### New Solid-State On-Load Tap-Changer Topology for Distribution Transformers

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**Abstract:** High controllability advantages of power electronic switches led to their application in tap-changers of distribution transformers. Using such switches lends itself to quick operation of the tap-changer and thus improved performance. Their application reduces maintenance and repair costs of tap-changers. This paper introduces a new solid-state on-load tap-changer topology that has many steps with fewer power electronic switches compared to those reported in the literature. This tap-changer is designed for an 800 kVA, 20 kV/400 V distribution transformer, and the results are discussed.

**Keywords:** Solid-state tap-changer, transformer, power electronic switch.

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**Discussion Deadline:** October 2002

### Real-Time Dynamic Loading and Thermal Diagnostic of Power Transformers

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**Abstract:** A comprehensive approach to dynamic loading of power transformers is presented. It is based on the Annex G equations in the latest *IEEE Loading Guide*. The IEEE work is enhanced through a continuous update of rated temperatures. The algorithm was evaluated with nine transformer-months of real-time field data. Field observations and comparison with the IEEE Clause 7 and IEC thermal models are presented. Dynamic loading ratings are determined considering limitations imposed by top-oil and hottest-spot temperatures, load current and loss-of-life as defined by IEEE for various types of loading. The rating calculations also consider temperatures of bushings, voltage, present value and historical trend of ambient temperature, preload parameters, cooling mode during the overload, moisture content in the paper, presence of bushing enclosures, and type of the oil-preservation system.

**Keywords:** Cooling mode, dynamic loading, loss of life, power transformer, temperature.

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**Discussion Deadline:** October 2002

### Fast Ferroresonance Suppression of Coupling Capacitor Voltage Transformers

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**Abstract:** This paper describes a procedure for fast suppression of the phenomenon of ferroresosnance in coupling capacitor voltage transformers (CCVT) without major change in the CCVT design. It is possible to adjust parameters of the secondary overvoltage protection and the filter circuit so that the ferroresonance can be cleared in a very short time interval. Study cases show that ferroresonance is effectively cleared within two cycles. An implementation of metal oxide varistors (MOV) as part of passive ferroresonance protection is also addressed. The electromagnetic transients program (EMTP) is used for modeling transients and fine-tuning the ferroresonance suppressing circuit. The studies are conducted on the Trench TEHMP161A GOVT.

**Keywords:** CCVT, CVT, ferroresonance, EMTP, electromagnetic transients.

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**Discussion Deadline:** October 2002

### Transformer Phase Coordinate Models Extended for Grounding System Analysis

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**Abstract:** The transformer model in phase coordinates should be extended to enable a proper analysis of the associated grounding system currents and potentials. A separate ground connection node is introduced through which the transformer interacts with the substation grounding system. The model proposed yields the transformer terminal phase variables in their natural form, reflecting the voltage ratios and phase shifts introduced by transformer winding connections.

**Keywords:** Transformer modeling, phase coordinates, grounding systems.

**Preprint Order Number:** PE-015PRD (05-2002)

**Discussion Deadline:** October 2002

## Transmission and Distribution

### Compensation of Distribution System Voltage Using Dynamic Voltage Restorer (DVR)

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**Abstract:** A *dynamic voltage restorer* (DVR) is a power electronic controller that can protect sensitive loads from disturbances in the supply system. This device can tightly regulate the voltage at the load terminal against imbalance or harmonic in the source side. The behavior of the device is studied through steady-state analysis, and limits to achievable performance are found. This analysis is extended to the study of transient operation where the generation of the reference voltage of the DVR is discussed. Once the reference signals are generated, they are tracked using a switching band scheme. A suitable structure in which the DVR is realized by voltage source inverters is also discussed. Particular emphasis on the rating of this device is given. Extensive simulation results are included to illustrate the operating principles of a DVR.

**Preprint Order Number:** PE-013PRD (05-2002)

**Discussion Deadline:** October 2002

### A Branch-Estimation-Based State Estimation Method for Radial Distribution Systems

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**Abstract:** This paper presents a new branch-based state-estimation method that is an estimation technique for radial distribution systems that can handle most kinds of real-time measurements. In contrast to the traditional weighted-least-square (WLS) method, the idea of this algorithm is to decompose the WLS problem of a whole system into a series of WLS subproblems, and each subproblem is to deal with only single branch state estimation. This approach can be implemented in a forward/backward sweep scheme for radial distribution systems and does not need the sparse matrix technique. Test results of a large-scale practical distribution system in China show that the proposed method is valid and efficient.

**Keywords:** Distribution management system, state estimation, distribution system.

**Preprint Order Number:** PE-531PRD (05-2002)

**Discussion Deadline:** October 2002

### Optimal Acquisition and Aggregation of Offshore Wind Power by Multiterminal Voltage-Source HVdc

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