SLOVENSKI STANDARD

SIST-TP CLC/TR 60034-16-2:2005

01-junij-2005

Elektriļ ni rotacijski stroji - 16-2. del: Vzbujalni sistemi za sinhronske stroje - Modeli za ġtudije moļ nostnega sistema (IEC/TR 60034- 16-2:1991)

Rotating electrical machines - Part 16-2: Excitation systems for synchronous machines - Models for power system studies (IEC/TR 60034- 16-2:1991)

Drehende elektrische Maschinen - Teil 16-2: Erregersysteme für Synchronmaschinen - Modelle für Netzstudien (IEC/TR 60034- 16-2:1991)

Machines électriques tournantes - Partie 16-2: Systèmes d'excitation pour machines synchrones - Modèles pour les études de réseaux (CEI/TR 60034- 16-2:1991)

Ta slovenski standard je istoveten z: CLC/TR 60034-16-2:2004

ICS:

29.160.10	Sestavni deli rotacijskih strojev	Components for rotating machines

SIST-TP CLC/TR 60034-16-2:2005 en

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CLC/TR 60034-16-2

September 2004

ICS 29.160.00

English version

Rotating electrical machines
Part 16-2: Excitation systems for synchronous machines - Models for power system studies
(IEC/TR 60034-16-2:1991)

Machines électriques tournantes
Partie 16-2: Systèmes d'excitation pour machines synchrones -
Modèles pour les études de réseaux
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Drehende elektrische Maschinen
Teil 16-2: Erregersysteme für Synchronmaschinen -
Modelle für Netzstudien
(IEC/TR 60034-16-2:1991)

This Technical Report was approved by CENELEC on 2004-06-12.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. CLC/TR 60034-16-2:2004 E

Foreword

The text of the Technical Report IEC/TR 60034-16-2:1991, prepared by IEC TC 2, Rotating machinery, was submitted to the formal vote and was approved by CENELEC as CLC/TR 60034-16-2 on 2004-06-12 without any modification.

Endorsement notice

The text of the Technical Report IEC/TR 60034-16-2:1991 was approved by CENELEC as a Technical Report without any modification.

RAPPORT TECHNIQUE

TECHNICAL REPORT

CEI
IEC
34-16-2

Première édition
First edition
1991-02

Machines électriques tournantes

Seizième partie:
Systèmes d'excitation pour machines synchrones
Chapitre 2: Modèles pour les études de réseaux

Rotating electrical machines

Part 16:
Excitation systems for synchronous machines
Chapter 2: Models for power system studies

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE V

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This report has been prepared by IEC Technical Committee No. 2: Rotating machinery.

The text of this report is based on the following documents:

Six Months' Rule	Report on Voting
2(CO)533	2(CO)548

Full information on the voting for the approval of this report can be found in the Voting Report indicated in the above table.

This report forms Chapter 2 of Part 16 of a series of publications dealing with rotating machinery, the other parts being:

Part 1: Rating and performance, issued as IEC 34-1.

Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles), issued as IEC 34-2.

Part 3: Specific requirements for turbine-type synchronous machines, issued as IEC 34-3.

Part 4: Methods for determining synchronous machine quantities from tests, issued as IEC 34-4.

Part 5: Classification of degrees of protection provided by enclosures for rotating machines, issued as IEC 34-5.

Part 6: Methods of cooling rotating machinery, issued as IEC 34-6.

Part 7: Symbols for types of construction and mounting arrangements of rotating electrical machinery, issued as IEC 34-7.

Part 8: Terminal markings and direction of rotation of rotating machines, issued as IEC 34-8.

Part 9: Noise limits, issued as IEC 34-9.

Part 10: Conventions for description of synchronous machines, issued as IEC 34-10.

Part 11: Built-in thermal protection. Chapter 1: Rules for protection of rotating electrical machines, issued as IEC 34-11.

Part 11-2: Built-in thermal protection. Chapter 2: Thermal detectors and control units used in thermal protection systems, issued as IEC 34-11-2.

