration while allowing full observability of the network; Depth First Search (DFS), Simulated Annealing (SA) and Minimum Spanning Tree (MST) algorithms. The applied methodologies included the system observablility during normal operating conditions, as well as single branch forced outages in order to obtain a reliable system. The book also adopts two efficient heuristic techniques for optimal PMU placement; Greedy algorithm and Single Vertex Algorithm. To verify the effectiveness of the introduced algorithms, comparative studies are conducted on four test systems with encouraging results. The obtained results are compared with the results of other approaches from literature to demonstrate the effectiveness of the applied methods.

Oscillation Monitoring System Based on Wide Area Phasor Measurements in Power Systems Sep 11 2021

Synchronized Phasor Measurements for Smart Grids Dec 26 2022 The use of advanced technologies such as Phasor Measurement Units (PMUs) have made it possible to transform the power grid to an intelligent Smart Grid with realtime control and monitoring of the system. This book explores the application of PMUs in power systems.

Power System State Estimation Using Phasor Measurement Units Nov 13 2021

Synchronized Phasor Measurements and Their Applications Mar 29 2023 This book builds on the cutting edge research presented in the previous edition that was the first of its kind to present the technology behind an emerging power systems management tool still in the early stages of commercial roll-out. In the intervening years, synchrophasors have become a crucial and widely adopted tool in the battle against electricity grid failures around the world. Still the most accurate wide area measurement (WAMS) technology for power systems, synchronized phasor measurements have become increasingly sophisticated and useful for system monitoring, as the advent of big data storage allows for more nuanced real-time analysis, allowing operators to predict, prevent and mitigate the impacts of blackouts with enhanced accuracy and effectiveness. This new edition continues to provide the most encompassing overview of the technology from its pioneers, and has been expanded and updated to include all the applications and optimizations of the last decade.

Study of the Utilization and Benefits of Phasor Measurement Units for Large Scale Power System State Estimation Jan 23 2020 This thesis will investigate the impact of the use of the Phasor Measurement Units(PMU) on the state estimation problem. First, incorporation of the PMU measurements in aconventional state estimation program will be discussed. Then, the effect of adding PMUmeasurements on the state estimation solution accuracy will be studied. Bad data processing in the presence of PMU measurements will also be presented. Finally, a multiareastate estimation method will be developed. This method involves a two level estimation scheme, where the first level estimation is carried out by each area independently. The second level estimation is required in order to coordinate the solutions obtained by each area and also to detect and identify errors in the boundary measurements. The first objective of this thesis is to formulate the full weighted least square state estimation method using PMUs. The second objective is to derive the linear formulation of the state estimation problem when using only PMUs. The final objective is to formulate atwo level multi-area state estimation scheme and illustrate its performance via simulationexamples.

Prediction and Control of Transient Instability Using Wide Area Phasor Measurements Dec 02 2020

Assessment of Applications and Benefits of Phasor Measurement Technology in Power Systems Feb 04 2021

Use of Phasor Measurement Unit Advancement for Power System Stability Using Load Shedding Jul 21 2022 This thesis deals with synchrophasors which provide time synchronized phasor measurements that help in many applications. Nevertheless, the main objective in this thesis is to explore the maintaining of the stability of the power system; the author also focuses on the synchrophasor definition, its working, and its various applications in the power system. On this topic the author mainly discusses the load shedding that is under-frequency load shedding and under-voltage load shedding, and how the data obtained from these satellite synchronized clock phasor measurement units turns into information which is readily displayed on visualization software provided by different institutions. In the writing of the thesis a program was developed using the Simulink in MATLAB which illustrates the under frequency load shedding as well as the emergency control to maintain the stability of the power system.

