as a measure of power system performance. Four different kinds of FACTS controllers are used and modeled for steady-state studies: TCSC, TCPST, TCVR, and SVC. Simulations are done on a 118-bus power system for several numbers of devices. Results show the difference of efficiency of the devices used in this context. They also show that the simultaneous use of several kinds of controllers is the most efficient solution to increase the loadability of the system. In all the cases (single- and multi-type FACTS devices), we observe a maximum number of devices beyond which this loadability cannot be improved.

Keyword: FACTS devices, optimal location, genetic algorithms, system loadability.

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Deterministic Annealing Clustering for ANN-Based Short-Term Load Forecasting

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Abstract: This paper presents a clustering method for preprocessing input data of short-term load forecasting in power systems. Clustering the input data prior to forecasting with the artificial neural network(ANN) decreases the prediction errors observed. In this paper, an MLP ANN is used to deal with one-step-ahead daily maximum load forecasting, and the deterministic annealing (DA) clustering is employed to classify input data into clusters. The DA clustering is based on the principle of maximum entropy in statistical mechanics to evaluate globally optimal classification. The proposed method is successfully applied to real data. A comparison is made between the proposed and the conventional methods in terms of the average and the maximum prediction errors. The effectiveness of the proposed method is demonstrated through comparison of the real load data with short-term forecasted values.

Keywords: Short-term load forecasting, artificial neural network (ANN), deterministic annealing (DA) clustering, global optimization, data classification.

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Discussion Deadline: October 2001

Power System Planning and Implementation

A Flexible Unit Maintenance Scheduling Considering Uncertainties

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Abstract: This paper presents a new methodology for maintenance scheduling that takes into account the uncertain constraints of the unit maintenance problem. If the spinning reserve is enough, this model can obtain an optimal solution based on reliability or cost concerned. Since the power development is more difficult than ever before, scheduling the unit maintenance under tight spinning reserve is a difficult task. In such a situation treating various constraints, such as the spinning reserve, duration of maintenance, the maintenance crew, etc., as soft constraints, a fuzzy 0-1 integer programming model is adopted to find the minimum violation solution. In order to verify that this model can be implemented in the real system, a case study of the Taiwan Power System is carried out using the algorithm.

Keywords: Maintenance scheduling, spinning reserve, crisp model, fuzzy model, 0-1 integer programming.

Preprint Order Number: PE-002PRS (05-2001)

Discussion Deadline: October 2001

A Mixed Integer Disjunctive Model for Transmission Network Expansion

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Abstract: The classical nonlinear mixed integer formulation of the transmission network expansion problem cannot guarantee finding the optimal solution due to its nonconvex nature. We propose an alternative mixed integer linear disjunctive formulation, which has better conditioning properties than the standard disjunctive model. The mixed integer program is solved by a commercial Branch and Bound code, where an upper bound provided by a heuristic solution is used to reduce the tree search. The heuristic solution is obtained using a GRASP metaheuristic, capable of finding suboptimal solutions with an affordable computing effort. Combining the upper bound given by the heuristic and the mixed integer disjunctive model, optimality can be proven for several hard problem instances.

Keywords: Transmission planning, combinatorial optimization, heuristics.

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Discussion Deadline: October 2001

Power System Relay

A Fault Classification Method by RBF Neural Network with OLS Learning Procedure

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Abstract: This paper presents a new approach to identify fault types and phases. A fault classification method based on a radial basis function (RBF) neural network with an orthogonal-least-square (OLS) learning procedure was used to identify various patterns of associated voltages and currents. The RBF neural network was also compared with the back-propagation (BP) neural network in this paper. It is shown that the RBF approach can provide a fast and precise operation for various faults. The simulation results also show that the proposed approach can be used as an effective tool for high-speed relaying.

Keywords: Fault classification, radial basis function (RBF) neural network, orthogonal least-squares (OLS) learning procedure, back-propagation (BP) neural network.

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Discussion Deadline: October 2001

Adaptive Transformer Thermal Overload Protection

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Abstract: This paper is based on a report of the same title, prepared by Working Group K3 of the Substation Protection Subcommittee of the Power System Relaying Committee of the Power Engineering Society of the IEEE. The paper begins with background information on the causes, measurement techniques, and consequences of overheating in mineral-oil-immersed power transformers. Then techniques for adaptive transformer thermal overload protection based on the real-time solution of the transient heating equations are presented. An adaptive overcurrent protection implementation, and the related functional requirements, are discussed. The equations of Clause 7 of the 1995 IEEE *Guide for Loading Mineral-Oil-Immersed Transformers* are used in the analysis, with a slight modification to allow for continuously varying ambient temperature.

Keywords: Transformer, protection, temperature.

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