Part 11-3: Built-in thermal protection. Chapter 3: General rules for thermal protectors used in thermal protection systems, issued as IEC 34-11-3.

Part 12: Starting performance of single-speed three-phase cage induction motors for voltages up to and including 660 V, issued as IEC 34-12.

Part 13: Specification for mill auxiliary motors, issued as IEC 34-13.

Part 14: Mechanical vibration of certain machines with shaft heights, 56 mm and higher - Measurement, evaluation and limits of the vibration severity, issued as IEC 34-14.

Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils, issued as IEC 34-15.

Part 16-1 Excitation systems for synchronous machines. Chapter 1: Definitions, issued as IEC 34-16-1.

INTRODUCTION

When the behaviour of synchronous machines is to be accurately simulated in power system stability studies, the excitation systems of these machines should be modelled adequately. Since expenditure for data acquisition, programming and computation has to be limited in so far as is permissible, it is necessary to use simplified models that provide reasonable accuracy. The models should adequately represent the actual excitation system performance:

- during steady-state conditions prior to occurrence of the fault studied;
- during the time interval from application to clearing of the fault;
- during the oscillations following fault clearing.

The modelling does not account for frequency deviations. It is assumed that in stability studies frequency deviations of up to ±5 % from the rated frequency can be neglected as far as the excitation system is concerned.

The excitation system models should be valid for steady-state conditions, for the natural oscillation frequency of the synchronous machines, and the frequency range in between. The frequency range to be covered will typically be from 0 Hz to 3 Hz.

Analysis of out-of-step operation, of sub-synchronous resonance or of shaft torsional effects is beyond the scope of these models.

The operation of protective functions and field discharge or suppression equipment is also beyond the scope of these models.

The excitation system modelling guidelines and standard models may also be used for studies of other dynamic problems regarding synchronous machines. However, the models should then be checked to determine their suitability for that purpose.

The general functional block diagram in figure 1 indicates the various excitation system components which have to be considered in power system stability studies. These components include:

- voltage control elements;
- limiters;
- power system stabilizer (if used);
- exciter power converter (exciter).

The limiters are not normally represented in power system studies.

The main distinctive feature of an excitation system is the manner in which the excitation power is supplied and converted.

ROTATING ELECTRICAL MACHINES

Part 16: Excitation systems for synchronous machines
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1 Scope

This report recommends modelling guidelines and appropriate models for excitation systems for use in power system stability studies and includes a nomenclature defining the parameters and variables used.

Definitions for the terms used are given in IEC 34-16-1.

