IEC 60034-4-1

Edition 1.0 2018-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Rotating electrical machines –
Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests

Machines électriques tournantes –
Partie 4-1: Méthodes pour la détermination, à partir d'essais, des grandeurs des machines synchrones à excitation électrique

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INTERNATIONAL
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ROTATING ELECTRICAL MACHINES –

Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests

FOREWORD

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International Standard IEC 60034-4-1 has been prepared by IEC technical committee 2: Rotating machinery.

IEC 60034-4-1 first edition cancels and replaces the third edition of IEC 60034-4 published in 2008. This edition constitutes a technical revision.

This publication includes the following significant technical changes with respect to IEC 60034-4 edition 3:

a) improvement of several procedures with respect to evaluation of quantities;

b) deletion of uncommon procedures;

c) applicability of procedures for permanent magnet machines.

The text of this International Standard is based on the following documents:

CDV	Report on voting
2/1829/CDV	2/1869/RVC

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

ROTATING ELECTRICAL MACHINES –

Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests

1 Scope

This part of IEC 60034 applies to three-phase synchronous machines of 1 kVA rating and larger.

Most of the methods are intended to be used for machines having an excitation winding with slip-rings and brushes for their supply. Synchronous machines with brushless excitation require special effort for some of the tests. For machines with permanent magnet excitation, there is a limited applicability of the described tests, and special precautions should be taken against irreversible demagnetization.

Excluded are axial-field machines and special synchronous machines such as inductor type machines, transversal flux machines and reluctance machines.

It is not intended that this document be interpreted as requiring any or all of the tests described therein on any given machine. The particular tests to be carried out are subject to agreement between manufacturer and customer.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-2-1, *Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60051 (all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
<synchronous motors> initial starting impedance
quotient of the applied armature voltage and the sustained average armature current, the machine being at standstill

3.2
direct-axis synchronous reactance
quotient of the sustained value of that fundamental AC component of armature voltage, which is produced by the total direct-axis primary flux due to direct-axis armature current, and the value of the fundamental AC component of this current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-07]

3.3
direct-axis transient reactance
quotient of the initial value of a sudden change in that fundamental AC component of armature voltage, which is produced by the total direct-axis primary flux, and the value of the simultaneous change in fundamental AC component of direct-axis armature current, the machine running at rated speed and the high decrement components during the first cycles being excluded

[SOURCE: IEC 60050-411:1996, 411-50-09]

3.4
direct-axis sub-transient reactance
quotient of the initial value of a sudden change in that fundamental AC component of armature voltage, which is produced by the total direct-axis armature flux, and the value of the simultaneous change in fundamental AC component of direct-axis armature current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-11]

3.5
quadrature-axis synchronous reactance
quotient of the sustained value of that fundamental AC component of armature voltage, which is produced by the total quadrature-axis primary flux due to quadrature-axis armature current, and the value of the fundamental AC component of this current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-08]

3.6
quadrature-axis transient reactance
quotient of the initial value of a sudden change in that fundamental AC component of armature voltage, which is produced by the total quadrature-axis armature winding flux, and the value of the simultaneous change in fundamental AC component of quadrature-axis armature current, the machine running at rated speed and the high decrement components during the first cycles being excluded

[SOURCE: IEC 60050-411:1996, 411-50-10]

3.7
quadrature-axis sub-transient reactance
quotient of the initial value of a sudden change in that fundamental AC component of armature voltage, which is produced by the total quadrature-axis primary flux and the value of the simultaneous change in fundamental AC component of quadrature-axis armature current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-12]

3.8
positive sequence reactance
quotient of the reactive fundamental component of the positive sequence armature voltage, due to the sinusoidal positive sequence armature current at rated frequency, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-14]

3.9
negative sequence reactance
quotient of the reactive fundamental component of negative sequence armature voltage, due to the sinusoidal negative sequence armature current at rated frequency, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-15]

3.10
zero sequence reactance
quotient of the reactive fundamental component of zero sequence armature voltage, due to the presence of fundamental zero sequence armature current at rated frequency, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-16]

3.11
Potier reactance
reactance taking into account the leakage of the field winding, on load and in the over-excited region, which is used in place of the armature leakage reactance to calculate the excitation on load by means of the Potier method

[SOURCE: IEC 60050-411:1996, 411-50-13]

3.12
armature-leakage reactance
quotient of the reactive fundamental component of armature voltage due to the leakage flux of armature winding and the fundamental component of armature current, the machine running at rated speed

3.13
armature resistance
resistance measured by direct current between terminals of the armature winding, referred to a certain winding temperature, expressed as per phase value

3.14
excitation winding resistance
resistance measured by direct current between terminals of the excitation winding, referred to a certain winding temperature

3.15
positive sequence resistance
quotient of the in-phase component of positive sequence armature voltage corresponding to losses in the armature winding and stray load losses due to the sinusoidal positive sequence armature current, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-18]

