IEC 60034-18-42

Edition 1.0 2017-02

INTERNATIONAL STANDARD

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colour inside

Rotating electrical machines –
Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters – Qualification tests

Machines électriques tournantes –
Partie 18-42: Systèmes d'isolation électrique résistants aux décharges partielles (Type II) utilisés dans des machines électriques tournantes alimentées par convertisseurs de tension – Essais de qualification

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.160.01

ISBN 978-2-8322-3822-6

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FOREWORD

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International Standard IEC 60034-18-42 has been prepared by IEC Technical Committee 2: Rotating machinery.

IEC 60034-18-42 cancels and replaces IEC TS 60034-18-42 (2008).

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

FDIS	Report on voting
2/1854/FDIS	2/1856/RVD

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 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- withdrawn,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.

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INTRODUCTION

The approval of electrical insulation systems for use in rotating electrical machines fed from voltage converters is set out in two International Standards. These standards separate the systems into those which are not expected to experience partial discharge activity within specified conditions in their service lives (Type I) and those which are expected to experience and withstand partial discharge activity in any part of the insulation system throughout their service lives (Type II). For both Type I and Type II insulation systems, the power drive system integrator (the person responsible for co-ordinating the electrical performance of the entire power drive system) shall inform the machine manufacturer what voltage will appear at the machine terminals in service. The machine manufacturer will then decide upon the severity of the tests appropriate for qualifying the insulation system. For insulation systems which have been qualified through IEC 60034-18-41 or IEC 60034-18-42 for use in converter-fed applications, an impulse voltage insulation class may be derived. This indicates the ability of the insulation to withstand the electric stresses resulting from converter operation. For Type I systems, the severity is based on the impulse rise time and the peak to peak voltage. For Type II systems, the severity is additionally affected by the impulse voltage repetition rate and the fundamental voltage characteristics. After installation of the converter/machine system, it is recommended that the system integrator measures the phase to phase and phase to ground voltages between the terminals and ground to check for compliance.

IEC 60034-18-41

Type I insulation systems are dealt with in IEC 60034-18-41. These systems are generally used in rotating machines with rated voltage less than 700 V r.m.s. and tend to have random-wound coils. In IEC 60034-18-41, the necessary normative references and definitions are given together with a review of the effects arising from converter operation. Having established the technical basis for the evaluation procedure, the conceptual approach and test programmes are then described.

IEC 60034-18-42

In IEC 60034-18-42, tests are described for qualification of Type II insulation systems. These insulation systems are generally used in rotating machines which have form-wound windings, mostly rated above 700 V r.m.s. The qualification procedure is completely different from that used for Type I insulation systems and involves destructive ageing of test objects under accelerated conditions. The manufacturer requires a life curve (as described in IEC 60034-18-32) for the insulation system that can be interpreted by use of appropriate calculations and/or experimental procedures to provide an estimate of life under the service conditions with converter drive. Great importance is attached to the qualification of any stress control system that is used and testing here should be performed under sinusoidal and repetitive impulse conditions applied separately. If the insulation system can be shown to provide an acceptable life under the specified ageing conditions, it is qualified for use.

ROTATING ELECTRICAL MACHINES –

Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters – Qualification tests

1 Scope

This part of IEC 60034 defines criteria for assessing the insulation system of stator/rotor windings of single or polyphase AC machines which are subjected to repetitive impulse voltages, such as those generated by pulse width modulation (PWM) converters, and are expected to experience and withstand partial discharge activity during service. It specifies electrical qualification tests on representative specimens to verify fitness for operation with voltage-source converters. It also describes an additional classification system which defines the limits of reliable performance under converter-fed conditions.

Although this document deals with voltage converters, it is recognised that there are other types of converters that can create repetitive impulse voltages. For these converters, a similar approach to testing can be used.

Qualification of insulation systems may not be required for rotating machines which are only fed from voltage converters for starting and so they are excluded from this document.

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 60034-1:2010, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-18-1:2010, *Rotating electrical machines – Part 18-1: Functional evaluation of insulation systems. General guidelines*

IEC 60034-18-31, *Rotating electrical machines – Part 18-31: Functional evaluation of insulation systems – Test procedures for form-wound windings – Thermal evaluation and classification of insulation systems used in rotating machines*

IEC 60034-18-32, *Rotating electrical machines – Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation by electrical endurance*

IEC 60034-18-41:2014, *Rotating electrical machines – Part 18-41: Partial discharge free (Type I) electrical insulation systems used in rotating electrical machines fed from voltage converters – Qualification and quality control tests*

IEC TS 60034-27, *Rotating electrical machines – Part 27: Off-line partial discharge measurements on the stator winding insulation of rotating electrical machines*

IEC TS 61934, *Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses*

IEC 62539, *Guide for the statistical analysis of electrical insulation breakdown data*

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
partial discharge
PD
electric discharge that only partially bridges the insulation between electrical conductors

Note 1 to entry: It may occur inside or outside the insulation or adjacent to an electrical conductor.