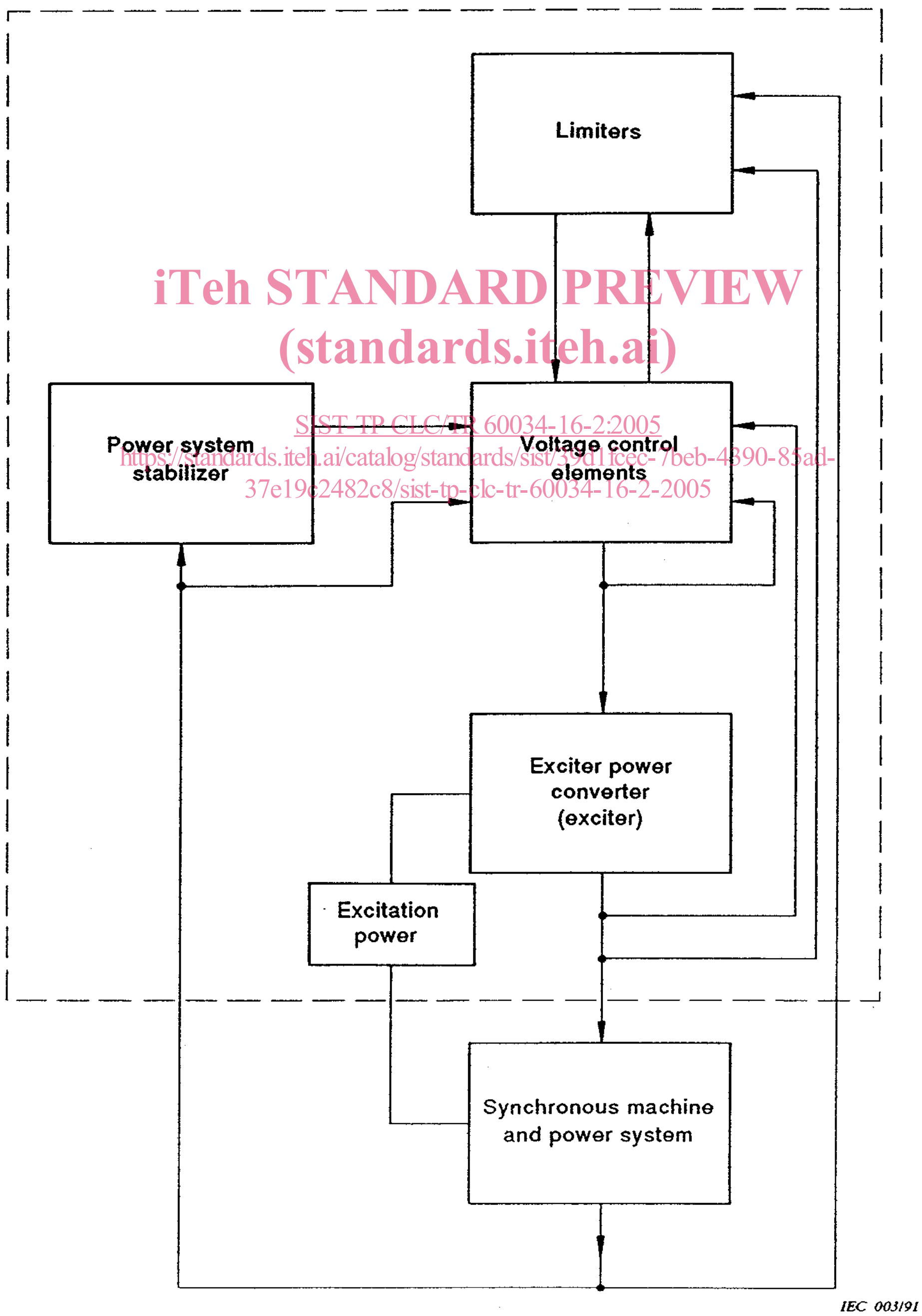

Figure 1 – General functional block diagram of excitation systems (within the dotted block) for synchronous machines

2 Exciter categories - Graphical representation and mathematical models for stability studies

2.1 *D.C. exciter*

Although not frequently used on new machines, d.c. exciters are considered because many synchronous machines presently in service are equipped with this type of exciter. Figure 2 shows a graphical representation of the type with one separately excited field winding and figure 3 shows the corresponding model. The term K_E has been introduced in the model to account for the characteristic of exciters having self-excitation. Note that $K_E = 1$ in the case of separately excited exciters.