Distributed State Estimation with Phasor Measurement Units (PMU) for

Power Systems Apr 06 2021 Wide-area monitoring for the power system is a key tool for preventing the power system from system wide failure. State Estimation (SE) is an essential and practical monitoring tool that has been widely used to provide estimated values for each quantity within energy management systems (EMS) in the control center. However, monitoring larger power systems coordinated by regional transmission operators has placed an enormous operational burden on current SE techniques. A distributed state estimation (DSE) algorithm with a hierarchical structure designed for the power system industry is much more computationally efficient and robust especially for monitoring a wide-area power system. Moreover, considering the deregulation of the power system industry, this method does not require sensitive data exchange between smaller areas that may be competing entities. The use of phasor measurement units (PMUs) in the SE algorithm has proven to improve the performance in terms of accuracy and converging speed. Being able to synchronize the measurements between different areas, PMUs are perfectly suited for distributed state estimation. This dissertation investigates the benefits of the DSE using PMU over a serial state estimator in wide area monitoring. A new method has been developed using available PMU data to calculate the reference angle differences between decomposed power systems in various situations, such as when the specific PMU data of the global slack bus cannot be obtained. The algorithms were tested on six bus, IEEE standard 30 bus and IEEE 118-bus test cases. The proposed distributed state estimator has also been implemented in a test bed to work with a power system real-time digital simulator (RTDS) that simulates the physical power system. PMUs made by SEL and GE are used to provide real-time inputs to the distributed state estimator. Simulation results demonstrated the benefits of the PMU and distributed SE techniques. Additionally a constructed test bed verified and validated the proposed algorithms and can be used for different smart grid tests.

COMPARISON OF STATE ESTIMATION ALGORITHMS CONSIDERING PHASOR MEASUREMENT UNITS AND MAJOR AND MINOR DATA LOSS. Feb 22 2020 Various sensors distributed across different parts of the electric power grid provide measurements to the control center operator for situational awareness of the system. Voltage transformer, current transformer, relay and phasor measurement units (PMU) are types of sensors for power system monitoring. The utilities monitor the operating condition of their system by processing the measurements received from these various sensors using a state estimator. A state estimator refines these measurements, compensates for any lost data and provides a snapshot of the power system. The operator at the control center does further analysis using energy management system tools based on the most recent data and required state of the system. The electric power grid is vulnerable to blackouts caused by physical disturbances, human errors and external disasters. These disturbances can also cause loss of data, sensor failure or communication link failure. This research work focuses on comparing state estimation algorithms with loss of measurement data. The measurements are assumed to be lost as clustered and scattered data sets. Weighted Least Square (WLS), Least Absolute Value (LAV) and Iteratively Reweighted Least Squares (IRLS) implementation of Weighted Least Absolute Value (WLAV) algorithms are compared for state estimation with clustered and scattered loss of data. These algorithms are tested on a six bus, IEEE 30 bus and 137 bus utility test cases. The test results indicate the best possible algorithm in several considered scenarios based on an error index. Additionally, phasor measurements data are included in two of the state estimation algorithms to study their ability to mitigate the loss of measurement data.

Frequency Estimation Using Phasor Measurements Feb 28 2023

Power System Dynamics and Stability Dec 22 2019 Classic power system dynamics text now with phasor measurement and simulation toolbox This new edition addresses the needs of dynamic modeling and simulation relevant to power system planning, design, and operation, including a systematic derivation of synchronous machine dynamic models together with speed and voltage control subsystems. Reduced-order modeling based on integral manifolds is used as a firm basis for understanding the derivations and limitations of lower-order dynamic models. Following these developments, multi-machine model interconnected through the transmission network is formulated and simulated using numerical simulation methods. Energy function methods are discussed for direct evaluation of stability. Small-signal analysis is used for determining the electromechanical modes and mode-shapes, and for power system stabilizer design. Time-synchronized high-sampling-rate phasor measurement units (PMUs) to monitor power system disturbances have been implemented throughout North America and many other countries. In this second edition, new chapters on synchrophasor measurement and using the Power System Toolbox for dynamic simulation have been added. These new materials will reinforce power system dynamic aspects treated more analytically in the earlier chapters. Key features: Systematic derivation of synchronous machine dynamic models and simplification. Energy function methods with an emphasis on the potential energy boundary surface and the controlling unstable equilibrium point approaches. Phasor computation and synchrophasor data applications. Book companion website for instructors featuring solutions and PowerPoint files. Website for students featuring MATLABTM files. Power System Dynamics and Stability, 2nd Edition, with Synchrophasor Measurement and Power System Toolbox combines theoretical as well as practical information for use as a text for formal instruction or for reference by working engineers.