3.2
partial discharge inception voltage
PDIV
lowest voltage at which partial discharges are initiated in the test arrangement when the voltage applied to the test object is gradually increased from a lower value at which no such discharges are observed

Note 1 to entry: With sinusoidal applied voltage, the PDIV is defined as the r.m.s. value of the voltage. With impulse voltages, the PDIV is defined as the peak to peak voltage.

3.3
repetitive partial discharge inception voltage
RPDIV
minimum peak to peak impulse voltage at which more than five PD pulses occur on ten voltage impulses of the same polarity

Note 1 to entry: This is a mean value for the specified test time and a test arrangement where the voltage applied to the test object is gradually increased from a value at which no partial discharges can be detected.

3.4
peak (impulse) voltage
U_p
maximum numerical value of voltage reached during a unipolar voltage impulse (e.g. U_p in Figure 1)

Note 1 to entry: For bipolar voltage impulses, it is half the peak to peak voltage.

3.5
steady state impulse voltage magnitude
U_a
final magnitude of the voltage impulse

SEE: Figure 1.

3.6
voltage overshoot
U_b
magnitude of the peak voltage in excess of the steady state impulse voltage

SEE: Figure 1.

3.7
peak to peak impulse voltage
$U'_{pk/pk}$
peak to peak voltage at the impulse voltage repetition rate

SEE: Figure 2.

3.8
peak to peak voltage
$U_{pk/pk}$
peak to peak phase to phase voltage at the fundamental frequency

SEE: Figure 2.

Note 1 to entry: The definition of peak to peak voltage is clarified in Clause 4.

3.9
unipolar voltage impulse
voltage impulse, the polarity of which is either positive or negative

Note 1 to entry: The term impulse is used to describe the transient stressing voltage applied to the test object and the term pulse is used to describe the partial discharge signal.

3.10
bipolar voltage impulse
voltage impulse, the polarity of which changes alternately from positive to negative or vice versa

3.11
impulse voltage repetition rate
f
inverse of the average time between two successive impulses of the same polarity, whether unipolar or bipolar

3.12
impulse rise time
t_r
time for the voltage to rise from 10 % to 90 % of its final value

SEE: Figure 1.

3.13
electrical insulation system
insulating structure containing one or more electrical insulating materials together with associated conducting parts employed in an electrotechnical device

3.14
motorette
special test model used for the evaluation of the electrical insulation system for random-wound windings

3.15
formette
special test model used for the evaluation of the electrical insulation system for form-wound windings

3.16
electric stress
electric field in V/mm

3.17
rated voltage
U_N
voltage assigned by the manufacturer for a specified power frequency operating condition of a machine and indicated on its rating plate

3.18
impulse voltage insulation class
IVIC
limits of the applied voltage for operation of a Type I or Type II converter-fed machine

Note 1 to entry: The limits are shown as severity levels for which the machine has been qualified.

Note 2 to entry: The severity levels are to be shown in the documentation for the machine.

3.19
fundamental frequency
first frequency, in the spectrum obtained from a Fourier transform of a periodic time function, to which all the frequencies of the spectrum are referred

Note 1 to entry: For the purposes of this document, the fundamental frequency of the machine terminal voltage is the one defining the speed of the converter-fed machine.

Note 2 to entry: It is calculated as the reciprocal of the time taken for one complete cycle of the applied voltage (Figure 2).

3.20
impulse duration
interval of time between the first and last instants at which the instantaneous value of an impulse reaches a specified fraction of its impulse magnitude or a specified threshold

3.21
jump voltage
U_j
change in voltage at the terminals of the machine occurring at the start of each impulse when fed from a converter

SEE: Figure 3.

3.22
dc bus voltage
U_{dc}
voltage of the intermediate circuit of the voltage converter (dc-link-circuit)

Note 1 to entry: For a 2-level converter U_{dc} is equal to U_a in Figure 1.

Note 2 to entry: For a multilevel converter, U_{dc} is equal to ½ $U_{pk/pk}$ minus the overshoot in Figure 2.

3.23
power drive system
PDS
complete drive module and rotating machine together with the connecting cable if necessary

3.24
voltage endurance coefficient
n
exponent of the inverse power model or exponential model on which the relationship between life and stressing voltage amplitude for a specific insulation system depends

3.25
life
time to failure

3.26
conductive slot coating
conductive paint or tape layer in intimate contact with the mainwall insulation in the slot portion of the coil side, often called semi-conductive coating

Note 1 to entry: The purpose of the coating is to prevent slot discharges from occurring.

