AL presents a remedy to duality gap encountered with the ordinary Lagrangian for nonconvex problems. It shapes the Lagrangian function as a hyperparaboloid associating penalty in the direction of the coupling constraints. This work accounts further for the transmission constraints. We use a hydrothermal resource model with pumped-storage units. An IEEE 24-bus test system is used for AL performance illustration. Computational models are all coded in C. The results of the test case show that the AL approach can provide better scheduling results as it can detect optimal on/off schedules of units over a planning horizon at a minimal cost with no constraint violation. It requires no iteration with economic dispatch algorithms. The approach proves accurate and practical for systems with generation diversity and limited transmission capacity.

Keywords: Hydrothermal scheduling, augmented Lagrangian, transmission constraints, pumped-storage units.

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Discussion Deadline: October 2001

Coordination of Power Flow Control in Large Power Systems

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Abstract: Implementation of a new electricity trading arrangement is imminent in the UK. It aims to improve power industry efficiency and economy, but its dynamic nature is also associated with more uncertainties. The flexible ac transmission systems (FACTS) concept is particularly applicable to a dynamically changing transmission system. Advantages of FACTS could be compromised by interactions in a transmission system, however, in particular where multiple power flow control devices are used. This paper addresses the coordination of power flow control in a large power system, managing transmission constraints to meet the security standards against the background of this open market structure.

Keywords: System constraint, FACTS, interaction, sampled regulator design.

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Discussion Deadline: October 2001

An Improved Sequential Method for AC/MTDC Power System State Estimation

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Abstract: This paper reports the development of a novel and effective approach in multi-terminal dc (ac/MTDC) power system state estimation, called the improved sequential method. The proposed approach is sequential in nature in which the MTDC system is solved, followed by the ac system. Because the new method decouples the ac and MTDC systems without neglecting the coupling submatrices in the gain matrix, it exhibits good convergence characteristics. The variables and measurement equations of the MTDC system related to the problem formulation are discussed. The effectiveness of the proposed algorithm is demonstrated in this paper with extensive testing in several test systems and the results are compared with other state estimators. The main advantage of the method is that the proposed algorithm can be used to easily adapt existing state estimation algorithm to cater for MTDC.

Keywords: MTDC, state estimation, EMS.

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Discussion Deadline: October 2001

Analysis of Load Frequency Control Performance Assessment Criteria

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Abstract: This paper presents the development and application of an analytic framework for the formulation and evaluation of control performance criteria in load frequency control (LFC). The framework is constructed so as to explicitly represent the uncertainty in the measured variables in LFC and to use metrics that are meaningful for the structure of the problem. The framework makes effective use of probability and random processes concepts to develop rather general criteria for LFC performance assessment. In fact, the NERC criteria **CPS1** and **CPS2** are special cases of the criteria of the framework. The paper thus provides an analytic rationale for the NERC control performance criteria. Analysis of the **CPS1** and **CPS2** criteria shows that, under conditions that are typically in effect in North American interconnections, the two criteria are redundant. Consequently, there is good analytical basis for not requiring the application of **CPS2** once **CPS1** is satisfied. Numerical results with four interconnections are given to illustrate the analytic results. The framework is a powerful construct that may be used to construct new criteria for LFC performance assessment.

Keywords: LFC, AGC, IOS, control performance assessment criteria, random processes, unbundled ancillary service.

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Time-Varying Contingency Screening for Dynamic Security Assessment Using Intelligent-Systems Techniques

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Abstract: A time-frequency-based approach for contingency severity ranking and rapid stability assessment is described. The aim is to classify correctly all single or multiple contingencies that may result in loss of voltage or frequency stability in the first 20 s following the last disturbing action. We start by selecting a number of strategic monitoring buses where the phasor measurement units are located to capture representative voltage magnitudes and angles during detailed time-domain simulations, which cover special protection systems and on-load tap changers. The short-time Fourier transform is then dynamically applied to the responses for extracting selected decision features as the simulation time evolves. It is shown that frequency-domain features such as the peak spectral density of the angle, frequency, and their dot product evaluated over the grid areas are reliable time-varying stability indicators that can form the basis of an entirely secure classification system able to respond within 2 to 3 s after the last event in the contingency. This allows early termination of about 60% of permanently stable simulations. Fuzzy logic and neural networks are used together to make initial decisions, which are then mixed by voting in order to improve the assessment reliability and security at the expense of a reduced yield. The proposed DSA scheme is successfully tested with 1027 contingencies from two widely differing test systems: a 67-bus fictitious system and a 783-bus system in actual use at Hydro-Québec's operations planning department.

Keywords: Dynamic security assessment (DSA), transient stability, dynamic stability, voltage stability, operations planning, phasor measurement unit (PMU), contingency simulation, ranking and screening.

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Discussion Deadline: October 2001

Optimal Location of Multi-Type FACTS Devices in a Power System by Means of Genetic Algorithms

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Abstract: This paper presents a genetic algorithm to seek the optimal location of multi-type FACTS devices in a power system. The optimizations are performed on three parameters: the location of the devices, their types, and their values. The system loadability is applied