3.16
negative sequence resistance
quotient of the in-phase fundamental component of negative sequence armature voltage, due to the sinusoidal negative sequence armature current at rated frequency, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-19]

3.17
zero sequence resistance
quotient of the in-phase fundamental component of zero sequence armature voltage, due to the fundamental zero sequence armature current of rated frequency, by the value of that component of current, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-20]

3.18
short-circuit ratio
ratio of the field current for rated armature voltage on open-circuit to the field current for rated armature current on sustained symmetrical short-circuit, both with the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-50-21]

3.19
direct-axis transient open-circuit time constant
the time required, following a sudden change in operating conditions, for the slowly changing component of the open-circuit armature voltage, which is due to direct-axis flux, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-27]

3.20
direct-axis transient short-circuit time constant
time required, following a sudden change in operating conditions, for the slowly changing component of direct-axis short-circuit armature current to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-28]

3.21
direct-axis sub-transient open-circuit time constant

time required, following a sudden change in operating conditions, for the rapidly changing component present during the first few cycles of the open-circuit armature winding voltage which is due to direct-axis flux, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-29]

3.22
direct-axis sub-transient short-circuit time constant
time required, following a sudden change in operating conditions, for the rapidly changing component, present during the first few cycles in the direct-axis short-circuit armature current, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-30]

3.23
quadrature-axis transient open-circuit time constant
time required, following a sudden change in operating conditions, for the slowly changing component of the open-circuit armature winding voltage which is due to quadrature-axis flux, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-32]

3.24
quadrature-axis transient short-circuit time constant
time required, following a sudden change in operating conditions, for the slowly changing component of quadrature-axis short-circuit armature winding current, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-33]

3.25
quadrature-axis sub-transient open-circuit time constant
time required, following a sudden change in operating conditions, for the rapidly changing component of the open-circuit armature winding voltage which is due to quadrature-axis flux, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-34]

3.26
direct-axis open-circuit equivalent damper circuit time constant
time required for the induced current component in the equivalent damper circuit to decrease to 1/e ≈ 0,368 of its initial value following a sudden change in operating conditions with open-circuited armature winding and the excitation winding being also open, the machine running at rated speed

3.27
direct-axis short-circuit equivalent damper winding time constant
time required for the induced current component of the equivalent damper winding to decrease to 1/e ≈ 0,368 of its initial value following a sudden change in operating conditions with short-circuited armature winding the excitation winding being open, and the machine running at rated speed

3.28
quadrature-axis sub-transient short-circuit time constant
time required, following a sudden change in operating conditions, for the rapidly changing component, present during the first few cycles in the quadrature-axis short-circuit armature winding current, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-35]

3.29
short-circuit time constant of armature windings
time required, following a sudden change in operating conditions, for the DC component present in the short-circuit armature winding current, to decrease to 1/e, that is 0,368 of its initial value, the machine running at rated speed

[SOURCE: IEC 60050-411:1996, 411-48-31]

3.30
unit acceleration time
time which would be required to bring the rotating parts of a machine from rest to rated speed if the accelerating torque were constant and equal to the quotient of rated active power by rated angular velocity

[SOURCE: IEC 60050-411:1996, 411-48-15]

3.31
stored energy constant
quotient of the kinetic energy stored in the rotor when running at rated speed and of the rated apparent power

3.32
rated excitation current
current in the excitation winding when the machine operates at rated voltage, current, power-factor and speed

3.33
excitation current
current in the excitation winding when the machine operates at rated speed and sustained rated armature current, the armature (primary) winding being short-circuited

3.34
rated voltage regulation
change in the terminal voltage when rated operation is replaced by no-load operation with open-circuit armature and with unchanged speed and excitation current

3.35
frequency response characteristics
set of characteristic curves or analytical expressions relating complex admittance or its reciprocal complex impedance (or components thereof) to slip at rated supplied frequency unless otherwise stated

3.36
frequency response characteristic of direct-axis reactance
complex quotient expressed as a slip function of the sustained complex value (phasor) of that fundamental component of armature voltage which is produced by the d-axis armature current, and the vector of the fundamental component of this current, the machine running at a given slip, with the excitation winding short-circuited

Note 1 to entry: The term for the complex representation of a sinusoidal quantity of one single frequency is phasor or, alternatively, vector which is the term used in this document.

3.37
frequency response characteristic of quadrature-axis reactance
complex quotient expressed as a slip function of the sustained phasor of that fundamental component of armature voltage which is produced by the q-axis armature flux due to q-axis armature current and the vector of the fundamental component of this current, the machine running at a given slip, with the excitation winding short-circuited

3.38
frequency response characteristic of excitation factor
complex quotient of the sustained phasor of the armature voltage, produced by the current in the excitation winding at frequency $s \cdot f$, and the complex value of the voltage applied to the excitation winding, the machine running at a rated speed