Comparison of State Estimation Algorithms Considering Phasor Measurement Units and Major and Minor Data Loss Aug 10 2021 Various sensors distributed across different parts of the electric power grid provide measurements to the control center operator for situational awareness of the system. Voltage transformer, current transformer, relay and phasor measurement units (PMU) are types of sensors for power system monitoring. The utilities monitor the operating condition of their system by processing the measurements received from these various sensors using a state estimator. A state estimator refines these measurements, compensates for any lost data and provides a snapshot of the power system. The operator at the control center does further analysis using energy management system tools based on the most recent data and required state of the system. The electric power grid is vulnerable to blackouts caused by physical disturbances, human errors and external disasters. These disturbances can also cause loss of data, sensor failure or communication link failure. This research work focuses on comparing state estimation algorithms with loss of measurement data. The measurements are assumed to be lost as clustered and scattered data sets. Weighted Least Square (WLS), Least Absolute Value (LAV) and Iteratively Reweighted Least Squares (IRLS) implementation of Weighted Least Absolute Value (WLAV) algorithms are compared for state estimation with clustered and scattered loss of data. These algorithms are tested on a six bus, IEEE 30 bus and 137 bus utility test cases. The test results indicate the best possible algorithm in several considered scenarios based on an error index. Additionally, phasor measurements data are included in two of the state estimation algorithms to study their ability to mitigate the loss of measurement data.

Phasors for Measurement and Control Sep 23 2022 This book is focused on the development of Phasor Measurement Units (PMUs) as a tool to analyse and control power systems. The book develops a nonlinear system-wide approach to control using PMU signals and provides numerous examples of different power systems to demonstrate the robustness of the approach in comparison to heuristic optimization. Some of the applicable controls include: · Excitation systems;· Wind power;· Static VAR compensators;· High evoltage DC; and· Inverter dynamics. For the operation of transmission and distribution systems, the book explains the dynamics of power systems and explores how well-established tools such as energy-based control and Kalman filters can address many of the existing and developing issues in their operation. By providing a thorough guide to PMUs, this book enables readers to fully understand the potential benefits their implementation can bring.

Implementation of Phasor Measurements in San Diego Gas & Electric State Estimator Jan 03 2021

Novel Applications for Phasor Measurement Units and Synchrophasor Data Apr 25 2020 The last decade has seen an intensified effort towards an improved, technologically advanced electric grid. This effort is largely in part to the need for cleaner and renewable sources of energy. Another motivator for this “smarter grid” is the need for a more reliable and efficiently operated of the wide scale electric infrastructure. The impact of these changes can expect to be seen at both the transmission and distribution level. At the transmission level phasor measurement units and synchrophasor data has emerged as one of the most

enabling technologies for the smart grid movement. These devices measure and time synchronize, the magnitude and phase angle of the electrical quantities over wide areas of an electric grid. These measurements are then made available to utilities and system operators to facilitate new and improved applications that foster enhanced grid reliability, security and efficiency. Synchrophasor data provides increased visibility into the phenomenon occurring within the electric grid, as measurements are taken at rates up to 60 Hz. This is a stark improvement compared to traditional supervisory control and data acquisition systems which operate at a rate of once every 2 to 5 seconds. This increased data rate therefore has the potential to feed applications that would not have traditionally been seen with SCADA, and improve the operation of those that are already functional. These applications can vary from real-time operation to off-line applications for post-event analysis and planning. Some of the more well known of these appplications are state estimation, inter-area oscillation, and wide area monitoring and control. There are however, some novel applications of synchrophasor data less publicized and deployed within the industry. One such application developed by the Power IT lab at the University of Tennessee involves using synchrophasor data to authenticate digital audio recordings. Another application developed by Dominion Virginia Power involves the automatic calibration of instrument transformers across a system using this synchrophasor data. This thesis outlines these novel applications and the work I performed to facilitate their implementations.
Placement of Phasor Measurement Units Aug 30 2020 Phasor measurement units (PMUs) provide measurements with high precision at a high resolution (up to 50 samples per second). These measurements are synchronized and time-stamped using the Global Positioning System. Despite these advantages, the industry has been slow in adopting PMU technology due to the high cost of installing PMUs. Therefore, PMU locations must be judiciously selected through optimal placement of PMUs (OPP), which enables the minimization of installation cost. This dissertation examines the OPP problem from several perspectives. First, the OPP problem definition is re-examined since most OPP literature associates the PMU installation cost with the PMU unit. Most techniques in the literature have proposed to minimize the number of PMUs while considering the complete observability of the system. However, PMUs require sufficient infrastructure to be in place before they can perform most of their intended functions. Therefore, the OPP problem should be reformulated to include the supporting infrastructure of PMUs. The proposed OPP formulation is implemented by using a bi-level framework. This framework can accommodate different varieties of OPP, such as single-stage, multistage, and application-based approaches. Moreover, the proposed framework achieves the optimal solution with the maximum observability in the case of multiple optima. Second, this dissertation examines application-based OPP approaches, where specific technical benefits are prioritized over the cost of the OPP. Three applications are