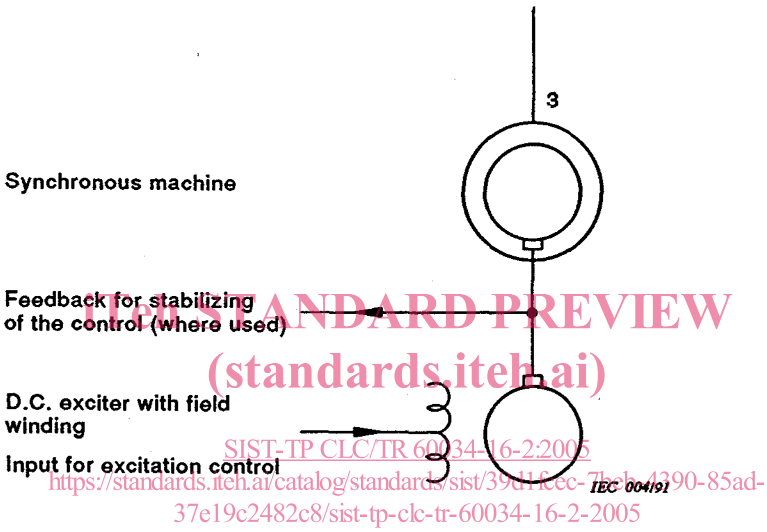

Figure 2 – D.C. exciter with one separately excited field winding

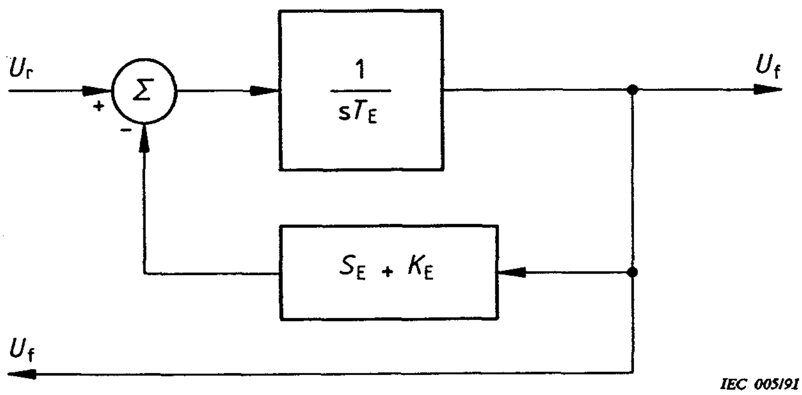

Figure 3 - Model corresponding to figure 2

Several forms of excitation control are in use:

- electro-mechanically operated rheostat;
- motor-operated rheostat;

- periodically closing and short-circuiting of the shunt field circuit;

- use of additional, separately excited fields for buck and boost action;

- use of the terminal voltage of an amplidyne in series with the field winding for boost and buck action.

Considering the dwindling percentage and importance of units equipped with d.c. exciters, the simple model of figure 3 should prove adequate for these cases.

2.2 *A.C. exciter*

A.C. exciters employ an a.c. generator together with a stationary or rotating rectifier to produce the field current for the synchronous machine. The rectifiers may be uncontrolled or controlled. In the case of uncontrolled rectifiers, control is effected via one or more field windings of the a.c. exciter.

It is essential to know the source of supply for the a.c. exciter field current via its control equipment in order to model the control. The source may be an auxiliary generator or a potential or compound static source.

Figure 4 shows the graphical representation of an a.c. exciter with an uncontrolled stationary rectifier. The stationary rectifier is fed from the a.c. generator and delivers d.c. current to the field winding of the synchronous machine via brushes and slip-rings. The connection of the rotating field winding of the exciter generator to the excitation control is also made by slip-rings and brushes.

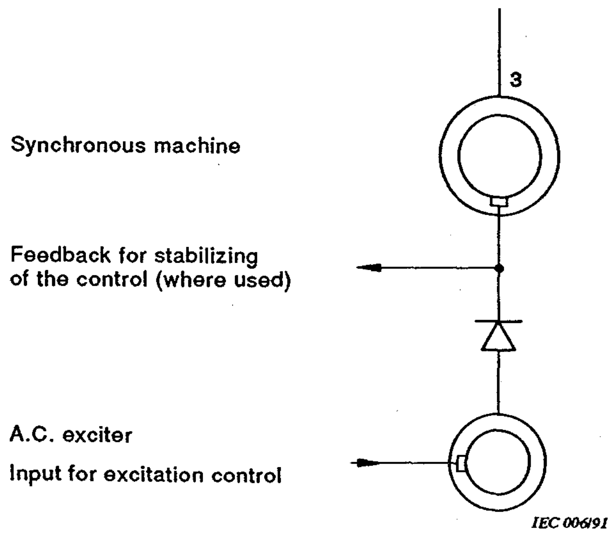

Figure 4 – A.C. exciter with an uncontrolled stationary rectifier