Modeling Competition in Transmission Expansion

Gil, H.A.; da Silva, E.L.; Galiana, F.D.

Author Affiliation: Universidade Federal de Santa Catarina, Santa Catarina, Brazil; McGill University, Quebec, Canada.

Abstract: The transmission network plays a key role in allowing access to the most efficient generators to all consumers. In most cases, the new transmission projects are defined by a system operator, which focuses on improving the bulk system's reliability and reducing short-term operating problems. Because electricity market participants are prevented from investing in transmission facilities that may benefit them, transmission expansion may not have been sufficient to stimulate competition within the market. In this paper, we show formally through a mathematical formulation based on the Lagrangian relaxation technique that the investment in transmission capacity can be a profitable activity, therefore the introduction of competition in the transmission expansion could be possible. Such a competitive expansion of transmission capacity would allow the participants to improve the efficiency of the electricity market.

A Joint Energy and Transmission Rights Auction: Proposal and Properties

O'Neill, R.P.; Helman, U.; Hobbs, B.F.; Stewart, W.R.; Rothkopf, M.H.

Author Affiliation: Federal Energy Regulatory Commission, Washington, D.C.; Johns Hopkins University, Baltimore, Maryland; College of William & Mary, Williamsburg, Virginia; Rutgers University, Piscataway, New Jersey.

Abstract: An auction-based process is proposed that allows power market participants to acquire and reconfigure financial transmission rights. The process simultaneously accommodates flowgate and point-to-point options and obligations along with energy production and consumption futures. A sequence of auctions is held during which participants can buy and sell rights, culminating in a real-time auction, at which time all rights are cashed out. By allowing flowgate and point-to-point obligations and options to be reconfigured and exchanged, the market can decide what combination of financial rights are most useful to power generators, consumers, and traders. Rights can be exchanged not only for capacity of individual flowgates, but also for more complex transmission constraints, such as nomograms. Under certain conditions, we prove that the auction is revenue adequate for the market operator, in that payments to rights holders cannot exceed congestion revenues. We present a linearized (dc) auction along with a numerical illustration.

Derivation of UPFC DC Load Flow Model with Examples of its Use in Restructured Power Systems

Alomoush, M.I.

Author Affiliation: Yarmouk University, Irbid, Jordan.

Abstract: The unified power flow controller (UPFC) integrates properties of both shunt and series compensations and can effectively alter power system parameters in a way that increases power transfer capability and stabilizes the system. This paper presents an approximate model for power flow studies that takes into consideration modeling of lossless UPFC-embedded transmission lines including the effect of line charging susceptance. The approximate model is then simplified to a dc load flow model that takes into account the modeling of the UPFC. The equations derived in this paper are applied to an optimal power flow of a small test system, where the results obtained by approximate load flow method are compared to those of dc load flow method. The results presented in the paper show valuable impacts of putting UPFC in service on out-of-merit costs and locational marginal prices (LMPs) in a restructured power system environment. The results show that the dc load flow relations can be modified to reflect the effects of the UPFC. In addition, results show that UPFC may reduce generation out-of-merit costs and let LMPs regain uniformity.

A Rule-Based Expert System with Colored Petri Net Models for Distribution System Service Restoration

Chen, C.S.; Lin, C.H.; Tsai, H.Y.

Author Affiliation: National Sun Yat-Sen University, Kaohsiung, Taiwan; National Kaohsiung University of Applied Sciences, Kaohsiung, Taiwan.

Abstract: A rule-based expert system with a colored Petri net (CPN) inference model is developed for service restoration of distribution systems. The CPN models of distribution components such as four-way line switches are proposed to derive the proper restoration plan after the faulted location has been identified and isolated. The unfaulted but out-of-service areas are restored by applying parallel-like reasoning in the CPN for multiple contingencies simultaneously. To assure the restoration plan can comply with the operation regulation, heuristic rules based on the standard operation procedures of the Taipower distribution system are included in the best first search of the CPN. For the fault contingency during summer peak season, the load shedding is executed and the CPN models are designed to restore service to as many key customers and loads as possible. The priority indices of each feeder and service zone are determined according to the key customers within the service territory. A Taipower distribution system with 18 feeders is selected for computer simulation to demonstrate the effectiveness of the proposed methodology. It is found that the service restoration of distribution system can be obtained very efficiently by applying the proposed CPN model.

Power System Dynamic Performance

An Interim Dynamic Induction Motor Model for Stability Studies in the WSCC

Pereira, L.; Kosterev, D.; Mackin, P.; Davies, D.; Undrill, J.; Zhu, W.

Author Affiliation: Northern California Power Agency, Roseville, California; Bonneville Power Administration, Vancouver, Washington; Navigant Consulting, Inc., Rancho Cordova, California; Western Systems Coordinating Council, Salt Lake City, Utah; General Electric International, Inc., Schenectady, New York.

Abstract: An interim composite load model containing a static part and a dynamic part has been implemented in the WSCC. The static part of the load model is about 80% of the total load and comprises of existing static load data from the WSCC members. The dynamic part is a default induction motor model for approximately 20% of the total load. This composite model is used for all loads in the full-scale WSCC grid models that are the basis for system interconnection studies. The model is designed primarily to capture the effects of dynamic induction motor loads for highly stressed north to south flow conditions during summer peaks in the WSCC.