proposed. The first application is a fault-tolerance based OPP approach, where the network fault-tolerance is enhanced by deploying PMUs to the vulnerable elements in the network. In the second application, a voltage stability criterion is developed and proposed, where the critical buses are identified and prioritized for PMU allocation. The third application addresses false data injection attacks (FDIAs), where the system topology is used by the adversary to bypass the bad data detection of state estimators. The proposed OPP approach enhances bad data detection against FDIAs by utilizing the PMUs as authenticators for each other.

Obtaining High Performance Phasor Measurements in a Geographically Distributed Status Dissemination Network Dec 14 2021

Investigation of Fault Location Performance Utilizing Synchronized Phasor Measurements with a Two-ended Fault Location Impedance Method Jun 08 2021 Transmission lines are an essential part of the electrical grids. Thus, utilities cannot afford to have any transmission line out service because it can result in power outages and causes overloading other lines in the same grid. However, transmission lines are exposed to faults caused by short circuits, birds, adverse weather conditions, and human made accidents. Transmission line faults can be temporary or permanent. Temporary faults are mostly self-cleared. But, permanent faults do not self-cleared and cause damage to transmission line infrastructure. Most of these faults result in mechanical damage to power lines, poles, or insulators which need to be repaired before returning the line to service. For this reason, transmission line faults must be located accurately to allow field crews arrive at the scene and repair the faulted equipment as soon as possible. The most obvious method to locate the faulted equipment is just to patrol the whole line, but one of the main obstacles following that method are the geographical layout in some sections of the line making difficult for the field crews accessing to the scene, the long time it takes to patrol the line and the associated high cost which makes it uneconomical. Meanwhile, if the utility has a software tool to calculate fast and accurate fault location under any power system conditions, the utility will enhance the restoration time of the line with less cost and consequently it will short customer outage time by pointing field crews to narrow range to check. Fault location algorithms are one method for utilities use to detect fast and accurate fault location. However these fault location algorithms are typically embedded in fault locator devices or protective relays. This is an obstacle because in order to get the fault location out those devices, they need to be interrogated and normally these devices are located in remote areas. Now with the advances in synchrophasor technology, it is possible to collect synchronized phasor measurements in a convenient central location such as operating center or dispatch center and perform fast and accurate fault location based on synchronized phasor measurements. For this thesis, an impedance based fault location technique will be used because it is the most simple and practical method for implementation. However, this fault location technique in conjunction with relay data is known for being susceptible to a number of sources of errors. So by utilizing real-time and very accurate synchronized phasor measurement data, this thesis will investigate how accurate the impedance based fault location technique result.

Synchronized Phasor Measurements and Their Applications Apr 30 2023 This book provides an account of the field of synchronized Phasor Measurement technology, its beginning, its technology and its principal applications. It covers wide Area Measurements (WAM) and their applications. The measurements are done using GPS systems and eventually will replace the existing technology. The authors created the field about twenty years ago and most of the installations planned or now in existence around the world are based on their work.

