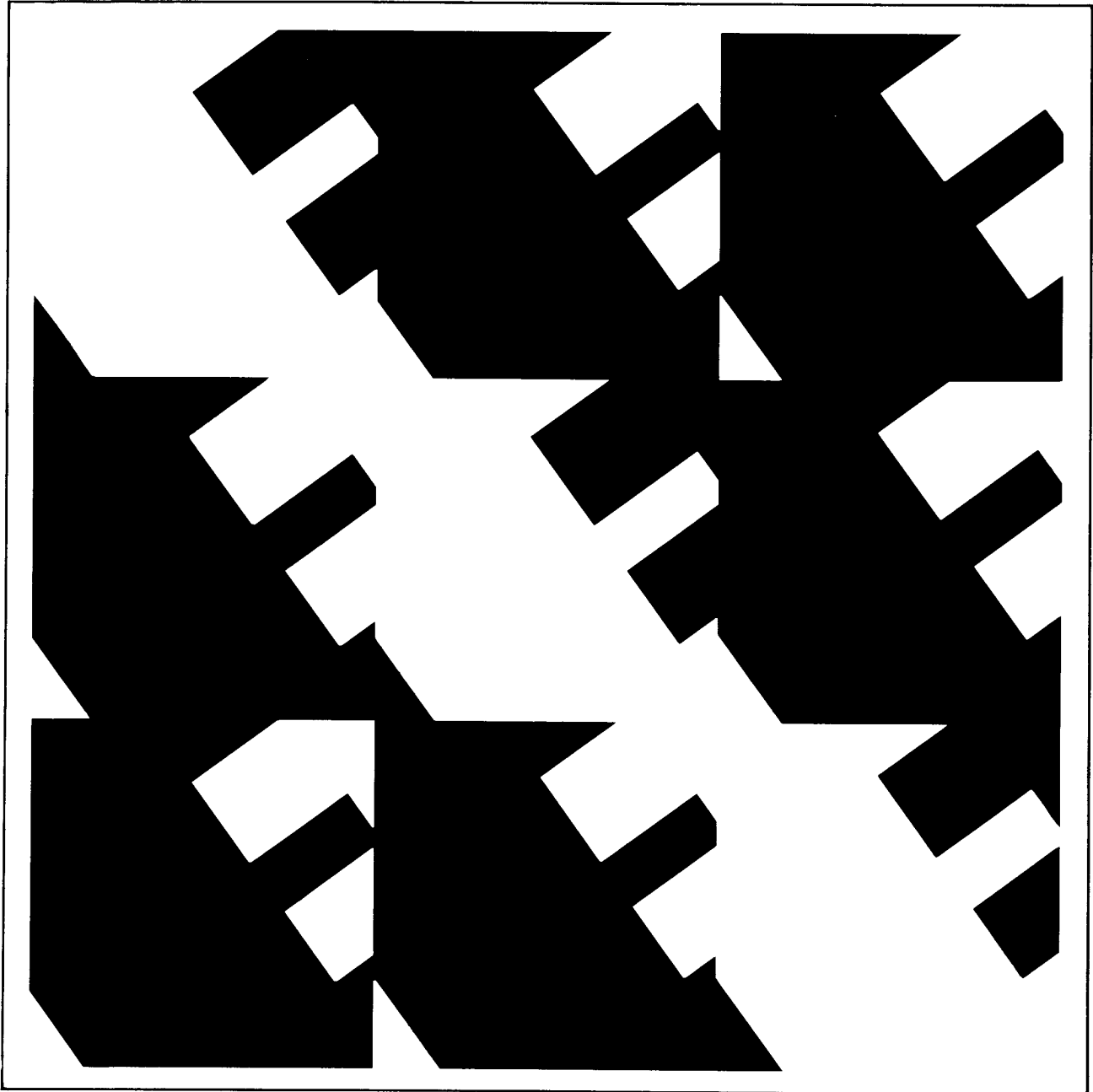


IEEE Standard Procedures for Obtaining Synchronous Machine Parameters by Standstill Frequency Response Testing

(Supplement to ANSI/IEEE Std 115-1983)

IEEE Std 115A-1987



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**IEEE Standard Procedures for
Obtaining Synchronous Machine Parameters
by Standstill Frequency Response Testing**
(Supplement to ANSI/IEEE Std 115-1983, IEEE Guide:
Test Procedures for Synchronous Machines)

Sponsor
**Power System Engineering Committee
and the
Rotating Machinery Committee
of the
IEEE Power Engineering Society**

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Foreword

(This Foreword is not a part of IEEE Std 115A-1987, IEEE Standard Procedures for Obtaining Synchronous Machine Parameters by Standstill Frequency Response Testing.)

This document is the result of work undertaken by the Task Force on Definitions and Procedures, which was formed in 1978 by the Joint Working Group on Determination and Application of Synchronous Machine Models for Stability Studies. The Joint Working Group was itself constituted in 1973 by the Power System Engineering Committee and Rotating Machinery Committee. The working group reported to the Computer and Analytical Methods Subcommittee of the PSE Committee and the Synchronous Machinery Subcommittee of the Rotating Machinery Committee.

The initial thrust of their work could be construed as power system oriented, since the need for higher order stability models, principally for turbogenerators, became apparent as power system analysis began applying static excitation systems and supplementary excitation controls in order to improve stability. With this application came the need for improved computer simulations and the corresponding need for better stability data.

