technique, the proposed method is an effective three-phase load flow method and has great potential for real-time use.

Keywords: Newton-Raphson method, three-phase load flow, unbalanced distribution system, branch voltage, current injection mismatches.

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Power System Planning and Implementation

On the Robust Application of Loop Optimization Heuristics in Distribution Operations Planning

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Abstract: Loop optimization heuristics are widely used techniques in distribution operations planning. These heuristics are acknowledged as approximate optimization techniques. However, the approximation error and its dependence on the system have not been quantified with generality. Thus, being able to classify distribution systems by the extent of the expected approximation error is of interest for many. In this paper we project a set of heuristic errors on a defined system parameter, which we designate by network complexity. The projection results exhibit a two-stage evolution that suggests the existence of a complexity boundary for the robust application of loop optimization heuristics.

Keywords: Loss minimization, branch-exchange, network complexity, network optimization.

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A Heuristic and Algorithmic Combined Approach for Reactive Power Optimization with Time-Varying Load Demand in Distribution Systems

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Abstract: Reactive power optimization with time-varying load demand in distribution systems is investigated in this paper. The objective of this paper is to determine the proper setting values of capacitor banks and transformer taps for the 24 hours in the next day. A heuristic and algorithmic combined approach is proposed in this paper. The approach simplifies the mathematical model of the daily setting values of reactive power/voltage control devices, solves the temporal optimization of each control device by heuristic rules, and then converts the optimization model with time-varying load into the same one as conventional optimization model with constant load. Therefore, the algorithms applied to the conventional optimization model can be easily used to solve the optimization model with time-varying load demand. Results from numerical examples show that a proper dispatch schedule for capacitor banks and transformer taps can be reached by this approach efficiently.

Keywords: Power system, distribution network, reactive power optimization.

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Power System Relaying

Artificial Neural Networks in Power System Restoration

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Abstract: Power system restoration (PSR) has been a subject of study for many years. In recent years many techniques were proposed to solve the limitations of the predetermined restoration guidelines and procedures used by a majority of system operators to restore a system following the occurrence of a wide area disturbance. This paper discusses limitations encountered in some currently used PSR techniques and a proposed improvement based on artificial neural networks (ANN). The proposed scheme is tested on a 162 bus transmission system and compared with a breadth-search restoration scheme. The results indicate that the use of ANN in power system restoration is a feasible option that should be considered for real-time applications.

Keywords: Artificial neural networks, power system restoration, wide-area disturbances, artificial intelligence.

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Load Model Effects on Distance Relay Settings

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Abstract: The purpose of this paper is to study load model effects on distance protective relay settings in Taipower's transmission system. Five load models have been used in order to explore the effects of load characteristics on relay settings: (1) static ZIP model, (2) dynamic motor model, (3) composite model, (4) PTI IEEE model, and (5) exponential model. The major points of this study include (1) setting of impedance values for the three distance protective relay zones and the protection against loss of synchronicity in the outermost periphery, (2) exploring the effects of load models on impedance angles at the time of distance relay tripping, (3) study whether the load model will cause a malfunction in the distance relay when the system swings due to a sudden change in the power system, (4) analyze the coordination of the blocking time of the out-of-step blocking relay during system power swings, and (5) propose how to select a better load model for accuracy in relay settings.

Keywords: Blocking time, distance relay, load model, power swing.

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Substations

Time Domain Analysis of Grounding Electrodes' Impulse Response

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Abstract: Lightning protection studies require estimation of grounding systems' dynamic behavior. This paper presents the results of a new methodology for calculating the lightning response of the basic component of any grounding system, the grounding electrode. Lightning strike is modeled using a double exponential time function. Closed-form mathematical formulae are used to describe current and voltage distribution along the electrode. The effect of soil ionization can be also taken into account. The proposed methodology is validated by comparison of the obtained results with experimental and simulated waveforms found in literature.

Keywords: Grounding electrode, open-ended transmission line, lightning protection.

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