Phasor Measurement Units and Wide Area Monitoring Systems Aug 22 2022 Phasor Measurement Units and Wide Area Monitoring Systems presents complete coverage of phasor measurement units (PMUs), bringing together a rigorous academic approach and practical considerations on the implementation of PMUs to the power system. In addition, it includes a complete theory and practice of PMU technology development and implementation in power systems. Presents complete coverage of the topic from the measurement to the system, bringing together a rigorous academic approach and practical considerations on the implementation of PMUs to the power system Includes a complete proposal of implementation for a PMU platform that could be replicated in every laboratory Covers PMU software compiled for National Instrument HW, a compiled monitoring platform to be used to monitor PMU data and developed custom solutions, and a compiled National Instrument schematic to be executed within a SmartPhone app

On The Security of Wide Area Measurement System and Phasor Data Collection Jul 09 2021 Smart grid is a typical cyber-physical system that presents the dependence of power system operations on cyber infrastructure for control, monitoring, and protection purposes. The rapid deployment of phasor measurements in smart grid transmission system has opened opportunities to utilize new applications and enhance the grid operations. Thus, the smart grid has become more dependent on communication and information technologies such as Wide Area Measurement Systems (WAMS). WAMS are used to collect real-time measurements from different sensors such as Phasor Measurement Units (PMUs) installed across widely dispersed areas. Such system will improve real-time monitoring and control; however, recent studies have pointed out that the use of WAMS introduces significant vulnerabilities to cyber-attacks that can be leveraged by attackers. Therefore, preventing or reducing the damage of cyber attacks onWAMS is critical to the security of the smart grid. In this thesis, we focus our attention on the relation between WAMS security and the IP routing protocol, which is an essential aspect to the collection of sensors measurements. Synchrophasor measurements from different PMUs are transferred through a data network and collected at one or multiple data concentrators. The timely

collection of phasors from PMU dispersed across the grid allows to maintain system observability and take corrective actions when needed. This collection is made possible through Phasor Data Concentrators (PDCs) that time-align and aggregate phasor measurements, and forward the resulting stream to be used by monitoring and control applications. WAMS applications relying on these measurements have strict and stringent delay requirements, e.g., end-to-end delay as well as delay variation between measurements from different PMUs. Measurements arriving past a predetermined time period at a data concentrator will be dropped, causing incompleteness of data and affecting WAMS applications and hence the system's operations. It has been shown that non-functional properties, such as data delay and packet drops, have a negative impact on the system functionality. We show that simply forwarding measurements from PMUs through shortest routes to phasor data collectors may result in data being dropped at their destinations. We believe therefore that there is a strong interplay between the routing paths (delays along the paths) for gathering the measurements and the value of timeout period. This is particularly troubling when a malicious attacker deliberately causes delays on some communication links along the shortest routes. Therefore, we present a mathematical model for constructing forwarding trees for PMUs' measurements which satisfy the end to end delay as well as the delay variation requirements of WAMS applications at data concentrators. We show that a simple shortest path routing will result in larger fraction of data drop and that our method will find a suitable solution. Then, we study the relation between cyber-attack propagation and IP multicast routing. To this extent, we formulate the problem as the construction of a multicast tree that minimizes the propagation of cyber-attacks while satisfying real-time and capacity requirements. The proposed attack propagation multicast tree is evaluated using different IEEE test systems. Finally, cyber-attacks resulting in the disconnection of PDC(s) from WAMS initiate a loss of its phasor stream and incompleteness in the observability of the power system. Recovery strategies based on the re-routing of lost phasors to other connected and available PDCs need to be designed while considering the functional requirements of WAMS. We formulate a recovery strategy from loss of compromised or failed PDC(s) in the WAMS network based on the rerouting of disconnected PMUs to functional PDCs. The proposed approach is mathematically formulated as a linear program and tested on standard IEEE test systems. These problems will be extensively studied throughout this thesis.
Power System Dynamics and Stability May 07 2021 Classic power system dynamics text now with phasor measurement and simulation toolbox This new edition addresses the needs of dynamic modeling and simulation relevant to power system planning, design, and operation, including a systematic derivation of synchronous machine dynamic models together with speed and voltage control subsystems. Reduced-order modeling based on integral manifolds is used as a firm basis for understanding the derivations and limitations of lower-