A milestone in the development of this work was the publication, by the Task Force of the Joint Working Group, of "Supplementary Definitions and Associated Test Methods for Obtaining Parameters for Synchronous Machine Stability Study Simulations" in the *IEEE Transactions on Power Apparatus and Systems*, July/August 1980. Thus the need to produce an IEEE standard on the new, recommended procedures, which involved frequency response testing, was apparent to the Joint Working Group. They recommended that the Task Force on Definitions and Procedures address this problem.

The first draft of the current document was transmitted by our Task Force in 1981 to a Working Group of the Synchronous Machinery Subcommittee. This working group, under the chairmanship of Paul I. Nippes, was reviewing IEEE Std 115-1965. Paul G. Cummings, liaison from the Rotating Machinery Committee to the Standards Board, recommended that the Trial Procedure be considered for the present as a supplement to the new ANSI/IEEE Std 115-1983, and hence it was designated IEEE Std 115A. It is presently proposed, when ANSI/IEEE Std 115 is again a candidate for revision, that IEEE Std 115A-1987 will become an integral part of it.

The Task Force and the Joint Working Group wish to acknowledge the assistance of Paul I. Nippes and his working group associates. J. C. White, as Chairman of the Synchronous Machinery Subcommittee during the initial submission of this document, was instrumental in expediting the approval process by the Rotating Machinery Committee. Carl Flick, current Chairman of the Synchronous Machinery Subcommittee, also helped materially, as did Paul G. Cummings, who was of considerable assistance during the Standards Board review process.

Many more names could be mentioned in this Foreword. The entire Task Force on Definitions and Procedures participated in the preparation of the first draft of this document, but special thanks should go to Wilfred Watson and Murray E. Coultres of Ontario Hydro for their comments and encouragement during the initial formulation, between 1979 and 1982, of the ideas presented in the following pages.

At the time this standard was initially approved, the Special Task Force on Definitions and Procedures had the following membership:

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Murray E. Coultres

L. N. Hannett
S. J. Salon

H. Reid Schwenk
Stephen Umans

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IEEE Standard Procedures for Obtaining Synchronous Machine Parameters by Standstill Frequency Response Testing

1. Introduction

In Section 8 of ANSI/IEEE Std 115-1983 [1]¹, methods are described for obtaining synchronous machine parameters in the form of reactances and time constants. These are the familiar synchronous, transient and subtransient reactances as well as open-circuit and short-circuit, transient and subtransient time constants.

Three reactances and two time constants have historically been determined from the test data resulting from the procedures outlined in Section 8 of ANSI/IEEE Std 115-1983 [1]. Accordingly, it has been customary to assume a two-rotor-circuit direct-axis model to describe the synchronous machine mathematically in stability and other related analyses. Figure 1 shows the corresponding equivalent circuit; the Laplace transform analysis of this circuit is detailed in [7].

The assumed quadrature-axis equivalent circuit is similar in structure, except that the field winding is replaced by a second (equivalent) iron circuit.

Accurate identification of the field circuit is a desirable feature for present day stability analyses where excitation controls play an important role. This is not possible with the tests described in Section 8 of ANSI/IEEE Std 115-1983 [1].

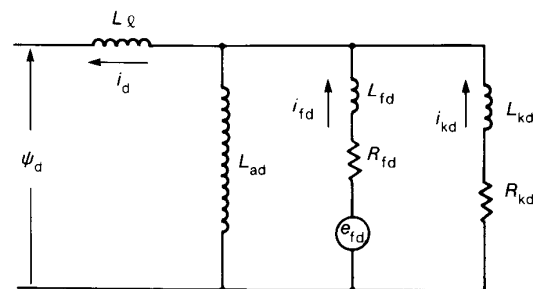
Another difficulty with ANSI/IEEE Std 115-1983 [1] lies in defining adequate tests for quadrature-axis quantities. Test procedures, described in 8.5, are available for determining quadrature-axis synchronous reactances. There are no practical or acceptable procedures listed in Section 8 for obtaining quadrature-axis transient or subtransient reactances or time constants. Present day stability studies require quadrature-axis as well as direct-axis values for an accurate and adequate synchronous machine stability simulation.

¹ The numbers in brackets correspond to those of the references listed in Section 2 of this standard.

A new approach has demonstrated that stability parameters for synchronous machines can be obtained by performing frequency response tests with the machine at standstill. Frequency response data describe the response of machine fluxes to stator current and field voltage changes in both the direct and quadrature axes of a synchronous machine. Some advantages of the method are that it can be done either in the factory or on site, it poses a low probability of risk to the machine being tested, and it provides complete data in both direct and quadrature axes. Resistances and reactances for the associated models can be calculated using the methods in the Appendix.

The model parameters derived from the standstill frequency response tests reflect linearized conditions, with extremely low flux conditions in

Fig 1
Conventional *d*-Axis Equivalent Circuit



- L_{ℓ} = armature leakage inductance
- L_{fd} = field leakage inductance
- L_{kd} = direct-axis rotor equivalent leakage inductance
- L_{ad} = stator to rotor mutual inductance
- R_{fd} = field resistance
- R_{kd} = direct-axis rotor equivalent resistance