3.27
stress control coating
paint or tape on the surface of the mainwall insulation that extends beyond the conductive slot coating in high-voltage stator bars and coils

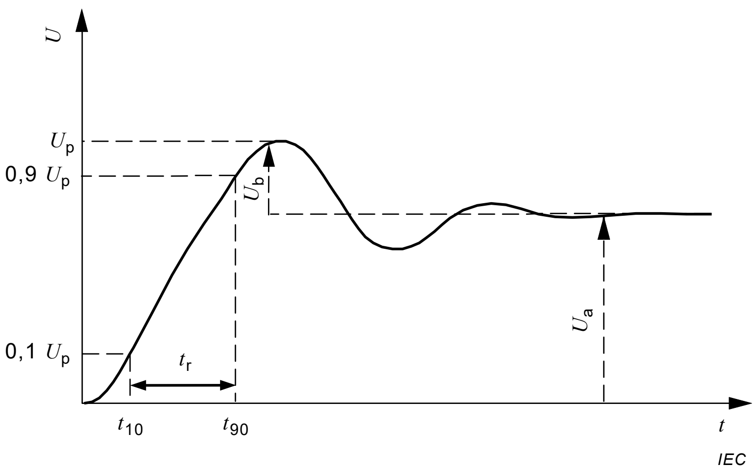
Note 1 to entry: The purpose of the coating is to grade the surface electric stress.

3.28
stress control system
generic name for the combination of the conductive slot coating and stress control coating in high-voltage stator bars and coils

3.29
maximum allowable peak to peak phase to ground voltage
U_{IVIC}
maximum allowable peak to peak phase to ground voltage in service

4 Machine terminal voltages arising from converter operation

The voltage appearing at the terminals of a converter-fed machine may be estimated using IEC TS 61800-8 [1][1] and depends upon several characteristics of the PDS. In order to apply this standard to the qualification and testing of the insulation system of a winding, it is necessary to specify the required parameters of the voltage appearing at the machine terminals (Clause 7).



Key

U voltage

t time

Figure 1 – Voltage impulse waveshape parameters

The amplitude and rise time of the voltage at the machine terminals depend upon the grounding system, various design aspects of the cable, the machine surge impedance and the

[1] Numbers in square brackets refer to the Bibliography.

presence of any filters that increase the impulse rise time. Examples of characteristics of converter impulses at the machine terminals of two motors are given in Table 1.

Table 1 – Examples of the values of characteristics of the terminal voltages for two converter-fed machines

Machine rating	3,3 kV	6,6 kV
Peak to peak voltage on the phase to ground insulation	5,4 kV	10,8 kV
Fundamental frequency	50/60 Hz	50/60 Hz
Number of levels for the converter voltage	5	3
Overshoot of the impulse voltage	60 %	60 %
Nominal voltage per step	650 V	3 kV
Impulse rise time at the motor terminals	1 µs	3 µs
Impulse repetition rate	1 kHz	900 Hz
IVIC required to qualify the insulation for this service (see Table D.2)	3	3

In the case of 2-level or other voltage converters, the impulses generate voltage overshoots at the machine terminals, depending on the rise time of the voltage impulse at the converter output and on the cable length and machine impedance. This voltage overshoot is created by reflected waves at the interface between cable and machine or converter terminals due to impedance mismatch. The voltage appearing at the machine terminals when fed from a 3-level converter is shown in Figure 2. The figure shows one cycle at the fundamental frequency.

The maximum change in voltage or jump voltage (U_j) at the impulse repetition rate is shown in Figure 3. This parameter is important in defining the voltage enhancement that can occur across the first or last coil in the winding. A double jump transition (Figure 3) is possible but it is the duty of the PDS integrator to ensure that the software controlling the PDS minimises its occurrence. When the double jump transition occurs in multilevel converter voltages, its effect is insignificant.

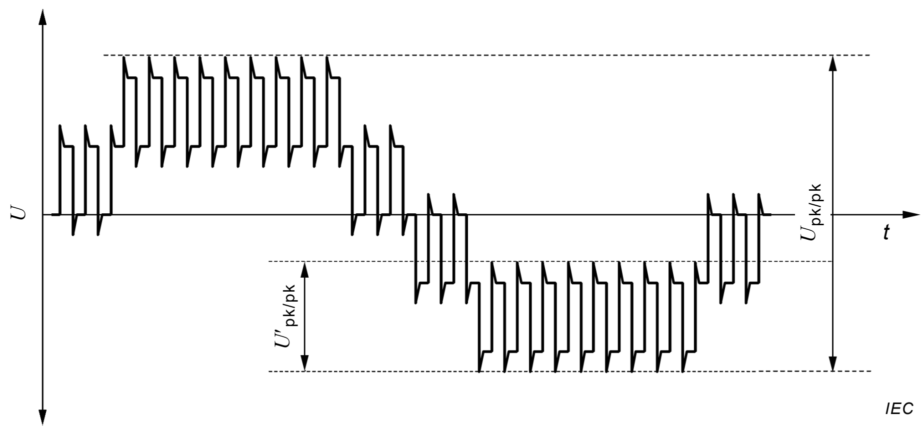


Figure 2 – Waveform representing one complete cycle of the phase to phase voltage at the terminals of a machine fed from a 3-level converter