order dynamic models. Following these developments, multi-machine model interconnected through the transmission network is formulated and simulated using numerical simulation methods. Energy function methods are discussed for direct evaluation of stability. Small-signal analysis is used for determining the electromechanical modes and mode-shapes, and for power system stabilizer design. Time-synchronized high-sampling-rate phasor measurement units (PMUs) to monitor power system disturbances have been implemented throughout North America and many other countries. In this second edition, new chapters on synchrophasor measurement and using the Power System Toolbox for dynamic simulation have been added. These new materials will reinforce power system dynamic aspects treated more analytically in the earlier chapters. Key features: Systematic derivation of synchronous machine dynamic models and simplification. Energy function methods with an emphasis on the potential energy boundary surface and the controlling unstable equilibrium point approaches. Phasor computation and synchrophasor data applications. Book companion website for instructors featuring solutions and PowerPoint files. Website for students featuring MATLABTM files. Power System Dynamics and Stability, 2nd Edition, with Synchrophasor Measurement and Power System Toolbox combines theoretical as well as practical information for use as a text for formal instruction or for reference by working engineers.

A Decision Modeling for Phasor Measurement Unit Location Selection in Smart Grid Systems Feb 16 2022 As a key technology for enhancing the smart grid system, Phasor Measurement Unit (PMU) provides synchronized phasor measurements of voltages and currents of wide-area electric power grid. With various benefits from its application, one of the critical issues in utilizing PMUs is the optimal site selection of units. The main aim of this research is to develop a decision support system, which can be used in resource allocation task for smart grid system analysis. As an effort to suggest a robust decision model and standardize the decision modeling process, a harmonized modeling framework, which considers operational circumstances of component, is proposed in connection with a deterministic approach utilizing integer programming. With the results obtained from the optimal PMU placement problem, the advantages and potential that the harmonized modeling process possesses are assessed and discussed.

Real-time Identification and Monitoring of the Voltage Stability Margin in Electric Power Transmission Systems Using Synchronized Phasor Measurements Jan 27 2023

Power System Online Security Assessment Using Synchronized Phasor Measurements and Decision Trees Jan 15 2022

Phasor Measurement Unit Data in Power System State Estimation Mar 25 2020

Adaptive Out-of-step Relaying with Phasor Measurement Nov 01 2020

Monitoring and Simulating Real-time Electric Power System Operation with

Phasor Measurements Oct 12 2021 In this research project, two important results have been achieved. The concept of generator axis load flow has been developed more fully, and has been tested through simulations on the 39-bus system (with 10 generators). Generator axis load flow is a load flow calculation which views the entire network from a few retained buses such as the internal nodes of the generators. As these nodes can be indirectly monitored in real time through phasor measurements of generator terminal quantities, it becomes possible to track and predict the behavior of the entire network from these few observation points. This is extremely valuable in the task of predicting network instability in real time. The task of instability prediction of a multi-machine power system is one of the most difficult analytical exercises. We investigated two of the most promising approaches: the extended equal area method, and the transient energy function method. Although both of these methods work well in many instances, we have shown that in other cases, the predictions made by the two methods are incorrect. The failure of the methods can be traced to their inability to deal with the behavior of the system after the first turning point of the motor swing curves. Instead of using these methods, we propose the direct integration of the machine swing equations following the start of a disturbance. Coupled with the generator aids load flow developed above, and using the high speed computers available now, we show that for systems of significant size (39 bus system), accurate predictions through direct computation are possible. The report also includes results on computational efficiency of the method of faster-than-real-time integration using machine equations and the generator aids load flow. It is anticipated that this technique will be useful in most practical applications in power system control centers of the future.
Precise Synchronization of Phasor Measurements in Electric Power Systems Nov 25 2022 Phasors representing positive sequence voltages and currents in a power network are the most important parameters in several monitoring, control, and protection functions in interconnected electric power networks. Recent advances in computer relaying have led to very efficient and accurate phasor measurement systems. When the phasors to be measured are separated by hundreds of miles, it becomes necessary to synchronize the measurement processes, so that a consistent description of the state of the power system can be established. GPS transmissions offer an ideal source for synchronization of phasor measurements. The paper describes the concept and implementation of this technique. Several uses of synchronized phasor measurements are also described. Among these are improved state estimation algorithms, state estimator enhancements, dynamic state estimates, improved control techniques, and improved protection concepts.
Phasor Measurement Unit Placements for Complete Observability Using Linear-time, Quadratic-time, and Subquadratic-time Heuristics Jun 27 2020
Distributed State Estimation with the Measurements of Phasor Measurement Units Sep 30 2020 The world-wide application of Phasor Measurement Units

