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IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems

IEEE Power and Energy Society

Sponsored by the
Energy Development and Power Generation Committee

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Abstract: This guide includes criteria, definitions, and test procedures for evaluating the dynamic performance of excitation control systems for synchronous machines as applied by electric utilities.

Keywords: Closed-loop performance, dynamic performance, excitation control systems, excitation system specifications, IEEE Std 421.2™, large signal disturbances, model, small signal disturbances, stabilizer, synchronous machine

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Introduction

This introduction is not part of IEEE Std 421.2-2014, IEEE Recommended Practice for Overvoltage and Insulation Coordination of Transmission Systems at 1000 kV AC and Above.

This guide presents dynamic performance criteria, definitions, and test objectives for excitation control systems as applied by electric utilities. It should be specifically noted that the term *excitation control system* refers to the entire control system including the synchronous machine and power system as well as the excitation system.

The Working Group on Excitation Control System Dynamic Performance of the Excitation Systems and Controls Subcommittee of the Energy Development and Power Generation Committee adopted many definitions and performance criteria, which are common to all control systems, and derived others specifically related to excitation control systems. In doing this, the material in IEEE Std 421.1, IEEE Standard Definitions for Excitation Systems for Synchronous Machines and the now discontinued IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI) was heavily used. Efforts were made not to conflict with existing definitions and criteria, but to clarify, supplement, and more fully define them as related specifically to excitation control systems. Definitions from these standards, which are reproduced in this standard, are included in Clause 3.

In preparing this guide, the working group recognized that both factory testing and field testing of excitation control systems and some of their components are costly and often impractical. Alternator-rectifier excitation systems in which the terminals of the exciter may not be available may preclude field testing of the exciter separately. Compound source excitation systems whose power is derived from the generator currents and voltages present special difficulties. Providing a load which reasonably duplicates the generator field characteristics, so that regulation effects and proper waveforms can be adequately simulated, may not be economically justifiable. Field tests on units under normal operating conditions are constrained to comply with the operating and security requirements of the power system, which often prohibit large excursions of the excitation control system variables. For many applications, it is necessary to devise practical test procedures for individual components and then by analytical means, to verify the total excitation system performance.

The need for models that accurately simulate the operation of excitation control systems during system disturbances demands effective test methods. However, the practical limitations on tests make it difficult to measure the parameters required for models. One solution is the collection of more complete data during system disturbances. Present instrumentation practices generally do not include the collection of data from enough excitation control system variables to permit the data to be used for model refinement. Improving the quantity and quality of data collected during system disturbances may be the only practical way to obtain the data required to significantly improve the accuracy of large signal models.

This revision incorporates a general introduction to the dynamic performance classification section to aid understanding, and the effects of excitation limiters are introduced. Clarifications have been introduced where technology advancements have changed approaches in modelling, such as the introduction of integral control terms whereby open-loop steady-state gain is considered infinite. Additional and improved figures have been introduced and some typical parameters are shown. It is important to note that this document is part of the IEEE 421 series of guides on the various aspects of excitation control systems for synchronous generators and that the IEEE Excitation Systems and Controls Subcommittee has also produced a tutorial on Power System Stabilization via Excitation Control which provides substantial supplemental material.

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IEEE Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems

1. Scope

This guide includes criteria, definitions, and test objectives for evaluating the dynamic performance of excitation control systems as applied by electric utilities. The term *excitation control system* (see Figure 1) is used to distinguish the combined performance of the synchronous machine, power system, and excitation system from that of the excitation system alone (see IEEE Std 421.1™). The primary purpose of this guide is to provide a basis for evaluating the closed-loop performance of excitation control systems, including synchronous machines, for both large and small signal disturbances. Confirming the adequacy of mathematical models for excitation control systems for use in analytical studies of power systems, identifying objectives for tests of excitation control systems and their components, and preparing excitation system specifications and additional standards will also be addressed (see IEEE Std 421.3™, IEEE Std 421.4™, and IEEE Std 421.5™,). Portions of this guide will also serve as educational material for people who are becoming familiar with excitation control systems. This guide is applicable to excitation systems used on all sizes and types of synchronous machines including those in nuclear power facilities.

Traditionally, large signal performance (see 4.2) has been more closely associated with equipment specification and acceptance testing, while small signal performance (see 4.3) has been more closely associated with stability and model studies. Matching actual disturbance data with model simulations, however, requires that both large and small signal performance criteria be considered during design, specification, and acceptance testing.