Genetically Optimized Neuro-Fuzzy IPFC for Damping Modal Oscillations of Power Systems

Mishra, S.; Dash, P.K.; Hota, P.K.; Tripathy, M.

Author Affiliation: University College of Engineering, Burla, India; Multimidia University, Malasia.
Abstract: An integrated approach of the radial basis function neural network (RBFNN) and Takagi-Sugeno (TS) fuzzy scheme with genetic optimization of their parameters has been developed in this paper to design intelligent adaptive controllers for improving the transient stability performance of power system. At the outset this concept is applied to a simple device such as the thyristor controlled series capacitor (TCSC) connected in a single-machine infinite bus power system and is then extended to the interline power flow controller (IPFC) connected in a multimachine power system. The RBFNN uses single neuron architecture and its parameters are dynamically updated in an online fashion with the TS-fuzzy scheme designed with only four rules and triangular membership function. The rules of the TS-fuzzy scheme are derived from the real or reactive power error and their derivatives either at the TCSC or IPFC buses depending on the device. Further, to implement this combined scheme only one coefficient in the TS-fuzzy rules needs to be optimized. The optimization of this coefficient, as well as the coefficient for auxiliary signal generation, is performed through genetic algorithm. The performance of the new controller is evaluated both in single-machine and multimachine power systems subjected to various transient disturbances. The new genetic-neuro-fuzzy control scheme exhibits a superior damping performance as well as a greater critical clearing time in comparison to the existing PI as well as RBFNN controller with updating of its parameters through the extended Kalman filter (EKF). Its simple architecture reduces the computational burden, thereby making it attractive for real-time implementation.

Transient Stability Preventive Control for Stable Operating Conditions with Desired CCT

Kato, Y.; Iwamoto, S.

Author Affiliation: Department of Electrical, Electronics and Computer Engineering, Waseda University, Tokyo, Japan.
Abstract: In recent years, power systems have become larger and more complicated. Deregulation of electric power industries has begun in some countries and power system operations have become more difficult. However, the stability of the power supply is the most important consideration for customers. Therefore, power system operators should consider not only economic load dispatch but also on-line stability aspects. In this paper, we pay attention to one of the most important transient stability indices, critical clearing time (CCT), and propose a new transient stability preventive control method using linear relationships between CCTs and generator rotor angles. At first, CCT calculations, as contingency screenings, are carried out to find contingencies that have smaller CCTs than predefined target values. The target values are taken as larger values than the actual circuit breaker operating times in the power system. A preventive control to achieve a more stable power system operating point is carried out by generator output rescheduling and generator terminal voltage control, which are determined using the relationships between CCTs and generator rotor angles. This proposed method is demonstrated using a Japanese standard power system, called the IEEJ EAST 10 machine system.

Power System Operations

Feature Analysis of Power Flows Based on the Allocations of Phase Shifting Transformers

Huang, C.N.

Author Affiliation: National Taipei University of Technology, Taipei, Taiwan.
Abstract: This paper proposes a novel approach for identifying the deviations of power flows that are controlled by multiple phase shifting transformers (PSTs). In order to control the power flows of each loop independently, at first the minimum need of PST sets is determined as the number of co-tree to the entire network. Because co-tree patterns are not unique, many PST allocations exist and can be found as the co-tree patterns. Features of the controllable area of power flows corresponding to all PSTs allocation candidates can be extracted by the eigenanalysis of the matrix. Finally, judging from the power flow profiles, the optimal allocation to the specific control target can be found. The optimal PST allocation for power flow control can be found by the flexible power flow control in an open-access network. The effectiveness of the proposed method is confirmed by the simulation studies of two model systems.

Restoration Testing and Training in Italian ISO

Sforna, M.; Bertanza, V.

Author Affiliation: GRTN, Italy.
Abstract: This paper describes both the experiences encountered and the procedures adopted during a campaign of field tests that GRTN (the Italian ISO) performed to check its restoration plan aimed at restoring power supply after a massive blackout. Some of the power system components and the restoration strategies involved were known to be critical so careful planning, including the use of a dynamic power system simulator, preceded the field tests. The results of the analysis prompted the adoption of original solutions that, although unusual for classic restoration techniques, proved to be effective in testing Italian restoration procedures, voltage regulators, and speed governors, with no significant disturbance to customers. This should allow the planning of frequent field tests to the advantage of both operators' training and the periodic check of the efficiency of this ancillary service.

A Novel and Fast Three-Phase Load Flow for Unbalanced Radial Distribution Systems

Teng, J.H.; Chang, C.Y.

Author Affiliation: I-Shou University, Kaohsiung, Taiwan.
Abstract: A novel and fast three-phase load flow algorithm for unbalanced radial distribution systems is proposed in this paper. The proposed method uses branch voltages as state variables and employs the Newton-Raphson algorithm to solve the load flow problem. By utilizing branch voltages as state variables, a constant Jacobian matrix can be obtained and a building algorithm for Jacobian matrix is then developed from the observation of the constant Jacobian matrix. A solution technique, which takes the network structure into account to avoid the time-consuming LU factorization, is also developed. Since the factorization procedure can be avoided, the proposed method can save computation time. For any power system equipment, if its equivalent current injection or admittance matrix can be obtained, it can be integrated into the proposed method. Test results demonstrate that by integrating the Jacobian building algorithm and efficient solution