(PMUs) brings great benefit to power system state estimation. The synchronised measurements from PMUs can increase estimation accuracy, synchronise states among different systems, and provide greater applicability of state estimation in the transient condition. However, the integration of synchronised measurements with state estimation can introduce efficiency problems due to the substantial burden of data. The research is divided into two parts: finding a solution to cope with the computational efficiency problem and developing a transient state estimation algorithm based on synchronised measurements from PMUs. The computational efficiency problems constitute important considerations in the operation of state estimation. To improve the low computational efficiency, two distributed algorithms are proposed in Chapters 4 and 5. In these two algorithms, the modelling, structure, and solution are described, and the corresponding procedures of bad data processing are presented. Numerical results on the IEEE 30-bus, 118-bus and 300-bus systems can verify the effectiveness of the two proposed algorithms. A novel transient state estimation algorithm based on synchronised measurements is proposed in Chapter 6. Considering the scanning cycle and sampling rate of PMU measurements, the proposed algorithm can estimate transient states in a practical way. The performance of the proposed algorithm is demonstrated in a transient simulation on the IEEE 14-bus system. *Optimal Placement of Phasor Measurement Units Using the Advanced Matrix Manipulation Algorithm* Oct 24 2022 "This thesis investigates the problem of the Optimal Placement scheme of Phasor Measurement Units in electrical power systems for State Estimation to facilitate improved monitoring and control of the system parameters. The research work done for this thesis begins with review of Supervisory Control and Data Acquisition systems (SCADA). SCADA-based systems are currently employed for condition monitoring and control of industrial and utility electrical power systems. For utility power networks, the main problem with voltage and current phasor data captured by SCADA systems is that they are not synchronised with respect to each other in a present-time or Real-time framework. This implies that both magnitude and phase angle of the measured phasors tend to get affected by slow data flow provided by SCADA to the points of utilization and also by differences in time instants of data capture. These factors inhibit theefficiency and quality of the power system monitoring and control. "Phasor Measurement Unit" (PMU) is a relatively new technology that, when employed in power networks, offers real-time synchronised measurements of the voltages at buses and currents along the lines that connect them. This is accomplished by using a GPS based monitoring system which facilitates time synchronisation of measurements and unlike SCADA, makes the measured data available in Real-Time format. SCADA is not able to provide Real-time data due to the low speeds at which RTUs (Remote Terminal Units) provide data. Availability of time-stamped phasor measurements makes PMUs preferable for power system monitoring and control applications such as State Estimation, Instability Prediction Analysis, Real-time Monitoring of the system conditions, Islanding Detection, System Restoration and Bad Data Detection."

Analysis of Synchronization and Accuracy of Synchrophasor Measurements Mar 05 2021 In electric power systems, phasor measurement units (PMUs) are capable of providing synchronized voltage and current phasor measurements which are superior to conventional measurements collected by the supervisory control and data acquisition (SCADA) system in terms of resolution and accuracy. These measurements are known as synchrophasor measurements. Considerable research work has been done on the applications of PMU measurements based on the as-sumption that a high level of accuracy is obtained in the field. The study in this dissertation is conducted to address the basic issue concerning the accuracy of actual PMU measurements in the field. Synchronization is one of the important features of PMU measurements. However, the study presented in this dissertation reveals that the problem of faulty synchronization between measurements with the same time stamps from different PMUs exists. A Kalman filter model is proposed to analyze and calculate the time skew error caused by faulty synchronization. In order to achieve a high level of accuracy of PMU measurements, innovative methods are proposed to detect and identify system state changes or bad data which are reflected by changes in the measurements. This procedure is applied as a key step in adaptive Kalman filtering of PMU measurements to overcome the insensitivity of a conventional Kalman filter. Calibration of PMU measurements is implemented in specific PMU installation scenarios using transmission line (TL) parameters from operation planning data. The voltage and current correction factors calculated from the calibration procedure indicate the possible errors in PMU measurements. Correction factors can be applied in on-line calibration of PMU measurements. A study is conducted to address an important issue when integrating PMU measurements into state estimation. The reporting rate of PMU measurements is much higher than that of the measurements collected by the SCADA. The question of how to buffer PMU measurements is raised. The impact of PMU meas-urement buffer length on state estimation is discussed. A method based on hypothesis testing is proposed to determine the optimal buffer length of PMU measurements considering the two conflicting features of PMU measurements, i. e. uncertainty and variability. Results are presented for actual PMU synchrophasor measurements.

Distributed State Estimation Using Phasor Measurement Units (PMUs) for a System Snapshot May 27 2020 As the size of electric power systems are increasing, the techniques to protect, monitor and control them are becoming more sophisticated. Government, utilities and various organizations are striving to have a more reliable power grid. Various research projects are working to minimize risks on the grid. One of the goals of this research is to discuss a robust and accurate state estimation (SE) of the power grid. Utilities are encouraging teams to change the conventional way of state estimation to real time state estimation. Currently most of the utilities use traditional centralized SE algorithms for transmission systems. Although the traditional methods have been enhanced with advancement in technologies, including PMUs, most of these advances have remained localized with individual utility state estimation. There is an opportunity to establish a coordinated SE approach integration using PMU data across a system, including multiple utilities and this is using Distributed State Estimation (DSE). This coordination will minimize cascading effects on the power system. DSE could be one of the best options to minimize the required communication time and to provide accurate data to the operators. This project will introduce DSE techniques with the help of PMU data for a system snapshot. The proposed DSE algorithm will split the traditional central state estimation into multiple local state estimations and show how to reduce calculation time compared with centralized state estimation. Additionally these techniques can be implemented in micro-grid or islanded system.

Improvement of Phasor Measurement Unit & Synchrophasor Performance May 19 2022 Fast measurements of the instantaneous amplitude and phase angle of the fundamental components and frequency in three-phase power systems may be investigated with high accuracy through the use of modern power instruments such as Phasor Measurement Unit (PMU). However, this accuracy may be affected by several encountering power disturbances, such as abrupt frequency deviation, fast and slow dc offsets decaying due to sudden current changes, inter-harmonics, etc. To avoid these effects for improving the quality of measurements, this work presents a new method of real-time filtering for removing the unwanted DC offset and hence improving SDFT algorithm. To validate the proposed method, the performances of PMU are tested using the data generated by Simulink/MATLAB simulator. The obtained results are very encouraging. Synchronized phasor measurements, or synchrophasors, provided a real-time measurement of conditions. Frequency and phase angles were monitored both within the island and on the power grid. By using synchrophasor technology, frequency and phase angle in the two systems could be compared in real time without the use of a physical connection. From this information we can come to know the use of synchrophasor data to view frequency stability, verify system independence, and observe the synchronization point. Phasor measurement units, together with synchrophasor collector and display software, provided valuable data. Finally, this paper will review the application of synchrophasors to observe power system dynamic phenomenon and how they will be used in the real-time control of the power system.

Analysis of Power System Stability Using Synchronized Phasor Measurements Jun 20 2022

Power System Static State Estimation with Phasor Measurements Apr 18 2022

- Ghost Hunting True Stories Of Unexplained Phenomena From The Atlantic Paranormal Society Jason Hawes

- The Art Of Folding By Jean Charles Trebbi
- Deepak Chopra Spiritual Solutions
- Edgenuity Health Answers
- Georgia Notary Public Handbook
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